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PERCEPTIONS OF TECHNOLOGY AND EXISTING TECHNOLOGICAL CAPABILITY OF TONGAN SECONDARY SCHOOL STUDENTS

By

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THE HA'AMONGA 'A MAUI TRILITHON
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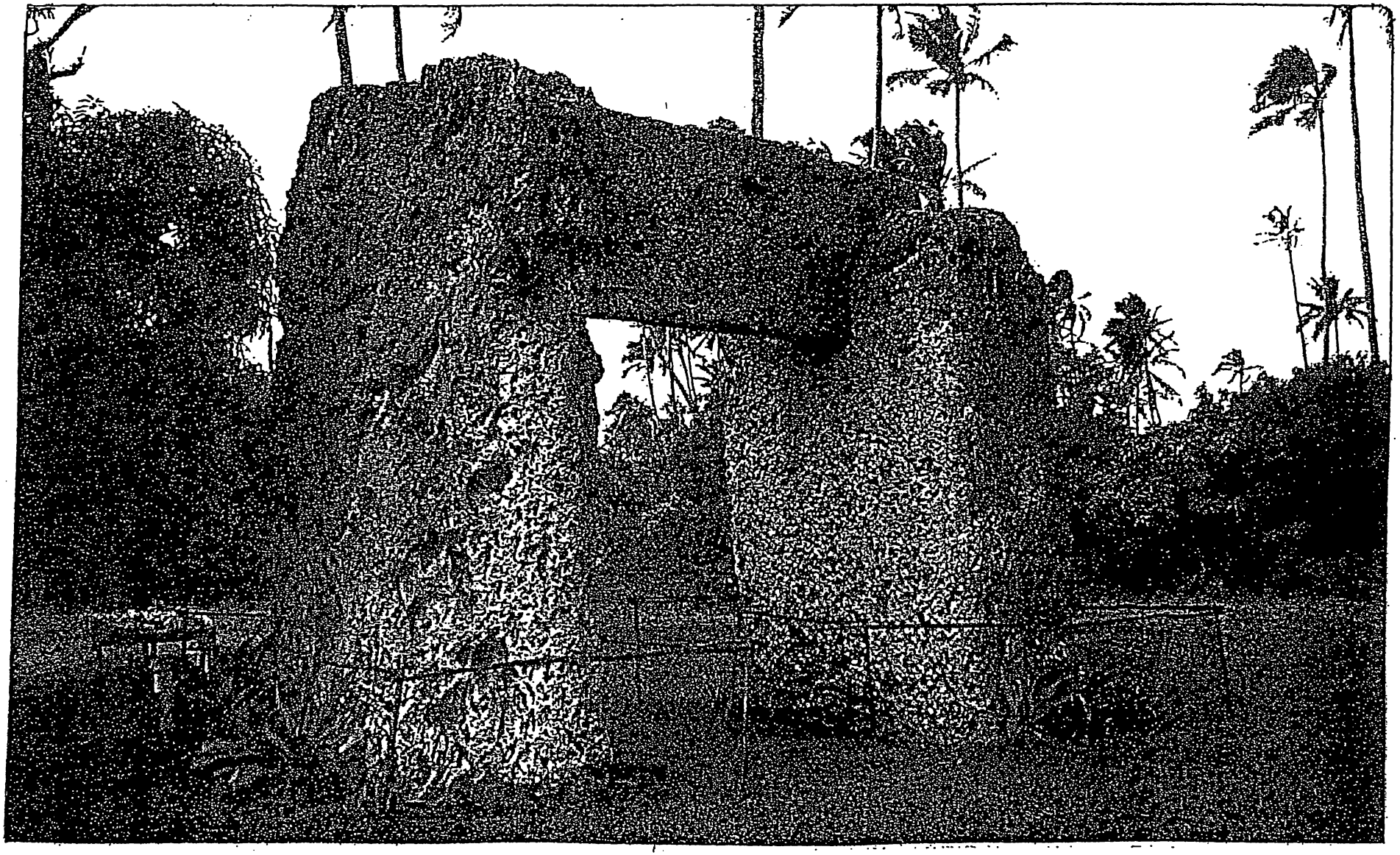

ABSTRACT

Many countries have now recognized Technology Education as a new subject in the school curriculum. It has been accepted internationally as a distinct area of education (McCormick, 1993; Layton, 1994; Lewis, 1996; and Jones, 1996). However, this worldwide trend has not yet reached most of the Pacific Island countries. These islands are unaware of the trend of transforming traditional technical subjects like Industrial Arts, with their focus on craft and technical skills, into Technology Education, which compounds more learning areas and emphasises technological literacy. Tonga, which is one of these islands, may benefit from this new development, in terms of teaching the more important aspects of technology, by developing a new curriculum in Technology Education.

There is evidence to suggest that the current Technical Education Curriculum in Tongan secondary schools is ineffective in teaching the higher-level skills in technology. A new and better curriculum should therefore be developed to enhance students' learning of concepts and processes in technology. This study argues that the best way of developing a new technology education curriculum for Tonga is to start by identifying the students' perceptions of technology and their existing technological capability. The curriculum should then build on this information, so that effective teaching and learning in technology may take place. This approach is guided by the socio-cultural view of learning. This learning theory recognises the impact of social, cultural, institutional and historical contexts on students' learning. It suggests that learning is a situated social process and knowledge is situated within particular historical, cultural, institutional and physical settings (Brown, Collins and Duguid, 1989; Wertsch, 1991; Resnick, 1991; Lave, 1991; Johnson, 1997).

This study was designed to identify Tongan students' perceptions of technology and existing technological capability. Data collection in this study was twofold. First it used modified versions of three instruments developed by Rennie and Jarvis (1995), to explore Tongan secondary school students' perceptions of technology. The second phase of data collection followed methods employed by Jones and Carr (1993b) on the second phase of Learning in Technology Education Project, to analyse Tongan secondary students' existing technological capability. This study was intended to show the perceptions of technology and the level of technological capability that the

present technical curriculum in Tonga is enabling students to achieve. These results may be used later to inform the development of a suitable Technology Education Curriculum for Tonga.

The research methodology adopted in this study belongs to the umbrella term of Postpositivist Paradigms and takes the stance of interpretive paradigm (Lather, 1992; Cohen, Manion and Morrison, 2000). Understanding and interpreting students' perceptions of technology and their existing technological capability were considered to be the dominant feature of this study. The research method employed is a combination of qualitative and quantitative methods of research.

The results of this study have shown that Tongan secondary school students have a poor perception of technology. Interest in technology was high among the students although many had limited ideas about the effect of technology on society. The overall performance of the students in the technological capability task was poor. They performed worst in searching for the best solution for the identified needs and opportunities and performed best in the production of the solution. Most of the students concentrated mainly on building the products and were not able to link the parts of the task together. One of the major factors that influenced the ability of the students to link the components of the task together was task affordance. Task affordance category challenge influenced the problem solving pathway that the students followed in the task.

The component of the task that contributed most to the quality of the students' final products was the production of the solution. The contributions that the other components could make towards the quality of the final products were minimal in the performances of the students in this study. No relationship was found in this study between the performances of the students in the three instruments that assessed their perceptions of technology and their performances in the technological capability task.

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DEDICATION

This thesis is dedicated to my father
The Late Reverend Kavaefiafi Mone

TABLE OF CONTENTS

	Page
Abstract	ii
Acknowledgements	iv
Dedication	v
Table of Contents	vi
List of Tables	xii
List of Graphs	xv
List of Figures	xvi
Chapter One: Introduction and Overview	**1**
1.1 Introduction	1
1.2 Rationale of the Study	3
1.3 Purposes and Research Questions	5
1.4 Background of the Researcher	6
1.5 Thesis Structure and Overview	8
Chapter Two: Technical and Technology Education in Tonga	10
2.1 Introduction	10
2.2 Tonga	10
2.2.1 Historical and Political Background	11
2.2.2 People and Country	11
2.2.3 Economy	13
2.2.4 Tongan Traditional Technology	14
2.3 Education	16
2.3.1 Historical Background	16
2.3.2 Organisation and Aims of Formal Education	17
2.3.3 Education System and Structure	19
2.4 Vocational and Technical Education	22
2.4.1 General Structure	22
2.4.2 Vocational and Technical Education in Secondary Schools	24
2.4.3 Post-compulsory Informal Vocational and Technical Education	24
2.4.4 Post-Secondary Formal Vocational and Technical Education	25
2.4.5 Vocational and Technical Education and Labour Market	26
2.5 Existing Secondary School Technical Curriculum	26
2.5.1. Introduction	26
2.5.2 Existing Curricula	27
2.5.3 Classroom Culture	27
2.5.4 Problems	28
2.5.5 Future development	30
2.5.6 The Need for this Study	30
Chapter Three: Perceptions of Technology and Technological Capability	**33**
3.1 Introduction	33
3.2 Recent Developments in Technology Education	33
3.2.1 Definition of Technology	34
3.2.2 Rationale for Teaching Technology in Primary and	

Secondary Schools 38
3.2.3 Recent International Developments in Technology Education 41

3.3 Learning in Technology 46
3.3.1 Knowledge Types in Technology 47
3.3.2 Learning in Technology 50

3.4 Perceptions of Technology 52
3.4.1 Definition of Perception 52
3.4.2 Theories of Perception 54
3.4.3 Recent Studies on Students' Perceptions of Technology 55

3.5 Technological Capability 62
3.5.1 Definition 62
3.5.2 Skills and Knowledge Involved in the Main Components of Technological Capability 65

3.6 Assessment of Technological Capability 68
3.6.1 Assessment Methods of Students' Technological Capability 69
3.6.2 Recent Studies of Students' Technological Capability 70

3.7 Summary 72

Chapter Four: Methodology 75

4.1 Introduction 75

4.2 The Research Framework 76
4.2.1 Theoretical Framework 76

4.3 The Research Methodology 78

4.4 The Research Method 80
4.4.1 Qualitative Research 81
4.4.2 Quantitative Research 83
4.4.3 A Combined Method Approach 85

4.5 The Research Procedure 87
4.5.1 Stage One: Students' Perceptions of Technology 87
4.5.2 Stage Two: Students' Existing Technological Capability 94

4.6 Ethical Considerations 102

4.7 Summary 103

Chapter Five: Students' Perceptions of Technology 106

5.1 Introduction 106

5.2 Writing/Drawing Activity 106
5.2.1 Main Ideas Mentioned by All Students in the Writing/Drawing Activity 106
5.2.2 Main Ideas Mentioned by Forms 1 to 6 Students in the Writing/Drawing Activity 108
5.2.3 Main Ideas Mentioned by Male and Female Students in the Writing/Drawing Activity 109

5.3 Technology Questionnaire 110
5.3.1 Students' Overall Responses for Part A of the Technology Questionnaire 110
5.3.2 Comparison of Form 1 and Form 6 Results for Part A

of the Technology Questionnaire 112
5.3.3 Comparison of Male and Female Students Results for the Technology Questionnaire 113
5.3.4 Students' Overall Responses for Part B of the Technology Questionnaire 115
5.3.5 Comparison of Form 1 and Form 6 Results for Part B of the Technology Questionnaire 116
5.3.6 Comparison of Male and Female Students' Results for Part B of the Technology Questionnaire 117
5.3.7 Comparison of Overall Mean Scores for Forms 1 and 6 Students in the Technology Questionnaire 118
5.3.8 Comparison of Overall Mean Scores for Male and Female Students in the Technology Questionnaire 118
5.3.9 Factor Analysis of the Responses for the Technology Questionnaire 119

5.4 Picture Quiz 122
5.4.1 Pictures Selected by Students to be Related to Technology in the Picture Quiz 122
5.4.2 Pictures Selected by Form 1 and Form 6 Students to be Related to Technology in the Picture Quiz 123
5.4.3 Reasons Mentioned by Students for Selection of Pictures Related to Technology in the Picture Quiz 123
5.4.4 Reasons Mentioned by Form 1 to Form 6 Students for Selection of Pictures Related to Technology in the Picture Quiz 124
5.4.5 Reasons Mentioned by Forms 1 to 6 Students for Not Selecting Pictures Related to Technology in the Picture Quiz 125
5.4.6 Comparison of Male and Female Students Reasons for Selection of Pictures Related to Technology in the Picture Quiz 126
5.4.7 Number of Pictures Selected by Students as being Related to Technology in the Picture Quiz 127

5.5 Summary of Results 127

Chapter Six: The Existing Technological Capability of Students – The Planning Stages 136
6.1 Introduction 136

6.2 Technological Capability A: Identifying Needs and Opportunities 136
6.2.1 The Ability of Students to ask Important and Relevant Technological Questions to Identify Needs and Opportunities 137
6.2.2 The Ability of Students to Identify Important and Relevant Factors that Influence the Situation 140
6.2.3 The Ability of Students to Describe a Plan of an Investigation for Gathering Data on Needs and Opportunities 142
6.2.4 The Ability of Students to Identify Important and Appropriate Sources of Information on Needs and Opportunities 144
6.2.5 The Ability of Students to Collect Relevant and Sufficient Data on Needs and Opportunities 146
6.2.6 The Ability of Students to Analyse Data Collected to Identify Needs and Opportunities that Existed 147
6.2.7 The Ability of Students to Identify Intrinsic Needs and Opportunities 149

6.3 Technological Capability B: Exploring and Developing Best Possible Solutions and Strategies 151
6.3.1 The Ability of Students to Describe (a) Who will use the Product, (b) Where, (c) Why, (d) When, and (e) How the Product will be Used 151

6.3.2 The Ability of Students to Describe the Characteristics of Products that could Solve Needs and Opportunities Identified 154
6.3.3 The Ability of Students to Describe a Plan of Investigation to Collect Information on Solutions to Identified Needs and Opportunities 156
6.3.4 The Ability of Students to Consult Appropriate Sources of Information on Solutions and Strategies for Identified Needs and Opportunities 158
6.3.5 The Ability of Students to Collect Relevant and Sufficient Data on Solutions and Strategies for Needs and Opportunities Identified 160
6.3.6 The Ability of Students to Analyse Data Collected to Identify Solutions to Needs and Opportunities Identified 162
6.3.7 The Ability of Students to Identify Factors that could Influence the Making of the Proposed Product to Satisfy Needs and Opportunities Identified 164
6.3.8 The Ability of Students to Identify Knowledge and Skills Required for Making the Product 166

6.4 Technological Capability C: Planning the Production of the Solution 168
6.4.1 The Appropriateness of the Characteristics of the Product Planned by the Students to the Needs and Opportunities Identified 168
6.4.2 The Ability of Students to use Drawing or Explanation to Produce an Appropriate Plan of the Product with Proper Labels and Scales 170
6.4.3 The Ability of Students to Ascertain Materials and Tools Needed for the Task 172
6.4.4 The Ability of Students to Identify the Measurements Needed 173
6.4.5 The Ability of Students to Determine the Expenses Involved in Making the Products 175
6.4.6 The Ability of Students to Describe the Appropriate Steps Involved 177
6.4.7 The Ability of Students to Identify the Dangers Involved in Carrying out the Tasks 179
6.4.8 The Ability of Students to Identify the Assistance Needed from an Expert 180

6.5 Summary of Results 182

Chapter Seven: The Existing Technological Capability of Students – Production, Presentation and Evaluation 188
7.1 Introduction 188

7.2 Building the Solution 188
7.2.1 Using Appropriate Instruments to do Measurement 189
7.2.2 Using Appropriate Tools to Build Product 190
7.2.3 Taking Care of Safety Issues 192
7.2.4 Organisation of Workspace 193
7.2.5 Implementation of Plan of Action 195
7.2.6 Appropriateness of Solution to Criteria 196
7.2.7 Aesthetic of Solution 197

7.3 Presentation of Ideas, Design and Product 199
7.3.1 Preparation of Report of Technological Activity 199
7.3.2 Explanation of Design, Plan and Outcome of the Project 201
7.3.3 Use of Correct Specific Technological Terminology in Report 203
7.3.4 Describing Methods to Promote Selling of Ideas and Product 205

7.4 Evaluation of Progress, Process and Product 207
7.4.1 The Ability of Students to Assess Methods to Identify

Improvements Required 207
7.4.2 The Ability of Students to do Tests in the Development of the Product 209
7.4.3 The Ability of Students to Compare the Plan against the Product to Identify Differences 211
7.4.4 The Ability of Students to Evaluate the Quality of Products to Identify Improvements Required 213
7.4.5 The Ability of Students to Identify Skills and Knowledge Gained from the Project 215
7.4.6 The Ability of Students to Make Recommendations and Give Advice Regarding the Best Way of Doing This Project 216

7.5 Summary of Results 218

Chapter Eight: Relationships Between Students' Performances 223

8.1 Introduction 223

8.2. Links Between the Performances of Students on Various Components of Technological Capability 225
8.2.1 Group 1 – Home Economics Brooms 227
8.2.2 Group 2 – Home Economics Fans 232
8.2.3 Group 3 – Home Economics Food for the Canteen 236
8.2.4 Group 4 – Industrial Arts Brooms 241
8.2.5 Group 5 – Industrial Arts Wooden Pillows 244
8.2.6 Group 6 – Industrial Arts Kava Drinking Seats 248
8.2.7 Whole Group of Students Involved in the Study 252

8.3 Links Between the Performances of Students on Six Components of Technological Capability Assessed and the Quality of the Product 257
8.3.1 Identifying Needs and Opportunities and Quality of the Product 258
8.3.2 Searching for the Best Solutions and Quality of the Product 260
8.3.3 Planning of Production and the Quality of the Product 262
8.3.4 Production and the Quality of the Product 263
8.3.5 Presentation and the Quality of the Product 265
8.3.6 Evaluation and the Quality of the Product 266
8.3.7 Overall Results and the Quality of the Product 268

8.4 Relationship Between Students' Perceptions of Technology and Their Existing Technological Capability 269
8.4.1 Students' Total Score Number of Pictures Selected 270
8.4.2 Students' Total Score and Number of Ideas Mentioned 270
8.4.3 Students' Total Score and Type of Ideas Mentioned 270

8.5 Summary of Relationships 271

Chapter Nine: Discussion, Conclusions and Implications 274

9.1 Introduction 274

9.2 Students' Perceptions of Technology 274
9.2.1 Types of Perceptions of Technology Identified 275
9.2.2 Comparison of Perceptions of Form 1 and Form 6 Students 283
9.2.3 Comparison of Perceptions of Male and Female Students 285

9.3 Students' Existing Technological Capability 286
9.3.1 Identifying Needs and Opportunities 286
9.3.2 Searching for Best Solution of Identified Needs and Opportunities 289
9.3.3 Planning the Production of the Solution 291
9.3.4 Building the Solution (Product) 293

9.3.5 Presentation and Promotion of Ideas, Design and Solution (Product) 295
9.3.6 Evaluation of Progress, Process and Solution (Product) 296

9.4 Relationships Between the Performances of Students 298
9.4.1 Nature of Links Between the Performances of Students 299
9.4.2 Causes of the Weakness of Links Between Students' Performances 300
9.4.3 The Influence of Task Affordance 303

9.5 The Relationships Between the Performances of Students and the Quality of Their Final Products 305
9.5.1 Production of a Solution was the Main Contributor to Quality 305
9.5.2 Students' Performance in Two Types of Criteria 306
9.5.3 Correlation Coefficients and Students' Holistic View of Task 306
9.5.4 Evaluation, Total Scores and Quality of the Products 307

9.6 The Relationship Between Students' Perceptions of Technology and Their Existing Technological Capability 307

9.7 Conclusions 308
9.7.1 Students' Perceptions of Technology 308
9.7.2 Students Existing Technological Capability 309
9.7.3 Relationships Between the Performances of Students in Various Components of the Task 310
9.7.4 Relationship Between Students' Perceptions of Technology and their Existing Technological Capability 311

9.8 Implications 311
9.8.1 Implications for Curriculum Development 311
9.8.2 Implications for Teaching and Learning in Technology Education 313
9.8.3 Implications for Further Research 314

APPENDICES **315**
Appendix A. Research Instruments for Studying Students' Perceptions of Technology 316
Appendix A(1): Writing/Drawing Activity (English Version) 316
Appendix A(2): Writing/Drawing Activity (Tongan Version) 317
Appendix A(3): Technology Questionnaire (English Version) 318
Appendix A(4): Technology Questionnaire (Tongan Version) 320
Appendix A(5): Picture Quiz (English Version) 322
Appendix A(6): Picture Quiz (Tongan Version) 323

Appendix B. Research Documents for Studying Students' Existing Technological Capability 324
Appendix B(1): Assessment Criteria 324
Appendix B(2): Performance Descriptors 325
Appendix B(3): Students Worksheet (English Version) 333
Appendix B(4): Students Worksheet (Tongan Version) 350

Appendix C. Communication to Conduct Field Research in Tonga 369
Appendix C(1): Letter to Tonga Government 369
Appendix C(2): Letter of Approval from Tonga 370

REFERENCES **372**

LIST OF TABLES

Tables		Pages
3.1	Summary of Current International Practices and Trends of Technology Education	44
4.1	Number of Students Involved in the Study of Perceptions of Technology	91
4.2	Characteristics of Schools Involved in Perceptions Study	91
4.3	Groups and Task Areas Involved	100
4.4	Time Table for Data Collection on Technological Capability	100
5.1	Ideas About Technology Mentioned by At Least 10% of All the Students Involved	107
5.2	Ideas About Technology Mentioned by At Least 10% of the Students in Each Form	108
5.3	Ideas About Technology Mentioned by at Least 10% of Male and Female Students	109
5.4	Students' Responses for Part A	111
5.5	Mean and Standard Deviation for Form 1 and Form 6 Students on the First Part of the Technology Questionnaire	112
5.6	Mean and Standard Deviation for Male and Female Students on the First Part of the Technology Questionnaire	114
5.7	Students' Responses for Part B	115
5.8	Mean and Standard Deviation for Form 1 and Form 6 Students on the Second Part of the Technology Questionnaire	116
5.9	Mean and Standard Deviation for Male and Female Students on the Second Part of the Technology Questionnaire	117
5.10	Maximum Possible Score, Mean Total Scores and Standard Deviations for Boys and Girls on the Questionnaire	118
5.11	Maximum Possible Score, Mean Total Scores and Standard Deviations for Boys and Girls on the Questionnaire	118
5.12	Factor Loadings for Seven-Factor Solution of the Perceptions About Technology	120
5.13	Percentage of Students Selecting Pictures Related to Technology	122
5.14	Percentages of Students Selecting Pictures Related to Technology in Form 1 and Form 6	122
5.15	Top Eight Reasons for Selecting and Not Selecting Pictures to be Related to Technology	124
5.16	Percentages of Reasons Mentioned by Students in Form 1 to Form 6 for Selection of Pictures Related to Technology	125
5.17	Percentages of Ideas Mentioned by Form 1 to Form 6 Students for Not Selecting Pictures	125
5.18	Reasons Given by Male and Female Students for Their Choice of Pictures	126
5.19	Number of Pictures Chosen by Forms 1 to 6 Students as being Related to Technology	127
6.2.1a	Percentages of Types of Questions Asked to Identify Needs and Opportunities	137
6.2.1b	Performance Descriptors for the Ability to Ask Questions	138
6.2.2a	Percentages of Factors Mentioned by Students	140
6.2.2b	Performance Descriptors for Identifying Factors	141
6.2.3a	Percentages of Plans Described by Students	142
6.2.3b	Performance Descriptors for Planning an Investigation	143
6.2.4a	Sources of Information Consulted by Students	144
6.2.4b	Performance Descriptors for Identifying and Consulting Sources of Information	145
6.2.5a	Types of Information Collected by Students	146
6.2.5b	Performance Descriptors for Collecting Information	147
6.2.6a	Percentages of Needs and Opportunities Identified by Students	148
6.2.6b	Performance Descriptors for Analysing Data to Identify Needs and Opportunities	148

6.2.7a	Percentages of Intrinsic Needs and Opportunities Identified	149
6.2.7b	Performance Descriptors for Identifying Intrinsic Needs and Opportunities	150
6.3.1a	Describing who, where, why, when and how	152
6.3.1b	Performance Descriptors for Describing Who, Where, Why, When and How	152
6.3.2a	Characteristics Described by Students	154
6.3.2b	Performance Descriptors for Describing Characteristics of Products	155
6.3.3a	Types of Plans Described by Students	156
6.3.3b	Performance Descriptors for Describing a Plan of Investigation	157
6.3.4a	Sources of Information Consulted	158
6.3.4b	Performance Descriptors for Consulting Appropriate Sources of Information	159
6.3.5a	Percentages of Types of Information Collected by Students	160
6.3.5b	Performance Descriptors for Collecting Data on Solutions	161
6.3.6a	Types of Information Extracted by Students	162
6.3.6b	Students' Descriptions of Solutions and Strategies	162
6.3.6c	Performance Descriptors for Identifying Solutions and Strategies from Data	163
6.3.7a	Percentages of Factors Identified by Students	164
6.3.7b	Performance Descriptors for Identifying Factors Affecting Building of the Product	165
6.3.8a	Percentages of Types of Knowledge and Skills Described by Students	166
6.3.8b	Performance Descriptors for Identifying Knowledge and Skills	167
6.4.1a	Percentages of Students Giving Each Characteristic	168
6.4.1b	Performance Descriptors for the Ability to Describe the Appropriate Characteristics of Products	169
6.4.2a	Percentages of Students with Types of Plans Prepared	170
6.4.2b	Performance Descriptors for Drawing or Explaining Plan of Product	171
6.4.3a	Percentages of Students Giving Each Description	172
6.4.3b	Performance Descriptors for Describing Tools and Materials Required	172
6.4.4a	Percentages of Students Giving Things to be Measured	173
6.4.4b	Performance Descriptors for Describing Measurements to Make	174
6.4.5a	Percentages of Students Describing Expenses	175
6.4.5b	Performance Descriptors for the Ability to Describe Expenses Expected	176
6.4.6a	Percentages of Students Giving Each Description	177
6.4.6b	Performance Descriptors for the Ability to Describe the Steps involved in Task	178
6.4.7a	Percentages of Dangers Involved Described by Students	179
6.4.7b	Performance Descriptors for Identifying Dangers Involved	179
6.4.8a	Percentages of Students Giving Each Description	180
6.4.8b	Performance Descriptors for the Ability to Identify Assistance Needed	181
7.2.1	Performance Descriptors for Students' Ability to do Measurement	189
7.2.2	Performance Descriptors for the Ability of Students to use Tools	191
7.2.3	Performance Descriptors for Students' Practicing Safety Rules	192
7.2.4	Performance Descriptors for Organisation of Workspace	194
7.2.5	Performance Descriptors for Following Plan of Action	195
7.2.6	Performance Descriptors for Appropriateness of Solution to Criteria	196
7.2.7	Performance Descriptors for Producing an Aesthetic Product	198
7.3.1a	Percentages of Types of Reports Prepared by Students	199
7.3.1b	Performance Descriptors for Writing a Report	200
7.3.2a	Percentages of Types of Explanations Students Delivered	201
7.3.2b	Performance Descriptors for Doing a Presentation	202
7.3.3a	Performance Descriptors for Using Technological Terms	204
7.3.4a	Percentages of Methods Explained by Students	205
7.3.4b	Performance Descriptors for Promoting Ideas and Products	206
7.4.1a	Types of Improvements Suggested by Students	207
7.4.1b	Performance Descriptors for the Ability to Assess Methods	208
7.4.2a	Types of Tests Students Carried Out	209
7.4.2b	Performance Descriptors for the Ability to do Tests	210

7.4.3a	Differences Between Plan and Product	211
7.4.3b	Performance Descriptors for the Ability to Compare Plan and Product	212
7.4.4a	Types of Improvements Identified by Students	213
7.4.4b	Performance Descriptors for the Ability to Identify Improvements Required	214
7.4.5a	Types of Skills and Knowledge Gained by Students	215
7.4.5b	Performance Descriptors for the Ability to Identify Knowledge and Skills	215
7.4.6a	Types of Answers Provided by Students	217
7.4.6b	Performance Descriptors for the Ability to Make Recommendations	217
8.2.1	Marks of Group 1 in Each Component	228
8.2.2	Marks of Group 2 in Each Component	233
8.2.3	Marks of Group 3 in Each Component	236
8.2.4	Marks of Group 4 in Each Component	241
8.2.5	Marks of Group5 in Each Component	245
8.2.6	Marks of Group 6 in Each Component	248
8.2.7	Marks of Groups in Each Component	253
8.3.1	Marks of Groups for Identifying Needs and Quality	259
8.3.2	Marks for Searching for the Best Solution and Quality of the Product	261
8.3.3	Marks for the Planning of Production and the Quality of the Product	262
8.3.4	Marks for the Production of the Solution and the Quality of the Product	264
8.3.5	Marks for Presentation and Quality of the Product	265
8.3.6	Marks for Evaluation and Quality of the Product	267
8.3.7	Marks for Overall Average	268

LIST OF GRAPHS

Graphs		Pages
6.2.1	Ability of Students to Ask Questions	139
6.2.2	Ability of Students to Identify factors	141
6.2.3	Ability of Students to Plan an Investigation	143
6.2.4	Ability of Students to Identify Appropriate Sources of Information	145
6.2.5	Ability of Students to Collect Appropriate Information	147
6.2.6	Ability of Students to Analyse Data to Identify Important Needs	149
6.2.7	Ability of Students to Identify Intrinsic Needs and Opportunities	150
6.3.1	Ability of Students to Describe Who, Where, Why, When and How	153
6.3.2	Ability of Students to Describe Characteristics of Product	155
6.3.3	Ability of Students to Describe Plan of Investigation	157
6.3.4	Ability of Students to Consult Appropriate Sources of Information	159
6.3.5	Ability of Students to Collect Appropriate Information	161
6.3.6	Ability of Students to Identify Important Information in Data	163
6.3.7	Ability of Students to Identify Factors Influencing Building	165
6.3.8	Ability of Students to Identify Knowledge and Skills Required	167
6.4.1	Ability of Students to Describe Characteristics of Product	169
6.4.2	Ability of Students to Draw/Describe Plan of Product	171
6.4.3	Ability of Students to Describe Tools and Materials Required	173
6.4.4	Ability of Students to Describe Measurements to Make	174
6.4.5	Ability of Students to Describe Expenses Expected	176
6.4.6	Ability of Students to Describe Steps of Task	178
6.4.7	Ability of Students to Identify Dangers Involved	180
6.4.8	Ability of Students to Identify Assistance Needed	181
7.2.1	Ability of Students to do Measurements	189
7.2.2	Ability of Students to use Tools	191
7.2.3	Ability of Students to Take Care of safety Issues	193
7.2.4	Ability of Students to Organise Workspace	194
7.2.5	Ability of Students to Follow Plan of Action	195
7.2.6	Ability of Students to Satisfy Identified Criteria	197
7.2.7	Ability of Students Produce an Aesthetic Product	198
7.3.1	Ability of Students to Write a Report of the Project	200
7.3.2	Ability of Students to do a Presentation of the Project	203
7.3.3	Ability of Students to Use Appropriate Technological Terms	204
7.3.4	Ability of Students to Promote Ideas and Product	206
7.4.1	Ability of Students to Assess Methods Used	208
7.4.2	Ability of Students to do Tests in Developing Product	210
7.4.3	Ability of Students to Compare Plan Against Product	212
7.4.4	Ability of Students to Identify Improvements Required	214
7.4.5	Ability of Students to Identify Skills and Knowledge Gained	216
7.4.6	Ability of Students to Make Recommendations for Improvement	217

LIST OF FIGURES

Figures		Pages
2.1	The Map of Tonga	12
2.2	Tonga Ministry of Education Organisational Chart, 1998	18
2.3	Structure of Tongan Formal Education System	20
2.4	General Structure of Vocational and Technical Education in Tonga	23
2.5	Proposed Structure of Technical and Vocational Education	31
3.1	Pacey's Diagrammatic Representation of Technology	35
3.2	Nature of Technological Knowledge	48
3.3	Possible Pathways in Problem Solving	64
4.1	Structure of Second Stage of Data Collection	94
5.1	Forms 1-6 Mean Item Scores for the Four Subscales	120
5.2	Male and Female Mean Item Scores for the Four Subscales	121
8.2	The Main Stages of the Technological Capability Assessment Task	226
8.2.1	Problem Solving Pathway for Home Economics Brooms	231
8.2.2	Problem Solving Pathway for Group 2	235
8.2.3	Problem Solving Pathway for Group 3	240
8.2.4	Problem Solving Pathway for Group 4	244
8.2.5	Problem Solving Pathway for Group 5	247
8.2.6	Problem Solving Pathway for Group 6	251
8.2.7	Problem Solving Pathway for the Whole Students Involved	256

CHAPTER ONE

INTRODUCTION AND OVERVIEW

1.1 INTRODUCTION

One of Tonga's most intriguing monuments, the *Ha'amonga 'a Maui Trilithon* or 'Burden of Maui' was erected around 1500 B.C. It is an enormous archway made of two upright coral-lime stone pillars, each of 4.9 meters in height and each weighing approximately 50 tons. These pillars support a cross beam which is 5.8 meters long and weighs approximately 8 tons (Childress, 1996). The cross beam lies in grooves carved at the top ends of the upright stones. The structure and design of the archway reflects an era with a well developed craft of stone cutting. Childress (1996), in describing the aesthetic of the structure, admits that 'Walking around it, one can marvel at the feat of engineering that has created this impressive monument' (p. 26).

Tongan tradition believes that the stones were brought across the ocean in large canoes from Uvea (Wallis Islands). This task echoes competency in the arts of building and rigging canoes, together with high seafaring skills. The huge size of the archway suggests that a great number of labourers were involved in building it, especially when tools and materials available were limited. Managing an estimated number of 1000 to 1200 strong men who cut the stones, transported them to the site and put them in place, needed a high level of organization.

The most fashionable theory regarding the purpose of this archway proposes that it is an astronomical device with which the Polynesian lunar seasons and zodiac were measured. Notches at the top of the cross bar were recently discovered and the present king of Tonga, Taufa'ahau Tupou IV, in 1967, demonstrated that these marks could be used to notify the longest and shortest days of the year. Many Tongan scholars now believe that the *Ha'amonga 'a Maui Trilithon* was a part of ancient Tongan (and Polynesians in general) observatory in which the stars and the skies were studied to enhance the navigators' knowledge of astronomy and ancient celestial navigation. It is a huge and magnificent piece of indigenous technological artefact and it served a very outstanding purpose. It was a result of a combination of many *tufunga* (artisans). The *tufunga ta maka* cut and shaped the stones, while the

tufunga fo'u vaka built the canoes that brought the stones from Uvea. The *kau kaivai* were required to navigate the great canoes back to Tongatapu, while the *tufunga langa fale* transported the stones to the site, planted the upright pillars in their positions and lifted the 8 tons cross bar and placed it in the grooves of the uprights. The *matapule* were responsible for the organization of the whole project.

The *Ha'amonga 'a Maui Trilithon* is an example of a very fine indigenous technology, fabricated by the ingenuity of the people of Tonga. It is an example of how technology has always been with people as they have sought and provided for their survival and enjoyment of life in their environment. However, the introduction of modern artefacts and foreign ways of doing things into Tonga has created an attitude that good technological innovation is performed in the European countries. Local technological inventiveness has therefore been discouraged and ignored and developments observed in technology in Tonga today are shadows of intriguing technologies that are advancing in developed countries. There is a need to revive the skills of technological inventiveness and innovation in Tonga, as well as teaching knowledge about the imported technologies and their effects. Technological literacy is now a high priority in many education systems lists throughout the world. Technology education curricula have been developed in many countries for primary and secondary general education. This study aims to collect data on Tongan students' perceptions of technology and their existing technological capability. This will form baseline data for Tonga in the future development of a technology education curriculum. The rest of this chapter will present:

1.2 Rationale of the Study;
1.3 Research Questions;
1.4 Scope of the Study; and
1.5 Organisation of the Thesis.

1.2 RATIONALE OF THE STUDY

There have been a number of studies carried out in many countries on students' perceptions of technology and technological capability. These have been carried out often with the purpose of informing curriculum developments in technology education. These studies provide a good background for the necessity of this present study. The rationale for the present study includes the following:

Towards Technology Education

It is hoped this study will stimulate an increased awareness of the importance of teaching the new and more general concepts and processes of technology in secondary schools in Tonga. The international shift towards including technology education in primary and secondary education has been heard in the Pacific islands including Tonga. The only difficulty is that the movement observed in the Pacific islands is merely towards more technical education. For example, the South Pacific Board for Educational Assessment has offered a course in the Pacific Senior Secondary Certificate Level (Form 6 or Year 12) called technology, which started in 2001. The title is 'Technology' but the content of the curriculum is very much in the area of traditional technical subjects. Also in Tonga, the Government invited the Australian Agency for International Development (AusAID) in 1998 to study its Vocational and Technical Education Sector in order to make recommendations for developments. Part of the recommendations made as a result of the AusAID project was a proposed structure of Technical and Vocational Education. In this proposed structure, broad general education including Home Economics, Industrial Arts, Agricultural Studies and Arts/Handicrafts were to be offered in Forms 1 – 3. For Forms 4-6, specialized courses like Plumbing, Carpentry, Design, Clothing/Textiles and Catering/Food Technology were suggested. It is evident from these examples that the essence of the new international developments in technology education has been overlooked in the Pacific islands. It is hoped that this study will stimulate a movement towards the inclusion of proper technology education in Pacific islands schools.

Relevance of curriculum

This study will initiate an awareness of the importance of including students' perceptions, views, skills and feelings in determining the type of learning areas and activities that should be included in a particular curriculum. Curriculum development has been active in the Tongan Education Sector during the past two decades. It started when the Tongan School Certificate Examination took over from the New Zealand School Certificate Examination and the Pacific Senior Secondary Certificate Examination replaced the New Zealand University Entrance Examination in the late 1980's. The main feature of this curriculum development process has been the modification of existing overseas curricula to fit the Tongan situation. These modification processes were carried out by teachers, curriculum development employees and consultants. No study has been carried out to collect data on students' perceptions, existing knowledge and skills and feelings to inform curriculum development processes. This present research considers it crucial for the success of a curriculum, to include attitudes and views of learners in determining the learning areas and learning activities to be covered in that particular course of study, thereby making the curriculum more relevant and adequate to the students.

Curriculum development based on research results

Curriculum development in Tonga is based mainly on curriculum materials imported from other countries, advice of foreign consultants and experiences of teachers in the field. Tonga has yet to recognize the benefit of utilizing research results in curriculum development and teaching and learning. In fact there is no research institution in the Tongan Education Department with the purpose of providing research results to inform curriculum development. This study will not only help in providing data that would enlighten curriculum development and teaching and learning in technology education, but will also set an example of an appropriate and effective way of research to inform practice in a pacific nation rather than importing curricula from other countries.

Towards effective methods of teaching and learning technological knowledge and processes

The information that will be produced in this study will be important in terms of the enhancement of teaching and learning of concepts in technology and development of problem solving approaches for the enhancement of technological capability. Technological knowledge does not exist in abstract but in specific context and domain (Brown, Collins & Duguid, 1989; Lave, 1991; Hennessey, 1993). It is part and product of the activity, context, and culture in which it is developed (Perkins and Salomon, 1989; Brown, Collins and Duguid, 1989; Hennessey, 1993). Not only is technological knowledge socially constructed and context dependent but also human mental processes are situated in their historical, cultural and institutional background (Wertsch, 1991). It is therefore considered crucial in this study to identify students' perceptions of technology and their existing technological capability to provide environment and context information for the development of learning activities for a technology education curriculum for Tonga. This will help to produce teaching and learning activities that will be effective and efficient.

A method for analysing students' technological capability

Technology education is still at the early stages of its development. Researchers in the field are beginning to identify the effective methods of analyzing students' technological capability. This study will provide more data towards this end.

A foundation for further research

No research data regarding technology education is available in Tonga. This study will be the first of its kind to be conducted in Tongan classrooms. The results will not only be important to the development of a new course in technology education in Tonga, but will also form a base for further research in this area.

1.3 PURPOSES AND RESEARCH QUESTIONS

The purposes of this study are to: adopt and/or develop appropriate methods to obtain students' perceptions of technology; to adopt and/or develop appropriate methods to assess and evaluate students' existing technological capability; and to make

recommendations for changes in Tongan technical education curricula and/or development of a technology education curriculum for Tonga.

More specifically, this study will address the following research questions:

1. What are the Tongan secondary school students' perceptions of technology?
2. What are the levels of Tongan secondary school students' existing technological capability?
3. How do the performances of students in the main components of technological capability relate to one another?
4. How do the performances of students in the main components of technological capability relate to their final products?
5. How do Tongan secondary students' perceptions of technology affect their technological capability?

1.4 BACKGROUND OF THE RESEARCHER

It is vital for any research that the researcher is not biased when conducting the research. It is however noted that irrespective of this view, each researcher has their own view of the subject that they are researching. It is therefore important that the background of the researcher is presented for it may have affected the analysis and the interpretations of the data used in the study.

The researcher of this study is Tongan and was born and raised in Tonga. The first 13 years of his life were spent in the outer islands Tonga (Niua, Vava'u and Ha'apai groups), where his father was serving as a Methodist Minister. Returning to the main island of Tongatapu at the age of 14, the researcher was amazed by the advanced technological lifestyle such as the use of electricity, enjoyed by the people of the main island. It was quite a shocking experience. The researcher has also lived in Fiji for five years and in Australia for two years.

The researcher attended primary and intermediate schools in the outer islands returning only to attend the last seven years of high school in the main island. His

tertiary education was in Fiji where he attained Bachelor of Science majoring in Physics and Mathematics, as well as a Graduate Certificate in Education. He attained a Masters of Education majoring in Science Education was attained in Australia. His thesis was titled "Monitoring Standards of Science Investigation Skill Attainment by Tongan Secondary Science Students".

The researcher spent 15 years teaching Science and Mathematics for Form 5, and Physics, Mathematics and Biology for Form 6 at various High Schools in Tonga. During these years he was appointed as President of the Science Teachers Association of the Free Wesleyan Church Education Department. This system provides secondary education for more students than any other school system in the kingdom (Tonga Ministry of Education, 1999). He was also a member and a Vice President of the Tonga Science Teachers Association. He was the Head of the Science Department of all the High Schools that he was serving at. He was Deputy Principal for seven years and became Principal for one year before starting this course of study.

The quests towards the development of students to meet the challenges of education led to the involvement of the researcher in the establishment of the Language Laboratory at Tupou College. It is equipped with advanced technologies in teaching and learning foreign languages. He was also instrumental in the establishment of a Gymnasium at Tupou College, to enable students with sports talents to pursue their dreams and make a better life for themselves. Tupou College has been the home for many well known international rugby players. The researcher began working on the establishment of a Training Course on Fishing for the Taufa'ahau Pilolevu College on the island of Ha'apai where the majority of people earn their livelihood from the sea. The project was at its early stages when the researcher left to read for this degree of Doctor of Philosophy.

The knowledge and experience of the researcher as a teacher and an educator were instrumental in conducting this research. His insight knowledge of the Free Wesleyan Education System as well as the Tonga Government Education System had helped in facilitating this study. The understanding of the students' perceptions

of technology and their existing technological capability will provide the framework for the development of a curriculum that will be appropriate and for the secondary schools in Tonga.

1.5 THESIS STRUCTURE AND OVERVIEW

This section outlines the composition of the remaining chapters. A summary of each chapter will be given in order to highlight the general nature of this thesis.

Chapter 2 discusses the background information regarding technical and technological education and the technical career opportunities in Tonga. Brief background information about Tonga, its people, history, economy, land, education and political situation are also presented to acquaint the reader with the context of this study. This is important in this study because of the interpretive method of research being adopted. Chapter 3 discusses recent international developments in technology and technology education. The aim is to examine current international views of technology education and determine how these views relate to the development of technology education in Tonga. Results of various studies of students' perceptions of technology and analysis of students' technological capability are also presented to enlighten the worldwide background of research and curriculum development in schools on technology and technology education.

Chapter 4 presents and justifies the research methodology and investigation designs employed in this study. Chapter 5 presents data regarding perceptions of technology held by Tongan secondary school students. Chapter 6 presents the results of the assessment of the first three components of students' technological capability. These components are: Identifying Needs and Opportunities; Exploring and Developing Best Possible Solutions to Identified Needs and Opportunities; and Planning the Production of the Solution. Chapter 7 presents the results of the assessment of the last three components of students' technological capability assessed in this study. These are related to making, presenting and evaluating of the product.

Chapter 8 describes the relationships observed in the performances of students in the components studied. These relationships were examined in order to determine: the

total technological problem solving process that students proceeded through while carrying out the technological activity; the relationship between their performances in the other components to the quality of the product produced; and the relationship between their perceptions of technology and technological capability. These relationships are used in this study to show the total picture of students' existing technological capability. They are also used to show the pathway that students took in building the products. Chapter 9 discusses the results and presents the conclusions and implications of this study.

CHAPTER TWO

TECHNICAL AND TECHNOLOGY EDUCATION IN TONGA

2.1 INTRODUCTION

The previous chapter introduced this study by presenting the general context, rationale and the research questions. This chapter will discuss the background information regarding technical and Technological Education and the technical career opportunities in Tonga. Brief background information about Tonga, its people, history, economy, land, education and political situation will also be presented. The aim is to enable the reader to be acquainted with the context of this study. Providing this broad context is important in this study because of the interpretive method of research being adopted. The results of this study are to be interpreted in the context of Tonga. Also, since there was no technology education in Tonga at the time of this study, technical education, the common tradition of technology education found in other countries, will be highlighted to provide the context of technology in Tonga. The remainder of this chapter will present:

2.2 Tonga;
2.3 Education;
2.4 Vocational and Technical Education in Tonga;
2.5 Existing Secondary School Technical Curriculum; and
3.6 Summary

2.2 TONGA

This study was carried out in secondary schools in Tonga. Since this study adopts an interpretive research paradigm, it is considered essential to make available some general information about Tonga in order to make good interpretations of Tongan secondary school students' perceptions of technology and their existing technological capability. This section presents a few facts regarding the historical and political background, the people, the islands and economy of Tonga.

2.2.1 Historical and Political Background

Tonga, also known as the 'Friendly Islands', was united into a Polynesian kingdom in 1845. It became a constitutional monarchy in 1875 and a British protectorate in 1900. Tonga's independence was gained in 1970 and it became a member of the Commonwealth of Nations. It remains the only monarchy in the Pacific. Under its Constitution of 1875, the Government consists of the King in Privy Council and the Cabinet, the Legislative Assembly and the Judiciary.

The Privy Council comprises the Cabinet and any persons appointed by the King. The Cabinet consists of the Prime Minister, Ministers and the Governors of Tonga's two provinces, Ha'apai and Vava'u. The Legislative assembly consists of the Ministers and two Governors, nine elected representatives of the holders of the 33 hereditary noble titles, and nine elected representatives of the people. Elections of the Nobles' and the People's Representatives are held separately every three years.

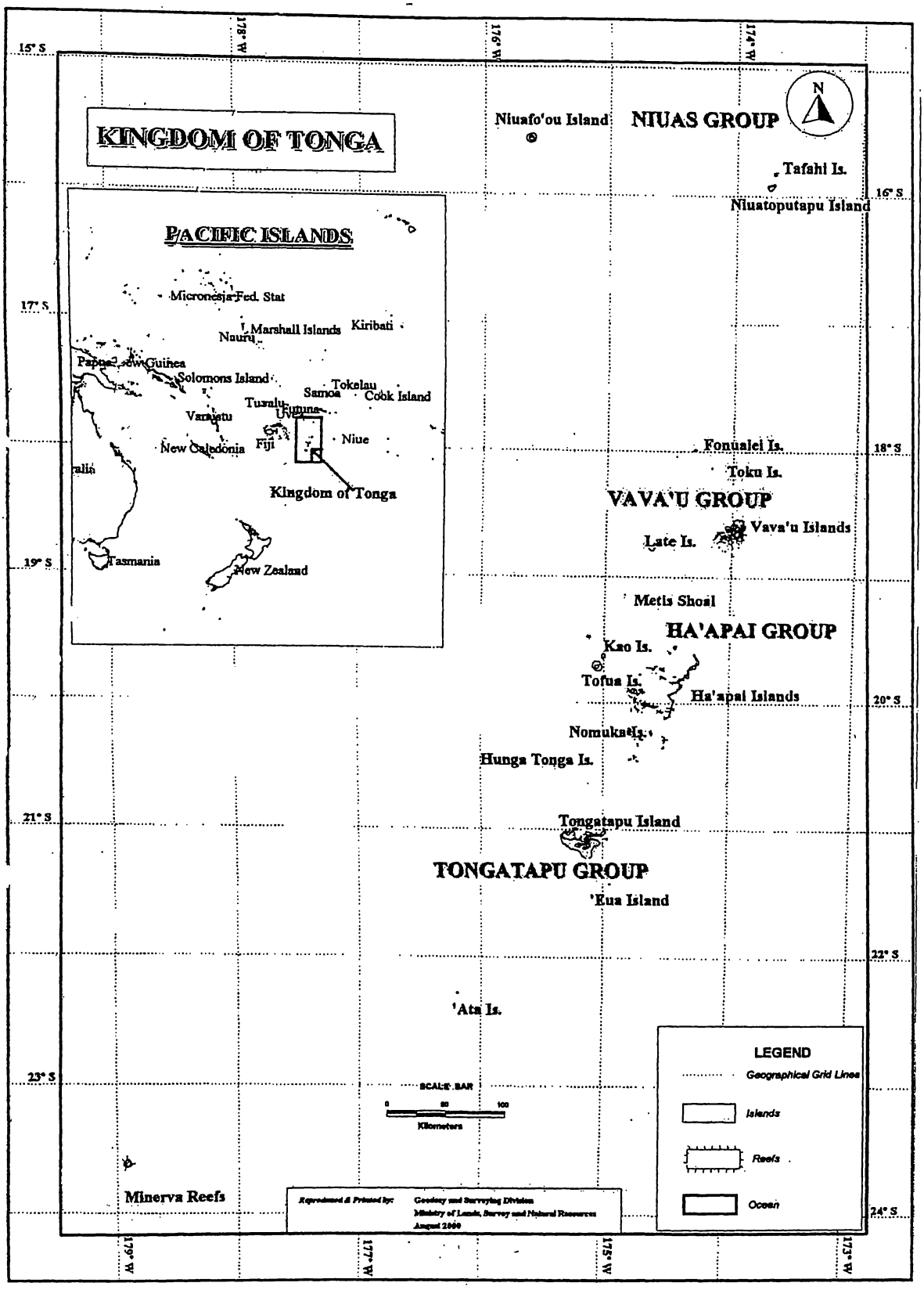
2.2.2 People and Country

The Kingdom of Tonga consists of 170 islands, most of them are very small and only 36 are inhabited. The total land area is about 670 square kilometers, and the islands are scattered across 362,000 square kilometers of the South Pacific Ocean. There are four main groups of islands, Tongatapu, Ha'apai, Vava'u and The Niuas. The island groups are spread over 900 kilometers in a north-south alignment, the Niuas are the most northern and Tongatapu is the most southern, between 15° South and 23.5° South, and longitudes 173° West and 177° West (see Fig.2.1). The map of Tonga shows that Tonga is just to the left of the International Dateline and has been advertised to be 'where time begins'. Tongatapu is the main island with 259 square kilometers of land. This is where the capital Nuku'alofa is situated, and where the government and parliament reside.

The population of Tonga is about 100,000 and 96% are pure Tongans. They belong together with the Samoans, Maoris, Tahitians, Hawaiians and other people in the Central Pacific Ocean to the Polynesian race (Polynesian means 'many islands').

FIGURE 2.1

The Map of Tonga
(Source: Tonga Central Planning Department, July 2001, p. iv)



In the Population Census of 1996 (Tonga Statistics Department, 1996), 68% of the population are shown to live on the main island of Tongatapu, which is the centre for businesses, education and employment. The average growth rate for the interval 1986-1996 was highest for Tongatapu with 0.5% per annum. People are attracted from the outer islands to the main island searching for education and employment opportunities. The average growth rate for the whole of Tonga in the interval 1986-1996 was 0.3% per annum. The annual birth rate was estimated in the same population census to be 2.7%, the death rate was 0.65%, and the natural growth rate was 2.1%. From the above data, the net migration rate was calculated to be 1.8% per annum. This indicates that a considerable fraction of the population migrates overseas each year. The number of Tongans living overseas was estimated to be about 40,000 (World Bank, 1993). A further analysis of the population growth by broad age group for the 1986-1996 interval found that the growth rate for the age group 15-24 years old was negative. This suggests that most of the people who migrated were youths. Another important feature of the broad age group analysis is that there was no expansion in numbers for 50 and above age groups. This suggests that return migration is insignificant.

2.2.3 Economy

Tonga has a small economy with an estimated annual revenue of T$70 million (US$33 million) and a total expenditure of about T$126 million (Tonga Ministry of Finance, 2000). Many of the economic activities are mostly associated with agriculture, fisheries, public administration and tourism. The real GDP growth rate for the fiscal year 1999/2000 was 6.1%, a strong growth performance in the Pacific Islands standards. The economy has expanded by about 2% per annum since 1995. The GDP per capita for 1999 was estimated to be US$1542, which places Tonga in the lower middle-income group countries. However, social indicators such as adult literacy, life expectancy, access to safe water and infant mortality, are better in Tonga than those of the middle-income group countries.

The Tonga Budget Statement for the Fiscal Year 2000/2001 (Tonga Ministry of Finance, 2000) reported that Agriculture, Forestry and Fisheries were the dominant sectors contributing to the Tongan economy, accounting for 29% of GDP. Squash

was the highest earning crop with 47% and fish followed with 25%. It was observed that the main part of agriculture output originated from small-scale holdings cultivated by farmers. The next sector was the Community and Personal Services with 22.9% contribution. The Manufacturing sector accounted for only 5.6% of GDP. This sector involves small firms, many of which are located at a small industry center (processing zone) on the outskirts of Nuku'alofa. This is an area that possesses immense opportunities for development.

An important factor affecting the Tongan economy is the issue of Tongans living overseas, especially in New Zealand, Australia and the USA. Despite its effect on the domestic supply of higher level human resources, this emigration is a major positive influence on Tonga's trade and capital flow. The World Bank (1993) estimated that overseas remittances represented around 30% of GDP. Overseas remittances also helped to balance the trade deficit, which increased by 6.28% from T$90.8 million in 1998 to T$96.5 million in 1999 (Tonga Ministry of Finance, 2000). As the export base of Tonga's economy is narrow, a reduction in overseas remittances would make sectors of the economy dependent on domestic expenditure very difficult to sustain. However, much of this money was from unskilled labourers. Most of them had left high school with not much gained from it, except for 'a few English words' and an ability to 'add and subtract'. Most of the Tongans who do well overseas have had tertiary technical education and/or worked in a technical job before they migrated overseas.

2.2.4 Tongan Traditional Technology

William Mariner, a British who resided in Tonga for several years during the eighteenth century, listed the Tongan traditional arts and their manufacturers (Martin, 1827; Gifford, 1929). The most imperative arts were hereditary and exercised by men. The skillful artisans who performed them were called *tufunga.* These artisans included *tufunga fo'u vaka* (canoe builders), *tufunga fono lei* (cutters of whale teeth), *tufunga tapu* (funeral directors), *tufunga ta maka* (stone-masons), *tufunga sia kupenga* (net-makers), *tufunga toutai ika* (fishermen), *tufunga langa fale* (large house builders) *tufunga ta tatau* (tattooers), *tufunga tongi 'akau* (club carvers), *tufunga fai kava* (barbers), *tufunga fei'umu* (chefs). Gifford

(1929) added on to Mariner's list two artisans, they were *tufunga lalava* (sinnet artist) and *tufunga tui la* (sail maker). The other Tonga traditional arts performed by men were: rope making, making bows and arrows and club and spears. The arts carried out by women included tapa making and weaving. Most of Tonga's distinct traditional arts have vanished. In fact, at the present time the word *tufunga* refers to a carpenter.

There is no appropriate word in the Tongan vernacular that expresses the concept technology. The term *'tekinolosia'* has been recently introduced to mean technology. Therefore the term and its substance are considered by many to be foreign to Tonga. This has been greatly due to the way in which formal education was introduced into Tonga. The first post-primary school established in Tonga did not include in its curriculum Tongan technical skills and arts (Cummins, 2002). The term *'poto'* (scholarly) refers only to an academically successful person. Therefore Tongan traditional knowledge and skills, which were obtained through trial and error in their struggle for survival, perfected and passed down through the generations, and which represented the living characteristics of the Tongan way of life, began to be devalued with the introduction of western type education. Traditional knowledge was eventually replaced with the technological knowledge of the '*palangis*' (Mara, Foliaki and Coxon, 1994).

It was only recently that a subject that includes Tongan traditional technical skills and arts was introduced into formal education. This subject is *'Ngaue Faka-Tonga'* (Tongan Crafts), and the content of this vocational curriculum is the closest to what present writers in technology education would call Tongan Traditional Technology. This course includes traditional skills in making fishing tools and weapons, building canoes and traditional forms of houses, weaving and tapa-making. Teachers of this course have to consult elderly people for knowledge and skills required in this course. The imported ways of doing things have taken over the Tongan ways (*faka-Tonga*) with the exception of a few. For instance, boats have replaced canoes and *'palangi'* houses have replaced *'faletonga'*. Traditional skills in weaving and tapa-making are examples of the very few portions of Tongan indigenous technology that are still preserved for their value in the society

and culture. The rest of the skills, such as wood carving and traditional fan and basket making, are mainly preserved for the needs of the tourist industry. None of these skills are included in the traditional technical courses such as Industrial Arts and Home Economics. In Tonga, therefore, technical education does not relate to traditional ways of doing things. Technical education is new to Tonga and this new arrival of technology is considered by many to be modern.

2.3 EDUCATION

Formal education was brought to Tonga by the Europeans. It has been considered by many Tongans that the most important assets the Europeans brought to the islands of Tonga are Christianity and Education. They believe that education ensures a good life in this world while Christianity ensures a good life in the next!

2.3.1 Historical Background

The Europeans who arrived in the late eighteenth century found Tonga unique in the Pacific in that it had a traditional monarchy under the *Tu'i Tonga* (King of Tonga) (Leyard, 1982). The Tongan society was (and still is) epitomized by a three-tiered social system that consisted of *Tu'i* (king), *Hou'eiki* (chiefs) and *Tu'a* (commoners). Their responsibilities depended on their rank in the society (Cummins, 1977). They did not live in villages but had their houses close to where they worked (Cambell, 1992). They lived their life according to the seasons, tides, planting and harvesting of crops and fulfillment of their responsibilities to the *Tu'i* and *Hou'eiki* and the social functions including birth, marriage and death. Their daily activities were comprised of weaving, *tapa* making, canoe and house building, fishing and planting. Thus, the children learned the skills of their elders through informal observation and practical application in the real situation close to the family and home environment (Cummins, 1977; Tupouniua, 1977). This ensured that knowledge and skills remained within the occupational classes and passed down from one generation to another within each *ha'a* (extended family).

The first formal school in Tonga was established by Wesleyan missionaries from the London Missionary Society under the leadership of the Rev. J. Thomas and the

Rev. J. Hutchinson in 1828. The main objective was to enable the teaching and learning of the Bible. Later on, the missionaries found it necessary to educate the local people on basic skills such as literacy, numeracy and writing. The constitutional government was established in 1862, and with it came the demand for appropriately trained people to run the various establishments of the government. The first secondary school was established by the Wesleyan mission in 1866, through a request made by King George Tupou 1, and the school was named 'Tupou College' after the king. The syllabus taught was similar to that found in English grammar schools of the nineteenth century (Tonga Ministry of Education, 1999).

The first Act of Parliament was passed in 1876, after the Tonga Constitution was drawn in 1875, making education compulsory for 7-16 years old. This Act was revised in 1882, 1903 and 1913. The education act of 1927 was the beginning of modern secondary education in Tonga. A common syllabus for all secondary schools was introduced with special programs for students intending to enter the civil service. The Education Act was revised in 1947 and again in 1974. The 1974 Act is the one that is currently being used in Tonga. The Tonga Curriculum Development Unit was established in 1976 and Tonga became a member of the United Nations Educational, Scientific and Cultural Organisation (UNESCO) in 1980 (Tonga Ministry of Education, 1999).

2.3.2 Organisation and Aims of Formal Education

The present developments of education in Tonga follow the broad aims laid down in the Tonga Seventh Strategic Development Plan 1996-2000 (Tonga Central Planning Department, 1996). Education aims to provide a balanced program for the full development of children, both as individuals and as productive members of society, by developing Tonga's human resources to meet the country's manpower needs which are required to:

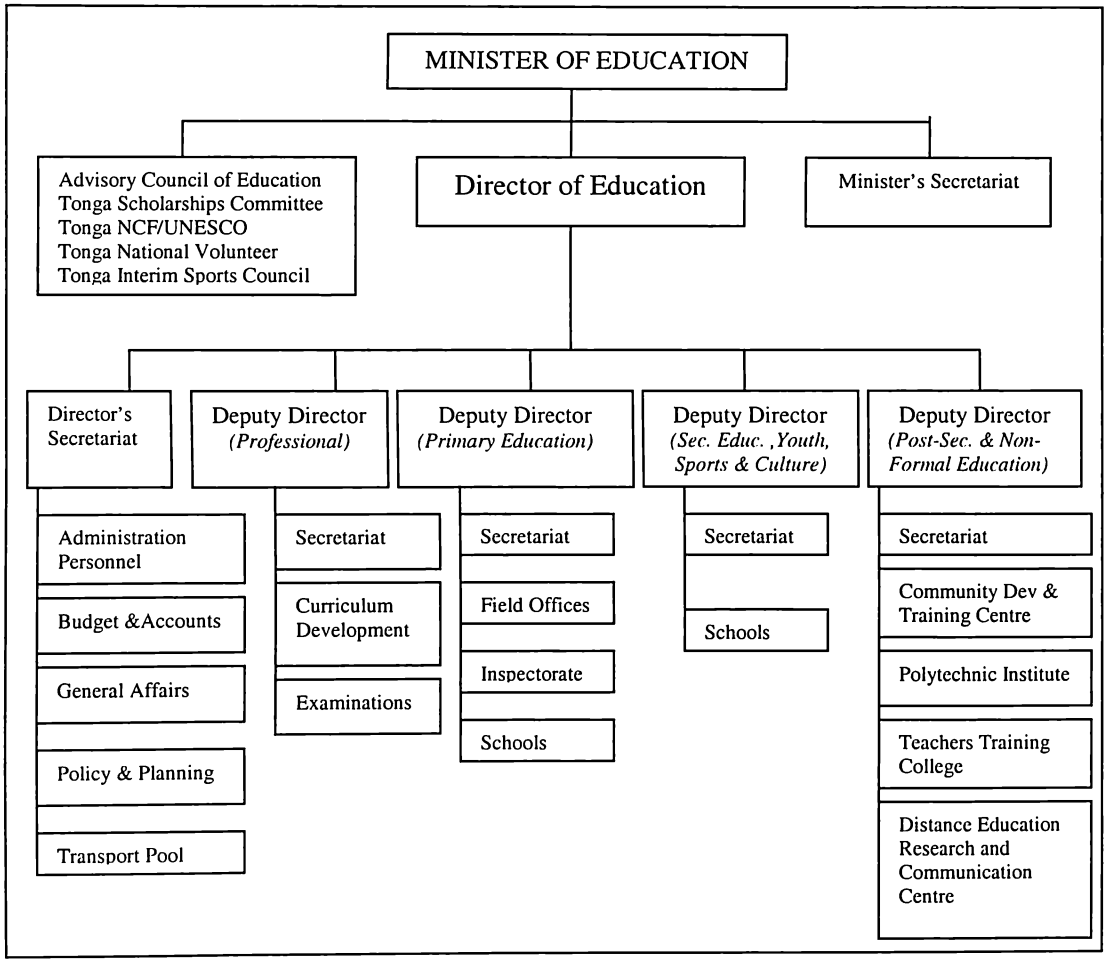
- achieve a high quality of life for the people overall;
- achieve a high standard of living throughout the kingdom;
- respect the options of both present and future generations;

- maintain a highly valued and adaptive culture;
- achieve individual fulfillment;
- achieve political stability; and
- achieve a stable economic and financial environment with less dependence on foreign aid.

(Tonga Central Planning Department, 1996)

The management of Tonga's education system is extremely centralized. This means that the Minister of Education, through the power granted upon him by the Education Act of 1974, has the right to make the final decision in all the issues relating to Education in Tonga.

FIGURE 2.2
Tonga Ministry of Education Organisational Chart,1998



(Tonga Ministry of Education, 1999, p. 17)

The Minister of Education is personally appointed by the king and is a member of the Privy Council, the Cabinet and Legislative Assembly. The organisation of the Tonga Ministry of Education is presented in Figure 2.2. The Minister is assisted by the Director of Education in the implementation and general administration of policies and programs formulated for the efficient operation of the Ministry. The Director is in turn supported by the four Deputy Directors who direct, supervise and execute educational programs in the core divisions of the Ministry.

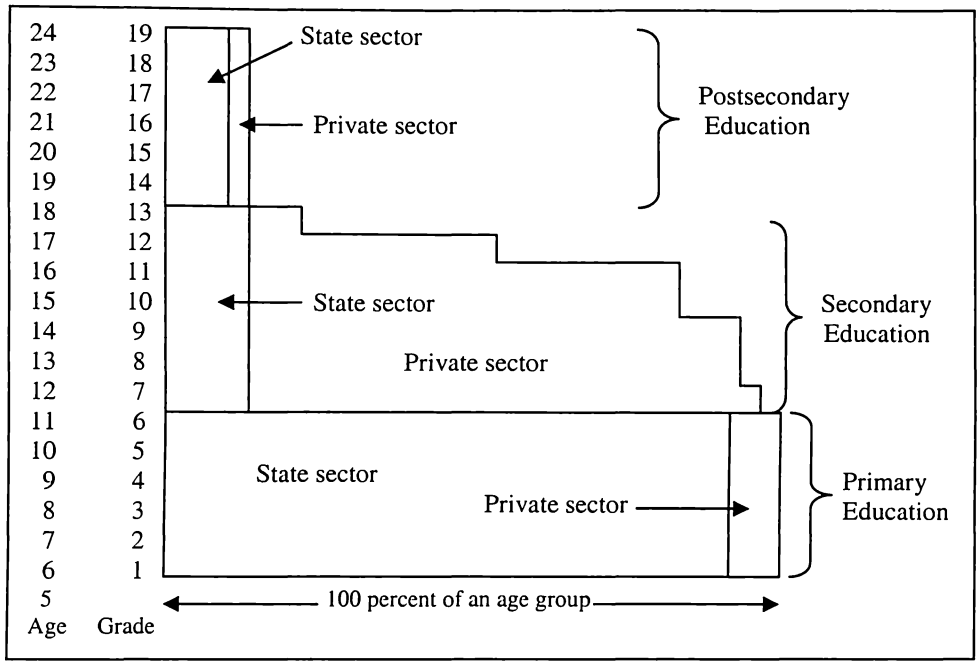
The matters relating to vocational and technical education are under the direction of the Deputy Director for Post-Secondary and Non-Formal Education.
Technical education in high school is under the direction of the Deputy Director for Secondary Education, Youth, Sports and Culture. Communication between these two deputy directors must be efficient in order for the relationship between secondary school technical education and post-secondary technical education to be strong. However, as it was found by the Sector Review Study (Australian Agency for International Development, 1998), Tonga has very disorganized vocational and technical education. It recommended that Tonga should develop a national and uniform system of vocational and technical education that runs through from primary, secondary into tertiary education.

2.3.3 Education System and Structure

Primary education in Tonga is compulsory and free. It begins with children of six years old and has a duration of six years. Access to primary school was estimated to be 100% or universal in 1999 (Tonga Ministry of Education, 1999) and the participation rate to be 99.9%. The subjects taught at this level are: English, Tongan, Maths, Environmental Science, Music, Physical Education and Arts and Craft. The medium of instruction is Tongan with a progressive use of English in senior classes. The results of the exam at the end of primary school determine to a great extent the high school a student can enter. The government high schools take the top students and the non-government schools share the rest. The major provider of primary education is the Government, teaching 93% of primary students. In 1999 there were 117 primary schools in Tonga, the Government owned 106 (91%) of them and the remainder were managed by church education

systems (Tonga Ministry of Education, 1999). The structure of the formal education system in Tonga is represented in Figure 2.3.

FIGURE 2.3
Structure of Tongan Formal Education System



Secondary education takes seven years. The subjects offered reflect that Tonga Government places much emphasis on the academic stream subjects. English, Maths, Science and Tongan are compulsory in Forms 1 – 4, while the technical subjects, Home Economics, Industrial Arts and Agriculture are optional. The only technical subjects offered at Form 6 are Computer Studies and Agriculture. The medium of instruction is English. At Form 5 the students sit the Tonga School Certificate Exam, the Pacific Senior Secondary Certificate Exam at Form 6, and the New Zealand Bursaries Exam at Form 7. Churches are the main providers of secondary education in the country, educating 74% of secondary students (Tonga Ministry of Education, 1999).

In 1999, there were 39 secondary schools in Tonga. Eight of these secondary schools were managed by the Government and the remaining 31 were managed and operated by non-government education authorities. The non-government systems are: Free Wesleyan Church (11 schools); Roman Catholic Church (4); The Church of the Latter Day Saints (7); Free Church of Tonga (3); Tokaikolo

Church (1); Seventh Day Adventist Church (3); Anglican Church (1) and; 'Atenisi Institute (1).

Enrolment trends in both primary and secondary education in Tonga have been a negative direction during the past two decades. The primary education enrolment dropped from 17,364 in 1981 to 16652 in 1999, while the secondary education enrolment went down from 14283 in 1981 to 13987 in 1999. Population projections (Demographic Analysis, 1999) indicate that for the next five years, the population of the age group 15-19 years old will decline from 12093 in 2001 to 11388 in 2005. This is an unusual situation for developing countries.

Much progress has been observed regarding the qualifications of primary and secondary teachers. In primary education the number of untrained teachers decreased from 18% in 1989 to 2.7% in 1999, while the number of diploma holders increased from 4.3% to 40% in the same interval. In secondary education, the number of teachers with no post-secondary qualifications decreased from 23% in 1989 to 10% in 1999, while the number of Masters or PhD holders increased from 3% to 5%.

Tertiary education has been carried out by the following institutions:
(i) Tonga Teachers College (Government);
(ii) Tonga Maritime Polytechnic Institute (Government);
(iii) Police Training School (Government);
(iv) Queen Salote School of Nursing (Government);
(v) Technical Apprentice (MOW) (Government);
(vi) Civil Service Training Centre (Government);
(vii) St. Joseph Business College (Roman Catholic);
(viii) 'Ahopanilolo Technical College (Roman Catholic);
(ix) Montefort Technical Institute (Roman Catholic);
(x) Hango Agricultural School (Free Wesleyan Church); and
(xi) Sia'atoutai Theological College (Free Wesleyan Church).

Education has been receiving a high proportion of the Tonga National Budget in the past two decades. In the 1998/1999 Budget, Education received the highest allocation of public expenditure with 18.4%. In the 1999/2000 Budget, it received the second highest allocation behind the health sector, getting 12.2%. Primary education takes the largest share of the Education Budget each year. In 1999 it received 42.9% while the secondary education received 21% and post-secondary education had 14% of the Education Budget. More than 75% of the education share is spent on salaries alone each year. The more expensive services such as curriculum development, post-secondary education and examinations are partly funded through external aid schemes.

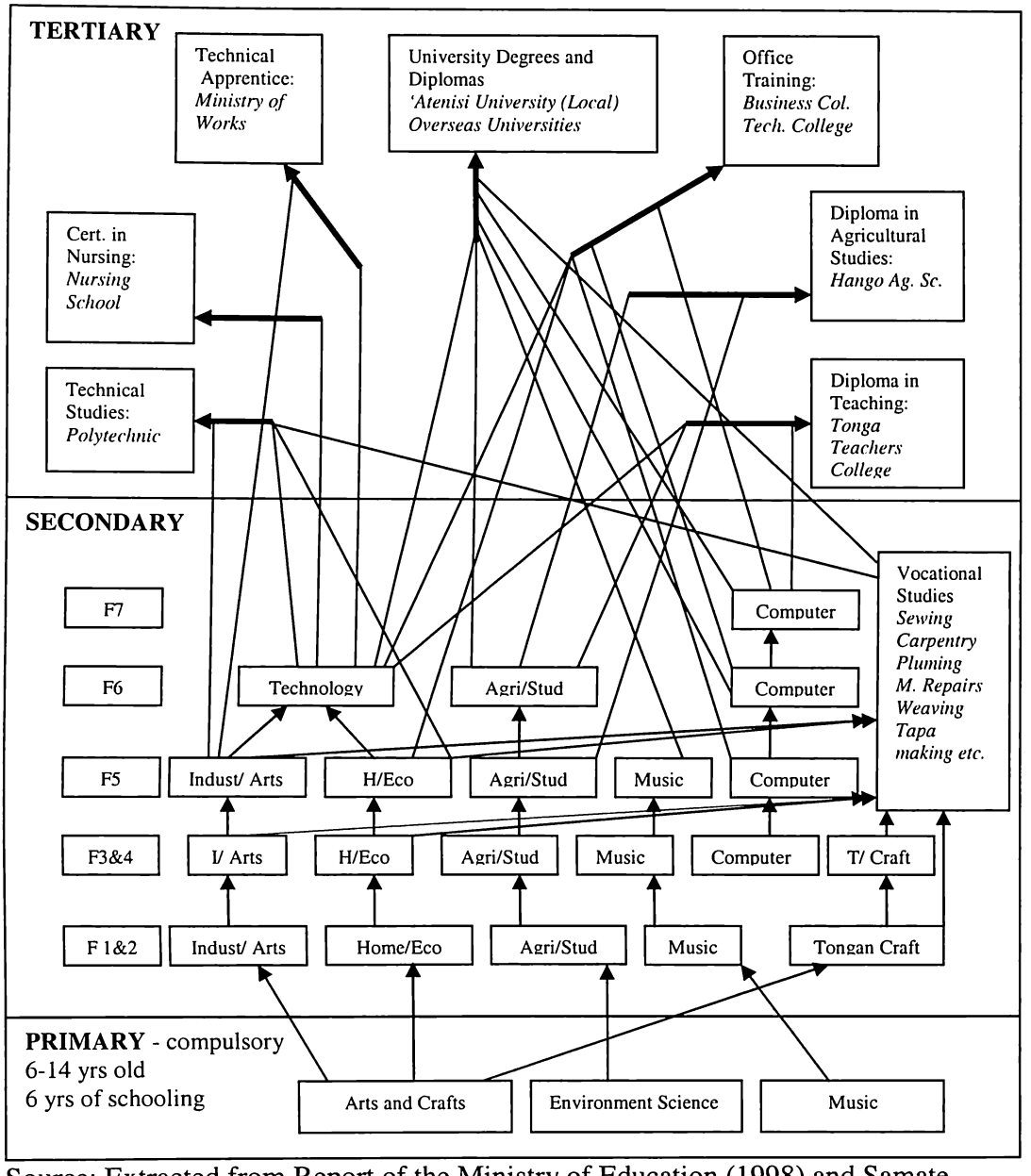
2.4 VOCATIONAL AND TECHNICAL EDUCATION

2.4.1 General Structure

Vocational and Technical Education (VTE) in Tonga is represented in many forms. It comprises secondary school technical education; private (non-formal) organizations; private colleges and institutes (formal VTE); and public post-secondary and tertiary institutes (formal VTE). Figure 2.4 presents the general structure of Vocational and Technical Education in Tonga.

The current system of VTE in Tonga has been described as a reflection of the geography of the country: '... many scattered islands, some populated, many not, and each characterized by its particular size, terrain, demography and level of development' (Australian Agency for International Development, 1998, p.15). This means that Tonga has a wide range of institutions, facilities and arrangements underpinning VTE, but without an organisational structure. The study by the Australian Agency for International Development (1998) found that current provisions for VTE in Tonga are 'fragmented, uncoordinated, developed without an integrated plan and are cost inefficient' (p.16). It also reported that mainstream

FIGURE 2.4
General Structure of Vocational and Technical Education in Tonga



Source: Extracted from Report of the Ministry of Education (1998) and Samate (1995).

unifying terms such as post-compulsory education, post-secondary education, secondary technical education, technical education, higher education and tertiary education can not neatly describe the situation of VTE in Tonga. It recommended that there was a need to improve the overall planning and coordination of VTE,

and strengthen its national organizational structure, before any steps can be made towards the enhancement of VTE in Tonga.

2.4.2 Vocational and Technical Education in Secondary Schools

VTE exists mainly in two forms in Tongan secondary schools. In some schools it is in the form of technical subjects such as Industrial Arts, Home Economics, Agriculture, etc., while in some schools, a pre-vocational stream is also offered to enable students to take life skills subjects such as weaving, sewing, carpentry, mechanical repairs, plumbing, piggery, cattle-raising and so on. The government schools have the technical subjects but not the pre-vocational stream. The pre-vocational stream exists mainly in the big church schools. The main reason given by the principals of these schools for providing this stream was to solve problems relating to students' early drop-out, boredom in classroom, and needing to have something useful when they leave school (Samate, 1995).

Pre-vocational and Technical Education in secondary schools are confined by problems including; poor, out-of-date or run-down machinery and plant; unreliable and expensive power supply; under-qualified and/or under-trained technical education teachers; insufficient technical assistance from overseas technical teachers and teacher trainers; a curriculum that is rapidly dating; and low interest in technical subjects (Australian Agency for International Development, 1998). Despite these identified problems, it was recognized in the same study that school based technical education has the potential to benefit the majority of the students population and to diversify the largely academic secondary school program in Tonga.

2.4.3 Post-compulsory Informal Vocational and Technical Education

This refers to technical and vocational informal courses offered outside formal education systems for persons older than 14 years of age. Providers are Women in Development Groups (WID), Non-Government Organisations (NGOs), Tonga Council of Churches, and the mainstream churches. They provide informal technical and vocational education programs for youth, women and girls, the unemployed and isolated populations in skills related to different occupations in

the labour market. Various government departments also provide opportunities for informal technical and vocational education.

2.4.4 Post-Secondary Formal Vocational and Technical Education

It is difficult to differentiate the institutions offering VTE from those that are offering post-secondary education. Therefore all provisions for post-secondary education will be included in the discussion.

The institutes managed by various government departments are: the Community Development and Training Centre (CDTC), which provides, coordinates and facilitates VTE and post-secondary education, acting as an umbrella organization for post-secondary education in Tonga; the Tonga Maritime Polytechnic Institute, which provides maritime and seafaring training, and offers training in other trade areas such as automotive mechanics, industrial welding, plumbing, carpentry, electrical, etc. up to certificate and diploma levels; the Tonga Teachers College, which trains teachers for primary and secondary education up to diploma level; the Queen Salote School of Nursing, which trains school leavers to become nurses and provides in-service and specialized training for nursing staff; and Police Training School which trains school leavers to enter the police force, fire and prison services.

The institutes managed by the Catholic Church Education System are: St. Joseph's Business College, which provides training in typing and secretarial work; 'Ahopanilolo Technical College, which provides training in cooking, hospitality and fashion and design; and Montfort Technical Institute, which provides training in carpentry, automotive mechanics, painting and welding.

The institutes managed by the Free Wesleyan Church are: Sia'atoutai Theological College, which offers study programs in Divinity up to diploma and degree level, and also carries out in-service training to pastoral ministers; and Hango Agricultural College which offers courses on farming concepts up to diploma level.

The other privately owned institutes are: The University of the South Pacific Extension Centre, administered by the University of the South Pacific from Fiji, which offers extension courses up to master's level; the 'Atenisi Institute which offers courses in science and arts up to master's level; and The University of the Nations which offers courses in Christian Studies and Youth Leadership and other life skills training programs.

2.4.5 Vocational and Technical Education and Labour Market

In the 1996 Census, the unemployment rate of Tonga was 13.3%. A share of 54.4% of the employed population of Tonga was either in agriculture (58.5%), fishing (27%) or making handicrafts (14.5%) and 45.3% were engaged in paid employment. For those making handicrafts, 58.5% produced for their own use. Males dominated farming and fishing while females dominated handicrafts. The Government employed 60% of those in paid employment. Small businesses, tourism and hospitality and services accounted for 29% and the manufacturing sector accounted for 11%. These figures not only highlight the surplus of labour over the number of paid occupations, but also the misfit between the current provisions for VTE and labour market requirements. Apart from the generic training provided in the police, health, education, defense and public administration, the Government does not provide through VTE skills and competencies demanded for successful expansion of the labour market.

2.5 Existing Secondary School Technical Curriculum

2.5.1. Introduction

The Ministry of Education provides the overall curriculum framework upon which other educational provisions are based. This is not compulsory, but since the external examination at Form 5 is provided and administered by the Tonga Ministry of Education, the other educational providers are apprehended to abide by and follow the curriculum provided by the Ministry of Education.

2.5.2 Existing Curricula

There are four Technical subjects offered at the government secondary schools namely: Home Economics, Industrial Arts, computer studies and Agricultural Science. The Ministry of Education provides comprehensive curricula for these technical subjects for Forms 1 to 5. Agricultural Science and Computer Studies are the only subjects that are offered at the Form 6 level. Other technical subjects such as Technical Drawing, Arts and Music are offered in some of the non-government schools. A new technical subject, technology education, was made available in 1999 for Form 6 only. This was initiated by the South Pacific Board for Educational Assessment. This is the body that administers the Pacific Senior Secondary Certificate Examination (PSSC) at the Form 6 level. The PSSC Examination is the External Examination the Pacific Islands Form 6 students (except Fiji) sit at the end of Form 6. The technical subjects are all offered as optional subjects from Forms 1 to 6. This reflects the weakness of the emphasis placed by the education system in Tonga on Technical Education. Despite the availability of the curriculum materials for Forms 1-4, many of the schools find it difficult to follow these curricula. There is a great difference between what is taught at the various forms (1-4) amongst the church schools and that of the government schools. This difference is caused mainly by the availability of resources and the perception of the school Principals of what the students should learn at a particular level. The schools however tend to follow the prescribed Government curricula for Form 5 in view of the qualification offered by Government at the end of each academic year.

2.5.3 Classroom Culture

A typical Tongan classroom is quiet and a common activity is the teacher writing notes on the blackboard and students quietly copying them into their books. The teacher is in charge of all the activities in the classroom. These activities are also commonly observed in technical subjects although they are meant to be more practical. This is because many of the machines and tools required are not available and diagrams of them are drawn on the blackboard and students are required to copy them into their books and learn their parts and functions. It is understood that this is not an appropriate method to employ in technical subjects,

but it has been considered important that students have some idea of structure and function of common tools in Industrial Arts and Home Economics. The current curricula for technical subjects have 2 components: the theoretical and the practical activities. Assessment in these subjects assigns 60% for theory and 40% for the practical part of the course (Tonga Ministry of Education, 1994). Most students do their best to obtain good grades on practical work to enhance their chances of passing the course. Teachers also are pressured to drive their Forms 5 and 6 students to pass the external examinations. This results in most practical activities being carried out with the help of parents and friends to ensure good quality final products for assessment. The students tend to gain the knowledge part of these courses but fail to attain the important skills targeted.

2.5.4 Problems

There are a few problems that have been identified regarding technical subjects in secondary schools in Tonga. These problems were spotted during discussions and interviews with technical education teachers and officials from the curriculum development unit. The problems include the following:

Government attitude towards technical education

The government education system puts too much emphasis on academic subjects such as Mathematics, Science and English. These subjects are compulsory in all government secondary schools in Tonga for Forms 1-4. Technical courses are only optional, indicating that it is not a priority interest of government schools. Commitment of Government to technical courses in terms of equipment, teachers, machinery and tools are poor. The government schools do not offer vocational subjects, and most schools offer Industrial Arts and Home Economics in Forms 1 and 2 but they are only optional. Further, a school that was originally established by the government to take care of technical and vocational subjects has slowly transformed back and become another academically biased school.

Poor relevance of technical curricula to Tonga

The secondary school technical curricula in Tonga are poorly related to the labour market, society and Tongan culture. These curricula are adaptations of overseas

curriculum materials. Their contents reflect little consideration of the context of Tonga. It seems that during curriculum development processes, very little consultations were made with technical industries and technical tertiary institutions regarding the contents of these curricula (Australian Agency for International Development, 1998).

Lack of co-ordination of technical courses

There is no common body whereby the technical curricula are coordinated and administered for the whole education system in Tonga (Australian Agency for International Development, 1998). There are officials in the Tonga Curriculum Development Unit that take care of each of the technical subjects but their job descriptions do not allow them to work towards coordinating the method in which these subjects are taught in different schools and at different levels.

Inconsistency of course content

There are 39 secondary schools in Tonga, eight schools are operated by Government and the remaining schools are managed by non-government education systems. There is a curriculum document which has been prepared by the Government Curriculum Development Unit for Industrial Arts, Home Economics, Agricultural Science and Computer Studies. However, there are no text books to support these curricula and tools and equipment available vary from one school to another. The government schools do not take the technical courses seriously, as they are more interested in the traditional academic courses. On the other hand, the non-government schools, who take these courses more seriously, do not have the money to buy the appropriate tools and equipment for these courses. Thus, in reality, the content of the technical courses that are taught in the classrooms are not consistent throughout the schools. There is a lack of unification in the content that is followed by the schools in Tonga.

Influence of external examinations

There is too much emphasis on the results of the external examinations in Forms 5 and 6. The results of these examinations have been used by the public to compare the performances of schools. The results are announced in Radio Tonga and

published in both of Tonga's two weekly news papers. This has influenced schools and teachers to direct almost all of their effort towards enhancing the external examinations passing rates. Thus, technical courses tend to lose emphasis on practical work and are taught primarily towards passing the examinations.

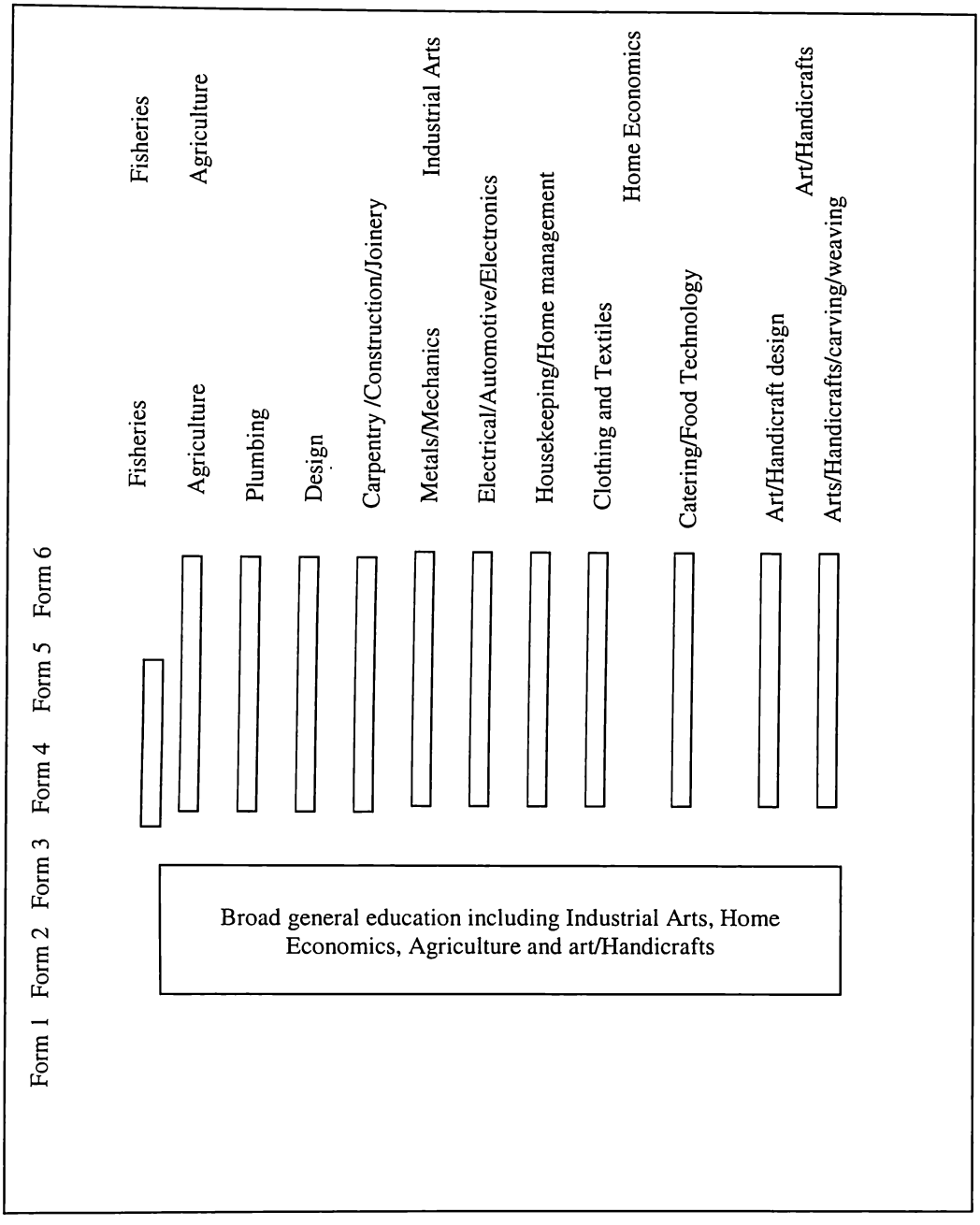
2.5.5 Future development

At the present time, developments in technology education are heading in two directions. First is a recommendation made as a result of the study of the Vocational and Technical Education Sector in Tonga (Australian Agency for International Development, 1999). This development heads deeper towards the traditional technical type education. The technology education structure recommended is shown in Figure 2.5. The other direction is a late development. The Tonga Government has proposed a subject called Technology for Forms 1 – 5 to be implemented in 2003 (Tonga Ministry of Education, 2003). It adopts Australia's definition and aims of technology designated in the technology curriculum profile for Australian schools (Australian Education Council, 1994). However, the content of Tonga's proposed technology curriculum is very much the same as its existing technical curriculum. This new development is a consequence of worldwide developments regarding technical and technology education. Tonga is still struggling with the problems of the present technical curriculum. To be able to develop a suitable technology education program for Tonga, it must follow what the other countries have done.

2.5.6 The Need for this Study

It is evident from the problems relating to technical and vocational education in Tonga that there is a need to revise the secondary school curriculum in this area. The Tonga Government has heard this call and has obtained assistance from Australia towards revising Tonga's technical and vocational curriculum. At the same time, it has observed international developments in technology education and has indicated interest by the late development of a technology curriculum material for Forms 1-5. It is evident from this proposed curriculum that Tonga is heading towards the more traditional form of technical education.

FIGURE 2.5
Proposed Structure of Technical and Vocational Education



(Australian Agency for International Development, 1999).

This study believes that the best way to move is to follow what other countries have done in the development of a technology education curriculum. A comprehensive study must be carried out in Tonga to identify the current situation in order to establish a base for technology education in Tonga. This present study will provide a good beginning towards this end.

This chapter has discussed the background information regarding technical and technological education and the technical career opportunities in Tonga. The next chapter will discuss the international developments in technology education and determine how these developments relate to the development of technology education in Tonga.

CHAPTER THREE

PERCEPTIONS OF TECHNOLOGY AND TECHNOLOGICAL CAPABILITY

3.1 INTRODUCTION

The two previous chapters discussed the context of this study. The rationale and research questions were given in chapter one and the background information regarding technical and technological education and technical career opportunities in Tonga were discussed in chapter two. This chapter will discuss recent developments in technology education. The aim is to examine current international views of technology education and determine how these views relate to the development of technology education in Tonga. Results of various studies of students' perceptions of technology and analysis of students' technological capability will also be presented to provide the background for this research. The remainder of this chapter will present:

3.2 Recent Developments in Technology Education;

3.3 Learning in Technology;

3.4 Perceptions of Technology;

3.5 Technological Capability;

3.6 Assessment of Perceptions of Technology and Technological Capability; and

3.7 Summary

3.2 RECENT DEVELOPMENTS IN TECHNOLOGY EDUCATION

This section on recent developments in technology education will accomplish three main tasks. First, various definitions and perceptions of technology will be examined in order to ascertain the most recent and most common views held by educators and researchers about technology. Second, the reasons put forward by various advocates of technology will be summarized in order to understand the reasons why many countries have started to teach technology in primary and secondary schools. Finally, recent international developments in technology education will be discussed to identify the various approaches used and the problems encountered as effective ways are developed to teach

technology in schools. The main aim will be to establish an argument for: (i) the need to teach the latest ideas about, and processes of, technology in Tonga; and (ii) the appropriateness of using students' perceptions of technology and their existing technological capability to inform the development of technology education suitable for Tonga.

3.2.1 Definition of Technology

Defining technology is not an easy task to accomplish, especially as it not only covers an enormous range of human activity but it includes wide differences in scale. For example, it comprises activities from as large as a huge space project down to a single person working in a small workshop project (McCormick, Newey and Sparkes, 1992; Gardner, 1994). There is little wonder that the meaning of technology has been changing with time. However, the growing importance of teaching technology has prompted a search for a consensus of meaning. Many writers in technology education in the past two decades have therefore scrutinized the differing meanings of the term technology in order to formulate a definition that would be appropriate for technology curricula developing in primary and secondary schools throughout the world.

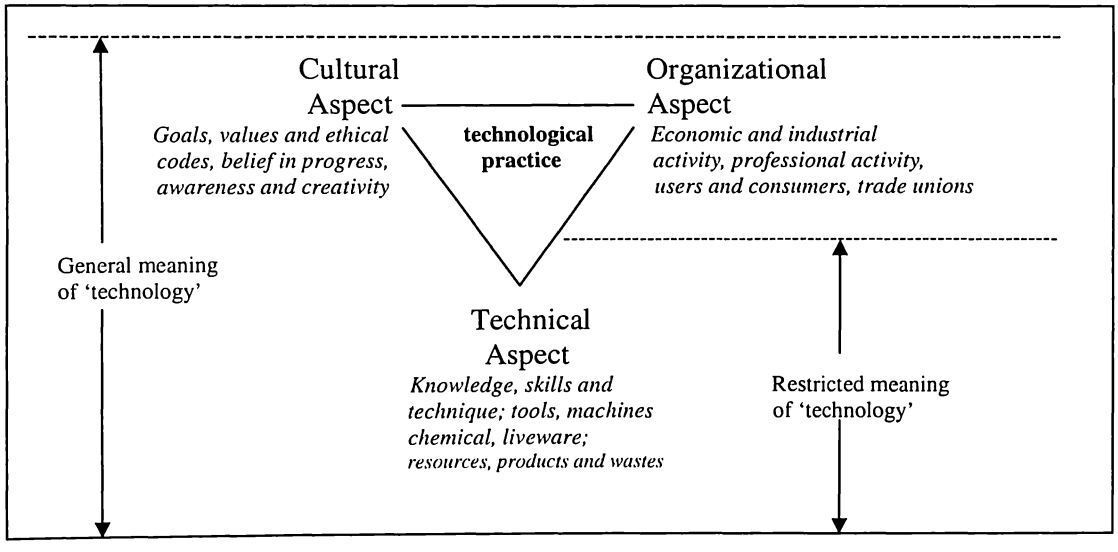
Technology is described as artefacts, as activities, as a process and as a socio-cultural system (Kline, 1985). But Layton (1993) explains that the meaning of technology changes with time and that educators and researchers in technology education have identified and invalidated the restricted views about technology and have started to share a common understanding and promote the more general meaning of technology. For example, Naughton (1992) nullifies the idea of technology as just machinery and argues that "Technology is the application of scientific and other knowledge to practical tasks by organizations that involve people and machines" (p. 9). Three implications of this definition are: (i) Technology involves practical activity, with a goal of problem solving; (ii) Technology involves applying other types of knowledge apart from scientific knowledge; and (iii) Technology involves complex interactions between people, social structures and machines.

Therefore, the meaning of technology has been evolving away from its crafts and industrial original meaning and gaining more ground towards the involvement of people and social structures. The relationship between the evolution of technology and society has been recognized by some writers. Changes in the meaning of technology have been related to the evolution of society. For example, Swernofsky (1989) observes that the evolution of the way technical subjects are taught in schools reflects the way technology develops in society. He claims that, "Manual arts reflects a handicraft society, industrial arts reflects an industrial society, technology education reflects today's information processing society." (p.vi). Technology has been increasingly recognized as a part of society. The changes in the meaning of technology have been from technology as tools and machines to that which comprises social and cultural aspects.

This trend is well expressed in the model of technology put forward by Pacey (1983), which gives a diagrammatic representation of the definition of technology, showing both the restricted and the general meaning of technology.

FIGURE 3.1

Pacey's Diagrammatic Representation of Technology



(Pacey, 1983, p. 6)

In the diagram, Pacey suggests that thinking about technology as artefacts, products or tools is a restricted view of technology. The broader view of technology incorporates the planning and organizational activity associated with the production and use of the artifact and also the values, beliefs and creativity that influence the characteristics of the artefact. The trend of the evolution of the meaning of technology has been towards that which involves organizational and cultural aspects. Figure 3.1 shows Pacey's diagrammatic definition of technology.

Other writers like McGinn (1978), Kline (1985, cited in Layton, 1993) and Fleming (1989) have come to similar conclusions regarding the broad view of technology in which culture and society are included.

Many of the ideas that have been consistently mentioned in literature to be related to technology are expressed by McGinn (1978) in his discussion of the meaning of technology. He claims that technology is a form of human activity with the following characteristics:

- It is an activity in which materials are made;
- The overall process is fabricative in nature;
- It is highly purposive;
- It is a resource-based, resource-expending form of human activity;
- It is an activity that utilizes and generates a complex body of knowledge;
- It integrates and proceeds in accordance with certain methods; and
- It is the sociocultural- environmental context within which the activity unfolds;
- It is the ideas that one has regarding any of the preceding aspects, as well as towards the meaning and significance of his or her activity.

McGinn also considers the content of technology to be: the combination of knowledge, resources and methods of individual technologies involved in the production of an artefact; a function of time; and dependent on the variables of the society. He went further to argue that technology is value laden and not value free. Significant in this definition is the recognition that technology utilizes and generates a body of knowledge.

This body of knowledge is distinct and worthy of study in its own right (Medway, 1989). Technology has been viewed by many to be the application of science. However, it has been shown that technology is different from science (Gardner, 1994; Layton, 1992).

Summing up the discussion made by technology educators and researchers about the meaning of technology, a few characteristics seem to emerge. First, technology is practical in nature, requires resources and involves design. Second, it is a purposeful human activity, especially towards solving technological problems. Third, technology is concerned with values and not value neutral. Fourth, technology is multi-dimensional and involves organization of different groups of people like designers, engineers and consumers. Fifth, technology is a distinct body of knowledge, a field of study in its own right, and finally, technology shapes and is shaped by the society in which it unfolds.

These ideas are well expressed in some of the definitions of technology in many countries. For example, in Australia, technology is defined as involving "the purposeful application of knowledge, experience and resources to create products and processes that meet human needs" (Australian Education Council, 1994, p. 2). In New Zealand, technology is defined as "A purposeful activity aimed at meeting needs and opportunities through the development of products, systems and environments. Knowledge, skills and resources are combined to help solve practical problems. Technological practice takes place within, and is influenced by, social context" (Jones and Carr, 1993a, p. 2).

Technology therefore has come to be viewed as a very important activity in human culture. Jones (2001) contends that technology is a major and determining feature of the world that we inhabit. Therefore young people, as future citizens, must understand how technology affects the world and how they can participate in it. Black and Harrison (1992) refer to technology as "... the practical method which has enabled us to raise ourselves above the animals and to create not only our habitats, our food supply, our comfort and our means of health, travel and communication, but also our arts-painting, sculpture, music and literature. ... Technology has always been called upon when

practical solutions to problems have been called for."(p. 51). Discussing the various reasons for teaching technology is the purpose of the next section.

3.2.2 Rationale for Teaching Technology in Primary and Secondary Schools

The previous attempts to teach technology in primary and secondary schools have failed because of lack of appropriate support. The present thrust for technology education has been supported by a higher number of agencies. Further, there are more influential bodies that have rendered their support for the inclusion of technology in primary and secondary schools throughout the world today than ever before (Layton, 1994). Sources like governments, industries, worldwide organizations, international conferences, educators, researchers and even journals are now supporting the case for technology education in schools. Many authors have explained different reasons for the widespread interest in technology education, but the main one has been for technological literacy (Layton, 1994). One of the most important statements showing UNESCO's advocacy and support for technology education identifies technology as something that should be part of everyone's basic education. It was prepared by the International Commission for the Development of Education, and quoted by Faure et al. (1972, cited in Layton, 1994, p. 12). It argues that:

> Lack of understanding of technological methods makes one more and more dependent on others in daily life, narrows employment possibilities and increases danger that the potentially harmful effects of the unrestrained application of technology ... will become overwhelming. Most people benefit from technology passively, or submit to it, without understanding it. They cannot, therefore, control it. Education in technology at the conceptual level should enable everyone to understand the ways in which he can change his environment. ... In present-day general education, technology is not treated in a systematic, conceptual fashion. ... For a grasp of technology, it may be viewed as a process through which materials are transformed, and this always requires both energy and information. Following this, a unified approach should analyse the principles underlying all processes, simple and sophisticated, and show that technology deals with everything man does to modify his world.

The above statement emphasizes the importance of technological literacy. A better informed citizen will attain more freedom and independence, better chances of obtaining employment, and is in a much better position to make intelligent decisions regarding

which technological developments should be allowed and which should be rejected for the benefit of the environment, society and humankind as a whole.

Jones (2001) supports teaching technology for technological literacy because of its major role as a determining feature in human culture. Bybee (2000) clarifies the effect of technology on society by using the top news headlines of the 20th century. Bybee reports that 45% of the top 100 news headlines of the 20th century were directly related to technology. The Wrights brothers flying the first powered plane in 1903, Japan bombing Pearl Harbour in 1941, the United States bombing of Hiroshima and Nagasaki in 1945, and the first human to walk on the moon in 1969 are all technology–related stories which have become the top four news headlines of the 20th century. He argues that the involvement of technology in the important events of the world is justification enough in itself for promotion of higher levels of technological literacy. He also stresses that because United States society is deeply dependent on technology, the need to achieve technological literacy is a national imperative. School programs must include technology as an essential part of every student's education as can be seen in many other industrialized countries of today. Medway (1989), McCormick (1992) and Jones (1997b) describe several reasons that have helped in the worldwide acceptance of the importance of teaching technology in schools. They are:

Economic

First, since society and education value academic subjects above the practical ones, putting technology in the curriculum for all would make the subject more attractive and thus acquire higher status in young students' views. This would put more able students into industry and business. Second, a highly skilled workforce is required to match the introduction of newer and more modern pieces of equipment. This would allow the introduction of new technologies to be successful, which in turn would make the modern productive processes more efficient. Third, pressure has been exerted by various enterprises and the wider community for education to develop people who are more creative, innovative and resourceful. To boost the economy, the country needs people

who are more effective in translating ideas into action, in working as a team, in adapting to a rapidly changing world and in developing both products and market niches.

Social

Members of society need to be well informed about technology. This would enable them to envisage the possible effects of the introduction of a system or a process, appreciate the restrictions that certain technologies might achieve and identify problems for which certain technologies might provide solutions. It is also imperative that students are aware of the impact of technology on their environment. This would enable them to be prepared to properly handle the various effects of the advance of technology.

Educational

Schools have been denying pupils whose bent is towards practical status, high-value qualifications and ultimately life chances by concentrating their efforts mainly on 'knowing' subjects. Also, technology is a distinct mode of human operation and is an area worthy of study in its own right. For pedagogic reasons, technology provides a perfect opportunity for students to integrate their existing knowledge, skills and understanding. It is an enriching and innovative learning situation for students. Further, students' knowledge base will increase along with development in their practical capability and thus become more creative and innovative.

Motivational

Human needs and interests provide good motivation for engaging in technology. The practical nature of technology, in which students can see and experience the applicability of knowledge and skills in sports, health etc. is an exceptionally strong motivator.

Cultural

Technology provides a perfect opportunity for students to learn and appreciate different technologies of different cultures. Knowing a wide variety of cultural perspectives can help in developing a diversity of appropriate solutions and responses to problems.

Personal

Technology education provides the opportunity for students to address their personal needs through being empowered members of a technological society who are actively participating and contributing to making important decisions about technology. Technology education also provides the opportunity for students to operate in unstable and unpredictable situations which encourage risk-taking and making innovative decisions. The kind of situations that is common in the real world of technology.

The education systems that have included technology education in their school general curricula have been inclined to do so for one or more of the above reasons. Economic reason was the major initiator for the original interest in technology education. However, technological literacy and educational reasons have been responsible for the present worldwide interest in technology education.

3.2.3 Recent International Developments in Technology Education

Technology education has been internationally accepted as a distinct area of education (McCormick, 1992a; Lewis, 1996). Its emergence as a new subject in school curricula is not just rare, but is in itself a worldwide curriculum historical event (Layton, 1994). Layton claims that many education systems around the world have taken technology as a component of general education. He also stresses that although previous attempts to incorporate technology as a school subject failed, due to the influential science curriculum reforms of the 1960s, the present situation is different and receives greater support from powerful sources including government and industry.

Because technology education is still in its infancy as a school subject, it is practiced in a variety of forms internationally (McCormick, 1992a; Kimbell, 1997). There are many factors that have contributed to the variation in models of technology education practiced throughout the world. First is the variation in interpretations of technology and technology education between countries. Second is the variation in pressures applied by parties interested in the introduction of technology education from one country to another. Layton (1994) describes the influence of various stakeholders in the

development of the curriculum. Prominent in them are: 'economic instrumentalists' who view education with an aspiration of achieving national economic competitiveness; 'professional technologists' who regard technology as another culture besides arts and science; 'sustainable developers' who coerce to ensure the compatibility of economic growth and environmental protection; and 'girls and women' who view technology education as an opportunity to counter gender biases that have existed in traditional technical subjects. Third is the variation in traditions of technology education between countries. These traditions include Craft, Design and Art, Science, Science Technology and Society (STS) and Industry, Productive work and Education (McCormick, 1992a).

Black (1994) presents five perspectives of technology education that have been adopted by various education systems around the world. They are:

(i) Technology as craft skills: This is a narrow viewpoint of technology which is mainly associated with making things. It is oriented towards the vocational purposes of education;

(ii) Technology as craft and design (or craft, design and technology-CDT): A broader vocational view of technology which attaches concepts of techniques and design to craft skills. It advances pupils from making from prescription to design and make;

(iii) Technology as science and technology (or science, technology and society – STS): This perspective views technology as applied science, which in many countries reduces to only applied physics. It is still vocational, although different from the first two, in that its purpose in general education is for future citizenship of technological societies;

(iv) Technology as design and made in the context of the application of mathematics and scientific principles:
This is a broader perspective with an amalgamation of the second and third. Craft and design are taught in the context of the application of mathematics and scientific principles. Values and problems regarding political and social pressures are considered. Its purpose in general education is towards preparation of future citizens; and

(v) *Technology as practical capability*: This perspective emphasizes the ability of the pupil to work co-operatively, to define needs and to design, implement, and evaluate solutions. Its purpose in general education is towards personal development and for vocational fitness.

Table 3.1 presents how technology education is adopted in various countries. Technology traditions (Black, 1994; McCormick, 1992b), current practice and trends, place of technology within the school curriculum and subjects offered, are given for each of the countries identified in literature. The aim here is to enlighten the kind of decisions that are being made in various countries about technology education.

It is evident from Table 3.1, that there is an international momentous conversion towards the development and formalization of the general curriculum for technology education. It has become a significant international occasion. Nearly all of the countries considered in Table 3.1 have established some form of the new approach to technology education. There are two aims in which technology education has been directed across the countries. First is towards technological capability, and this model views technology as *process*. The other is towards technological literacy, and views technology as *content knowledge*. Technology education in the UK, USA, Australia and New Zealand will be discussed further here as examples of the international trend towards including technology education as a mandatory subject in the curriculum.

In England and Wales, technology education is viewed in terms of *process* with an emphasis on design. The prime objective is towards technological capability (Lewis, 1996). It has been considered by the national curriculum as a foundation subject. It is defined through two distinct profile components, 'design and technology' and 'information technology'. Information technology is cross-curricular, while design and technology activities are integrated in art and design, business studies, CDT (Craft, Design and Technology), home economics and information technology (McCormick, 1992a).

TABLE 3.1
Summary of Current International Practices and Trends of Technology Education

Countries	Technology Tradition	Current Practice and Trend	Place in Curriculum and Subject(s) Offered	References
Scotland	(i) Craft (ii) Engineering science	General course in curriculum	(i) Technological Studies (ii) Craft and Design	McCormick, 1992b
England and Wales	(i) Craft and Arts (ii) Craft, Design and Technology	Foundation subject (5-16 years)	(i) Design and Technology (ii) Information Technology	McCormick, 1992b Gradwell, 1996
Northern Ireland	(i) Craft (ii) CDT (iii)Art and Design	Subject	(i) Technology and Design	McCormick, 1992b
Netherlands	(i) Vocational Craft	General course in both Vocational and General schools	(i) Technology education in General schools (ii) General technique (V.S.)	De Vries, 1992
Nordic Countries	(i) Craft (Sloyd movement) (ii) Design	Technical subjects Technology education beginning to be introduced	(i) *Forming* in Norway (ii) *Teknik* in Sweden (iii) *Technical work* in Finland	Kananoja, 1994
South-East Asia: Malaysia, Singapore...	(i) Craft and Design (ii) High Technology	Technical and Vocational schools Still approaching General approach in Singapore	Technical and vocational courses	Morgan, 1994
Africa	(i) Craft	Vary in states (i) Technical and Vocational (ii) Technology Education in Botswana	Technical and vocational courses	Kerre, 1994
Latin America	(i) Traditional Craft	Vary in countries (i) Technical subjects (ii) computers (iii) New tech. ed. (iv) Tech. of new era Moving to general approach	Technical subjects	Londono, 1994
Germany	(i) Craft and (ii) Industrial arts	Vary in states (*Lands*) Two separate streams in (i) Vocational schools and (ii) General schools	(i) Technical subjects (VS) (ii) Computer science (GS)	de Vries, 1994 Kimbell, 1997
France	(i) Craft	Technology courses dominated by Economic and Industrial-STS and High-tech approach	Technology courses	de Vires, 1994 Gradwell, 1996
USA	(i) Crafts, Industrial Arts and Design	Emphasis on STS New York: Primary – almost no T/Ed Intermediate – Mandatory Senior High - Elective	(i) Mandatory curriculum in intermediate (9-12) (ii) Almost nil in Primary (iii) Elective- Senior H/Sch	ITEA, 2000 Lewis, 1996 Gradwell, 1996 Kimbell, 1997 McCormick, 1992c
Taiwan	(i) Industrial Arts (ii) Vocational training	Twin-track system Different curri. in vocational and High school Move to convert vocational to comprehensive H/ schools	(i) Industrial Arts–Voc/ Sch (ii) Living Technology- CHS	Kimbell, 1997
Australia	(i) Craft Practice (ii) Industrial Arts	National curriculum learning area Study program - vary in states	NSW: (i) Science and technology (ii) Design and technology WA: Technology and Enterprise	Kimbell, 1997 Morgan, 1994
New Zealand	Craft and Manual Training	Technological Literacy	Technology Education- a core subject for all students	NZ Ministry of Education, 1995

In the United States, the prime objective of technology education is for the development of technological literacy (Dyrenfurth, 1994). A recent advance in the USA is the publication of the Standards for Technological Literacy, a result of a collaborative effort by the International Technology Education Association (ITEA) and its Technology for All Americans project (TfAAp). This document bases its effort towards technological literacy in five key areas: the nature of technology, technology and society, design, abilities of a technological world, and the designed world (International Technology Education Association, 2000).

In Australia, the Hobart Declaration in 1989 established national goals for schooling, an endeavour to give Australian schools a unified sense of direction and purpose. Eight common curriculum areas were formed from these goals, and one of these curriculum areas was technology education (Morgan, 1994). It aims to equip students with skills in problem solving and information processing and computing, and also for technological literacy. These aims are taught in four strands; designing/ making/ appraising, materials, information, and systems. The Hobart Declaration was an effort towards providing a national framework for curriculum development, but a change in national government brought with it a decision to return the framework to the individual states and allowed them to interpret and implement it in their separate education systems (Kimbell, 1997). As a result, technology education has been adopted differently by the states of Australia. There has been no consistency in the model of the technology course that has been adopted across the states of Australia.

New Zealand has a long history of Technical Education, but technology education for all students has only recently been developed (Jones, 1997b). The aim of technology education in New Zealand is for technological literacy. Development of the New Zealand technology education curriculum started in 1992 with writing of policy papers (Jones and Carr, 1993a) and the research project 'Learning in Technology Education Project, 1992-1994' (Jones and Carr, 1993b and Jones, Mather and Carr, 1995). This process resulted in the publication of the Technology in the New Zealand Curriculum (New Zealand Ministry of Education, 1995). The New Zealand technology education curriculum

approaches technological literacy with a holistic view and covers a broad range of technological areas.

It is also revealed in Table 3.1 that many of the countries which have been considered in this review are still struggling to establish the general form of technology education by means of transforming the existing traditions. Craft tradition is the form in which technology education became established in many of the countries. In some countries, the problem originates from the converted technology teacher in the technology education classroom. The teacher may lack motivation to experiment with new challenges, competency in teaching the new curriculum or the appropriate materials and training support from the school. In some cases, the decision makers are not prepared to see the 'curriculum for the hand' to be taken up by the 'pupil with the mind'. Countries like Germany have two separate streams for technology education. They delegate the lower academic ability students to the vocational schools to follow the technical vocational version of the curriculum, while the higher academic ability students attend the proper high schools to do the 'modern version' (usually computer and science) of the curriculum. Further, there is a reflection of the values of each society in its national education policies. These varieties of problems point to the importance of the context in which the technology education curriculum is established in the success and failure of the effort.

3.3 LEARNING IN TECHNOLOGY

This section discusses the nature of technological knowledge and the type of learning theories that are most appropriate for technology education. Since technology is a new learning area, it is important to identify what types of knowledge are involved and how they would best be taught and learnt in technology classrooms. These are important in this study for the identification of the best method of research regarding students' learning in technology. The method of research on students' perceptions of technology and their existing technological capability should reflect both the nature of technological

knowledge and also the nature of learning in technology (Jones and Moreland, 2001) in order for collected data to be reliable and valid.

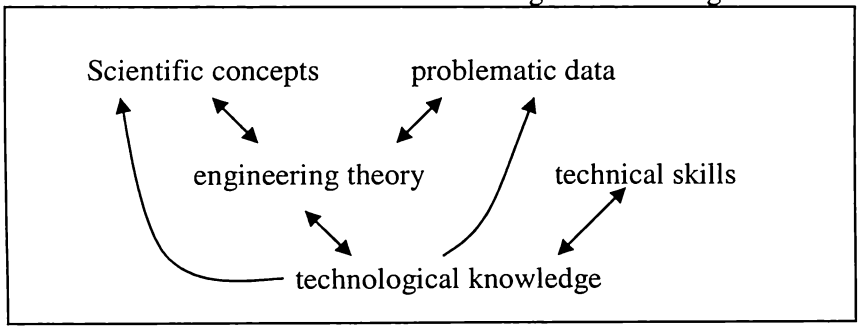
3.3.1 Knowledge Types in Technology

Technology has been shown to not only differ from science but also it is a distinct form of cognition worthy of study in its own right (Layton, 1993; Fleming, 1989). However, designating the exact type of knowledge to be classified as technology is a task that technology educators are just beginning to get a grip on. The difficulty of this task has been greatly due to the evasiveness of the nature of technological knowledge. It was believed that the information obtained in any activity was composed of two components namely knowledge and skills (Oslon, 1973). This is an advocate of a line of distinction made by Ryle (1949) between propositional (or conceptual) knowledge (knowing that) and procedural knowledge (knowing how). Technology was only identified as involving craft skills (knowing how) and therefore described as applied science. However, the debate between content and process in science and mathematics has been observed in technology education (McCormick, 1997). In England and Wales, the technology curriculum is shifting direction towards more emphasis of content knowledge. Important in this development is the recognition that technology is a unique form of cognition, having both procedural and conceptual knowledge as in science and mathematics (McCormick, 1997).

Staudenmaier (1985) supported the distinctiveness of technological knowledge by pointing out that it has four unique components namely scientific concepts, problematic data, engineering theory and technical skill. Scientific concepts refer to technological knowledge resulted from altering scientific knowledge to cater for the exigencies of time, cost and personnel involved in technology (and not in science), and to accommodate the needs of technologists. The resulting altered scientific knowledge is unique to technology. Problematic data suggests that technology is not completely understood, further data is required as technology unfolds. This data is about the unknown areas that technologists usually confront. Engineering theory is claimed to be a crucial characteristic of technological knowledge, comprising both scientific concepts and

problematic data. The procedures implicated in this theoretical viewpoint are structured by the demands of practice rather than theoretical knowledge production. Technical skill refers to a blend of sophisticated ability with specific machines and technique along with pragmatic judgment based on tacit knowledge. This is the kind that amalgamates knowing and doing. Layton (1992b) presents a model of the nature of technological knowledge using Staudenmaier's four components. This model (Figure 3.2) shows the interactions between the four components of technological knowledge. Intrinsic in this model is the focus of technological knowledge on practice. The conceptual knowledge involved in engineering theory (and therefore in scientific concepts and problematic data) is not directed towards production of theoretical knowledge but towards practice. It is this combination of both procedural and conceptual knowledge in informing practice that makes technological knowledge unique.

FIGURE 3.2
Nature of Technological Knowledge



(Layton, 1992, p. 18)

McCormick (1997) cautions about the danger of artificial distinctions between conceptual and procedural knowledge in technology and recommends working towards unifying them. He believes that technological knowledge is not only a combination of conceptual and procedural knowledge, but is multi-dimensional and unpredictable. Layton (1993) on the same line denounces the effort to debate over content and process in technology and argues that they should not be divorced.

Another important aspect of the model above is the specific nature of the technological knowledge involved. This claim is supported by McCormick (1997) who suggests that

the type of knowledge required in technology is bound up with the activity that one is performing. This specific nature of technological knowledge not only demonstrates the difficulty in transfer of knowledge (Layton, 1993) but also the attachment of knowledge to its specific context. Many writers in technology have advocated this perspective of situated cognition (Brown, Collins & Duguid, 1989; Lave, 1991; Hennessey, 1993). This perspective claims that cognition does not exist in abstract but in a specific context and domain. Perkins and Salomon (1989) and Brown, Collins and Duguid (1989) believe that knowledge is part and the product of the activity, context, and culture in which it is developed. Hennessey (1993) supports this view by emphasizing that cognitive activity is socially defined, interpreted and supported. On the same line, Wertsch (1991) goes further and claims that not only technological knowledge is socially constructed and context dependent but also that human mental processes are situated in their historical, cultural and institutional background. Jones (2001) adds that as for the social context, the physical context like objects and tools of action also associate and structure technological knowledge. Therefore exploring students' learning should consider not just conceptual and procedural understanding but also the way technological tools and objects impinge and interact with students' thinking and doing.

Technological knowledge is problematic because defining a knowledge base for technology that can comprise a unique common set of procedures or concepts is difficult (McCormick, 1997). However, it has been recognized that there are technology and technologies (McGinn, 1978; Layton, 1994; Jones & Moreland, In Press 2003). Jones & Moreland (In Press, 2003) describe that technologies, the specific sense, include recognizable technologies dealing with textiles, food, biotechnology, robotics, electronics, mechanical engineering and automobile industry. Technology, the generic sense, refers to the common elements such as the general processes of 'design' and 'fault finding' and general concepts such as 'systems', 'product development' and 'innovation', that are common across the technologies. The next section will discuss the learning theories that are considered by various writers in technology education to be most suitable for teaching and learning in technology.

3.3.2 Learning in Technology

Discussing students' learning in technology is considered important here, in order to identify an appropriate method of exploring students' understanding of technology. Learning in technology is different from learning in any of the traditional subjects area like arts and science. This is because it cannot happen in the abstract, since technological knowledge cannot be removed from the context in which it is constructed. The process in which knowledge is developed and deployed is not detachable from or extra to learning and cognition. Technological thinking is situated within particular historical, cultural, institutional and physical settings. Learning in technology therefore can only be effective if it takes place in the appropriate context. Brown, Collins and Duguid (1989) believe that learning is a process of enculturation.

Many learning theories have been formed to describe the situated nature of learning. For example, cognitive apprenticeship, in which the effect of the context in the structure of cognition is recognized, has been claimed to describe the situated nature of knowledge better than the conventional practices (Brown, Collins and Duguid, 1989). This view of learning is supported by Lave (1991) who suggests that learning is a situated social process in which the learner is becoming a member of a sustained community of practice, a social process of increasing centripetal participation in which the newcomers become old timers.

Learning in technology has similarities to what Johnson (1997) calls informal learning. Informal learning is learning that takes place in activities and actions in everyday life. It does not take place in a formal classroom environment. It is self-motivated, goal directed, it fuses intellectual and emotional factors and the problems involved are authentic (Hennessy, 1993). Johnson (1997) claims that informal learning is situated, co-operative, goal-based and reflective. He identifies four elements of informal learning that are critical to enhancing conceptual learning and development of intellectual skills. First is contextual learning, which includes situated learning, anchored instruction and cognitive apprenticeship. Second is peer-based learning, which encourages co-operative learning, peer tutoring, reciprocal learning, cross-age tutoring and paired problem solving. Third is

activity-based practice, which accommodates apprenticeship, work-based learning, problem-based learning, structured-on-the-job training and goal-based learning. The last one is reflective practice, which includes metacognition and strategic knowledge.

The New Zealand Ministry of Education (1995) sums up the nature of learning in technology with the following as characteristics: it builds on existing knowledge and skills, values and aspiration; it deals with real, identified needs or problems and with multiple solutions; it usually leads to a multiple outcome; it is advanced by sharing ideas; it is enhanced by good teacher assistance; it encourages risk taking and innovation; it requires co-operation and collaboration; it recognizes different students' starting points; and it provides opportunities for specialist inputs from the community. Therefore, effective research regarding learning in technology must have all these characteristics considered when the research methodologies are decided.

Further, the factors that influence students' learning of technological concepts and processes must also be taken into account while doing research in students' learning in technology. Jones (1997b) identifies that students' learning in technology is influenced by: the students' and teachers' existing concepts of technology and the difficulties in defining technological concepts and processes; the need for translation and transfer of knowledge; the nature of the technology curriculum; the classroom culture; students' expectation of the technology task; the nature of the learning activity; and the assessment approaches.

These factors must be considered for a fruitful research in learning in technology. The importance of students' perceptions of technology to their learning is the subject of the next section.

3.4 PERCEPTIONS OF TECHNOLOGY

Recently, many researchers in education have collected a wealth of data which indicate that students' existing concepts significantly affect their predictions, explanations and

perceptions of events and problems (Hennessy, 1993). Hennessy also supports the idea that how a learner perceives the world affects the whole process of teaching and learning. Students' and teachers' concepts of technology, including concepts of technological knowledge and processes that students bring to learning in technology will impact on their learning. Educators must understand the way learners extract information, and receive educational instruction, so that curricula and learning activities are designed in such a way as to enhance the effectiveness of the teaching and learning process. In technology education, many studies have been carried out to determine students' perceptions of technology during efforts to develop suitable curricula for technology education in various countries (Hennessey, 1993; Jones, 1995; Mather, 1995).

Researchers have studied perception over the years for various reasons. The studies that tried to determine the relationships between the stimulus received, the interpreted information registered and the experiences obtained by the perceiver are relevant to and of interest in this study. This is because the observed existence of the relationships between these aspects enlightens the effects of perceptions that learners have on the learning process.

This section discusses the definition, natures and theories of perception and also the recent studies on students' perceptions of technology.

3.4.1 Definition of Perception

Perception has different meaning to different authors, but the definition that this study adopts is the one described by Sekuler & Blake (1985). Perception is described as the final link in a chain of related events which is initiated externally in the physical world and converted to a stimulus which is later converted in the sense organs into neural events and finally into conscious experience in the brain. It is a kind of knowledge-gathering process that defines human views of the world. Heil (1983) describes it as a linkage that connects beliefs to ordinary physical objects and events.

Common among the views of different authors about human perception is the recognition that what one perceives is not uniquely determined by the stimuli received but also by the perceiver's knowledge and experience of the world. They claim that the perceiver is aware of, actively extracts, responds, represents mentally, converts information from and connects beliefs to, external information about objects or events (Sekular and Blake, 1985). James (in Sekular and Blake, 1985, p. 447) suggests that, "Whilst part of what we perceive comes through our senses from the object before us, another part always comes ... out of our head".

Forgus and Melamed (1976) prepared a model to explain the perceptual process in which physical information is translated into information messages. It starts with stimulus energy and ends with response feedback. In this model, perception is broken down into an ordered set of stages, from simple to complex. In each stage, the relationship between the informational aspects of stimulus energy and the corresponding psychological experience is identified. It starts with the stimulus energy bringing a message to the perceiver. This message is translated in the sensory transduction into an information message that the nervous system can use. Although the information message obtained from transduction originates in the external environment, it is also a consequence of changes in the internal organs. The information is maintained in the sensory register for a brief interval of about 300 milliseconds as an icon. It is then stored in the short-term memory for about 30 seconds and then moves to the long-term memory. The information not only flows from the lower stages to the higher ones but also outflows from the central structures involved in the long-term memory to the lower-level processing stages. This outflow of information enables selective filtering, modification and active construction of information from the incoming message. Perception is therefore not a mere passive decoding of stimulus information as a result of direct stimulation, but involves an active construction of information from available cues, external as well as internal.

This model is similar to the generative model of learning described by Osborne and Wittrock (1985). The generative model of learning suggests that an individual's existing ideas influence the process in which the brain makes sense of stimuli received. The brain

uses the existing ideas to determine which stimuli to attend to and what meaning is given to these stimuli. Links are established between the selected stimuli and related facts of knowledge in memory. The brain uses these links to construct meaning and therefore form perceptions.

3.4.2 Theories of Perception

There have been many theories outlined in literature regarding human perception. Most of them are well represented by three theories depicted by Rock (1983).

*(i) **Stimulus Theory***. This theory claims that for every distinct kind of perceptual property, for example, colour, size, depth, movement, and the like, there is a unique corresponding stimulus reaching the sense organ. What is going on internally is a direct function of the incoming stimulus. The problem with this stimulus theory is that the isolation of the relevant stimulus does not provide a sufficient account of perception. There is a lack of one-to-one correlation between local stimulus and percept. The same stimulus can produce different percepts and conversely, different stimuli can produce the same percept. Some internal constructive process is suggested to mediate between the incoming stimulus and the percept.

*(ii) **Constructive Theories***. These theories claim that an important component of what is perceived by an individual is a construction made in the mind of the perceiver during the perceptual process. There are two theories under the constructive theories.

(a) Spontaneous Interaction Theory

This theory suggests that perception is not an exact 'copy' of the stimulus received but corresponds to the result of spontaneous interactions between representations of several stimuli or interactions between the stimulus and more central representations. Stimuli or their internal representations interact, thereby affecting or modifying one another, producing properties not all accounted for by the incoming stimuli.

(b) Cognitive Theory

This theory suggests that perception is only in part determined by the stimulus, because internal 'construction' or 'descriptions' play the fundamental role. The incoming message is used to construct information actively and describe meaning.

This study views perception as the mental representation of events and objects (Rock, 1983). It is considered to be similar to the idea of concept, but it includes the affective and attitudinal aspects of one's views. It includes both affective perceptions and cognitive perceptions. An individual's perception of a phenomenon is affected by that person's attitudes, beliefs, personality, knowledge and understanding, experiences and awareness of that particular phenomenon. Perception is an individual's personal theory of reality. It guides a person's knowledge-gathering process and it is from perceptions that one builds concepts. It is important to identify perceptions that a learner holds because the existing perceptions provide the foundation on which to construct other perceptions, as well as guiding ones views of the world.

This study was designed to collect data on Tongan students' perceptions of technology and existing technological capability to inform development of a technology education curriculum for Tonga. This study considers it crucial for the success of a technology curriculum for Tonga to include perceptions, attitudes and views of Tongan learners in determining the learning areas and learning activities to be covered in the curriculum. The next section will discuss results of some of the previous studies of students' perceptions of technology.

3.4.3 Recent Studies on Students' Perceptions of Technology

This section reviews previous studies on students' perceptions of technology. The aim is to examine methods employed and the results obtained in various studies of students' perceptions of technology and the effects of various factors like culture, gender and age on students' perceptions.

Many of the studies on students' perceptions of technology used the Pupils' Attitudes Towards Technology (PATT) questionnaire (Raat, de Klerk Wolters & de Vries, 1987) or a modified form of it. This contains a 60-item Likert-type attitude scale and a 28-item Likert-type concept scale, with a five point response format including an undecided category. Twenty-two countries were surveyed with the PATT questionnaire and most of the countries at the time of the survey did not have technology education in their compulsory national curriculum. The findings from this study indicate that although students generally have a positive attitude towards technology, they have poor concepts of technology. Most of them perceived technology as being a recent phenomenon and as artefacts. Similar results were obtained from The Netherlands, France, Denmark and Belgium.

It has been noted that the studies that employed the PATT method and carried it out before the introduction of technology education as a compulsory subject in the national curriculum obtained results similar to the results obtained in the first PATT study in the twenty-two countries described above. The studies that were held as continuous assessments of the implementation of technology education in schools showed a significant increase of perception of technology as design and as science. It has been also shown that generally, students' perceptions of technology have been influenced by gender, age and the availability of modern artifacts at home. Further, cultures and the economic environment tended to influence students views about technology. The rest of this section discusses various studies on students' perceptions of technology.

In Australia, the PATT study was conducted in Perth, Western Australia (Rennie, 1987). The questionnaire contained 78 items in eight categories: general knowledge of technology, interest in technology, importance of technology, girls and technology, creativity in technology, and consequences of technology. The response categories were agree strongly, agree, undecided, disagree, and disagree strongly. The questionnaire was administered to 229 year eight students in nine intact classes, sampled to be representative of overall academic ability and socio-economic status of the age group, in the Perth metropolitan area. It was found that (i) most students agreed that technology

was important, (ii) many did not have an understanding of technology, (iii) more than half of the students were unaware of the pervasiveness of technology in everyday life, (iv) more than half of the students failed to appreciate that technology had existed more than 100 years ago, and (v) 6% agreed that technology only concerned computers and 14% agreed that technology always had to do with electricity. The study also showed that most of the students disagreed that technology was too difficult for them to do, most students showed interest in technology and agreed that at school they did not hear much about technology. Boys generally were more aware of, more interested in and had broader view of technology than girls did. Pupils' perceptions about technology revealed a lack of understanding of the nature of technology, and girls seemed to be less informed than boys.

Rennie and Jarvis (1995) used a writing/drawing activity, in which children were asked to write and/or draw what they understood technology to be, to collect data from samples in Year 2-6 (age 7-11 years) from 13 classes in six primary schools in central England and 745 children of similar age from 27 classes in three primary schools in Western Australia. The results showed that: (i) most children's ideas were related to the design process and to products, manufactured or 'man-made' things, (ii) more abstract references about technology were made as being modern, up-to-date, important or interesting, helpful and useful to us, (iii) a very significant proportion of children confused technology with science or with acquiring knowledge or learning.

Another study carried out by Rennie and Jarvis (1995) in England and Western Australia used three different methods, a picture quiz, a writing/drawing activity and a technology questionnaire, to determine English and Australian children's perceptions of technology. The instruments were administered to 910 years 3-6 (aged 7-11 years) from 37 classes in 12 schools in Perth, and 772 children, years 3-6, from 32 schools in England. The results showed that: (i) many children commonly associated technology only with computers and modern electrical appliances, (ii) some children from England showed ideas dominated by model-making, (iii) design process was recognized to be involved in technology, (iv) children had interest in technology and had generally positive attitudes

about its social aspects, and (v) children had an enormous variety of ideas about technology so that even children of the same class held widely different views.

Jarvis and Rennie (1998) went on to determine the factors that influence children's developing perceptions of technology by administering a writing/drawing activity, a picture quiz and interview to children in England and Western Australia. The results showed that: (i) children's conceptual development of 'technology' was mainly age-related, (ii) the rate of development varied with individuals depending on a number of inter-related factors including home, school, ability, gender and opportunity to discuss ideas, (iii) older children were more likely to use several concepts in their explanation, and (iv) a few of the oldest primary children had begun to link apparently different ideas to produce generalizations that showed an appreciation of the diversity of technology, how it satisfied human needs and its significance in the past and future.

In Hong Kong, Volk and Ming (1999) adapted and translated the PATT-USA questionnaire into Chinese, producing 58 items on pupils' attitudes toward technology, categorized under six main headings: interest in technology, technology as an activity for both boys and girls, perception of the difficulty of technology, consequences of technology, technology in the school curriculum and ideas about pursuing a career related to technology. A total of 3481 completed questionnaires were obtained from participants of 14 and 15 years of age. From the data collected, six student characteristics were obtained, namely: gender, ownership of technical toys, working space for modeling at home, personal computer at home, chosen a technical profession and taken D&T or a technical subject in school. T-tests were conducted to explore the relationship between students' attitudes toward technology and the six student characteristics identified in the data. The results showed that: (i) no significant difference was observed in each of the six student characteristics for the areas of 'gender', 'choose a technical profession' and 'taken D&T or a technical subject in school', which means that gender, opting for a technical profession and taking D&T or a technical subject in school, do not affect students' attitude towards technology; (ii) significant differences were found in four of the six attitude categories for having 'technical toys', 'working space at home', and

'personal computer at home', which means that having toys, a working space and a computer at home make a difference in students' attitude towards technology; (iii) generally boys had more positive attitudes towards technology than girls; and (iv) students interest in technology indicated the importance of prior exposure through such avenues as 'technical toys' and having a 'working space at home'.

Assessment of South African learners' attitudes towards technology was carried out by Rensburg, Ankiewicz and Mybyrgh (1999) using part of the PATT questionnaire validated for USA. The questionnaire consisted of 58 items on the affective component of attitudes towards technology. Responses of 500 girls and 510 boys from the Gauteng Province of South Africa were analysed, first by applying the Principal Component Analysis (PCA) and followed by a Scree test. The following attitude factors were identified: disposition towards technology, contributions of technology, dislike of technology, gender discrimination, personality prerequisites and technology for all. These attitude factors were used to compare between boys and girls. It was found that (i) there were no significant differences between the attitudes of boys and girls in: 'contributions that technology makes to society', 'personal prerequisites for studying technology' and 'technology should be for all', (ii) the boys had a stronger view on the 'dislike of technology' , and (iii) the girls had a stronger view on 'gender discrimination related to technology' and on 'disposition towards technology'. In general, the girls had more positive views towards technology than boys, which is different from the results of similar studies in other countries like Australia (Rennie, 1987), New Zealand (Burns, 1992) and Hong Kong (Volk and Ming, 1999). Cultural and societal issues were suggested as the main cause for the discrepancy. In traditional African culture, the male was involved in management tasks in tribal structures while the women tilled the lands, carried the water and welcomed the assistance of technology more. The boys could also have viewed technological jobs as being of lower status compared to white collar jobs through academic education. It was also suggested that technology education should take care of value issues and the effects that culture and society have on learners' attitudes towards technology in order for any implementation of technology education to be successful.

A later study by Ankiewicz, Rensburg, and Mybyrgh (2001) piloted an Attitudinal Technology Profile (ATP) questionnaire, developed to evaluate the effects of curricula on the technology profile of learners in South African schools. This was administered to 439 learners in Grades 9 and 10 in two high schools closely located in the Gauteng Province. One high school offered technology education in Grades 8 and 9 for one year, and the other school did not offer technology education. Differences among learners with regard to their exposure to technology education as well as gender differences were also investigated. The results from an application of the Principal Component Analysis (PCA) followed by a Scree test on the data identified four factors: disposition towards the technological process, proximal technology, distant technology and innovation. The four factors were used to investigate the differences regarding exposure to technology education and gender. The results showed that: (i) exposure to technology education did not make any difference with regard to the attitudinal technology profile of the learners; (ii) there was no significant difference between boys' and girls' disposition towards technological process; and (iii) the attitudes of the boys towards innovation, and the uncertainty associated with it, were more positive than those of girls.

In New Zealand, a study of students' perceptions of technology was carried out by the Research and Statistics Division of the Department of Education as part of the New Zealand Technology Education Project launched in July 1988, to improve students' and teachers' technological literacy. The study used a modified version of the PATT questionnaire followed by an open question asking students about their understanding of technology (Burns, 1992). A national sample of 1469 third form (13-year-old) students completed the questionnaire and answered the open question. The overall results were similar with results of the PATT studies in other countries, showing that students generally had positive attitudes towards technology, but poor concepts of technology. The items on attitudes towards technology revealed that: (i) girls had more positive attitudes than boys toward non-stereotyped gender roles in technology (namely, that girls as much as boys have an interest and ability to do technology); (ii) girls perceived technology as being easier than boys did; (iii) boys were more interested in technology

and generally saw technology in the curriculum, as a career and its consequences more positively; and (iv) high ability students had more positive attitudes than students of average ability, although attitudes improved again with lower ability students. The items on concepts of technology showed that: (i) New Zealand students' overall total concept scores and scores on all four subscales were the same with PATT results for other countries; (ii) ability was related to concepts more significantly than to attitudes, showing that students with higher ability had better concepts of technology; and (iii) concepts and ability were found to correlate significantly, suggesting that students with better, that is a broader, contemporary view of technology, felt more positive about the subject. Students' answers to the open question showed that: (i) overwhelmingly, students saw technology as a recent phenomenon and as artefacts; (ii) approximately, one-third of the students saw technology as a problem-solving process, involving improving and especially inventing things; (iii) few students saw it as a technical process or as a scientific process; and (iv) many students saw more than one process involved. It was also found that more girls than boys appreciated the involvement of technology in everyday life, and more girls than boys thought technology was beneficial more than it was harmful. However, while these third form students base their view of technology on artefacts, results of a study by Mather and Jones (1995) indicated that younger students (5 to 6 year old) base their view of technology more on people.

Also in New Zealand, results of various studies such as Jones and Carr (1993a) and Jones, Mather and Carr (1995) report that there are strong links between students' concepts of technology and their technological practice or the way students carry out technological activities in the classroom. They claim that students with a broader concept of technology will undertake a technological task in a more holistic manner than students with a narrow concept of technology. Students with a broad concept of technology will be able to link the components of a technological task better and show a better level of technological capability. The relationship between students' perceptions of technology and their existing technological capability is an important aspect of this study.

The results of the studies discussed above identified a few factors that seem to influence students' perceptions of technology. First is the nature of the socio-cultural environment of students. For example, in South Africa, women till the land and carry water, the activities that are normally carried out by men in other countries. The study in South Africa (Rensburg, Ankiewicz and Mybyrgh, 1999) showed that girls had more positive views towards technology than boys, which is the opposite to the results of studies in other countries. Second is the presence or absence of technology education in school. Some of the students in schools that had offered technology education viewed technology as design and modeling. These were never mentioned by students from schools with no technology education. Other factors that influenced students' perceptions of technology include academic ability, gender and age.

This section has discussed perceptions and its relevance to curriculum development. The next section will discuss the meaning and natures of students' technological capability together with results of various studies on students' technological capability. This will provide a background for the second part of this study.

3.5 TECHNOLOGICAL CAPABILITY

This section discusses the ideas related to technological capability. First, the definition of technological capability will be presented. Second, an attempt will be made to determine the important skills and knowledge involved in the main components of technological capability.

3.5.1 Definition

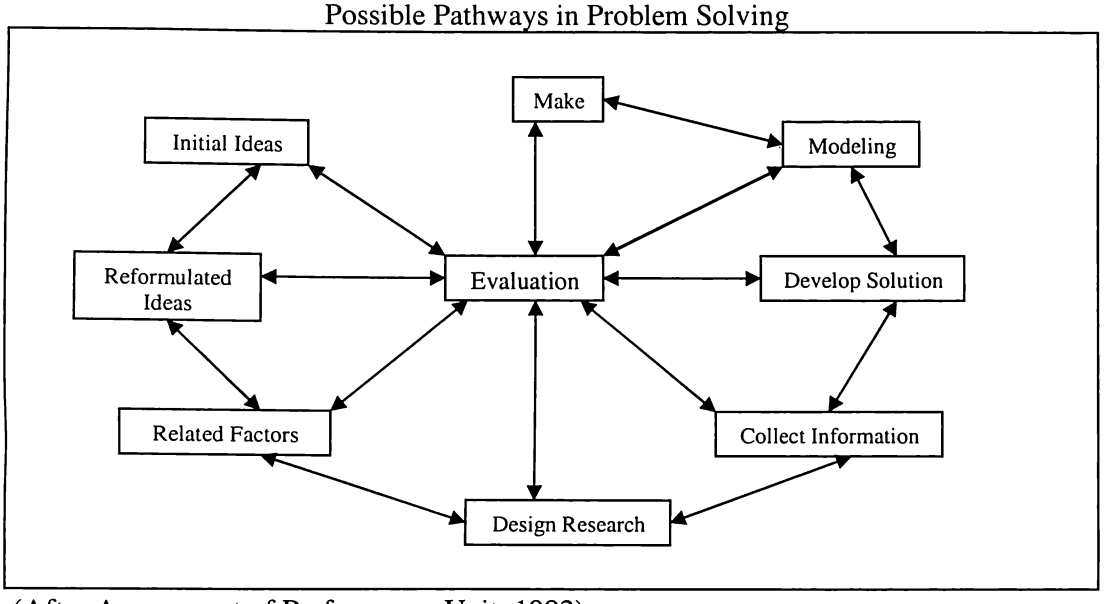
Capability is the combination of knowledge, skills and attitudes a person has towards a certain task. Black and Harrison (1992) believe that human capability relies on the interaction between a person's innovative processes or action-based qualities and the resources of knowledge, skill and experience required for a particular task; a good balance of which will make an active, knowledgeable and skilful person.

A capable person is someone who is determined, resourceful, imaginative, intuitive, inventive, logical, and has good powers of observation and perception, and is sensitive and reactive to the needs being served and values involved. Kimbell (1997) describes capability as '... that combination of skills, knowledge and motivation that transcends understanding and enables pupils creatively to intervene in the world and 'improve' it'' (pg 46). It is a combination of understanding, practical skills, procedural skills, judgment and emotional toughness in carrying out a task at hand. Human capability is therefore central in technology. It is this capability that has enabled man to rise above the animals and create habitats, food supply, comfort, means of health, travel and communication, and also arts, sculpture, music and literature (Black and Harrison, 1992). Human technology relies heavily on human capability, the interaction between them can be referred to as 'technological capability'. Technological capability refers to the capacity of a person to do technology, or to the capability of humans in technology.

Technological capability is the tool with which humans solve problems in technology and satisfy needs. It is with this combination of thought and action, known as technological capability, that technology meets human needs (Gardner, 1994). It refers to the capacity to develop a technological solution. It is the capacity to identify problems, to gather information from a variety of sources using a variety of techniques, to explore ideas, to make models and to test and evaluate (New Zealand Ministry of Education, 1995).

Developing a technological solution is an holistic activity, in which advancing from one stage to another does not follow a straight line, but moves in circular loops along a complex network of pathways, as shown in Figure 3.3. Traditional technical subjects emphasize mainly 'design, make and appraise' in the practical part of the courses. This is represented by just the top right hand triangle in the pathway below. The new approach of technology education emphasizes design, make and appraise, together with the initial planning processes and with evaluation being central to all the stages of problem solving.

FIGURE 3.3
Possible Pathways in Problem Solving



(After Assessment of Performance Unit, 1992)

The pathway involves the technologist at the beginning of the activity in examining and evaluating the initial ideas. The related and relevant factors are considered and the resulting ideas are used in designing of research. This research is in two parts. First it aims to identify information regarding problems to be solved and opportunities to be met. The second part aims to identify existing resources that could be used to solve the problems. The information obtained from research is used to develop the best possible solution. The best possible solution is obtained through designing, modeling, testing and evaluating. Once the best possible design or model of the solution is obtained, preparation and planning for production start. Production of the solution is the final stage and still accompanied by evaluation. A technologically capable person advances in a holistic fashion, circling the loop automatically while progressing towards 'making' the solution. Knowledge and skills required to carry out the tasks in each of the stages are also crucial towards the quality of the solution produced.

Many education systems have identified technological capability as one of the main components of the technology education curriculum. A good example is the New Zealand technology education curriculum. It is divided into three strands and one of the strands is technological capability. The achievement objectives are:

- Identifying needs and opportunities
- With reference to identified needs and opportunities:
    a. generating, selecting, developing, and adapting appropriate solutions;
    b. managing time, and human and physical resources, to produce technological outcomes – products, systems, and environments;
    c. presenting and promoting ideas, strategies, and outcomes;
    d. evaluating designs, strategies, and outcomes.

This study will explore Tongan students existing technological capability using the design model above and the technological capability objectives identified in the New Zealand Technology Education Curriculum.

3.5.2 Skills and Knowledge Involved in the Main Components of Technological Capability

Learning to become technologically capable is learning to become competent in solving a technological problem or satisfying a technological need. Technological capability involves the ability to solve technological problems, a process in which new designs are created, existing technologies are used and adapted and technological solutions are evaluated. It is a complex activity which involves the ability to identify problems, needs and opportunities, to gather information from a variety of sources using a variety of techniques, to explore ideas, and to design, make, present and evaluate solutions (Jones and Carr, 1993a). Students have existing concepts of these technological processes, which affect technological practice as well as future learning of technological concepts and processes. It is important to identify and understand students' existing technological capability in order for teaching and learning in technology to be effective. Context plays a very important role in students' performance of a technological task. It comprises the tasks that students are engaged in, the classroom in which they are taking place, and the students' expectations of the learning situation. Reference will be made to these context settings throughout the paper.

Identifying needs and opportunities is a skill that sparks off most technological tasks. It is a skill in identifying what the people need. This is important because technological progress with its boundaries is mostly driven by human desires (Kimbell, 1994). Technological activities are fuelled by the needs of people. The essence of a technological task is that it is a purposeful activity in which one is designing and making something for somebody. However, in classrooms, students find it difficult to carry out open and unfocused technology projects where they are required to 'identify needs and opportunities' of people (Kimbell, 1994, and McCormick, Murphy & Hennessy, 1994). Adding to this is the fact that some technology teachers do not consistently consider 'Identifying needs and opportunities' as a relevant part of technological tasks (Kimbell, 1994 and McCormick et al., 1994). Most of the projects in the traditional technical subjects do not require students to identify what people need. Identifying needs and opportunities involves skills in: asking important and relevant technological questions about a given situation, identifying the factors that are relevant to and influence the given situation, describing a plan of an investigation for gathering data on needs and opportunities, consulting appropriate sources of information on needs and opportunities, collecting relevant and sufficient data on needs and opportunities, analyzing data collected to identify existing needs and opportunities and identifying needs and opportunities intrinsic in the situation.

The next important skill in carrying out a technological task is searching for the best solutions and strategies for the identified needs and opportunities. This involves skills in identifying the appropriate and important sources of information to consult, in searching and collecting relevant data, and carrying out tests to decide the best solution. However, Jones (1997b) found that when students were given problems to solve, most of them went straight into making the solutions without researching and considering factors relating to the problems. Even students who did collect some information relating to the given problems, did not use them in their designs. Students generally do not regard this as part of the process of building the product.

The next step in the technological capability cycle is the planning of production. This involves skills in designing, planning, identifying materials and tools needed, expenses involved and technical assistance required. McCormick et al. (1994) describe the purposes of modeling as to evaluate, to think through and to communicate, with 2D modeling important in forcing the students to consider design details. However, the present technical classroom culture and syllabi do not seem to be successful in teaching students the skills and purposes of planning and design. Jones (1997b) found that classroom culture and students' expectations influence the way students carry out technological activities, and that planning was absent when students were expecting to make cardboard models as their final products, and also with students from classrooms where the traditional aim of project work was to present something to the class. Rogers (1998) found that the link between students' designs and their products was very weak. Fleer (2000) reports that children found it difficult to use the plans they had drawn for making their products. Students often fail to produce what they design because of lack of knowledge and skills required for the task (Kimbell, Stable, Wheeler, Wosniak & Kelly, 1991 and Anning, 1994). Fleer (2000) found that children's failure to build what they had designed was due to the unavailability of materials required, lack of appropriate knowledge and skills and influence of peers. Jones (1997b) found that students often changed their ideas and modified their designs without considering the original purposes.

Production of solution has been the main focus of most of traditional technical curricula. It encompasses procedural skills, skills in using of tools, knowledge of workshop safety precautions, organisation skills, manipulative skills and technical skills needed in building a particular product.

Presentation of ideas behind design, plan and outcome has been considered an important component of student technological capability. It includes skills in preparing a report of the project, in using right technical terms and in explaining and promoting ideas behind design, plan and outcome.

An important integral part of the technological capability cycle is evaluation. Jones (1997b) noticed that evaluation was not a feature of students' technological capability, being undertaken by only a small proportion of students studied. McCormick et al. (1994) found that students' ability in evaluation depends on their understanding of the link between the problems they define and the solutions they seek.

Jones (1997b) found that students were good at some of the parts but were weak at linking the parts together. He suggested that unless students are taught about how technologists work, it would be difficult for them to see the relationship between different stages of the technological task. The next section will discuss the method of assessment of students' technological capability.

3.6 ASSESSMENT OF TECHNOLOGICAL CAPABILITY

Many researchers in technology education believe that while there has been much progress made in technology education curriculums, there has not been corresponding improvements observed regarding assessment. They believe that assessment lags behind curriculum development endeavors that have been observed in technology education in the past two decades (Kimbell, 1997). Assessment in education has been carried out to achieve three main purposes. First, to identify and report problems involved in students learning so that they can be solved. Second, to identify problems of learning programs so they can be improved. Third, to report achievements of students in a course of study to inform promotion and selection processes and parents. Formative assessment has been used towards improvement of students' learning. Evaluative system monitoring has been used to assess learning programs while summative assessment has been used to inform promotion and selection purposes and for public information (Black, 1998; Kimbell, 1997). This section discusses the methods of assessment employed by researchers and teachers in technology education to investigate students' technological capability.

Many researchers in technology education consider studying students' existing technological capability is crucial towards designing a curriculum that effectively teaches

concepts and processes in technology (Kimbell, 1994; Anning, 1994). Jones (1997) believes that existing concepts students have regarding technological processes of technology, such as problem solving and design cycle will affect teaching and learning in technology. Many studies have been carried out throughout the world to gather information on students' technological capability in order to form a base on which to build appropriate learning activities to teach the important processes in technology.

3.6.1 Assessment methods of students' technological capability

The traditional method of assessment of students' technological capability concentrates mainly on the products of the event. However, it has been verified that evidence for some features of students' technological capability is extremely momentary (Kimbell et al., 1991). Therefore, assessment that concentrates mainly on the products of the procedure may not reveal details of students' technological problem solving process. A number of different approaches should be employed to obtain the true picture of students' technological capability.

Atomised assessment, in which teachers are required to tick 'yes' or 'no' in pre-prepared statements of attainment, has been found to be problematic in technology education in England and Wales (Kimbell, 1997). It is not only difficult to manage but is also complex to draw meaning from. Further, students' technological capability cannot be categorized into just yes or no statements. Kimbell claims that since technological activity is so integrative, a holistic assessment approach is necessary to obtain a picture of students' technological capability. Further, knowledge required in a technological activity is multi-dimensional and unpredictable (McCormick, 1997). Therefore a method that recognizes such natures of technological activities should be employed in order for a true picture of students' technological capability to be obtained.

The dispute between the advocates of norm-referenced and those of criterion-referenced assessment has not helped the trend of assessment in technology education. Kimbell (1997) explains that while neither is sufficient for reliable assessment, a combined

method, in which the criteria provide the bearing and the norms provide the range, will provide a more reliable method.

3.6.2 Recent studies of students' technological capability

This section presents recent studies of students' technological capability. The first is a very detailed analysis of students' existing technological capability carried out by Jones (1997) in New Zealand. Jones obtained data from 261 students of 6-15 years of age. Jones analysed students' existing technological capability while the students were undertaking technological tasks in a number of different contexts. The approach was holistic and this study was able to provide insights into the strategies the students adopted in tackling the various components of the task. The following results were obtained: (i) The links between the performances of students in parts of the technological investigation, for example, research and model making, did not exist; (ii) Classroom cultures greatly affected students' performance; (iii) Students' expectations of what they should be doing affected the approach they took and the types of knowledge and skills they identified and operationalised in a particular activity; (iv) The appropriate classroom environment is crucial for students' learning of technological concepts and processes; (v) Students' technological capability tended to show better when they were involved in authentic technological activities; (vi) The students did not fully consider the technological process they might require when they put too much emphasis on the end product; (vii) The identification, transfer and application of knowledge and skills required in technological practice do not occur in a simplistic fashion; (viii) The existing concepts of technological processes that students have affect technological practice; and (ix) A lack of understanding of the overall process means that students undertake the parts in isolation or follow the design process as a ritual.

Fleer (2000) reports an investigation into how young children design and make during technology education. The main objective was to examine young children's ability to design and use their designs while building their products. This study was carried out on 16 students of 3-6 years of age from a middle class background in a child care centre in Canberra, Australia. The students were observed, video and audio taped, and interviewed

throughout the two weeks of the study. The following were the results of the study: (i) The correlation between what students intended to do and what they produced was strong; (ii) Most of the students were able to indicate in advance what they were going to make and what materials they needed; (iii) Prior experiences of children affected the way they carried out the tasks; (iv) Many children changed their minds between the design conceptualization stage and the construction stage. Most of the children found it difficult to use their plans for making their constructions; (v) The factors that influenced children's ability to follow their plans included materials available, their own developing physical skills and the influence of peers; and (vi) The students were unable to provide the appropriate details in their plans for successfully making their products.

McCormick, Murphy and Hennessy (1994) report the preliminary results of a pilot study on the problem-solving process in technology education. This study aimed at investigating the nature of the problem solving activity in technology classrooms, with a prime focus on the relationship and potential mismatch between teachers' and children's agendas, aims, perceptions and beliefs concerning design and technology activities. It was a case study of 11 weeks undertaken with students of 13 years of age. In-depth classroom observation and interviews identified the following results: (i) The design process is extremely multifaceted and not always communicated successfully by teachers; (ii) The problems that children typically encounter in design and technology projects vary according to the kinds of task and the stage reached in its solution, and require different approaches. This raised questions about the popular idea that 'problem solving' in technology denotes a holistic 'design and make'; and (iii) The assumption regarding the transfer of relevant bodies of knowledge from other contexts to technology is highly problematic.

The results of these studies show some of the important factors that affect the performance of students in the various aspects of the technological tasks. These include: (i) student's perception of the whole task. If the student views that task in a holistic fashion then linking of the components of the task will be strong; (ii) classroom culture, including interaction with teacher and peers; (iii) student's expectation of what is

important in the task; (iv) student's prior experiences, including social and cultural values; (v) skills student possesses or assistance available; and (vi) the nature of the task.

3.7 SUMMARY

The meaning of the term technology is evolving away from the original meaning of craft and design towards that of a process which includes social, cultural and organizational aspects (Layton, 1993). Technology is a practical process which involves design and make with a purpose of solving technological problems. It is multidimensional and involves organization of different groups. It is value laden and it shapes and is shaped by the society in which it unfolds.

Technology education has been adopted by many education systems throughout the world. The main reason for the widespread acceptance of technology education as a subject in schools has been for technological literacy. Several other reasons have been identified in literature, these include economic, social, educational, motivational, cultural and personal reasons (Medway, 1989; McCormick, 1992a; Jones, 1997b). Since technology education is still in its early years of development, many countries are still struggling to establish the general form of technology education by means of transforming the existing technology traditions (Kimbell, 1997).

Technological knowledge is a unique form of cognition, comprising a blend of procedural and conceptual knowledge (McCormick, 1997). Staudenmaier (1985) provides four components that make technological knowledge unique. They are: scientific concepts, problematic data, engineering theory and technical skills. Layton (1992a) produces a model of the nature of technological knowledge using Staudenmaier's four components. The model emphasizes the focus of technological knowledge on practice and the specific nature of technological knowledge. Technological knowledge is difficult to transfer because it is attached to the specific context in which it was developed. The situated nature of technological knowledge determines that learning in technology can only be effective if it takes place within the social, cultural and physical

context. Learning in technology is therefore viewed as a process of enculturation (Layton, 1993; Brown, Collins and Duguid, 1989; Lave, 1991; Hennessy, 1993).

Human perception is not entirely determined by the stimuli received but also by the perceiver's knowledge and experiences of the world (Secular and Blake, 1985). It is similar to the generative model of learning described by Osborne and Wittrock (1985). Therefore, students' perceptions of technology are expected to vary according to the social, cultural and physical environments and experiences of students. Many studies of students' perceptions of technology have been carried out in many countries and most of them employed the Pupils' Attitudes Towards Technology (PATT) questionnaire (Raat, de Klerk Wolters and de Vries, 1987) or a modified version of it. Results of these studies show that students' perceptions of technology have been influenced by gender, age and socio- cultural economic environment. It has also been noted that students' perceptions of technology before and after the introduction of technology education into a school are different. Many students viewed technology as artefacts or as recent phenomena before the introduction of technology education, while after the introduction of technology education, some students viewed technology as a design process. It was also identified that students who had a broad perception of technology tended to undertake a technological task in a more holistic fashion than those who had a narrow perception of technology (Jones, Mather and Carr, 1995).

Technological capability refers to the capacity to identify problems in a given situation, gather information from a variety of sources using a variety of techniques, to explore ideas, to make models, to test, to evaluate and to build solutions (New Zealand Ministry of Education, 1995). The traditional method of assessing technological capability using the products of the process has been claimed to be unreliable since evidence for some features of students' technological capability is extremely momentary (Kimbell et al., 1991). The recent studies of students' technological capability have been carried out while students were involved in technological tasks. The most appropriate way of exploring students' technological capability has been claimed to be a holistic method, using a variety of data collecting methods and students involved in an authentic

technological activity (Kimbell, 1997). The results of previous studies of students' technological capability show that students had difficulty in linking the parts of a technological task together, for instance, linking design and building. It was also shown that the factors that influenced the performances of students in the tasks include classroom culture, students' expectations, nature of the technological task, availability of resources, influence of peers and knowledge and skills one possesses.

This chapter has discussed the recent developments in technology education. These developments have been highlighted by the development of the technology education curriculum in primary and secondary education throughout the world. In most cases, the development of the technology education curriculum has been informed by studies of students' perceptions of technology and students' existing technological capability. In order to provide important information to inform the development of a technology education curriculum for Tonga, this study considers it important to answer the following questions:

1. What are the Tongan secondary school students' perceptions of technology?
2. What are the levels of Tongan secondary school students' existing technological capability?
3. How do the performances of students in the main components of technological capability relate to one another?
4. How do the performances of students in the main components of technological capability relate to their final products?
5. How do Tongan secondary students' perceptions of technology affect their technological capability?

Chapter 4 will discuss the research methodology and methods to explore the research questions above.

CHAPTER FOUR

METHODOLOGY

4.1 INTRODUCTION

The research questions, which guided the activities in this study, were introduced, developed and justified in chapters one, two and three. This study aspires to accomplish two main tasks. First is to identify the perceptions that Tongan secondary school students hold about technology. The second task is to investigate their existing technological capability. The research questions that guided this study are:

1. What are the Tongan secondary school students' perceptions of technology?
2. What are the levels of Tongan secondary school students' existing technological capability?
3. How do the performances of students in the main components of technological capability relate to one another?
4. How do the performances of students in the main components of technological capability relate to their final products?
5. How do Tongan secondary students' perceptions of technology affect their technological capability?

This chapter presents and justifies the research methodology and investigation designs employed in this study. This chapter discusses the following:

4.2 The Research Framework;
4.3 The Research Methodology;
4.4 The Research Method;
4.5 The Research Procedure;
4.6 Ethical Considerations; and
4.7 Summary

4.2 THE RESEARCH FRAMEWORK

A framework is commonly referred to as a structure for supporting or enclosing something, a basic arrangement, form or design. A research framework supports or encloses an investigation. Eisenhart (1991) specifies three types of research frameworks: theoretical, conceptual and practical. She believes that these frameworks inform the three conceptual steps involved in a project. The first step the researcher establishes the research problem. The second step, the perspective or the angle from which the investigation will be directed is decided. It is at this point that an explicit framework is required to define the perspective of the study and to direct the process of data collection. The third step involves the analysis of data.

4.2.1 Theoretical Framework

Eisenhart (1991) describes theoretical framework as "a structure that guides research by relying on a formal theory; that is, the framework is constructed by using an established coherent explanation of certain phenomena and relationships" (p.205). The theoretical framework guiding this study is the socio-cultural view of learning (Wertsch, 1991). Wertsch argues against psychological researches that investigate the individual removed from his or her socio-cultural context. He believes that human mental functioning is socially situated and therefore is unwise to examine mental processes outside of the socio-cultural setting in which the individual operates. He outlines a socio-cultural approach to mind that is grounded heavily in the writings of Vygotsky.

The three basic themes running through Vygotsky's writing has been summarized by Wertsch (1991): (a) a reliance on genetic or developmental analyses; (b) a claim that higher mental functioning in the individual derives from social life; and (c) a claim that human activity, on both the social and individual planes, is mediated by tools and signs. The first theme argues that in order to understand human mental processes, an analysis of their origin and the transitions they undergo is necessary. The second theme argues that mental functioning in the individual derives from participation in social life. It suggests that in order to understand the individual it is necessary to understand the social relations in which the individual exists. The third theme claims

that higher mental functioning is mediated by technical and psychological tools. Acquisition and use of these tools create new capabilities and transform cognitive functioning (Wood and Ahfield, 1996). Wertsch (1991) sums these up in the socio-cultural approach to intelligence, which argues that human mental functioning is inherently situated in social interactional, cultural, institutional, and historical context. This perspective requires that investigation of learning processes should take place within a socio-cultural setting.

This approach to human thinking is in line with the social constructive view of learning (Resnick, 1991). Resnick contends that cognition is not an individual act bounded by the physical facts of brain and body, as commonly defined, but a social phenomenon. She believes that knowledge construction is an integral part of the social context in which it takes place. Lave and Wenger (1991) follow the same approach by describing learning as a process of enculturation into a domain through participation in shared activities.

For technology education, Jones (2001) believes that technological knowledge is socially constructed and context dependent and a technological activity, as stated earlier, involves not only the social context but also the physical context. Therefore analysis of students' existing technological capability is best carried out while students are engaged in authentic technological assessment tasks (Kimbell, Stables, Wheeler, Wosniak and Kelly, 1991; Jones and Carr, 1993b). Jones (2001) believes that an activity that is authentic is coherent and personally meaningful and purposeful within a social framework.

This study believes that to develop a technology education curriculum for Tongan secondary schools, the students' perceptions of technology and their existing technological capability should be taken into account; the best way to obtain them is to study them in their socio-cultural context. This approach is guided by the socio-cultural view of learning (Wertsch, 1995; Resnick, 1991; Lave and Wenger, 1991). This learning theory recognises the impact of social interactional, cultural, institutional and historical contexts on students' learning. It suggests that knowledge construction is a result of the interaction between the learner and the socio-cultural

context in which learning takes place, including knowledge and skills the learner possesses.

This study aims at identifying Tongan students' perceptions of technology and existing technological capability. Data collection was carried out in two stages. First it used modified versions of three instruments developed by Rennie and Jarvis (1995a), to measure Tongan secondary school students' perceptions of technology. The second phase of data collection followed methods employed by Jones and Carr (1993b) on the second phase of Learning in Technology Education Project, to analyse Tongan secondary students' existing technological capability. These results show the types of perceptions and the level of technological capability that the present technical curriculum in Tonga is capable of helping students to learn. These results may be used later to develop a technology education curriculum more suitable for Tonga.

4.3 THE RESEARCH METHODOLOGY

The purpose of this study is to identify students' perceptions of technology and existing technological capability. It has been anticipated that this would be accomplished by interpreting students' language, written work, and actions, in order to understand their views and what they are capable of doing technologically. Interpretations were carried out both qualitatively and quantitatively.

It is important to identify the research paradigm a study follows in order for the reader to use the same lenses the researcher uses to view the world. Although debates are still going on between proponents of different paradigms, agreements have been reached regarding definitions, views of the world, meanings, implications and categorisations of the research paradigms.

A research paradigm is defined by Guba and Lincoln (1994) as 'a set of basic beliefs (or metaphysics) that deals with ultimates or first principles' (p.107). It represents the worldview that provides guidance for the investigator in selecting the ontological, epistemological and methodological stances an investigation adopts. Guba and

Lincoln (1994) describe four existing paradigms that can be used to guide inquiry, especially qualitative inquiry: positivism, postpositivism, critical theory and constructivism.

Critical theory is an umbrella term containing several alternative paradigms including neo-Marxism, feminism, materialism and participatory inquiry. However, unlike critical theory, the use of the term postpositivism here refers to the efforts made by positivists to respond to the most problematic criticisms of positivism. This is different from the same term that Lather (1992) uses in her description of research paradigms. Lather (1992) describes postpositivism as the great ferment over what is seen as appropriate within the boundaries of the human sciences. She classifies postpositivism into four categories according to their purposes: Predict, Understand, Emancipate and Deconstruct.

This is similar to the categories identified by Cohen, Manion and Morrison (2000), although they have only three types of paradigms. They have: Positivist, Interpretive and Critical Educational Research. Positivists view human behaviour as essentially 'rule-governed' and should be investigated by the methods of natural science. Paramount in their endeavour are objectivity, measurability, predictability, controllability, patterning and the construction of laws and rules of behaviour. The interpretive paradigm attempts to understand the subjective world of human experience, to delve inside and understand a person from within. The major intention is to understand and interpret the world in terms of its actors and a heavy emphasis is laid upon meanings and interpretations. The critical educational research paradigm seeks not only to give an account of behaviour of society, but also to emancipate individuals and groups and to attain equality and freedom of individuals in a democratic society.

This study belongs to the umbrella term of Postpositivist Paradigms. It is Postpositivist in terms of the attempt made by both positivists and others to respond to the problematic criticisms of positivism when researching human behaviour. Under Postpositivist, it takes the stance of interpretive paradigm (Lather, 1992; Cohen, Manion and Morrison, 2000). Lather (1992) describes the goal of interpretive

research as the 'revelation of participants' views of reality' (p. 93). The interpretive method is a research tool the researcher can use to obtain a contextualized account of an event from the 'inside' (Miles and Huberman, 1994). It is like an interpretation of interpretations, because interpretive qualitative approaches study events in their natural settings in an attempt to understand or interpret phenomena in terms of the meanings people bring to them (Denzin and Lincoln, 1994). Understanding and interpreting students' perceptions of technology and their existing technological capability are considered the overriding feature of this study.

There are two main reasons for the adoption of the interpretive method in this study. First, the research questions that guide this investigation focus on the perceptions and technological capability of particular participants (students) in a certain place (Tonga). The focus of the research on the actions of particular participants in a particular context is one of the features of interpretive research (Walsh, Tobin and Graue, 1993). Second, the theoretical stance of social-cultural view of learning that frames the structure of this research requires the study of activities of participants to be held in their social and cultural context. The interpretive method sees the social-cultural context which provides the link between the individual and the setting as a window through which data can be interpreted (Salomon, 1991). This window provides the opportunity through which the meaning that students construct while participating in classroom learning activities can be observed and analysed. These factors pressured the researcher towards the interpretive research method.

4.4 THE RESEARCH METHOD

Method and methodology are not considered the same in educational research. Methodology refers to the research paradigm that guides the whole research project while method refers to the technique employed in obtaining and interpreting data (Lather, 1992; Guba and Lincoln, 1994). The two main types of techniques for obtaining and interpreting data are qualitative and quantitative. As Lather (1992) describes it, "Qualitative is 'the other' to quantitative and, hence, is a discourse at the level of *method*, not *methodology* or *paradigm*" (p. 90).

Quantitative method dominated research in education for the most part of the last century. However, the gradual recognition that the rigid empiricist ideal embodied in the quantitative method of research cannot fully cater for the multifaceted aspects of human behaviour has led to an increasing interest in the qualitative method of research.

4.4.1 Qualitative Research

Qualitative research aims at understanding a problem or situation. The researcher participates and makes observation in the situation in an attempt to understand the meanings people give to their own behaviour and their interaction with others. It aims to produce a detail description of events in order to comprehend what is going on in the situation (Bouma, 1996). It aims to discover patterns from information obtained through intense observation, careful documentation and thoughtful analysis of the situation (Smith, 1989; Maykut and Morehouse, 1994).

Qualitative research is based on a phenomenological position, in which phenomena is the major concern. Phenomena refer to the things human directly apprehend through their senses as they go about their daily lives (Cohen, Manion and Morrison, 2000). The main characteristics of qualitative research include: an exploratory and descriptive focus, emergent design, a purposive sample, data collection in the natural setting, emphasis on 'human-as-instrument', qualitative methods on data collection, early and ongoing inductive data analysis, and a case study approach to reporting research outcome. The main research paradigms that are suitable for qualitative research are naturalistic, interpretivist alternative paradigms. These paradigms view reality to be multiple, consider knower and known as interdependent and claim that values mediate and shape what is understood (Maykut and Morehouse, 1994). Three schools of thought that adopt qualitative research are phenomenology, ethnomethodology and symbolic interactionism (Cohen, Manion and Morrison, 2000).

The major types of qualitative research are case study, ethnography and action research. The posture that a qualitative researcher assumes while engaging in a

qualitative research is 'indwelling'. Maykut and Morehouse (1994) refer to indwelling as "... being at one with the persons under investigation, walking a mile in the other person's shoes, or understanding the person's point of view from emphatic rather than a sympathetic position." (p25). The advantages of qualitative research include: the recognition of the significance of subjective experience, the opportunity to reach deeper into the roots of the situation, and a wealth of detailed data about a much smaller number is produced (Coll and Chapman, 2000).

Interview

The main modes of data collection in qualitative research are interview and participant observation. There are four main types of interview:

- *Informal conversational interview* – questions are not predetermined but emerge from the immediate context;
- *Interview guide approach* – topics to be covered are specified in advance but the interviewer still controls the order and type of questions to discuss as they emerge in the course of the interview;
- *Standardised open-ended interviews* – exact wording and sequence of questions are determined in advance and all interviewees are asked the same questions in the same order; and
- *Closed quantitative interview* – questions and response categories are determined in advance and interviewees respond by choosing from a fixed set of responses provided. (Patton, 1980).

The first two types are characterized by open ended questions and free conversations. The interviewer is required to be skilful in creating an interview situation in which the interviewees feel free to talk and express themselves. A rich, honest and authentic account of interviewees' experiences and views is what the researcher is after. These types of interview are favoured by qualitative researchers. The last two types, on the other hand, are characterized by short and closed questions with short and straight answers. The effect of the interviewer is minimized and collection of quantitative data simplifies data analysis. These types are favoured by quantitative researchers.

A group interview has been found to be an effective way of conducting an interview (Watts and Ebbutt, 1987; Lewis, 1992). It has been found to be much less intimidating for hesitant and nervous children and can produce a broader range of responses in less time and disruption than individual interviews. A group interview is useful especially when a group of people have been working together towards a common purpose.

Observation

Observation is a data collection method that "affords the researcher the opportunity to gather 'live' data from 'live' situations" (Cohen, Manion and Morrison, 2000, p. 305). Observations can be used to obtain data regarding the physical setting, human setting, interactional setting and programme setting that are of interest to certain researchers (Morrison, 1993). The types of observations accessible to the researcher align on a continuum from unstructured to highly-structured and from responsive to pre-ordinate (Cohen, Manion and Morrison, 2000, p. 305). In highly-structured observations, the researcher determines in advance what data is to be gathered (pre-ordinate observation). Observation categories are pre-determined. In semi-structured observations, although data to be collected is predetermined, the researcher has the freedom to record any aspects of the research settings deemed significant. In unstructured observations, the researcher determines what is significant to collect only after immersing in the situation and observing what is taking place in it.

There are four roles which the researcher can adopt while in the task of observation: complete participant, participant-as-observer, observer-as-participant and complete observer. Qualitative researchers tend to adopt the first two types. In these modes, the researcher immerses and observes phenomena in participants' natural settings. Quantitative researchers, on the other hand, tend to adopt the last two roles. In these modes, the researcher detaches from research participants in a way that is similar to the role of a video/audio cassette or photograph.

4.4.2 Quantitative Research

The overall aim of quantitative research is to eventually develop a body of valid or genuine knowledge including laws and theorems. It endeavours to determine how the

world operates and to explain relationships between events so that under a certain set of conditions one can use the occurrence of an event to predict the occurrence of another event (Smith, 1989). In social and educational inquiry, the main goal of quantitative research is to produce scientific explanation and prediction of phenomena.

Quantitative research in education is based on the scientific method of research. The research process begins with formulating guesses and hypotheses. Experiments are then designed, samples decided and variables identified, to test the hypotheses. Correlations between variables are then observed and patterns on data are identified. New hypotheses are formed to explain regularities and these are again tested. If the hypotheses are accepted then laws are developed and generalizations are made to form new theories (Verma and Beard, 1981; Cohen, Manion and Morrison, 2000). A quantitative method of research in education functions under the positivist paradigm. This paradigm views reality as one and the whole can be understood by dividing and studying the parts. The knower and the known are considered as independent of one another and claims that values can be suspended in order to understand phenomena (Maykut and Morehouse, 1994).

Quantitative research is characterised by involving a big number of research participants, an emphasis on objectivity, a considerable effort put towards development of research instruments and methods of data analysis, a tendency towards converting information into numbers and the involvement of detailed statistics to make generalisations and predictions. The major advantage of quantitative research is that responses of many participants to a limited set of questions can be measured, enabling comparison and statistical aggregation of data (Coll and Chapman, 2000). The major types of quantitative research in education are surveys and experimental studies, and are usually employed to study participants' learning, attitudes or existing ideas, or to find out how well these aspects are being developed, or to enable the comparison of various groups on these aspects (Fraenkel and Wallen, 1993).

4.4.3 A Combined Method Approach

Many researchers in education have claimed that quite a number of studies in education use a combination of both quantitative and qualitative approaches (Fraenkel and Wallen, 1993; Shulman, 1988). They contend that it would be more beneficial for researchers to select features from the two approaches that are most appropriate for conducting a particular study, rather than rigidly adhering to a specific paradigm. This claim is based on the recognition of the multiplicity and diversity of research purposes in educational research, which cannot be met by any one single paradigm (Walker and Evers, 1997). Developments of research design in the late 1980s and 1990s indicate that no one research paradigm can answer all the questions which arise in educational research. Moreover, it is generally recognised that it will be difficult to sustain the hardline distinction between quantitative and qualitative methods because complex statistical procedures have been developed for the analysis of qualitative data (de Landsheere, 1997). An increasing number of researchers in education believe that the research traditions, even if incommensurable, are equally legitimate and do not necessary conflict. The quantitative and qualitative approaches are not exclusive but complementary to each other (Husen, 1997; de Landsheere, 1997; Guba and Lincoln, 1989). The use of a combined method approach in educational research is gaining momentum, and many have claimed that the goal of the research should indicate which specific method, or if a combination of methods, is appropriate (Coll and Chapman, 2000; Patton, 1990). Cohen, Manion and Morrison (2000) emphasise that research design should be governed by the notion of 'fitness for purpose'.

This study employed a combination method of research. The first part of this study endeavored to identify the perceptions that Tongan secondary students have about technology. This was considered to be best served by a more quantitative approach. A survey was employed to obtain generalisations about what Tongan students perceive technology to be. However, the researcher observed the situation and collected background information to assist in interpreting students responses. The second part tried to understand Tongan secondary students' existing technological capability. This phase employed a combination of both qualitative and quantitative approaches. Although the two stages of data collection adopted two slightly different approaches, the influence and importance of contextual factors were constantly maintained

throughout the whole process of data collection activities. This study considers that interpretive methods can utilize data collection and analysis methods that are both qualitative and quantitative.

Validity is a vital ingredient of effective research (Cohen, Manion and Morrison, 2000) because an invalid piece of research is worthless. Validity is therefore a requirement for any form of research, including both quantitative and qualitative.
In qualitative research, there are a number of ways in which validity can be improved. The following were addressed in this study (Cohen, Manion and Morrison, 2000):

- Ethical issues were properly taken care of so that participants were observed in real and natural situation;
- Data collection activities were carried out in social-cultural settings;
- Multiple methods were employed to triangulate collection of a large amount of data;
- The researcher became part of the researched context;
- The researcher became part of the tools of research;
- A holistic research approach was adopted;
- Attempts were made to observe phenomena through the eyes of the participants;
- Attempts were made to present data in terms of participants' views; and
- Validation of data by participants was implemented.

Also in quantitative research, there are a number of ways in which validity is improved. The following were addressed in this study:

- Sampling was carefully done to obtain a representative sample of the Tongan students population to be studied;
- Research instruments were carefully selected, adjusted (including Tongan translations), piloted and adapted to the Tongan situation;
- Minute details of the components of the research process received appropriate attention; and

- Appropriate statistical methods of data analysis were selected to yield the true nature of data collected for interpretation.

4.5 THE RESEARCH PROCEDURE

This section presents the details of how the study was carried out. The development of research instruments, the method of data collection, the research participants and the method of data analysis will be discussed in this section.

This study comprised two stages of data collection. Stage One was the collection of data on students' perceptions of technology, and Stage Two was the collection of data on students' existing technological capability. These two sets of data are different and thus required different research instruments and methods of data analysis. Therefore, the procedures employed for the two stages of this study will be discussed separately.

The collection of raw data in this study was carried out in Tongan. The three instruments for assessing students' perceptions of technology were translated into Tongan. Administration of these research instruments and students responses to them were in Tongan and the interviews that followed the completion of these research instruments by each class were held in Tongan. The analysis of students' existing technological capability was also carried out in Tongan. The students' worksheets that guided students' activities were translated into Tongan. The interviews, group discussions, presentations of products and students written work were all in Tongan. All raw data was collected in Tongan and the researcher translated it into English for analysis. The main purpose for collecting the data in Tongan was to nullify the effect of a language barrier and to enhance the transparency of communications between the researcher and the students and between the students.

4.5.1 Stage One: Students' Perceptions of Technology

The purpose of this stage was to identify the Tongan secondary students' perceptions of technology. This part of the study was considered similar to previous studies held in many countries (Raat, de Klerk Wolters and de Vries, 1987; Burns, 1992; Rennie, 1987; Rennie and Jarvis, 1995a&b; Jarvis and Rennie, 1998; Volk and Ming, 1999;

Rensburg, Ankiewicz and Mybyrgh, 1999) regarding the perceptions of technology that students held about technology. All of these studies used the Pupils' Attitudes Towards Technology (PATT) questionnaire (Raat, de Klerk Wolters & de Vries, 1987) or a modified form of it. This part of the study therefore used one of the modified versions of the PATT research instruments.

Data Collecting Instruments

The instruments employed in this part of the study were three instruments developed by Rennie and Jarvis (1995a), with minor modifications to suit the Tongan secondary school students' population and also the purposes of this study. These instruments were a writing/drawing activity, a questionnaire and a picture quiz. The administration of the three instruments was followed by an interview of three students from each class to obtain reasons behind their answers. The three instruments were translated into Tongan and all the interviews and data collecting activities were carried out in the Tongan language. This was to ensure that the study was carried out in the real and social-cultural context of both students and teachers.

The Writing/Drawing Activity

This activity required the students to write and/or draw about 'what comes into your mind' when they were asked to think about the term technology. It was an open ended question and was part of the PATT studies research instruments (Raat, de Klerk Wolters & de Vries, 1987). The advantage of this open ended question over the questionnaire is that the students had the opportunity to write their own views, rather than having to choose from the alternative answers provided in a questionnaire item. The question reads, "Technology can mean different things to different people. When you read the word 'technology' what comes into your mind?" The students were asked to answer by writing, or by drawing or by both. The writing/drawing activity was translated into Tongan and the students were informed that they could write their answers in Tongan or in English. The Tongan version of this question was trialed on Tongan secondary students in Auckland and also on Form 1 to Form 6 students in a school in Tonga before the main study.

Technology Questionnaire

The questionnaire used in this study was developed by Rennie and Jarvis (1995a). It has two parts, Part A and Part B. Each part consists of 10 items on two different subscales. Part A measures students' cognitive perceptions about the Diversity of Technology and Technology as a Design Process. Part B measures students' affect in terms of their Interest in Technology and Social Aspects of Technology. This questionnaire was translated into Tongan and trialed once on Tongan secondary school students in Auckland and also once on Form 1 to Form 6 students in a large secondary school in Tonga before the main study. The results of these trials were used to adjust the wording of the questionnaire to suit the Tongan students better. The technology questionnaire can be found in Appendix A(3).

Picture Quiz

This was a modified version of the picture quiz developed by Rennie and Jarvis (1995a). The 28-item picture quiz developed by Rennie and Jarvis was translated into Tongan and trialed with Tongan secondary school students in Auckland. It was found that many students had problems with the pictures of objects that they were not familiar with. The following changes were made:

- Oak tree - replaced by *Toa tree*
- Fish & chips- replaced by *Restaurant*
- Windmill - replaced by *Canoe*
- Microwave - replaced by *Washing machine*
- Mine - replaced by *Quarry*
- Mat - *new item added*
- Poodle - *removed*
- Platypus - *removed*

The changes resulted in a 27-item picture quiz. It was trialed on Form1 to Form 6 students in a large school in Tonga. In this trial, it was found that most of the students interviewed after completing the instruments were reluctant to talk. It was then decided that it would be more fruitful to provide a space under each picture and invite the students to write in it the main reason for their selecting or not selecting a picture

to be related to technology. This would complement the information collected in the interview. Consequently, it was decided that the 27-item picture quiz would be too long to be completed together with the writing/drawing activity and the questionnaire in one 45 minutes period. It was then cut down to 20 items only. The following pictures were removed: plan of a house, rose, advertisement, music, bedroom, playground and statue.

The 20-item picture quiz was then further trialed in the same school and was found to work satisfactorily. The final version of the picture quiz in this study has 20 pictures and can be found in Appendix A(5).

Interview

It was decided that after administering the three research instruments to a class, a sample of three students would be selected and interviewed to find out the background information and reasons they used for selecting pictures related to or not related to technology.

Research Participants

The students involved in this part of the study were from four schools. The number of students targeted was 500. This number has been considered to be an appropriate sample size with regards to the purposes of this study. At the time of administration of this part of the study (1999), the total number of secondary school students in Tonga was 13,987. Therefore, a sample size of 500 is representative of the whole population of 13,987 with a confidence level of 95% and sampling error of 5% (Cohen, Manion and Morrison, 2000, p. 95) which is enough to satisfy the purposes of this study. The expected number of students (in brackets) and the actual number of students who participated in this study from each class and each school are recorded in Table 4.1

A total of 595 students actually participated and completed all the research instruments in this study. All of them were Tongans. The administration of research instruments was carried out on a class basis. The principals of the schools involved were asked to allow one class from each level to participate in this study. Thus the actual total number of students that participated in each form was dependent mainly on the sizes of the classes that were assigned for this study.

TABLE 4.1
Number of Students Involved in the Study of Perceptions of Technology

Classes	Total Number	Number of students from schools			
		School 1	School 2	School 3	School 4
Form 1	**120 (100)**	22 (25)	28 (25)	36 (25)	34 (25)
Form 2	**109 (100)**	25 (25)	27 (25)	26 (25)	31 (25)
Form 3	**109 (100)**	20 (25)	27 (25)	27 (25)	35 (25)
Form 4	**77 (80)**	15 (20)	14 (20)	21 (20)	27 (20)
Form 5	**90 (60)**	13 (15)	30 (15)	22 (15)	25 (15)
Form 6	**90 (60)**	22 (15)	18 (15)	19 (15)	31 (15)
Total	**595 (500)**	**117 (125)**	**144 (125)**	**151 (125)**	**183 (125)**

The schools and students involved in this study were selected to represent a good range of the secondary school students' population in Tonga. In 1999, there were 39 secondary schools in Tonga, eight of which were operated by the government education system, while the remaining 31 were managed and operated by non-government education authorities. It was decided to include only four schools in this part of the study. A summary of the characteristics of the schools involved in this study is given in Table 4.2.

TABLE 4.2
Characteristics of Schools Involved in Perceptions Study

School	Owner	Roll	Location	Boarding / Day	Co-educ.	Academic Standard	Technical Subjects	Students
1	Government	800	Urban	Day	Co-Ed	Very High	Electives in Forms 1 &2	5% non-Tongans
2	Church	800	Urban	Boarding and Day	All Girls	High	H/Eco up to Form 5	All Tongans
3	Church	700	Rural	Boarding	All Boys	Low	I/Arts up to Form 5	All Tongans
4	Church	1000	Urban	Day	Co-Ed	Moderate	H/Eco, I/Arts up to Form 5	All Tongans

The Role of the Researcher

The researcher directed the data collecting activities throughout this part of this study. He was responsible for the preparation and adoption of the research instruments right through to the collection of completed items. He was also responsible for interviewing the three students from each class for further information. The researcher was present in all of the classrooms while the students who participated in this study completed the research instruments. Class teachers acted as assistants, but the researcher intended to become part of the data collecting activities and observed the classroom environment and culture and also took note of the situation to collect further information that might complement the data collected.

Data Collection Method

The government of Tonga requires all research work to be carried out in Tonga to have obtained official approval from the Tongan Cabinet. A letter to the Government of Tonga requesting permission to do educational research in Tonga was forwarded to the Prime Minister's Office in June, 1999. In the second week of September of that year, a letter, granting approval of the request, was received from the Minister of Education. The letters can be found in Appendix C. Permission was also obtained from directors of relevant church education departments to do educational research in their schools. Meetings with the Deputy Director of Education for Primary and Secondary Schools were arranged and also with the principals of the schools involved in the study. In the meetings with the school principals, the details of the study were discussed and the research participants, place and time for the study to be held in each school were confirmed.

After the trial of the research instruments in a school in Tonga, collection of data on students' perceptions of technology started. This took place in October and November of 1999. With the help of teachers in the classes involved in the study, the researcher was able to administer the research instruments to all of the students involved in four weeks. All the students involved were required to complete all of the three instruments prepared for this part of the study. They were given the writing/drawing activity first. After completing it, the papers were collected and the students were then given the picture quiz. After collecting this, they were then given the technology

questionnaire. The order in which the instruments were administered was so decided to avoid the items in the technology questionnaire stimulating ideas for the writing/drawing activity and the picture quiz. The students were given 15 minutes to complete each of the research instruments. Three students were interviewed from each class to collect background information regarding their answers to the research instruments.

Data Analysis

Students' responses to the writing/drawing activity were categorized according to the ideas expressed. The number of times each idea was expressed, the ideas expressed by male and female students and also those expressed by Forms 1 to 6 students were tabulated. These were to enable: the identification of the main ideas that students had about technology; a comparison of the male and female students' ideas about technology; and a comparison of the ideas of Form1 and Form 6 students.

For the picture quiz, the responses of students were analysed in accordance to the number of times each individual picture was chosen to be related to technology, the number of pictures the students selected, and the reasons the students gave for their decisions. The types of pictures that were selected by the highest proportions of students would indicate the types of ideas that students had about technology. The number of pictures the students selected was compared in order to identify differences between students' views of technology. The reasons that students gave for their selection of pictures related to technology were analysed to reveal more of what they thought technology was about.

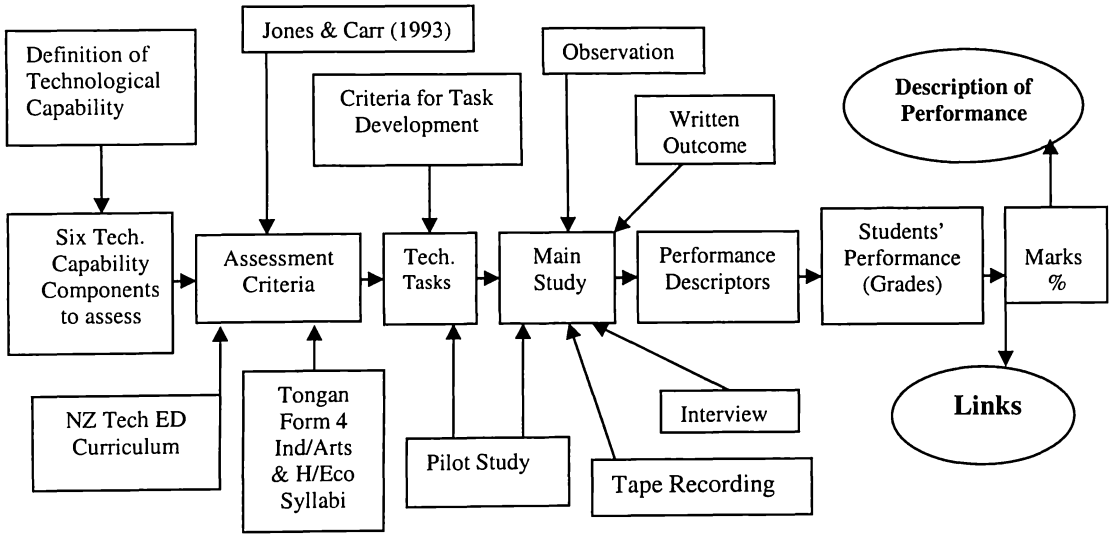
For the technology questionnaire, the responses of students were analysed using the statistical program SPSS. This was to enable the comparison of mean scores for male and female students and also for Form 1 and Form 6 students. Further, a factor analysis of the responses of the students for the technology questionnaire was carried out.

The recorded interview of three students from each class was transcribed and this information was used as background information that assisted in interpreting the responses that students made in the instruments.

4.5.2 Stage Two: Students' Existing Technological Capability

Stage Two involved collecting data on Tongan secondary school students' existing technological capability. In this part of the study, it was decided to adopt the method used by Jones and Carr (1993b) in their analysis of student technological capability. This study analysed students' existing technological capability while they carried out problem solving activities in a variety of contexts. These were considered necessary in order to be able to develop a 'picture' of students' existing technological capability. This method was piloted in Tonga in 1999. Results were analysed and adjustments were made and the main study was carried out in 2000. The overview of Stage Two is given in the figure below.

FIGURE 4.1
Structure of Second Stage of Data Collection



The purpose of this part of the study was two fold. First was to describe the performances of students in the various stages of the technological task. Second was to determine the links between the performances of students in the various stages of

the technological task. These were then used to describe a picture of students' existing technological capability. The overall approach to assessing students' performances in this task was holistic.

Kimbell (1994) cautioned about the use of atomized assessment in evaluating students' performance on tasks. He argued against the shift of assessment of technological capability in schools from broadly judgemental assessment to closely criterion-assessment. Stressing technological capability to be a complex of intellectual, procedural, emotional and practical elements, Kimbell believes that assessment of technological capability should be carried out holistically. Kimbell et al. (1991, cited in Kimbell, 1994) describe holistic judgements as: "Making holistic judgements involves subconsciously teasing a piece of work apart to look for evidence of important qualities ... but more importantly ... putting it all back together again to see how effectively the individual elements work together" (p.198). This is the method that this present study has tried to adopt. But instead of teasing the piece of work apart subconsciously to identify important qualities, this study used assessment criteria to consciously examine the performances of students in the various components of the task to identify not only the important qualities but also the critical weaknesses.

Subsequent to that, the performances of students were then pieced together to see how these individual elements fit together to combine as a whole. This was done through gauging the relationships between the performances of students in the components of the task and between the components and the quality of the final products. These links were then used to determine and draw the whole picture of students' existing technological capability. Therefore, although the assessment method employed in this part of the study may seem atomistic at first sight, the whole procedure is holistic.

Data Collecting Instruments

Initial stages of task development

Early in this stage, a working definition of technological capability was decided. Technological capability is defined in this study as a complex activity which involves the ability to identify problems, needs and opportunities, to gather information from a

variety of sources using a variety of techniques, to explore and develop ideas, and to design, make, present and evaluate solutions (Jones and Carr, 1993b). A technological capable person is one that can carry out these activities in a holistic manner.

The next task was determining the components of technological capability to be assessed. It was decided that the following components of technological capability would be assessed in this study: Identifying needs and opportunities; Searching for and developing the best solution; Planning the production of solution; Production of solution; Presentation and promotion of ideas and product; and Evaluation of progress, process and product.

Assessment criteria were then written to describe the range of skills and standards of performance on the six components of students' technological capability that the study was going to investigate. These were prepared using the analytical framework discussed by Jones and Carr (1993a & 1993b), the New Zealand Technology Education Curriculum and Tongan Form 4 Industrial Arts and Home Economics syllabi. Performance descriptors were then written to describe and give grades to the performance of students in each criterion. The grades that were obtained were to be converted into percentages and used to describe the overall performance of students in each criterion and to calculate the links between the performances of students in the six components of technological capability assessed. A content validity grid of criteria versus assessment methods was drawn to ensure coverage of the criteria in the investigation. This grid specified the activities that assessed the attainment of the range of technological processes described in the criteria in each technological capability. This was followed by the development of technological tasks. These tasks were developed using the list assessment criteria, a content validity grid and the results from the pilot study. Great care was taken to ensure that the tasks: could be used to examine students' existing technological capability in a holistic fashion; were intrinsically motivational; were challenging to Tongan Form 4 students; acknowledged cultural factors; were suitable to the context of Tongan schools and familiar to both teachers and students; took into account classroom constraints such as

equipment, access to resources, etc.; and ranged across different contexts (Jones and Carr, 1993b).

Pilot Study and Results Used in Design of Tasks and the Main Study

A pilot study was carried out in a Form 4 Industrial Arts class within an all-boys boarding school in Tonga. This was not only to check the administration techniques and the appropriateness of the tasks to the assessment criteria, but also to ascertain the level of performance that could be expected of Tongan Form 4 Industrial Arts students. This pilot study was carried out in October and November of 1999.

In the first session, the students identified and selected to work on four tasks: building a suitable pig-sty for a Tongan home; building a suitable desk for a Tongan boarding school student; renovating the college bathroom; and building a suitable chest for a Tongan boarding school student. It was decided at this stage to give students as much freedom as possible as they proceeded throughout the project. The purpose of this was to obtain the whole picture of the overall existing technological capability of students. Methods of administration and presentation were decided and booklets were prepared to guide the students in their work and to gain information about their thinking and activities. Twenty-five students participated and the pilot study was completed in three weeks.

It was found that the spontaneous open tasks developed allowed students to select tasks that were too large and difficult and were expensive in terms of money, materials needed and time to be completed. Identified open tasks where students identify tasks in a given area were recommended.

No student carried out any research to identify needs and opportunities relating to the tasks they selected to work on. Most of the students went straight to attempting to build the products. No plan or design was drawn and after two weeks, the students were not ready to start building their products. They were then asked to build only models of their products and be prepared to present the models to the class. Presentation centered only on explanation of the models and no attempt was observed being made towards evaluating both process and product. It was difficult to assess students' existing technological capability in identifying needs and opportunities,

searching for the best solution, planning and design and evaluation because none of the students carried them out. It was then decided that the students should be guided, using the booklets, to go through these stages so their performance could be assessed. Discussion with the teacher and students revealed that a common Form 4 Industrial Arts project work would require students to select a product to build from a given list, the school provided the materials and teachers prepared designs and carried out measurements and most of the cuttings required. The students put the pieces together and did the final finishing. The products were then collected and assessed.

Booklets were poorly completed and a few got lost. It was decided to divide the booklets into worksheets, one for each activity, and to collect them when completed. The worksheets gave instructions on what the students were expected to do and asked questions to obtain information on what they could do. It was also decided that materials required for the tasks would be prepared and provided for the students.

The students lacked technical skills and knowledge appropriate for the tasks they identified and all of them ended up making only models of the products. It was therefore decided that the students should be assisted to select simple tasks and to seek for expert assistance when necessary.

Tasks Developed

For the main study, five tasks areas were decided to be appropriate for the purposes of this study and for the Tongan students. The task areas identified for the Home Economics class were: Tongan brooms; hand fan; and food for the school canteen. For the Industrial Arts class, the tasks identified were: Tongan brooms; wooden pillow; and kava drinking seat.

Research Participants

The study of students' existing technological capability was carried out in a large secondary school in Tonga. It was an urban co-educational day school. The students' roll at the time of the study was about 1000 and its academic standard was moderate. The school offered Industrial Arts and Home Economics from Form 1 to Form 5. The

students were all Tongans. This school was selected with a view that it represented most of the secondary schools in Tonga.

It was decided in this study to work with mature students; students who could easily follow the design cycle and produce real products. It was felt that it would be easier to observe older students than the younger ones. Form 4 was selected because of the busy schedule of Form 5 students who sit for the Tonga School Certificate at the end of the school year. Also, in Form 6, the only technical subjects were agricultural science and computer studies. This study worked on groups of 45 Industrial Arts and 50 Home Economics students.

Role of the Researcher

The researcher adopted the role of a participant observer. The class teachers carried out the activities as if they were normal technical practical classes and the researcher assisted them and at the same time observed the whole situation. The researcher held frequent meetings with the teachers involved (see Time Table for Data Collection on Technological Capability) to discuss the requirements of this study. The researcher informed the teachers of the aims of this study, the research framework guiding data collection, the ideas regarding students' existing technological capability, the ideas behind the activities, the information required of students and possible solutions for foreseeable problems that may occur. The researcher observed students' activities and interviewed both students and teachers.

Data Collection Methods

On the first day of the study, the students were required to complete the three instruments for the perceptions of technology, namely, the writing/drawing activity, the technology questionnaire and the picture quiz. This was to obtain their perceptions of technology which would be used later to determine the relationship between their perceptions of technology and their existing technological capability.

On the second day, the students were divided into groups. The Industrial Arts students worked in groups of three, while the Home Economics students worked in pairs. The groups were asked to choose a task area to work on from three alternatives. However, only five groups were allowed for each task for the Industrial Arts students

and eight groups were allowed for each task for the Home Economics students. The groups working in each task areas are reported in the table below.

TABLE 4.3
Groups and Task Areas Involved

Task Areas	Groups
Home Economics Brooms	HEB1, HEB2, HEB3, HEB4, HEB5, HEB6, HEB7, HEB8
Home Economics Fans	HEF1, HEF2, HEF3, HEF4, HEF5, HEF6, HEF7, HEF8
Home Economics Food in Canteen	HEC1, HEC2, HEC3, HEC4, HEC5, HEC6, HEC7, HEC8
Industrial Arts Brooms	IAB1, IAB2, IAB3, IAB4, IAB5
Industrial Arts Wooden Pillows	IAW1, IAW2, IAW3, IAW4, IAW5
Industrial Arts Kava Seats	IAS1, IAS2, IAS3, IAS4, IAS5

In the titles of groups, HE denotes Home Economics while IA denotes Industrial Arts. The next letter stands for the name of the product, for example, B in HEB1 denotes broom and the number 1 designates the group number. So HEB1 denotes Home Economics broom group number 1. The tasks were introduced to the students and the worksheet for Component 1 of technological capability, that is, Identifying needs and Opportunities, was given out. The rest of the data collecting schedule is given in the table below.

TABLE 4.4
Time Table for Data Collection on Technological Capability

MONDAY	TUESDAY	WED	THU	FRIDAY
	25th July Travel to Tonga	**26** Meet with School Principal & Teachers involved	**27** *Meeting with Teachers& Students* (i)Perceptions Inst.	**28** (i)Introduction of Tasks (ii) Wrk/sht 1 given out
31 (i) Students work on Wrk/sht 1	**1st August** (i) Research work	**2** (i) Research work *Meet teachers*	**3** (i)Wrk/sht 2 out *Meet teachers*	**4** (i) Students work on Wrk/sht 2 *Meet teachers*
7 (i) Wrk/sht 1 in (ii) Wrk/sht 3 out	**8** (i) Meet Tonga Director of ED (ii) Research work	**9** (i) Research work *Meet teachers*	**10** (i) Wrk/sht 2 in (ii) Wrk/sht 4 out (Production) *Meet teachers*	**11** (i) Wrk/sht 4 (Production) (ii) Research work *Meet teachers*
14 (i) Wrk/sht 4 (Production)	**15** (i) Research work	**16** (i) Research work *Meet teachers*	**17** (i) Wrk/sht 3 in (ii) Wrk/sht 5 out *Meet teachers*	**18** (i) Students work on Wrk/sht 5 (ii) Presentation starts *Meet teachers*
21 (i) Wrk/sht 4 in (ii) Wrk/sht 6out (iii) Presentation	**22** (i) Presentation	**23** (i) Wrk/sht 6 in (ii) Presentation *Meet teachers*	**24** (i) All Wrk/sht in (ii) Presentation and (iii) Conclusion of study	**25th August** Back to NZ

Notes:

(i) Tasks of teachers - The Industrial Arts and Home Economics teachers carried out the tasks with the students as if in normal practical classes. The researcher was present as an observer and as an assistance to the teachers if the need arose.

(ii) Meeting with teachers – The researcher held meetings with the teachers involved to discuss the tasks to be carried out each day, the ideas behind the activities, the progress of students, the problems they encountered and the information required of students. The researcher attempted to obtain as much information as possible through the eyes of the teachers.

(iii) Collecting of worksheets- The worksheets were left with the students to make sure the information from the previous component of the task was available while they were working on the following component. The worksheets were then collected at the end of the following component to prevent them from getting lost.

(iv) Research work – Information about technology in Tonga was gathered from sources which included: various education systems in Tonga, the Tonga Ministry of Education, tertiary technical institutions, previous studies in Education in Tonga and the Tonga Labour and Commerce Department (for technical career opportunities in technology).

The methods used for collecting data were: classroom observation, individual and group interviews, teacher interviews and analysis of written outcomes.

Data Analysis

Data collected for the assessment criteria was converted into marks using the performance descriptors. These marks were used firstly to describe the level of performance of students in each of the components of the task. Secondly, the marks were used to describe the relationships between the performances of students in the components of the task and the relationships between the components and the quality of the final products. Correlation coefficients between the successive components of the task and between each component and the quality of the final product were calculated to assist in describing the relationships between the performances of students.

4.6 ETHICAL CONSIDERATIONS

This study considered it important to attend to the ethical issues relevant to this study, so that the rights of the participants were recognized and preserved and in doing so, the validity of the research was not threatened. Further, effort was made to ensure that the communication between the study and the participants was transparent in order to attain the trust of participants. This was important in producing a real and natural context for the study.

Taking care of ethical considerations started with the filling in of an ethics application form, a requirement made by the University of Waikato for any research study conducted by its students. The University's Human Research Ethics Committee examined the way this study was going to handle the ethical issues and approved. The following are part of the tasks carried out to ensure that the rights and welfare of the participants were retained.

(i) Informed consent

Educational administrators, the education department officials, principals, deputy principals and head tutors of schools in Tonga are responsible for all the activities that the students are involved in at school. They are perceived in Tonga to be the people who can make the best decision regarding students' education. A letter of acceptance from the government giving permission for the research to be carried out in Tongan schools represented the consent of principals, teachers, students and parents for involvement of teachers and students as participants. However, this study informed the students involved of their freedom to withdraw if they chose to, and also that they would be allowed access to the data collected about them.

(ii) Access to participants

Access to students was made through the principals and the class teachers. The students sat the written activities in their classrooms. The interviews were held during the normal school hours, and in a place where conversation was private. The practical activities were also held during normal class periods.

(iii) Confidentiality

Information collected in this study has been kept confidential. All names of students, teachers, participants and schools involved have been coded. No names are used in the report of the study. All data collected was handled only by the researcher. He carried out all the transcription of tapes and marking of students' papers on written activities. The information collected was used only to answer the research questions of the study, and for papers and presentations about the research study.

(iv) Ethical Statement

The following statement on the basic ethical principles guided the researcher during the research:

- The rights and welfare of students and teachers involved will take precedence over the interest of the research study. In the conduct and reporting of the research there will be thoughtful concern for the rights and interests of teachers, students and schools involved in and affected by the study;
- All research work will be undertaken in an ethical manner. Opinions unsupported by evidence shall be clearly distinguished from report findings;
- There will be in all aspects of the research study a spirit of open enquiry and open discussion;
- Research findings will be expressed in a way which will be readily understandable by those with an interest in them; and
- Acknowledgement will be given of the contributions that others make to the research.

4.7 SUMMARY

The theoretical framework that forms the structure of this study is the socio-cultural view of learning (Wertsch, 1991). Wertsch believes that human mental functioning is inherently situated in a social interactional, cultural, institutional, and historical context. This perspective requires the investigation of learning processes to take place within a socio-cultural setting. This view of learning is grounded heavily in the writings of Vygotsky.

The research methodology adopted in this study belongs to the umbrella term of Postpositivist Paradigms. Under Postpositivist, it adopts the interpretive paradigm (Lather, 1992; Cohen, Manion and Morrison, 2000). The goal of interpretive research is to disclose participants' views of reality (Lather, 1992). The interpretive method is an interpretation of interpretations, because in interpretive qualitative methods, the researcher studies events in their natural settings, in an effort to understand or interpret phenomena in terms of the meanings people bring to them (Denzin and Lincoln, 1994).

This study employs the interpretive method for two reasons. First, the research questions focus on the actions of particular participants (students perceptions of technology and their existing technological capability) in a particular context (Tonga), which is one of the features of interpretive research (Walsh, Tobin and Graue, 1993). Second, the theoretical stance of the social-cultural view of learning adopted in this research requires the study of activities of participants to be held in their social and cultural context. The interpretive method sees the social-cultural context which provides the link between the individual and the setting as an opportunity through which data can be interpreted (Salomon, 1991).

This study employed a data collection method that combined both quantitative and qualitative methods. The first part of this study was served by a more quantitative approach, while the second part employed a combination of both qualitative and quantitative approaches. Although the two stages of data collection adopted two slightly different approaches, the importance of contextual factors was constantly maintained throughout the whole process of data collection.

This study aims at identifying Tongan students' perceptions of technology and existing technological capability. Data collection was carried out in two stages. The first stage used modified versions of three instruments developed by Rennie and Jarvis (1995a), to measure Tongan secondary school students' perceptions of technology. The second stage of data collection followed methods employed by Jones

and Carr (1993b) on the second phase of Learning in Technology Education Project, to analyse Tongan secondary students' existing technological capability.

This chapter has presented and attempted to justify the research methodology employed in this study. The next chapter will present the results of the exploration of students' perceptions of technology.

CHAPTER FIVE

STUDENTS' PERCEPTIONS OF TECHNOLOGY

5.1 INTRODUCTION

This chapter describes the results of the study of perceptions of technology held by a sample of Tongan secondary school students. This study employed three instruments developed by Rennie and Jarvis (1995a) with minor modifications to suit the Tongan secondary school students' population and also the purposes of this study. This chapter is divided into five sections. The remainder of this chapter reports the findings from the:

5.2 Writing/Drawing Activity;

5.3 Technology Questionnaire;

5.4 Picture Quiz; and

5.5 Summary of Results.

5.2 WRITING/DRAWING ACTIVITY

This activity required the students to write and/or draw about 'what comes into your mind when you think about the term technology'. It was administered to all of the students involved in this study.

5.2.1 Main Ideas Mentioned by All Students in the Writing/Drawing Activity

The main ideas reported in Table 5.1 were the ideas mentioned by at least 10% of the students involved in the study. The most frequently mentioned idea about technology was that of change and development. The term *fakalakalaka,* which means development was mentioned by all of these students. These students believed that technology referred to changes and developments in buildings, food, culture, medicine, etc. The examples that students used to clarify what they meant by *fakalakalaka* included: better houses replacing the old ones; modern medicines taking the place of the traditional kinds; the adoption of different types and methods of preparation of food to replace the traditional types and methods; and foreign ways of

life being adopted to replace the traditional Tongan ways. Almost half of the students surveyed (i.e. 48.9%) mentioned this idea.

TABLE 5.1
Ideas About Technology Mentioned by At Least 10% of All the Students Involved (n=593)

	Ideas mentioned by students	Proportion (%)
1	Change/development in food, culture, medicine, building, etc.	48.9
2	Computer	29.2
3	Modern, better & newer tools/machines	22.9
4	Machines & engineering	18.5
5	New discoveries, ideas and ways of doing things	18.5
6	New goods in Tonga, imported form overseas	14.3
7	Vehicles, boats, etc.	12.3
8	Effort to make work easier and better	12
9	Electrical appliances	10.3
10	Other ideas	26

The next most frequently mentioned idea was about, or related to, computers. This was mentioned by 29.2% of the students. The ideas expressed by the students in this category include: technology is about computers; technology is produced by computers; and technology is related to computers. Some young students did not explain but only drew diagrams of computers. The third most frequently mentioned idea was modern, better and newer tools and machines. This idea was mentioned by 22.9% of the students. These students not only viewed technology as tools and machines, but also viewed it as modern, better and recent. This is a more general view which includes computers as examples of modern tools. The views in Table 5.1 can be categorized into only two divisions: technology as artefacts and technology as processes. Technology as artefacts comprises: computers; modern, better & newer tools and machines; machines & engineering; new goods in Tonga imported from overseas; vehicles, boats, etc.; and electrical appliances. Technology as processes includes: changes and developments in food, culture, medicine, building, etc.; new discoveries, ideas and ways of doing things; and efforts to make work easier and better. An important category, although it is expressed in both artefacts and processes, is the idea of new; new artefacts and new methods.

Another important feature of students' answers about technology is the enormous variety of ideas expressed. There were 25 different ideas students mentioned about technology. Some students also gave 'other ideas' that were different from the common ideas about technology. Twenty-six percent of the students involved in the study gave 'other ideas' that could not be included in the list of 25 common ideas about technology.

5.2.2 Main Ideas Mentioned by Forms 1 to 6 Students in the Writing/Drawing Activity

The ideas about technology mentioned by at least 10% of the students in any of the forms are given in Table 5.2. The percentages shown are the proportions of students in each class that mentioned each idea to be related to technology. The percentages that are less than ten (in italics) are also given to show the differences between the views of different forms. The most frequently mentioned idea throughout the classes was that of change and development. It was mentioned by more than half of Forms 5 and 6 students, 44% of Form 4 students, and the lowest was in Form 1 which was 13.4%.

TABLE 5.2
Ideas About Technology Mentioned by At Least 10% of the Students in Each Form

	Ideas mentioned by students	Percentage in each Form (%)					
		F1 n=119	F2 n=111	F3 n=106	F4 n=77	F5 n=90	F6 n=90
1	Change/development in food, culture, medicine and buildings	21	36.9	44.3	63.6	67.8	74.4
2	Computer	21	18	25.5	29.9	43.3	43.3
3	Modern, better & newer tools/machines	*4.2*	20.7	20.8	29.9	33.3	36.7
4	Machines, engineering & related education	*9.2*	*7.2*	20.8	20.8	30	28.9
5	New discoveries, new ideas, new ways	*8.4*	*6.3*	17.9	22.1	25.6	37.8
6	New in Tonga/ From overseas	*3.4*	*5.4*	14.2	16.9	24.4	27.8
7	Vehicles, boats, etc.	*4.2*	*5.4*	*8.5*	19.5	16.7	25.6
8	Effort to make work easier, faster and better	*0.8*	*5.4*	*7.6*	19.5	18.9	26.7
9	electrical appliances	*3.4*	*4.5*	*9.4*	10.4	17.8	20
10	Science & scientific development	*5.9*	*7*	*3.8*	*9.6*	12	17.8
11	Artefacts, clothings, etc.	*0*	*2.7*	*4.9*	*6.5*	11	10
12	Uses electricity or related to electronics	*3.4*	*1.8*	10	*3.9*	11	*6.7*
13	Others	44.5	38.7	34	19.5	*5.6*	*2.2*

Comparing the ideas mentioned by Form 1 and Form 6 students, the percentage of Form 6 students that mentioned each idea was always greater that the percentage of Form 1 students, except for the 'other ideas' about technology. These 'other ideas' were given by 36.1% of Form 1 students and 2.2% of Form 6 students. They were the ideas that could not fit into any of the 25 categories of common ideas about technology. The percentage of students that gave 'other ideas' decreased with age.

The percentages of students in the classes mentioning each idea generally increased with age, except for the 'other ideas', in which the percentages of students in the higher forms mentioning these ideas were lower than the percentages in the lower forms. Further, the number of ideas mentioned by the students increased with age. Students in Forms 4, 5 and 6 mentioned more ideas about technology than the students in the lower forms.

5.2.3 Main Ideas Mentioned by Male and Female Students in the Writing/Drawing Activity

The differences between the ideas mentioned by male and female students are reported in Table 5.3. The percentage of male students (57.3%) that mentioned the idea of change and development was higher than the percentage of the female students (43.8%). The male students also had higher percentages mentioning computers and new discoveries.

TABLE 5.3
Ideas About Technology Mentioned by at Least 10% of Male and Female Students

	Ideas mentioned by students	Male (n=225) (%)	Female (n=368) (%)
1	Change/development in food, culture, medicine, building, etc.	57.3	43.8
2	Computer	34.7	25.8
3	Modern, better & newer tools/machines	22.2	23.4
4	Machines, engineering & related education	17.3	19.3
5	New discoveries, new ideas and new ways	22.2	16.3
6	New in Tonga/ From overseas	8	18.2
7	Vehicles, boats, etc.	11.6	12.8
8	Effort to make work easier and better	12	12
9	Electrical appliances	4	14.1
10	Others	23.6	27.4

However, the female students had higher proportions mentioning two of the ideas in the Table 5.3. First was the idea that technology refers to new objects imported from

overseas and not produced in Tonga. Second was the idea that technology refers to electrical appliances. It is also important to note that the percentage of the female students mentioning 'other ideas' was higher than that of the boys.

The view of technology as the introduction of changes and developments, in the form of modern, better and newer artifacts and methods, was more common among the male students. The view of technology as new products from overseas was more common among the female students.

5.3 TECHNOLOGY QUESTIONNAIRE

The questionnaire used in this study (See Appendix A(3)) was developed by Rennie and Jarvis (1995). It has two parts, Part A and Part B, and each part contains 10 items on two different subscales. Part A measured students' perceptions in terms of Diversity of Technology and Technology as a Design Process. Part B measured students' affect in terms of their Interest in Technology and Social Aspects of Technology.

5.3.1 Students' Overall Responses for Part A of the Technology Questionnaire

Part A of the questionnaire measured students' perceptions about the Diversity of Technology using items P1, P3, P5, P7 and P9 and Technology as a Design Process using Items P2, P4, P6, P8 and P10. Students' choice of columns relating to the idea stated in each item is represented as percentages in each row.

In Part A, the students were asked the question 'What is Technology?'. Ten responses (items) were provided and the students were required to answer the question by choosing one from five alternatives ranging from 'strongly agree' to 'strongly disagree' provided for each of the responses. Table 5.4 reports the results of students' responses to the question asked in Part A.

The item with the highest percentage of students choosing the 'strongly agree' column was P1 with 51%. This item had the lowest percentage for the 'can't decide' column with 12% and also the lowest for the disagree columns with a sum of 7%. Next to P1 was item P3 with 46% for the 'strongly agree' column, 14% for the 'can't

decide' column and 9% for the sum of the disagree columns. The item with the highest percentage for the sum of the disagree columns was P5 with 33%. Next to that was item P7 with 27%, followed by the item P9 with 23% for the sum of the disagree columns. The top two items that the students agreed with were P1 and P3, and the bottom items were P5, P7 and P9. It is important to note here that items P1, P3, P5, P7 and P9, which measured students' perceptions of the Diversity of Technology, are all negatively worded and they represent common limited views of technology. The items are complex and explain different ideas about technology. They are only connected in that they are all narrow perceptions of the nature of technology (Rennie and Treagust, 1989).

TABLE 5.4
Students' Responses for Part A

Items		Proportion of students choosing each column (%)				
		Strongly agree	Agree	Can't decide	Disagree	Strongly disagree
P1	Mainly concerns computers and similar equipment	51	30	12	4	3
P2	Making models and testing them is part of technology	35	38	19	4	4
P3	Technological appliances can only be used by qualified people	46	31	14	7	2
P4	Working with materials is an important part of technology	31	26	29	9	5
P5	Without electricity, there would be no technology	24	20	23	19	14
P6	Technology involves designing solutions to problems	25	32	27	9	7
P7	Most people have little to do with technology in their everyday lives	16	30	27	15	12
P8	In technology there are opportunities to design new products	35	28	26	7	4
P9	Two hundred years ago there was no technology	25	17	35	12	11
P10	Technology means inventing new ways of doing things	40	35	16	7	2

The average percentage for the sum of the 'agree' columns for the Diversity items was 58%, which was lower than the average for the Design items of 65%. In the 'disagree' columns, the average for the Diversity items was 20% while the average for the Design items was 12%. In the 'can't decide' column, the average for Diversity items was 22% while that for Design items is 24%.

The percentage of students selecting the 'can't decide' column in each item was relatively high. The average percent for this column was 22.9%. Thirty percent of the

students were not sure whether technology existed two hundred years ago. Twenty-nine percent of the students could not decide whether working with materials was an important part of technology, 27% were not sure whether technology involved designing solutions to problems, and another 27% could not decide whether people had much to do with technology in their everyday life. It was also observed that generally students tended to agree with all of the statements about technology in the items.

5.3.2 Comparison of Form 1 and Form 6 Results for Part A of the Technology Questionnaire

To enable comparisons between the performances of different forms and between male and female students, students' responses in the questionnaire were converted into numbers. Number 1 strongly agree, 2 agree, 3 can't decide, 4 disagree and 5 strongly disagree. These numbers were used to calculate mean scores for Forms 1 – 6 and male and female students. A mean value that is close to 1 means strongly agree. A mean value that is close to 3 indicates undecided, and a mean value close to 5 indicates strongly disagree.

TABLE 5.5
Mean and Standard Deviation for Form 1 and Form 6
Students on the First Part of the Technology Questionnaire

Items		Form 1 (n=109)		Form 6 (n=88)	
		Mean	Standard deviation	Mean	Standard deviation
P1	Mainly concerns computers and similar equipment	1.75	1.12	1.75	0.86
P2	Making models and testing them is part of technology	2.49**	1.19	1.73	0.81
P3	Technological appliances can only be used by qualified people	1.82	1.01	2.10	1.21
P4	Working with materials is an important part of technology	2.69**	1.38	2.24	0.93
P5	Without electricity, there would be no technology.	2.94	1.54	2.77	1.32
P6	Technology involves designing solutions to problems	2.61**	1.21	2.09	0.96
P7	Most people have little to do with technology in their everyday lives	2.86	1.38	2.67	1.19
P8	In technology there are opportunities to design new products	2.71**	1.62	1.94	0.78
P9	Two hundred years ago there was no technology	2.52	1.35	2.76	1.27
P10	Technology means inventing new ways of doing things	2.28**	1.11	1.88	0.92

Note.
** $p<.01$ two-tailed t-test for independent samples.

The mean scores for Forms 1 and 6 students for each of the items in the first part of the questionnaire are recorded in Table 5.5. The Form 1 mean score for each item was greater than the Form 6 mean score except for items P1 and P3.

The highest mean score for Form 1 students was that of item P5. The lowest mean score was that of item P1. For Form 6 students, the highest mean score was also that of item P5 and the lowest mean score was that of item P2. Form 6 students, like Form 1 students, had also a low mean score for item P1, a response that suggests technology mainly concerns computers and similar equipment.

A two-tailed t-test for independent samples was used to compare the means for Form1 and Form 6 students. It was found that there was a significant difference between the mean scores for Form 1 and for Form 6 students in each of the items P2, P4, P6, P8 and P10. For example, for item P2, the Form 1 mean score (2.49) is significantly different from the Form 6 mean score (1.73), $t(204) = 5.47$, $p<.01$. These items examined students' perceptions of technology as a Design Process. Thus, Form 6 students had more agreement regarding the involvement of design in technology than Form 1 students.

It was also found that the difference between mean scores for Form 1 and Form 6 students for the items about Diversity of Technology, P1, P3, P5, P7 and P9 was not significant.

5.3.3 Comparison of Male and Female Students Results for the Technology Questionnaire

The mean scores for male and female students for each of the items in the first part of the questionnaire are recorded in Table 5.6.

There was no significant difference between the female students' mean score and the male students' mean score for each of the items of the first part of the questionnaire except for item P5 which suggested that without electricity, there would be no technology.

For male students, the highest mean score for item P7 and the lowest mean score was item P1. For female students, the highest mean score was for item P5 and the lowest mean score was, as for male students, item P1.

TABLE 5.6
Mean and Standard Deviation for Male and Female Students on the First Part of the Technology Questionnaire

Items		Male (n=225)		Female (n=368)	
		Mean	Standard deviation	Mean	Standard deviation
P1	Mainly concerns computers and similar equipment	1.77	0.99	1.75	0.99
P2	Making models and testing them is part of technology	2.02	1.02	2.01	1.04
P3	Technological appliances can only be used by qualified people	1.92	1.06	1.86	1.03
P4	Working with materials is an important part of technology	2.34	1.11	2.25	1.19
P5	Without electricity, there would be no technology.	2.67	1.33	2.92*	1.46
P6	Technology involves designing solutions to problems	2.48	1.14	2.42	1.93
P7	Most people have little to do with technology in their everyday lives	2.78	1.20	2.70	1.30
P8	In technology there are opportunities to design new products	2.21	1.08	2.14	1.39
P9	Two hundred years ago there was no technology	2.61	1.24	2.77	1.31
P10	Technology means inventing new ways of doing things	1.96	0.98	1.94	1.02

Note.
* $p<.05$ two-tailed t-test for independent samples.

The overall mean score of the male students for items on Diversity of Technology was found to be 2.35 while the mean score for the female students was 2.40. For items on Design, the overall mean score for male students was 2.20 and for female students it was 2.15. The mean scores for the items on Design were lower than the mean scores for the items on Diversity of Technology. This means that the students agreed more with the items on Design.

A two-tailed t-test for independent samples was used to compare the means for male and female students. It was found that there was no significant difference between the mean for female students and the mean for male students in each of the items except for the item P5. The difference between the two mean scores for item P5 was found to be significant. The male students' mean score was lower than the female students' mean score. This means that the male students agreed more with the idea that without electricity, there would be no technology.

5.3.4 Students' Overall Responses for Part B of the Technology Questionnaire

Part B of the questionnaire examined students' Interest in Technology, using items Q1, Q3, Q5, Q7, and Q9, and students' attitudes towards the Social Aspects of Technology using items Q2, Q4, Q6, Q8 and Q10. The students were asked to answer the question 'What do you think about Technology?' by selecting one of the alternatives ranging from 'strongly agree' to 'strongly disagree'. The results are presented in Table 5.7.

TABLE 5.7
Students' Responses for Part B

Items		Proportion of students choosing each column (%)				
		Strongly agree	Agree	Can't decide	Disagree	Strongly disagree
Q1	I am interested in technology	44	28	17	5	6
Q2	Technology makes the world a better place to live in	27	26	26	12	9
Q3	I would like to learn more about technology	45	28	18	4	5
Q4	Technology has brought more good things than bad things	28	25	30	11	6
Q5	I would like a career in technology later on	33	22	36	4	5
Q6	It is worth spending money on technology	22	26	27	16	9
Q7	I would like to read books and magazines about technology	43	38	12	4	3
Q8	Inventions in technology are doing more good than harm	27	25	34	8	6
Q9	I would like to join a hobby club about technology	25	26	29	10	10
Q10	Technology is needed by everybody	26	17	37	10	10

The first four highest percentages for the 'strongly agree' column were for items Q1, Q3, Q5 and Q7. These items all measured Interest in Technology. Students' choice of the 'can't decide' column was also high. For seven of the ten items in Part B, over 25% of the students ticked the 'Can't decide' column. Further, for the items Q4, Q5, Q6, Q8 & Q10, the percentage of students that chose the 'can't decide' column was higher than the percentages for the rest of the columns.

Higher percentages in the disagreeing columns were found in the items concerning Social Aspects of Technology. The average for the sum of the two disagree columns for the items about the Social Aspects of Technology was 20% while the average for the items about Interest in Technology was 11%. For the 'can't decide' column, the

average for items about the Interest in Technology was 22.4% while the average for the items on Social Aspects of Technology was 30.8%.

The average percentage of students agreeing with items for Interest in Technology was 67% and the average for items about the Social Aspects of Technology was 50%.

5.3.5 Comparison of Form 1 and Form 6 Results for Part B of the Technology Questionnaire

The mean scores for Forms 1 and 6 students for each of the items in the second part of the questionnaire are recorded in Table 5.8. Form 1 mean scores for each item were greater than that for Form 6 except for the item Q4.

The highest mean score for Form 1 students was for item Q10 and the lowest mean score was for item Q7. The highest mean score for the Form 6 students was for the item Q4, and the lowest mean score was for the item Q1.

TABLE 5.8
Mean and Standard Deviation for Form 1 and Form 6
Students on the Second Part of the Technology Questionnaire

Items		Form 1(n=95)		Form 6 (n=81)	
		Mean	Standard deviation	Mean	Standard deviation
Q1	I am interested in technology	2.28**	1.41	1.66	0.94
Q2	Technology makes the world a better place to live in	2.83**	1.26	2.32	1.30
Q3	I would like to learn more about technology	2.24**	1.36	1.74	0.87
Q4	Technology has brought more good things than bad things	2.36	1.30	2.47	1.18
Q5	I would like a career in technology later on	2.35	1.30	2.11	0.93
Q6	It is worth spending money on technology	2.79**	1.34	2.24	1.15
Q7	I would like to read books and magazines about technology	2.07	1.17	2.00	2.23
Q8	Inventions in technology are doing more good than harm	2.45	1.24	2.17	1.11
Q9	I would like to join a hobby club about technology	2.81**	1.41	2.33	1.11
Q10	Technology is needed by everybody	2.91**	1.31	2.27	1.22

Note.
** p<.01 two-tailed t-test for independent samples.

A two-tailed t-test for independent samples was used to compare the means for Form1 and Form 6 students. It was found that there was a significant difference between the mean

score for Form 1 and the mean for Form 6 students in each of the items Q1, Q2, Q3, Q6, Q9 and Q10. The mean score for Form 6 students was always lower than the mean score for Form 1 students in each of the above items. This means that Form 6 students agreed more with these items.

5.3.6 Comparison of Male and Female Students' Results for Part B of the Technology Questionnaire

The mean scores for male and female students for each of the items in the second part of the questionnaire are recorded in Table 5.9. The highest mean score for male students was item Q6 and the lowest mean score was for item Q1. The highest mean score for the female students was again item Q6, and the lowest mean score was the item Q7.

The overall mean score of the male students for the items on Interest in Technology was found to be 2.07 while the mean score for female students was 2.14. For items on the Social Aspects of Technology, the overall mean score for male students was 2.61 and for female students it was 2.50.

TABLE 5.9
Mean and Standard Deviation for Male and Female Students on the Second Part of the Technology Questionnaire

Items		Male (n=225)		Female (n=368)	
		Mean	Standard deviation	Mean	Standard deviation
Q1	I am interested in technology	1.84	1.11	2.09*	1.82
Q2	Technology makes the world a better place to live in	2.73**	1.35	2.35	1.19
Q3	I would like to learn more about technology	1.91	1.35	1.98	1.12
Q4	Technology has brought more good things than bad things	2.39	1.18	2.45	1.19
Q5	I would like a career in technology later on	2.21	1.13	2.28	1.11
Q6	It is worth spending money on technology	2.94	3.82	2.69	2.67
Q7	I would like to read books and magazines about technology	1.91	1.65	1.84	1.15
Q8	Inventions in technology are doing more good than harm	2.37	1.20	2.40	1.11
Q9	I would like to join a hobby club about technology	2.46	1.24	2.52	1.25
Q10	Technology is needed by everybody	2.64	1.28	2.60	1.25

Note.

* $p<.05$ two-tailed t-test for independent samples
** $p<.01$ two-tailed t-test for independent samples.

A two-tailed t-test for independent samples was used to compare the means for the male and female students for the second part of the Technology questionnaire. It was found that there was a significant difference between the mean for male and the mean for female students in each of the items Q1 and Q2.

5.3.7 Comparison of Overall Mean Scores for Forms 1 and 6 Students in the Technology Questionnaire

The overall mean scores for Forms 1 and 6 students for the technology questionnaire are shown in Table 5.10.

TABLE 5.10
Maximum Possible Score, Mean Total Scores and Standard Deviations for Boys and Girls on the Questionnaire

Maximum possible score	Form 1 (n=95)		Form 6 (n=81)	
	Mean	Standard deviation	Mean	Standard deviation
100	50.14**	9.71	43.31	8.72

Note.
** p<.01 two-tailed t-test for independent samples.

A two-tailed t-test for independent samples was used to compare the overall mean scores for Forms 1 and 6 students on the second part of the technology questionnaire. It was found that there was a significant difference between the overall mean scores for Form 1 and Form 6 students in the technology questionnaire.

5.3.8 Comparison of Overall Mean Scores for Male and Female Students in the Technology Questionnaire

The overall mean scores for male and female students are shown in Table 5.11.

TABLE 5.11
Maximum Possible Score, Mean Total Scores and Standard Deviations for Boys and Girls on the Questionnaire

Maximum possible score	Male (n=225)		Female (n=368)	
	Mean	Standard deviation	Mean	Standard deviation
100	46.16	10.07	45.79	9.98

A two-tailed t-test for independent samples was used to compare the overall mean scores for the male and female students on the technology questionnaire. It was found

there was no significant difference between the overall mean scores for male and female students.

5.3.9 Factor Analysis of the Responses for the Technology Questionnaire

Rennie and Jarvis (1995a) found that the Cronbach alpha reliabilities for the subscales of the technology questionnaire were 0.67 Diversity of Technology, 0.58 Technology as a Design Process, 0.82 students' Interest in Technology and 0.70 Social Aspects of Technology, when it was tested for its suitability for children of Years Seven to Ten students (12 – 15 year olds) in Australia. This questionnaire was translated into Tongan and administered to all of the 595 students involved in this study.

The statistical programme SPSS was used to analyse the results of the questionnaire. The Cronbach's alpha for the whole test results was found to be 0.65, which suggested that the 'commonality' between the items for the Tongan students was low. A Principal Components Analysis of students' responses resulted in the extraction of 7 components with eigenvalues greater that one, accounting for 54.7% of the variance. This was followed by a scree test and rotated using a varimax rotation. The result is reported in Table 5.12.

The result of the Principal Component Analysis clearly demonstrated the four-subscale structure of the questionnaire. However, items P1, P6, P7 and Q6 did not commune well with the rest of the items and could not fit into any of the subscales of the questionnaire.

Cronbach alpha reliabilities for the factors were 0.32, 0.52, 0.71 and 0.53 for Diversity of Technology, Technology as a Design process, Interest in Technology and Social Aspects of Technology, respectively.

Items P1 and P7 did not act 'in concert' with the rest of the items for Diversity of Technology, and nor did item Q6 with the items for Social Aspects of Technology. Removal of these items from the analysis produced a Cronbach's alpha of 0.70 for the remaining items of the questionnaire, which showed a more satisfactory 'commonality' between the items.

TABLE 5.12
Factor Loadings for Seven-Factor Solution of the Perceptions About Technology

	Diversity	Design	Interest	Social
P3	0.77			
P5	0.50			
P9	0.45			
P2		0.58		
P4		0.58		
P8		0.68		
P10		0.66		
Q1			0.65	
Q3			0.73	
Q5			0.76	
Q7			0.49	
Q9			0.67	
Q2				0.43
Q4				0.72
Q8				0.75
Q10				0.30

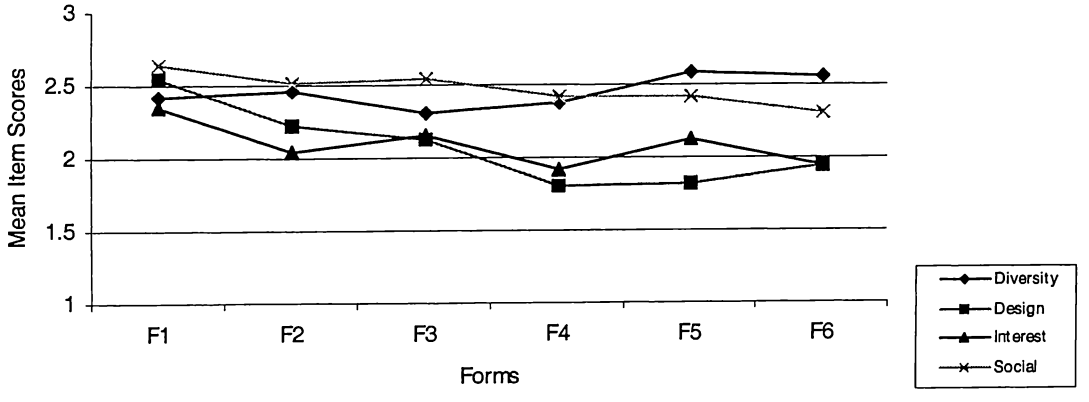
Note: Only factor loadings ≥ 0.30 are reported.

It is interesting to note that item P6 did not link well with the other items measuring students' perceptions about the involvement of design in technology.

The Likert-type items of the questionnaire were scored 1 for 'strongly agree', 3 'can't decide' and 5 'strongly disagree'. Therefore, means with low scores represent stronger agreement with the concept or a more positive attitude. Figure 5.1 shows the variations of the mean item scores for the subscales of the questionnaire from Form 1 to Form 6.

FIGURE 5.1

Forms 1 - 6 Mean Item Scores for the Four Subscales



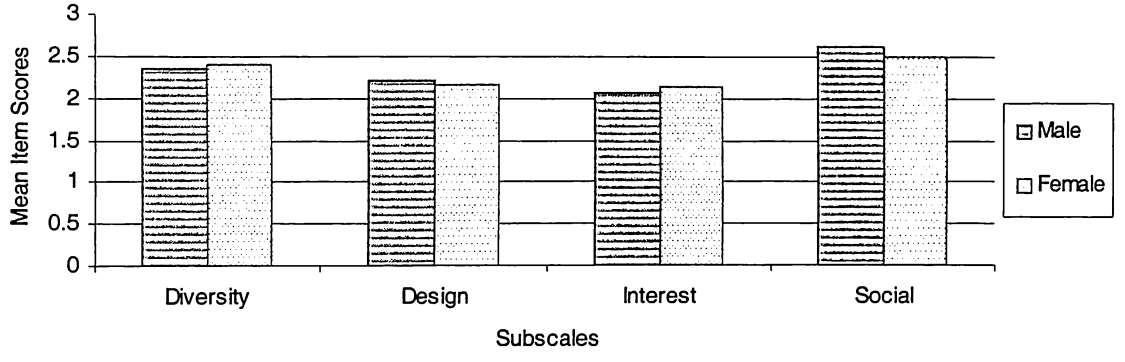
The graph shows that perceptions of the Diversity of Technology increased from Form 1 to Form 6. The trend was from the stronger agreement in Form 1 toward the 'can't decide' region at Form 6. Perceptions of Technology as a Design process, Interest in Technology and attitudes towards the Social Aspects of Technology all decreased with forms.

Form 6 students showed stronger agreement with the perception that Design process was an important component of technology than the Form 1 students. Further, Form 6 students showed a higher level of Interest in Technology and higher attitudes about the Social Aspects of Technology than Form 1 students. The line with the steepest slope was that for Interest in Technology and the slopes for the lines of Diversity of Technology and Social Aspect of Technology were low.

Figure 5.2 shows the comparisons of the male and female mean item scores on the four subscales of the technology questionnaire.

FIGURE 5.2

Male and Female Mean Item Scores for the Four Subscales



The graph shows that the differences between the mean item scores of the male and female students were not significant on the four subscales of the questionnaire. However, it is observed that the item mean scores for Design and Interest were lower than the item mean scores for Diversity and Social Impact of Technology. It is also important to note that all of the item mean scores for the four subscales were between 2 and 3.

5.4 PICTURE QUIZ

The responses of the students to the picture quiz were analysed in terms of the number of times each individual picture was chosen, the number of pictures the students chose and the reasons students gave for their decisions. The table below shows the percentage of students that chose each picture to be related to technology.

5.4.1 Pictures Selected by Students to be Related to Technology in the Picture Quiz

The percentages of students that selected the pictures to be related to technology are reported in Table 5.13.

TABLE 5.13
Percentage of Students Selecting Pictures
Related to Technology (n=593)

Picture	%	Picture	%
1. Computer	96	11. Book	56
2. Aeroplane	94	12. Jeans	48
3. Telephone	93	13. Cup	44
4. Refrigerator	87	14. Knife	42
5. Clock	86	15. Chair	40
6. Factory	75	16. Canoe	25
7. Shop	68	17. Hand Axe	24
8. Bridge	64	18. Mat	20
9. Gun	58	19. 'Ovava Tree	17
10. Quarry	57	14. Volcano	12

The picture most often chosen was the 'computer'. It was chosen by 96% of the students involved in the study. Eleven pictures were chosen by more than half of the students to be related to technology. The picture least often chosen was that of the 'volcano'.

Items that were not common and recently introduced into Tonga were chosen by higher percentages of students to be related to technology. The more common items that had existed in Tonga for longer periods of time were not chosen to be related to technology by higher percentages of students.

5.4.2 Pictures Selected by Form 1 and Form 6 Students to be Related to Technology in the Picture Quiz

The percentages of students choosing pictures as related to technology in Forms 1 and 6 are reported in the table below.

TABLE 5.14
Percentages of Students Selecting Pictures Related to Technology in Form 1 and Form 6

Pictures	F1 (n=119) (%)	F6 (n=90) (%)	Pictures	F1 (n=119) (%)	F6 (n=90) (%)
1. Computer	92	100	11. Book	48	70
2. Telephone	88	100	12. Jeans	33	65
3. Refrigerator	73	99	13. Cup	32	62
4. Aeroplane	87	97	14. Knife	30	61
5. Clock	75	92	15. Chair	31	57
6. Factory	73	92	16. Hand Axe	18	34
7. Gun	45	90	17. Canoe	31	17
8. Bridge	51	83	18. Mat	23	12
9. Shop	64	75	19. 'Ovava Tree	24	7
10. Quarry	53	73	20. Volcano	16	7

All of the Form 6 students chose 'computer' and 'telephone' to be related to technology. Fifteen pictures were chosen by more than half of the Form 6 students to be related to technology. The percentages for Form 6 were higher than the percentages for Form 1 students in 16 pictures, while the percentages for Form 1 students were higher than the percentages for Form 6 students in the other four pictures.

The reasons that students gave for choosing pictures relating and not relating to technology divided into 22 categories.

5.4.3 Reasons Mentioned by Students for Selection of Pictures Related to Technology in the Picture Quiz

The eight most frequently mentioned reasons for selecting and not selecting pictures to be related to technology by the whole of the students studied are reported in Table 5.15.

The most frequently cited reason for the 'Yes' column was about 'change and development'. Students mentioned better, faster, stronger, more accurate, easier to

use items replacing the older ones. Thirty-three percent of the students' reasons were in this category. The next popular category was about the 'usefulness' of objects. Uses of objects were given as reasons for their being viewed as related to technology. Twenty-seven percent of the students' reasons were in this category. The next category was 'new in Tonga'. Seventeen percent of the reasons were about the objects being new to Tonga, brought from overseas and not locally made in Tonga.

TABLE 5.15
Top Eight Reasons for Selecting and Not Selecting Pictures to be Related to Technology

Reasons for YES	%	Reasons for NO	%
1. Change/Development	33.1	1. Not new to Tonga	19
2. Useful	26.9	2. Natural	12
3. New to Tonga	17.1	3. No change, not better	12
4. Machines	4.9	4. Not using electricity	9.4
5. Related to Technology	4.42	5. Not related to technology	8.6
6. Use Electricity	4.18	6. Reason not clear	7.8
7. Man-made	2.24	7. Not machines	7.2
8. Bad to Tongan culture	0.03	8. Dangerous to man	7.2

For the 'No' column, three reasons different from the top eight reasons for the 'Yes' column emerged. The first was 'natural'. This was the reason why the ''ovava' tree and the 'volcano' were not viewed to be related to technology. The second was 'reason not clear'. Students had more unclear reasons when they answered 'No' than when they answered 'Yes'. The third was 'dangerous to man'. This was the reason why some students thought that 'gun' and 'volcano' were not related to technology.

Five of the top eight reasons the students gave for 'Yes' were also in the top eight for the 'No' column. It is also important to note that the first three reasons for the 'Yes' column covered 75% of the total reasons suggested by the students, while in the 'No' column, it took seven reasons to cover 75% of the total reasons.

5.4.4 Reasons Mentioned by Form 1 to Form 6 Students for Selection of Pictures Related to Technology in the Picture Quiz

The reasons given by Forms 1 and 6 students for their choice of pictures related to technology are reported in Table 5.16.

TABLE 5.16
Percentages of Reasons Mentioned by Students in Form 1 to Form 6 for Selection of Pictures Related to Technology

Reasons		Percentages in each form (%)					
		F1	F2	F3	F4	F5	F6
1	Change/Dev	**17**	**22**	**29.2**	**41**	**44.7**	**50**
2	Useful	**44**	**32**	**31.8**	**18.4**	**15.8**	**15**
3	New/Tonga	**8.2**	**28**	**11.4**	**28.7**	**13.5**	**12**
4	Machines	4.9	1.2	**6.64**	2.95	**6**	**8.6**
5	Electricity	**11**	0.8	**5.21**	1.33	**4.43**	2.3
6	Technology	3.2	3	**5.88**	3.05	**8.07**	3.8
7	Reason unclear	3.5	4.4	2.1	0.1	0.79	0.1
8	Man-made	0.3	2.1	1.85	2.19	2.95	**4.3**
9	Computer	1.5	0.4	0.59	0.19	0.69	1.2

The percentages of the answers mentioning 'change and development' increased from Form 1 to Form 6. In Form 1, it was mentioned by only 17% of the answers compared to 50% in Form 6. Usefulness of objects was mentioned by 44% of the answers in Form 1 and decreased to 15% in Form 6. The percentage of unclear reasons in Form 1 was 3.2% and decreased to 0.1% in Form 6. The rest of the ideas did not show any particular trend.

It is also important to note that computer was mentioned by low percentages of the answers suggested by students.

5.4.5 Reasons Mentioned by Forms 1 to 6 Students for Not Selecting Pictures Related to Technology in the Picture Quiz

Table 5.17 shows the percentages of ideas raised by students in each form as their reasons for not selecting pictures to be related to technology.

TABLE 5.17
Percentages of Ideas Mentioned by Form 1 to Form 6 Students for Not Selecting Pictures

Reasons		Percentages in each form (%)					
		F1	F2	F3	F4	F5	F6
1	Not new in Tonga	6.7	23.8	17.4	39.4	19	25
2	Natural	7.2	9.69	8.37	15.4	17.8	23
3	Not change or Dev	5.4	15	10.3	16.3	16	19.1
4	Reason not clear	15	12.7	5.44	1.13	0.93	1.1
5	Not Technology	9.6	5.78	23.2	2.71	6.88	2.63
6	Not using electricity	20	1.88	4.81	3.39	11.3	3.51
7	Not machines	6.6	4.06	5.23	6.33	10.6	11
8	Not safe, dangerous	8.7	10.6	9.83	5.43	3.9	1.97

The idea of 'Not new in Tonga' was the most frequently mentioned reason. 'Natural' was also high, which was used for the ''ovava tree' and 'volcano'. The 'Reasons not

clear' decreased from Form 1 to Form 6. This means that Form 1 students gave more answers that were not clear than Form 6 students. 'Not safe, dangerous' also decreased from Form 1 to Form 6 while 'Not change or development' increased from Form 1 to Form 6. These results indicate that Form 6 students were clearer with their meaning of technology than Form 1 students.

5.4.6 Comparison of Male and Female Students Reasons for Selection of Pictures Related to Technology in the Picture Quiz

The reasons given by male and female students for their choice of pictures related to technology in the picture quiz are reported in Table 5.18.

TABLE 5.18
Reasons Given by Male and Female Students
for Their Choice of Pictures

	YES (%)		NO(%)	
Reasons	BOYS	GIRLS	BOYS	GIRLS
1. Reason not clear	2.53	1.62	**10.3**	**6.42**
2. Useful	**25.6**	**27.8**	2.93	3.102
3. Change/Dev	**39.9**	**28.6**	**13.6**	**11.68**
4. New/Tonga	**11.9**	**20.5**	**19**	**19.3**
5. Machines	3.49	**5.83**	**5.4**	**8.272**
6. Technology	**6.06**	3.35	**10.4**	**7.54**
7. Electricity	3.3	**4.75**	**7.05**	**10.73**
8. Safe, not dangerous	0	0	**6.9**	**7.411**
9. Natural	0	0	**12.1**	**12.41**

The percentage of the male students that mentioned change and development as the reason for choosing pictures related to technology was 39.9%. For female students, the percentage was 28.6%. For not choosing pictures, the percentage for male students was 13.6% and 11.7% for the female students. The other significant difference was for 'New in Tonga', which was mentioned by 11.9% of the male students and 20.5% of the female students.

5.4.7 Number of Pictures Selected by Students as being Related to Technology in the Picture Quiz

The number of pictures that students selected as being related to technology are reported in Table 5.19. The number of pictures selected by 12.5%, the highest percentage in Form 1, was 10. In Form 2, 11 pictures were selected by 16.8%, 9 pictures selected by 16.4% in Form 3, 12 pictures in Form 4 selected by 13.2%, 14 pictures in Form 5 selected by 20.5% and 15

pictures in Form 6 selected by 18%. The number of pictures selected by the highest percentages of students increased with forms.

TABLE 5.19
Number of Pictures Chosen by Forms 1 to 6
Students as being Related to Technology

Number pictures chosen	Percentage in each form (%)					
	F1	F2	F3	F4	F5	F6
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0.83	2.8	0	0	0	0
4	4.17	4.67	4.31	0	1.2	0
5	8.33	1.87	4.31	0	1.2	1.12
6	4.17	5.61	4.31	6.58	1.2	2.25
7	8.33	2.8	6.9	9.21	3.61	4.49
8	11.7	4.67	7.76	5.26	7.23	6.74
9	9.17	6.54	**16.4**	10.5	3.61	5.62
10	**12.5**	15.9	9.48	2.63	3.61	1.12
11	9.17	**16.8**	9.48	3.95	6.02	7.87
12	5.83	7.48	5.17	**13.2**	7.23	11.2
13	6.67	7.48	10.3	10.5	14.5	7.87
14	5.83	8.41	7.76	10.5	**20.5**	14.6
15	6.67	4.67	7.76	7.89	15.7	**18**
16	5.83	5.61	3.45	10.5	3.61	12.4
17	0.83	4.67	0.86	5.26	7.23	2.25
18	0	0	1.72	3.95	2.41	4.49
19	0	0	0	0	1.2	0
20	0	0	0	0	0	0

The average number of pictures selected by the students as being related to technology also increased with forms. It was 9.9 in Form 1, 12.1 in Form 2, 11.1 in Form 3, 13.2 in Form 4, 12.8 in Form 5 and 12.8 in Form 6. The average number of pictures chosen by all students involved in the study was 11.3.

5.5 SUMMARY OF RESULTS

This section presents the summary of the results of the study of the perceptions of technology held by Tongan secondary school students. The types of ideas that students had about technology, a comparison of ideas of Form 1 against Form 6 students, and a comparison of the ideas of male against female students are summarised below.

5.5.1 Types of Ideas about Technology

Results of the writing/drawing activity, technology questionnaire and picture quiz were used to identify students' perceptions of technology. The following were identified:

(i) Technology as change and development

The idea of change and development was mentioned by the highest percentage (48.9%) of the students involved in this study in the writing/drawing activity. Change and development was also given by the highest percentage (33%) of students in the picture quiz as the reason for selecting pictures relating to technology. These students thought that technology referred to changes and development (*fakalakalaka*) that were taking place in their environment. The examples they used included: new houses replacing the old ones, new types of vehicles replacing old types, new types of food replacing old ones and new types of medicines taking the place of traditional herbal ones.

(ii) Technology as related to computers

The next popular idea about technology was that it is related to computers. This was mentioned by 29.2% of the students in the writing/drawing activity. In the technology questionnaire, 81% of the students agreed that technology mainly concerns computers and similar equipment. Also in the picture quiz, the most popular item, selected by 96% of the students involved to be related to technology, was computers.

(iii) Technology as modern, better and newer tools

The next popular idea in the writing/drawing activity was that technology referred to modern, better and newer tools and machines. This idea was given by 22.9% of the students in the writing/drawing activity. In the picture quiz, the modern pieces of equipment like 'computer', 'telephone', 'clock' were selected by more than 80% of the students while the older items like hand axe, knife and cup were selected by less than 50% of the students. The most frequently stated reason (33.1%) for the selection of items related to technology in the picture quiz was that of change and development. This idea of modern equipment was used together in students' explanation of the idea of change and development. Many students viewed that modern, better and newer tools were taking the place of the older ones. They claimed that items like clock,

telephone, and computer were modern, better and newer items replacing the old tools.

(iv) Technology as new discoveries, new ideas and new ways of doing things

The next popular idea in the writing/drawing activity, mentioned by 18.5% of the students involved in the study referred to technology as new discoveries, ideas and new way of doing things. In the technology questionnaire, 75% of the students agreed that technology means inventing new ways of doing things. Also in the picture quiz, high percentages of students selected the more recent artefacts to be related to technology because they related to new ways of doing things. These students did not emphasize the natures of the artefacts as in the ideas above. This idea was about process; the new discoveries and ideas involved in methods of doing something. They talked about the methods of baking bread, of keeping time and of building houses as examples of what they understood about the term technology. It is also interesting to note that the students did not mention anything related to the design process. None of the students mentioned anything about design or planning something as related to technology. This is contrary to the results of a similar study carried out by Rennie and Jarvis (1995a) of students' perceptions of technology in England and Western Australia. They reported that most of students' ideas about technology were related to the design process.

(v) Technology as machines and engineering

In the writing/drawing activity, 18.5% of the students referred to technology as machines and engineering. In the picture quiz, 4.9% of the students selected pictures to be related to technology because they were machines. The word technical is a similar term to technology but was a more familiar term in Tongan schools at the time of the study. Technical building was the name given to the buildings that housed the industrial arts and home economics practical rooms in many schools. In some schools, the technical building contained machines for the industrial arts and other technical courses like mechanical repairs, basic plumbing and carpentry for students who took life skills courses. Some students related technology to technical and came up with this idea that technology was about machines and engineering.

(vi) Technology as goods imported from overseas

This idea was mentioned by 14.3% of the students in the writing/drawing activity. It was also mentioned by 17.1% of the students in the picture quiz as the reason for selecting pictures to be related to technology. This idea could have been developed from the fact that almost all of the new changes and developments in the environment, modern machines, new ideas and new ways of doing things were imported from outside of the islands. Some people, including many students, hold the attitude that all good things came from overseas.

(vii) Technology as vehicles and boats

This idea was mentioned by 12.3% of the students in the writing/drawing activity. These students viewed technology as things that impressed them most. They thought of the modern types of cars, trucks, vans and boats that arrived in the islands. They were fascinated by the look and shape of these new forms of transportation and they were the dream of their lives.

(viii) Technology as an effort to make work easier

This idea was mentioned by 12% of the students in the writing/drawing activity. This is another idea that does not consider technology as artefacts. It is closer to the idea of technology as new ways of doing things. This idea was given by mostly mature students. They observed the effects of new machines, tools, vehicles and boats and concluded that they represented an effort to make work easier.

(ix) Technology as electrical appliances

This idea was mentioned by 10.3% of the students in the writing/drawing activity. Also in the technology questionnaire, 44% of the students agreed that there would be no technology without electricity. Further, 4.2% of the students in the picture quiz selected pictures as being related to technology because they used electricity.

(x) Technology as involving design

In the writing/drawing activity, none of the students related technology to design. The idea of change and development was too strong and also, there was no technology education in Tongan schools at that time. However, in the technology education questionnaire, the students were prompted with the idea of technology as design. The

result was positive. Fifty-seven percent of the students agreed that technology involves designing solutions to problems and 63% agreed that in technology there are opportunities to design new products. On the same line, 75% of the students agreed that technology means inventing new ways of doing things. In fact, for all of the five items that related technology to the idea of design process, more than half of the students agreed with each of them.

(xi) Technology as artefacts

In this study, only a very small proportion of the students referred to technology as something made by man. In the writing/drawing activity, only 5.6% of the students stated that they thought technology referred to the things made by man. Clothing was given as an example of the things made by man to be technology. In the picture quiz, only 2.2% of the students selected pictures to be related to technology because they were man made. Making of modern products was a process that did not happen in Tonga. Some students thought that technology was imported from overseas. They only saw the arrival of new products from overseas.

(xii) Technology as useful things (safe and not dangerous)

This idea was not mentioned by any of the students in the writing/drawing activity. However, in the picture quiz, 26.9% of the students mentioned this idea as the reason for selecting pictures related to technology. They thought that technology referred to things that are useful to man. A similar idea was mentioned in the pictures of a gun and a volcano. Some students (7.2%) decided they were not related to technology because they were dangerous to man. Also in the questionnaire, 52% of the students agreed that invention in technology is doing more good than harm, 53% agreed that technology has brought more good things than bad things and 53% agreed that technology makes the world a better place to live in. These students showed positive attitudes towards technology. Their views of technology were only limited to the good things about change and development.

(xiii) Technology and science

In the writing/drawing activity, 8.4% of the students related technology to science and scientific development. They viewed technology to be the practical use of the

science discoveries. Some commented that technology is when science ideas are used to build tools and machines.

(xiv) Many ideas about Technology

In the writing/drawing activity, the students mentioned 25 different ideas that could be categorized as technology. Another category, 'other', accounted for by 26% of the students, were ideas that could not be categorized into one of the 25 categories identified. Each of the ideas included in the 'other' ideas was only mentioned by a small proportion of the students. Some of these ideas were wrong and some did not make much meaning. For example, some young students confused technology with theology, a word that they were familiar with. They answered that technology was the study of the Bible and God. Some other students related technology to the word sociology, a word they had encountered in the subject Social Studies. They referred to technology as the study of the structure of the Tongan society. Some confused it with biology and described it as the study of plants and animals. So, not only the idea about technology was unknown to most students in Tonga but also the word itself was new to the students.

(xv) Interest in technology

In the questionnaire, five items examined the interest of students in technology. The results showed that most of the students involved in this study showed interest in technology. In the questionnaire, 72% of the students agreed that they were interested in technology. Seventy-three percent of the students agreed that they would like to learn more about technology. For the five items examining Interest in Technology, an average of 67% of the students agreed with the items.

(xvi) Social aspects of technology

Five items in the second part of the questionnaire examined the attitude that the students had about the effect of technology on society. The results showed that the percentages of students agreeing with the items on Interest in Technology were higher than the percentages agreeing with the items in the Social Effect of Technology. This means that although the students were interested in technology, many were not sure of its effect on society. For example, only 43% of the students agreed that technology was needed by everybody and 37% were not sure. Forty-eight

percent of the students agreed that it was worth spending money on technology while 27% were not sure. Fifty-three percent agreed that technology brought more good things than bad things while 30% were not sure. These results point to the fact that although the students showed interest in technology, many had limited ideas about it.

5.5.2 Comparison of Perceptions of Form 1 Against Form 6 Students

This section examined the differences between the perceptions that Form 1 students had about technology and those of Form 6 students.

(i) Form 1 students had a larger range of ideas about technology than Form 6 students

In the writing/drawing activity, the range of ideas provided by the Form 1 students was larger than those provided by the Form 6 students. The Form 6 students concentrated more on the 10 most popular ideas related to technology. The highest percent of Form 1 students (44.5%) mentioned the 'other' ideas. These were the ideas that could not be categorized to any of the 25 ideas that were decided in this study to be related to technology. The 'other' ideas were either meaningless or wrong ideas about technology. The Form 6 students seemed to have a better idea about technology than the Form 1 students.

(ii) Form 6 students provided more ideas about technology

In the writing/drawing activity, the percentage of Form 6 students mentioning each of the 12 most popular ideas about technology was higher than the percentage of Form 1 students except for the 'other' ideas. This indicates that the Form 6 students provided more ideas about technology than the Form 1 students. The Form 1 students managed to give an average of only one idea about technology. This result means that the Form 6 students knew more about the meaning of technology than the Form 1 students. This also indicates that the mature students had a broader view of technology than the younger students.

(iii) Form 6 students agreed more with technology as design

In the technology questionnaire, Form 6 students' and Form 1 students' mean scores for all of the items about the Technology as a Design Process were found to be significantly different. Form 6 students agreed more with the involvement of design in

technology. This indicates that the Form 6 students had a better understanding of the relationship between technology and design. Once again, this result also points to Form 1 students' lack of knowledge of the ideas related to technology.

(iv) Form 6 students were more interested in technology and knew more about the effects of technology on society

In the second part of the questionnaire, five items examined the interest of students in technology and another five items examined students' awareness of the effects of technology on society. It was found that the mean scores for the Form 6 students for six of the ten items were significantly smaller than the mean scores for the Form 1 students. This means that generally, Form 6 students were more interested in technology and more aware of the effect of technology in society than the Form 1 students. The graph of item mean scores for Interest in Technology and Social Aspect of Technology in Figure 5.1 shows that the mean scores decreases as the form increases. This means that the students tended to be more interested in technology and aware of the effects of technology on society as they matured.

5.5.3 Comparison of Perceptions of Male and Female Students

This section compared the perceptions of male and female students in this study about technology. The performances of the students in the three instruments were used to determine the differences between their perceptions.

(i) Higher proportion of boys viewed technology as change and development

In the writing/drawing activity, the proportion of boys mentioning technology as the coming of modern tools, machines and ways of doing things to replace the old ones was higher than the proportion of girls. The boys' proportion mentioning that technology was related to computer was also higher than that of the girls. Fifty-seven percent of the boys viewed technology as about change and development compared to only 43.8% of the girls. For computers, 34.7% of the boys referred to technology as related to computers compared to 25.3% of the girls. Also, 22.2% of the boys considered technology as new discoveries, new ideas and new ways of doing things compared to 16.3% of the girls. The boys had stronger ideas about technology as being modern tools, computers, new types of machines and new ways of doing things. They were more fascinated by the new developments that accompanied computerized

tools and machines. Many of the boys thought that this was what technology was all about. A similar pattern was observed in the results of the picture quiz. Giving reasons for selecting pictures relating to technology, 39.9% of the boys mentioned change and development compared to 28.6% of the girls.

(ii) Higher proportion of girls viewed technology as new things in the island

This idea referred to technology as things imported into Tonga. Technology was produced overseas. This idea was mentioned by a higher proportion of the girls. In the writing/drawing activity, 18.2% of the girls referred to technology as new things in Tonga, imported from overseas. This was mentioned by only 8% of the boys. Also in the picture quiz, 20.5% of the female students selected pictures as being related to technology because they were new to Tonga. This reason was mentioned by 11.9% of the boys.

(iii) Boys were more interested in technology than girls

In the questionnaire, the boys were more interested in technology than girls. A higher proportion of boys agreed with the item that suggested that 'I am interested in technology' than girls. It was found that the boys' mean score for this item was significantly less than the mean score for girls. This means that the boys agreed more with this idea than girls.

This chapter has given the results of the study of perceptions of technology held by a sample of Tongan secondary school students. The next chapter will present the results of the assessment of the first three components of students' technological capability. These components are: Identifying Needs and Opportunities; Exploring and Developing Best Possible Solutions to Identified Needs and Opportunities; and Planning the Production of the Solution.

CHAPTER SIX

THE EXISTING TECHNOLOGICAL CAPABILITY OF STUDENTS: THE PLANNING STAGES

6.1 INTRODUCTION

Chapters 6 and 7 present the results of the assessment of students' existing technological capability. The assessment activities were carried out in two classes in a large secondary school in Tonga. The purpose was to analyse students' existing technological capability while they carried out problem solving activities in a variety of contexts. Assessment criteria were written on six components of students' technological capability, and a set of performance descriptors were developed for each of the assessment criteria. These were used to describe the students' performances on the activities. This chapter describes the results of the assessment of three components of students' technological capability. These components are related to planning the solution (product) to be built. The planning section was divided into three stages: Identifying Needs and Opportunities; Exploring and Developing Best Possible Solutions to Identified Needs and Opportunities; and Planning the Production of the Solution. The remainder of this chapter reports students' performances on:

- Identifying Needs and Opportunities;
- Exploring and Developing Best Possible Solutions to Identified Needs and Opportunities; and
- Planning the Production of the Solution.

6.2 TECHNOLOGICAL CAPABILITY A: IDENTIFYING NEEDS AND OPPORTUNITIES

This section reports students' performances in the activities that assessed their ability to identify needs and opportunities in a given situation (See Appendix B(1)).

Six assessment criteria were written to cover the main aspects of this technological capability. The results will be presented in the order of the assessment criteria. Students' responses to the activities that assessed their performances in each criterion will be presented first. This will be followed by the use of performance descriptors to analyse students' performances. A graph of the number of students in each criterion will be drawn to highlight the nature of the performance of the students.

6.2.1 The Ability of Students to ask Important and Relevant Technological Questions to Identify Needs and Opportunities

The ability of students to ask important and relevant technological questions to identify needs and opportunities in a given situation was found to be limited. Either they did not know the right questions to ask or they were not interested in asking questions about needs and opportunities or both. The types of questions that students asked are reported in Table 6.2.1a.

TABLE 6.2.1a
Percentages of Types of Questions Asked to Identify Needs and Opportunities (n=94)

	Type of questions suggested by students	%
1	Questions about materials needed, sources, sizes, shapes, types and amount required to make the product	29
2	Questions about the method of making the product or part of the product	14
3	Questions concerning changes or improvements to be made on the existing products	13
4	Statements made about the problems of the product, materials needed and how the product should be made	9
5	Questions about shape, type, size, length, thickness, height, popularity, price, etc. of the existing products	9
6	Questions about the properties (shape, size, length, thickness, height) of the product to be made	5
7	Questions about the durability of the product	5
8	About the suitable properties (shape, size, length, thickness, height) of parts of product	4
9	Questions about the problems (and their causes) associated with the product	3
10	Questions about the usefulness of the product	3
11	Questions about the tools needed to build the product	2
12	Questions about methods of making people buy the product	2
13	Questions asking about the people who make the existing product	2

The type of questions asked by the highest percent of the students (29%) was about the materials needed, sources of materials, sizes, shapes, types and amounts of materials required to make the product. Another 14% asked questions about the

method of making the product. Nine percent of the students did not ask questions but only made statements, explaining the materials needed to make the product, problems and how the product should be made. A very small proportion of the students (2%) asked questions about the makers of the products or the experts in the field. Only 16% of the students asked about changes and improvements required and about problems of the existing products. No questions were asked about the context of the products, users and time.

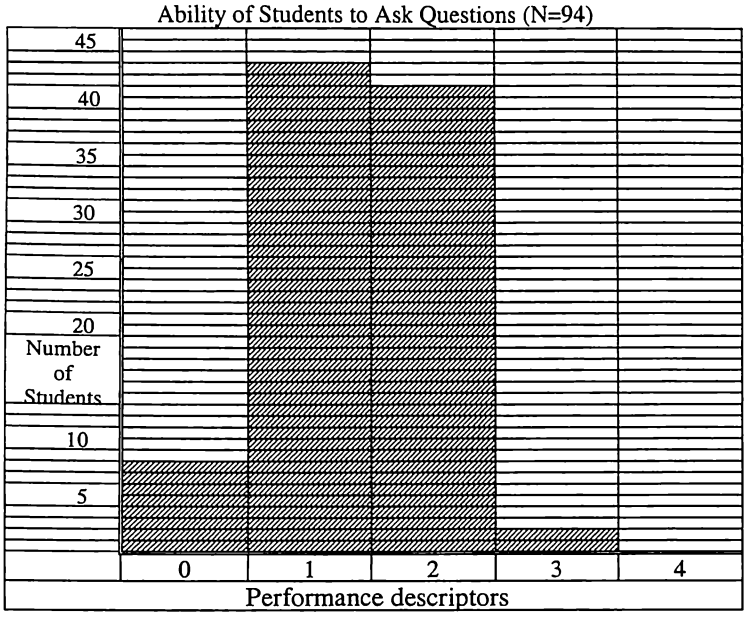
The results show that most of the students (61%) showed interest only in collecting the proper materials and methods for making the products. Only a small proportion (16%) of the students intended to find out needs and opportunities with regards to the products they were planning to produce. The set of performance descriptors developed to describe the ability of students to ask important and relevant technological questions to identify needs and opportunities is in Table 6.2.1b.

TABLE 6. 2.1b
Performance Descriptors for the Ability to Ask Questions

	Performance Descriptors
4	Student asks a wide range of relevant and important questions on users, makers, product, time and context.
3	Asks a very good range of relevant and important questions on most of the above.
2	A fair range of relevant and important questions on some of the above.
1	A limited range of relevant and important questions on one or two of the above.
0	Questions are irrelevant and not important.

Graph 6.2.1 shows the ability of students to ask important and relevant technological questions to identify needs and opportunities in a given situation. From the graph, the answers provided by 9% of the students were not questions about needs and opportunities but were descriptions of types of materials needed for the products they were going to make. Forty-five percent asked only one or two questions on the properties of materials needed for the products and another 44% asked questions mainly on the properties of the materials needed and the methods of making the products. Only 2% asked a good range of questions on the materials needed, the method of making the product, problems of the existing products, tools needed for the work and about the users of the product.

GRAPH 6.2.1
Ability of Students to Ask Questions (N=94)



Generally, the students failed to ask the appropriate questions that should have been asked in order to identify the needs and opportunities in their respective areas. Also, those who asked the right questions concentrated only on questions relating to the actual building of the product. The range of areas in which the questions were asked tended to be very narrow. Identifying needs and opportunities was neither taught nor included as part of the usual practical activities that students carried out in secondary school technical subjects in Tonga. The students were not required to analyse a given situation to identify needs and opportunities. Instead, they were asked only to build products to satisfy certain given criteria, and these criteria were mainly in terms of the physical properties of the products.

Another important factor is that not only did most students not ask the right questions, but some of them did not ask any questions at all. This is a reflection of how the children are brought up in Tongan families. At their homes with their elders, the children are not encouraged to ask questions. In their classrooms with their teachers, they are also not encouraged to ask questions. Respect, which is described in Tongan custom to be one of the 'Four Golden Strings' that hold the Tongan culture, discourages asking questions and encourages following instructions. Although changes have been observed in the last two decades, the traditional cultural gatherings

and occasions, the extended family meetings and the classrooms are still very quiet when the elders are present.

6.2.2 The Ability of Students to Identify Important and Relevant Factors that Influence the Situation

Most of the students (81%) found it difficult to identify a good range of the important and relevant factors that could influence the making and using of the product they were building. The range of factors identified was narrow, and the answers were mainly on the properties of the materials available for building the product. Students' answers are reported in Table 6.2.2a.

TABLE 6.2.2a
Percentages of Factors Mentioned by Students (n=94)

	Factors relevant to and affecting making and using the product	%
1	Properties of materials for the product – strong, durable, right type, straight etc. --	40
2	Whether we know how to make the product or not ----------	12
3	Characteristics of the existing products (strength, appearance, size, shape, etc.) ---	12
4	The properties of the product to be made – shape, size, amount, decorations, etc..-	9
5	Whether we know the right types of materials or not.----------	8
6	Needs of the users ----------	5
7	Money needed to buy the materials and price of product ----------	4
8	Problems that will be caused by the product ----------	4
9	Tools available for work ----------	4
10	Time given to complete the work ----------	1
11	Tongan culture ----------	1

The factor that the highest percentage of the students (40%) mentioned was about the properties of the materials available for building the product. Only a small proportion of the students mentioned social, cultural, environmental, financial, the needs of customers and time factors. Overall, 81% of the students talked about the properties, materials and methods of making the products. Only 19% of the students mentioned the needs of the users, money, tools, time, problems that the product might cause and Tongan culture.

Identifying factors influencing a given situation is a process that involves analytical skills, which are required to be taught before the students can successfully accomplish. The results show that students lacked appropriate analytical skills and were not able to analyse the given situations to identify the important factors that could affect building and using of the products.

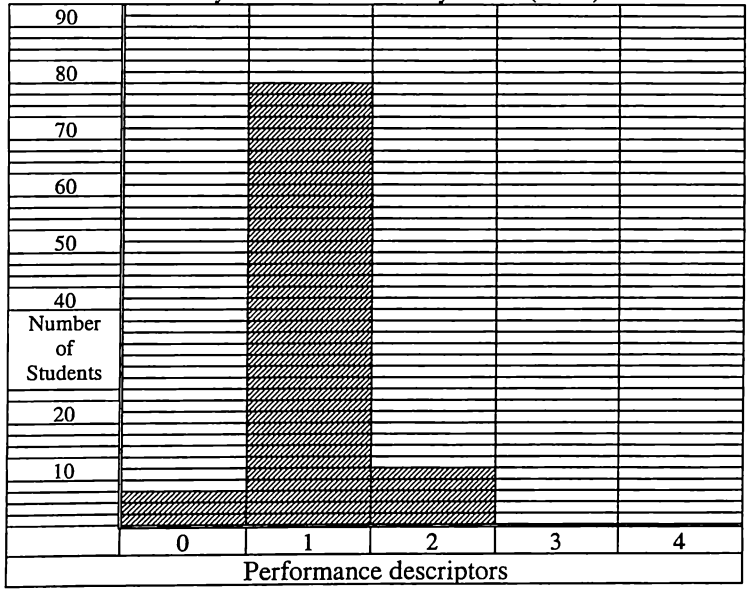
Another important result was little consideration of problems that would be caused by the product. This was mentioned by only 4% of the students. This one-sided view attitude is very common nation-wide. Many people tend only to look at benefits they themselves would obtain from a project or new piece of equipment and turn a blind eye on the resulting adverse effects on the environment, society and culture. The set of performance descriptors developed to describe the ability of students to identify the factors that would influence making and using of the product is in Table 6.2.2b.

TABLE 6.2.2b
Performance Descriptors for Identifying Factors

	Performance Descriptors
4	The student gives a wide range of social, cultural, environmental, legal, time, human, resources, financial and technical factors related to the situation.
3	The student gives a very good range of relevant and important factors related to the situation.
2	A fair range of relevant and important factors related to the situation.
1	A limited range of relevant and important factors related to the situation.
0	The student cannot identify the relevant and important factors related to the situation.

The result of students' performance on this section is shown on Graph 6.2.2.

GRAPH 6.2.2
Ability of Students to Identify factors (N=94)



Eighty-three percent of the students identified only one or two of the important and relevant factors influencing the given situations and 6% could not identify any. Most

of the factors identified by the students concerned only resources and technical work. Only 11% identified more than two important and relevant factors.

The students were able to identify mainly the factors related to the materials required and the method of making the product. Most of the students (89%) were not able to identify social, cultural, environmental, financial, and time factors. Consideration of these factors was not part of the projects carried out by students in secondary school technical subjects in Tonga.

6.2.3 The Ability of Students to Describe a Plan of an Investigation for Gathering Data on Needs and Opportunities

Most of the students (62%) were not able to describe a plan of an investigation for gathering data on needs and opportunities. Skills of investigation reflected in the plans described by students have shown a need for a lot of improvement. Further, the skills in describing a plan of an investigation, i.e., dividing the plan into subheadings stating the aim, materials needed, sources of data, data collection method etc. was lacking. The types of plan that students described are reported in Table 6.2.3a

TABLE 6.2.3a
Percentages of Plans Described by Students (n=94)

	Plans of investigations for collecting information on needs and opportunities	%
1	Interview experts for problems and improvements to be made on the product -	30
2	Ask people to find out how to make the product ----------	20
3	Materials for the product should be right- the right type, size, amount, length and strength ----------	18
4	Interview people carefully and take notes ----------	9
5	Interview users and observe how they use the product ----------	7
6	Ask people for the right materials for the product ----------	5
7	Proper tools are not available ----------	5
8	Find out alternatives for the existing type ----------	2
9	Compare new and old products to identify problems of product ----------	2
10	No answer ----------	2

Eighteen percent of the students gave answers that were not plans of investigations but descriptions of plans of products. They described properties of materials needed for the products. Another 25% of the answers, although describing investigations to be carried out, only aimed at finding out methods and materials for making the products. For method of data collection, 25% suggested 'asking' people, 46%

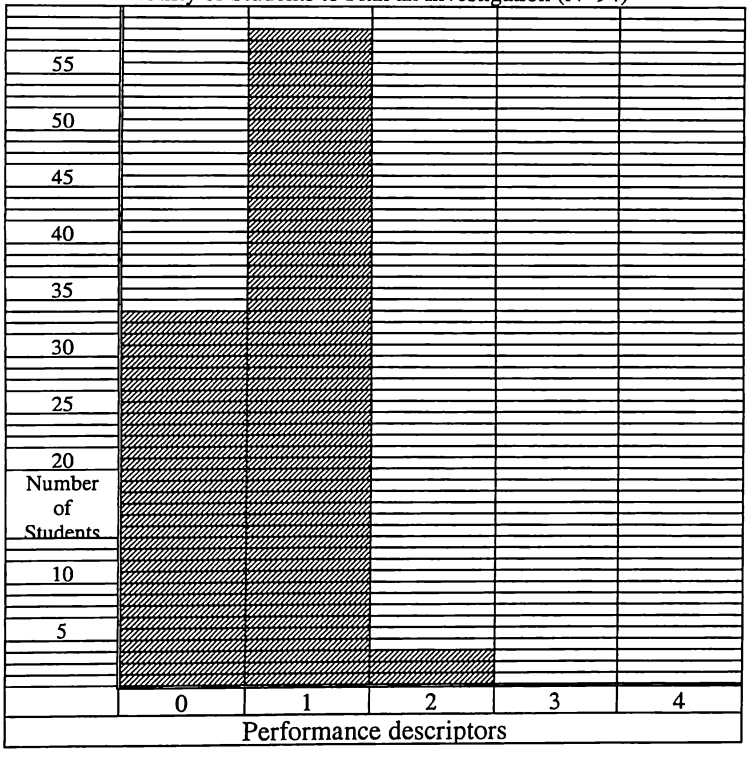
mentioned an 'interview' and the rest mentioned nothing. For sources of information, 34% planned to consult 'people' and 30% suggested consulting experts. The set of performance descriptors developed to describe the students' performance regarding the planning of an investigation is in Table 6.2.3b.

TABLE 6.2.3b
Performance Descriptors for Planning an Investigation

Performance Descriptors	
4	The plan described contains the aim of the investigation, materials and equipment needed, method of data collection, source of data and data management method
3	Plan contains much of the information described above
2	Plan described contains a fair amount of the information described above
1	Plan described contains one or two of the areas described above
0	The answer is not a plan of an investigation

Graph 6.2.3 shows the ability of students to describe a plan of an investigation to collect information on needs and opportunities.

GRAPH 6.2.3
Ability of Students to Plan an Investigation (N=94)



Answers described by 33% of the students were not about a plan of an investigation but descriptions of materials needed for the products to be made. A large proportion of the students (62%) described their plans in one or two sentences and in a very general manner. They suggested asking or interviewing people or experts about the

problems of the existing products and improvements to be made. They were not able to describe clearly the aims, materials needed, method of data collection, sources of information (sample), amount and type of information needed and method of data analysis. These results show that students lacked the appropriate skills in planning a research activity and had little knowledge of the components of research work.

6.2.4 The Ability of Students to Identify Important and Appropriate Sources of Information on Needs and Opportunities

The ability of students to identify and consult the important and appropriate sources of information regarding the needs and opportunities in their respective areas was found to be limited. The results expose lack of experience in doing research work. The sources of information that students consulted are reported in Table 6.2.4a.

TABLE 6.2.4a
Sources of Information Consulted by Students

	Sources of information	%
1	No investigation carried out	32
2	4 people from different villages	14
3	Members of family	14
4	2 people from different villages	11
5	5 people from different villages	11
6	3 people from different villages	5
7	6 people from different villages	5
8	One person	5
9	Observed users	3

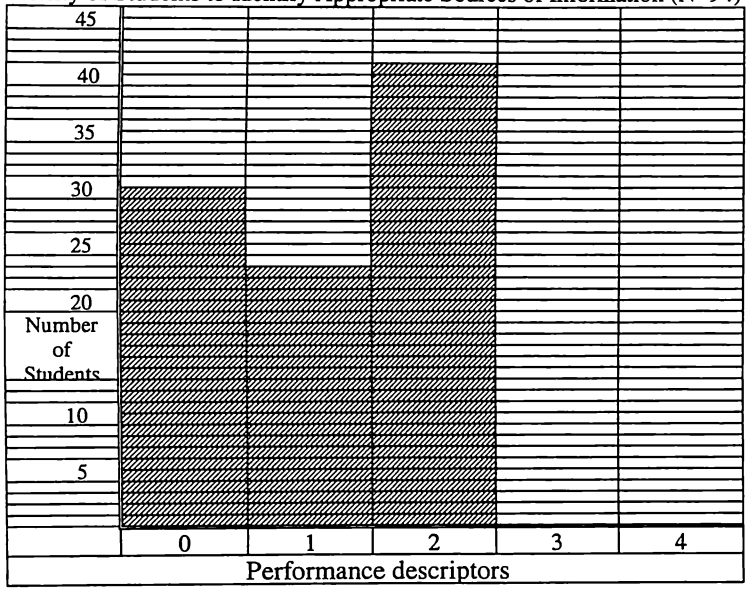
Thirty-two percent of the students did not do any research. No investigation was carried out and they consulted no one or any other source for information. Fourteen percent discussed their research questions with members of their family. No one consulted existing products (technology), books or scientific discoveries. Students' ability to identify and consult appropriate sources of information on needs and opportunities was described using the set of performance descriptors in Table 6.2.4b.

TABLE 6.2.4b
Performance Descriptors for Identifying and Consulting Sources of Information

	Performance Descriptors
4	The student consults consumer demands, users, makers and experts and searches library and books, existing technology and scientific discoveries.
3	The student consults a very good range of the sources above.
2	The student consults a fair range of the sources above.
1	The student consults a limited range of the sources above.
0	The student does not consult any of the resources above.

Graph 6.2.4 shows the students' ability to identify and consult appropriate sources of information on needs and opportunities.

GRAPH 6.2.4
Ability of Students to Identify Appropriate Sources of Information (N=94)



As mentioned before, 32% of the students did not carry out an investigation. They therefore did not consult the appropriate sources of information on needs and opportunities. Twenty-four percent consulted only users and makers and 44% consulted more than two important and appropriate sources of information. Many of these sources were makers, users and experts.

Comparing the work they had planned and what they actually carried out, the students performed better in the actual carrying out of the investigation than in the planning of it. Some of them even carried out more work than they had planned to do. The ability of students to view the project holistically and at the same time identify the details of the stages involved required a lot of improvement.

6.2.5 The Ability of Students to Collect Relevant and Sufficient Data on Needs and Opportunities

The ability of students to collect relevant and sufficient data on needs and opportunities was found to be very limited. The students collected information mainly on materials and methods of building the products. The types of information collected by the students are reported in Table 6.2.5a.

TABLE 6.2.5a
Types of Information Collected by Students (n=94)

	Information collected by students	%
1	Description of the materials needed, how the product should be made and the properties (size, shape etc.) the product should have are given	30
2	Problems caused by the products given and suggestions on how to solve the problems described	14
3	Description of the properties that materials needed or the product should have	14
4	Customers wanted choices beside the existing product	14
5	Advice on materials to use for the product and on how to take care of the product are given	7
6	Suggestions of alternatives	7
7	Money problem is suggested and customers wanting other choices beside the product is described	5
8	Improvements to the existing situation is suggested	3
9	Description of how to prepare materials for product	3
10	No information given	3

Fifty-four percent of the students collected information mainly about the materials that should be used to make the product, the properties that the product should have and how the product should be made. Fourteen percent collected information concerning some problems, but went on to discuss how they should be solved. Only 8% of the students collected information on problems and needs, and no data was collected regarding time and context.

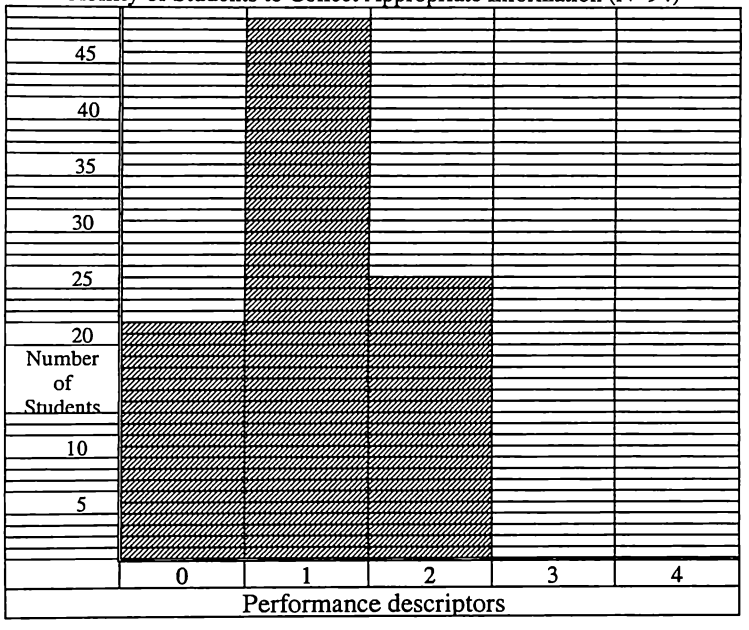
The results show that most students did not search for information on needs and opportunities. Instead, they concentrated mainly on materials and methods of making the products. The ability to collect relevant and appropriate information on needs and opportunities was described using the set of performance descriptors in Table 6.2.5b.

TABLE 6.2.5b
Performance Descriptors for Collecting Information

	Performance Descriptors
4	Student collects sufficient appropriate data from users, makers and experts, information on the product, costs, time and context.
3	Student collects a very good amount of appropriate data on the above.
2	Student collects a fair amount of appropriate data on the above.
1	Student collects a limited amount of appropriate data on the above.
0	Collects either no data or inappropriate and irrelevant data

Graph 6.2.5 shows the ability of the students to collect relevant and appropriate information on needs and opportunities.

GRAPH 6.2.5
Ability of Students to Collect Appropriate Information (N=94)



Twenty-two percent of the students collected information that could not be regarded as needs and opportunities. Further, another 51% of the students recorded information that had little relation to the needs and opportunities of the situation. Only 27% of the students collected a fair amount of data on the problems of the situation and on the improvements needed.

6.2.6 The Ability of Students to Analyse Data Collected to Identify Needs and Opportunities that Existed

Most of the students (81%) could not analyse data collected to identify needs and opportunities that existed. This activity was difficult especially because most of the information that students had collected was not about needs and opportunities but

mainly on properties and methods of building the products. The ways in which the students summarised needs and opportunities from the information they had collected are reported in Table 6.2.6a

TABLE 6.2.6a
Percentages of Needs and Opportunities Identified by Students (n=94)

	Type of questions suggested by students	%
1	Mentioned only part of the points in the information collected during research --	44
2	Mentioned part of the points in the information collected but raised new points not collected during research ----------	32
3	Mentioned only new points not in the information collected ----------	16
4	Mentioned all the points in the information collected ----------	8

All of the students missed the main purpose of this activity. None of them seemed to understand that they were required to identify only the information on needs and opportunities existing in the data they had collected. Forty-four percent of the students missed some important information collected during research. Forty-eight percent described new points that were not present in the information they had collected. These students were still collecting data at this stage. Only 8% mentioned all the important points they had collected.

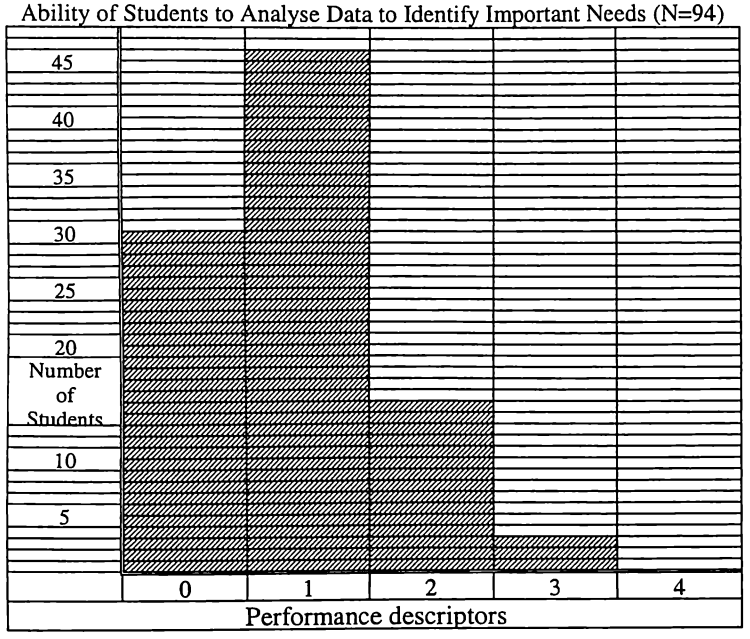
The relationship between the data collected and needs and opportunities discussed by students was very limited. The students seemed to be confused with the requirements of the task. The ability of students to identify needs and opportunities from the information collected was described using the set of performance criteria in Table 6.2.6b.

TABLE 6.2.6b
Performance Descriptors for Analysing Data to Identify Needs and Opportunities

	Performance Descriptors
4	Student identifies important needs and opportunities existing in data collected.
3	Identifies most of important needs and opportunities in data collected.
2	Identifies a fair number of important needs and opportunities in data collected.
1	Identifies a limited number of important needs and opportunities in data collected.
0	Cannot identify needs and opportunities existing in data collected.

Students' performance on analysing data to identify needs and opportunities is shown on Graph 6.2.6.

GRAPH 6.2.6
Ability of Students to Analyse Data to Identify Important Needs (N=94)



Thirty-two percent of the students could not identify any of the needs and opportunities in the information collected. Another 49% identified only a small fraction of the information collected in the investigation as being about needs and opportunities. Only 19% of the students identified the important information on needs and opportunities.

6.2.7 The Ability of Students to Identify Intrinsic Needs and Opportunities

Most of the students (82%) were not able to identify the intrinsic needs and opportunities existing in the situations they were given to work on. The students concentrated mainly on building the products. The types of needs they had identified showed that they were unable to dig deeply into the area and identify the more important needs and opportunities. The ability of students to identify the more intrinsic needs and opportunities on the situation are reported in Table 6.2.7a.

TABLE 6.2.7a
Percentages of Intrinsic Needs and Opportunities Identified (n=94)

	Needs and Opportunities	%
1	Identify problems of parts	24
2	Improve amount, lengths, shape and size of product	20
3	Identify better materials to be used	20
4	Identify additional new procedure to eliminate problems	12
5	Improve preparation of parts or components	8
6	Make product look good	8
7	Improve method of building product	8

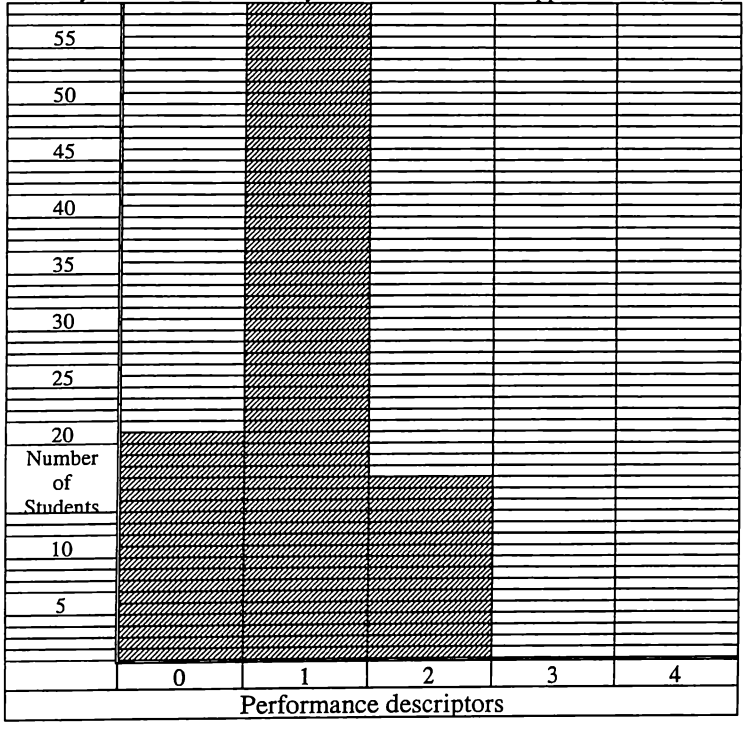
All of the needs and opportunities that the students identified were related primarily to the physical properties of the products and parts of the products. For example, they talked about the problems of the lengths of the handles of brooms and the fans. They mentioned the sizes of the pillows and the kava seats. Only a very small proportion of the students (16%) identified needs that were related to the functional problems of the products. The functional problems are those relating to time, place, reason, method of use and the people who would be using the products. The ability of students to identify intrinsic needs and opportunities in the situation was described using the set of performance criteria on Table 6.2.7b.

TABLE 6.2.7b
Performance Descriptors for Identifying Intrinsic Needs and Opportunities

Performance Descriptors	
4	Student identifies the important range of intrinsic needs and opportunities in the situation regarding the properties of the products in relation to who, when, where, how and when.
3	Identifies most of intrinsic needs and opportunities mentioned above.
2	Identifies a limited number of intrinsic needs and opportunities mentioned above.
1	Identifies a fair number of needs and opportunities but only in one area.
0	Identifies a limited number of needs and opportunities.

Students' performance on identifying intrinsic needs and opportunities in the situation is shown on Graph 6.2.7.

GRAPH 6.2.7
Ability of Students to Identify Intrinsic Needs and Opportunities (N=94)



Most of the students (83%) identified only needs and opportunities that were related to only one area of the properties of products. They were not able to find the needs and opportunities relating to the users of the products, the place where and when they would be used and the method of using the products. It is very clear that the students lacked the appropriate knowledge of the problem areas that had bearing on the using of the products. They also lacked appropriate skills of carrying out investigations to identify needs and opportunities in a given situation. They had not done any previous practical work in which they were asked to investigate the needs and opportunities in a given situation.

6.3 TECHNOLOGICAL CAPABILITY B: EXPLORING AND DEVELOPING BEST POSSIBLE SOLUTIONS AND STRATEGIES

This section reports the results of the performances of students in the activities that assessed their ability to explore and develop best possible solutions and strategies for the needs and opportunities identified. Eight assessment criteria were written to cover the main aspects of this technological capability. The results will be presented in the order of the assessment criteria.

6.3.1 The Ability of Students to Describe (a) Who will use the Product, (b) Where, (c) Why, (d) When, and (e) How the Product will be Used

This section reports on the ability of students to describe the main purposes of the project. The results show that the students found it difficult to describe clearly who, where, why, when and how the product would be used. The students were not specific in their answers and made little reference to the needs and opportunities they had identified in the previous stage. The main types of answers that students described are reported in Table 6.3.1a.

Students' answers were very general. They did not describe the specific persons who would use their products, the specific places where the products would be used, nor any specific reasons why people would want to buy or use their products. Also, no particular time was mentioned.

TABLE 6.3.1a
Describing who, where, why, when and how (n=94)

Answers to each question	%
(a) Who will use the product?	
(i) Different groups of people named but no particulars given ----------	63
(ii) Answered generally mentioning 'those who need the product' -----	37
(b) Where will the product be used?	
(i) Places like home and church were named but no specifics given ---	83
(ii) A very general answer meaning any place or anywhere ----------	15
(iii) For a particular purpose ----------	2
(c) Why will the product be needed?	
(i) General descriptions of the parts and of the product itself ---------	56
(ii) Descriptions of types of work or purpose of product ----------	44
(d) When will the product be needed?	
(i) When the product is needed for a purpose or to do some work ----	75
(ii) All the time or at any time ----------	20
(iii) As soon as possible ----------	3
(iv) When it is ready ----------	2
(e) How will the product be used?	
(i) General description of the purpose of the product ----------	78
(ii) Detailed information on how to use the product ----------	8
(iii) Name places where the product is to be used ----------	8
(iv) Can be used for any activity ----------	6

Seventy-five percent of the students mentioned that the products would be required when some work was needed to be carried out. In answering part (e) most students (89%) gave vague descriptions more to do with the purposes than with how to use the products.

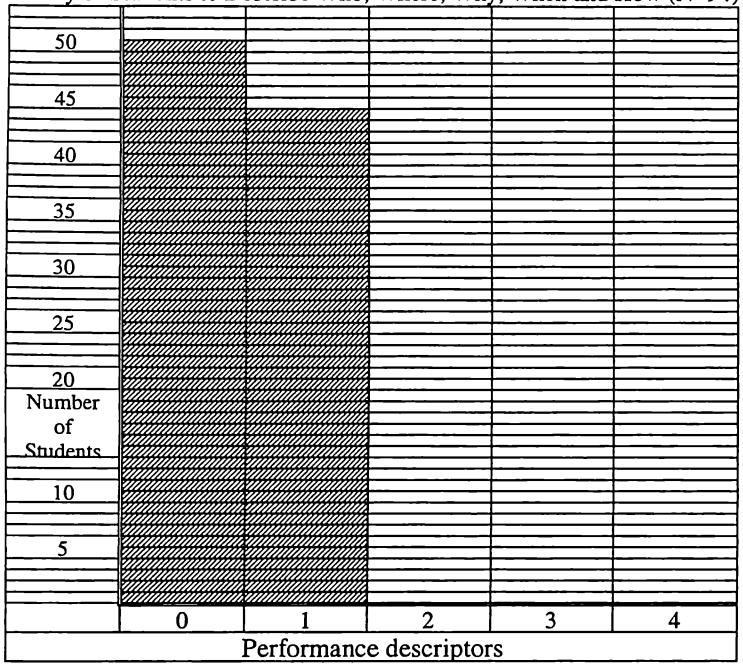
Table 6.3.1b presents the set of performance descriptors that was used to describe the performance of students when describing who, where, why, when and how would the product be used.

TABLE 6.3.1b
Performance Descriptors for Describing Who, Where, Why, When and How

	Performance Descriptors
4	The student specifically states who, where, why, how and when the product will be used.
3	Student specifically states almost all of the above.
2	Student specifically states half of the above.
1	Student specifically states 1 or 2 of the above.
0	The student cannot specifically state any of the above.

The ability of students to describe (a) who will use the product, (b) where, (c) why, (d) when and (e) how will the product be used is presented on Graph 6.3.1.

GRAPH 6.3.1
Ability of Students to Describe Who, Where, Why, When and How (N=94)



Many of the students (53%) were not able to describe specifically who would use their products, and where, when, how and why their products would be needed. Forty-six percent were able to describe only why their products would be needed and how their products would be used. The students concentrated more on making the products rather than making decisions on where their products would end up or who would use their products.

The purposes of the technological task as revealed in students' answers were not clear. Most of the students did not see anything special in the products they were building. They were not able to build purposeful products, the sort of products that could solve problems, needs and opportunities of certain people in the society. They were not able to establish and emphasize purposes in the activities that they were planning. The students built the products for the sake of learning to build something, as they usually do in common projects of technical subjects. The students had yet to learn to build something specifically for certain types of people, for a certain place, for a certain reason, for a certain time and to be used in certain ways. During

technical subjects projects, the students were expected only to build strong and aesthetic products.

6.3.2 The Ability of Students to Describe the Characteristics of Products that could Solve Needs and Opportunities Identified

Most of the students found it difficult to describe the characteristics that their products should have, in order to solve the needs and opportunities they had identified. The students were not sure of the characteristics of the products they were searching to develop in order to find solutions and strategies for the needs and opportunities they had identified. Most of them described the types of materials they needed and the lengths, sizes and shapes of the products they were going to build. Table 6.3.2a reports the characteristics of the products that the students described.

TABLE 6.3.2a
Characteristics Described by Students (n=37)

	Descriptions of the products that students wanted to make	%
1	Describes properties and types of products to be made (shape, size, components, amount of materials, etc)	33
2	Type of materials needed are named	28
3	Beautiful, good looking, clean	14
4	Skillfully (or properly)made	9
5	Durable	7
6	To be made with new and better ideas	7
7	Product to fit a particular type of people	2

Thirty-three percent of the students provided answers that were descriptions of the properties of the products to be made and 28% described the materials needed for the products. These students were intending to build strong and beautiful products. These students were ready to build their products at this stage. They had made up their minds as to what materials they wanted for their products and how they were going to make them. The relationship between most of these answers and needs and opportunities identified earlier was very weak.

It is important to note that 7% of the answers were able to continue on from the needs and opportunities identified earlier. These students decided they were going to search for new and better ideas for building their products and 2% planned to build products specifically for a particular type of people. These students went on and built products

that were not only different and better than the existing ones but were more suitable to the persons they were building the products for.

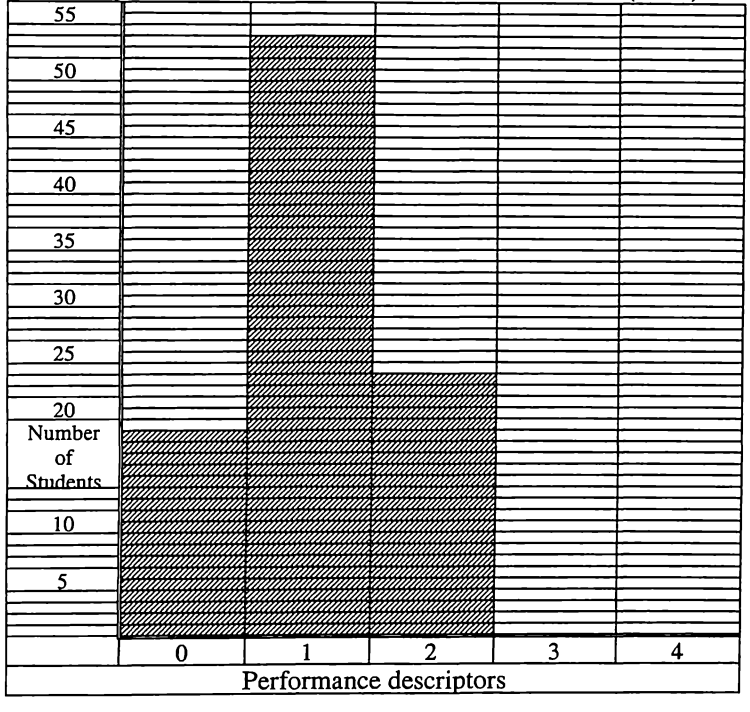
Table 6.3.2b gives the set of performance descriptors that were used to describe the ability of students to describe the characteristics the products should have in order to solve needs and opportunities.

TABLE 6.3.2b
Performance Descriptors for Describing Characteristics of Products

	Performance Descriptors
4	The student describes clearly the characteristics the product should have in order to solve identified needs and opportunities.
3	The student's description of the product to be made relates well to the needs and opportunities identified earlier.
2	The student's description of the product to be made relates fairly to the needs and opportunities identified earlier.
1	The student's description of the product to be made relates minimally to the needs and opportunities identified earlier.
0	The student's description of the product to be made does not relate to the needs and opportunities identified earlier.

Graph 6.3.2 shows the ability of students to describe the characteristics that the products should have in order to solve identified needs and opportunities.

GRAPH 6.3.2
Ability of Students to Describe Characteristics of Product (N=94)



Only 25% of students' answers were in some way related to the needs identified earlier. For 56% of the students, the relationships between the characteristics

described and the needs and opportunities identified earlier were very weak. Nineteen percent of the students described only how they were going to make the products.

6.3.3 The Ability of Students to Describe a Plan of Investigation to Collect Information on Solutions to Identified Needs and Opportunities

The results show that the students found it difficult to describe a plan of an investigation to collect information on solutions to the needs and opportunities they had identified. The students described the plans in a very general way, similar to their descriptions of plans for investigating needs and opportunities in Section 6.2.3. The types of plans that students described are presented in Table 6.3.3a.

TABLE 6.3.3a
Types of Plans Described by Students (n=94)

	Plans described by students	%
1	No plan for research, but provided a description of materials needed for the product -----	38
2	Plan to ask people how to make the product ----------	20
3	Use telephone to ask people about the problem but give description of product to be made	10
4	Plan to ask certain persons about how to make the product + materials needed ----------	3
5	Plan to ask people for solution of problem but give description of product to be made -----	3
6	Plan to observe brooms in homes and market and observe how a broom is tied together ---	2
7	Ask people and search for causes of problems ----------	2
8	Plan to ask people how to make the product and observe how it is made ----------	5
9	Plan to ask an expert for solution to problem ----------	2
10	Plan to ask experts about solutions and also test the existing products for problems --------	5
11	Interview an expert for methods and materials needed to make the product ----------	5
12	Interview users and makers ----------	5

Thirty-eight percent of the students gave answers that were not plans of investigation but descriptions of materials needed to make the products. Another 35% aimed to find out the materials needed for the product and the methods of making them. Ten percent were descriptions of plans for collecting information on problems of the products but went on to describe how the products should be made. Only 7% of the answers planned to search for causes of problems and solutions.

For method of investigation, 50% of the answers suggested 'asking' and 10% suggested an 'interview'. Forty-three percent planned to consult 'people', 12 % mentioned 'experts' and 5% suggested consulting 'users and makers'. Two percent wanted to observe the products in the market and homes. Time and the amount of information needed were not planned for and no one planned to carry out tests for best solutions.

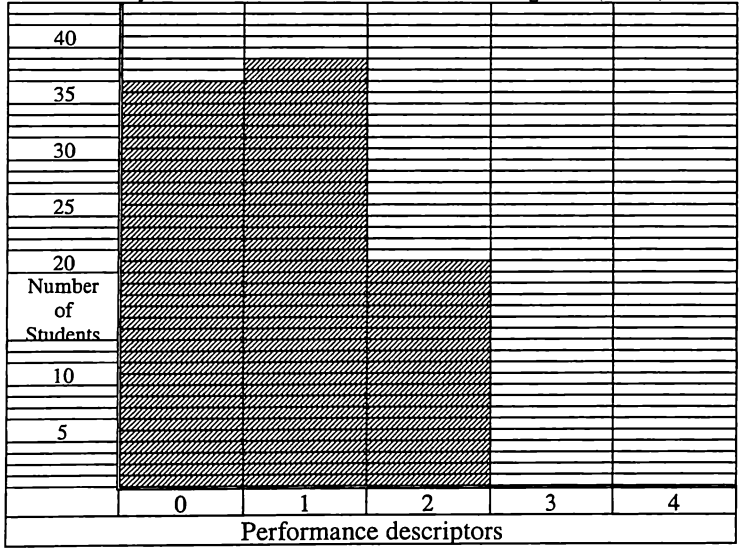
The results show that most students lacked the appropriate skills for carrying out and preparing a plan of investigation. Table 6.3.3b presents the set of performance descriptors that were used to describe the ability of students to describe a plan of an investigation to collect information on solutions and strategies.

TABLE 6.3.3b
Performance Descriptors for Describing a Plan of Investigation

	Performance Descriptors
4	The student describes a plan that contains the aim, materials and equipment needed, method of data collection, sources of data and data management method.
3	Plan described contains much of the information listed above.
2	Plan described contains a fair amount of the information described above.
1	Plan described contains one or two of the areas described above.
0	The answer is not about an investigation to be carried out.

The graph below shows the ability of students to describe a plan of an investigation to gather information on solutions to the identified needs and opportunities.

GRAPH 6.3.3
Ability of Students to Describe Plan of Investigation (N=94)



Thirty-eight percent of the students did not plan to do an investigation but did make plans for the actual building of their products. A larger proportion (40%) described only briefly the method of data collection and sources of data. Twenty-one percent described the method of data collection and sources of data more clearly. Failure of most students to describe clearly their plans of investigation indicated lack of experience in doing such researches, lack of knowledge of what they were going to

search for and lack of skills in research work. Planning of investigations requires one to have a good idea of the details of the information required, the total picture of the work to be done and the appropriate skills in planning an activity. These skills were not taught as part of the projects in technical subjects in Tongan schools.

6.3.4 The Ability of Students to Consult Appropriate Sources of Information on Solutions and Strategies for Identified Needs and Opportunities

The sources of information that students consulted to explore solutions and strategies for the identified needs and opportunities were mainly users and makers. Since the intention of most students was to build a product, searching for solutions and strategies did not have much meaning in their projects. This was reflected in the types of sources of information on solutions and strategies consulted by students. The sources of information that students consulted are reported in Table 6.3.4a.

TABLE 6.3.4a
Sources of Information Consulted (n=94)

	Sources of information students consulted	%
1	No research	22
2	4 people from different villages	14
3	Home	11
4	1 expert	11
5	2 experts	11
6	2 people from different villages	8
7	1 person	8
8	Observation	5
9	An old person	5
10	3 people from different villages	5

Twenty-two percent of the students did not do any research and another 11% obtained information only from home. Only 5% consulted existing products. The students were not specific in naming the kind of people they were consulting. They generally referred to them as 'people' or 'experts' and did not use words like users and makers. Library books were not consulted and no one mentioned searching the existing technology.

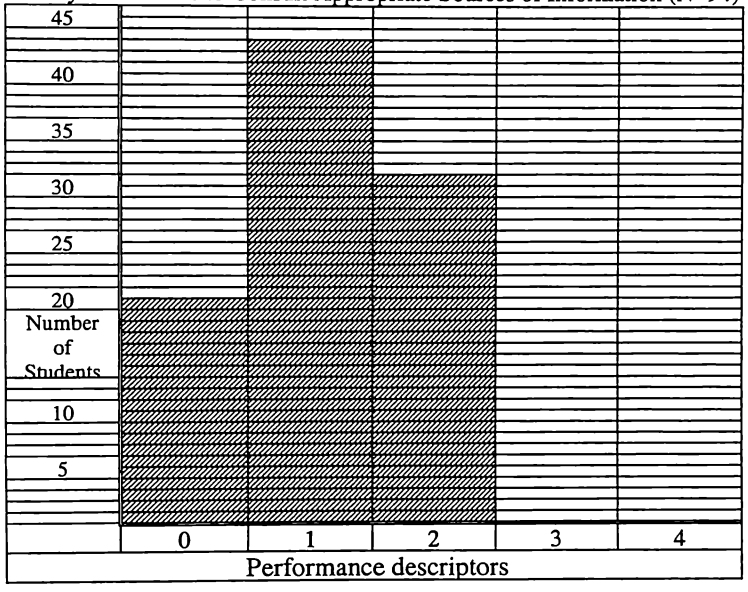
Table 6.3.4b reports the set of performance descriptors that was used to describe the ability of students to identify and consult the appropriate sources of information on solutions and strategies.

TABLE 6.3.4b
Performance Descriptors for Consulting Appropriate Sources of Information

	Performance Descriptors
4	Student consults experts, users, makers, resource materials, existing technology and scientific discoveries.
3	Student consults a very good range of the sources above.
2	Student consults a fair range of the sources above.
1	Student consults a limited range of the sources above.
0	Student consults no real sources.

Graph 6.3.4 shows the ability of students to identify and consult appropriate sources of information on solutions to the identified needs and opportunities.

GRAPH 6.3.4
Ability of Students to Consult Appropriate Sources of Information (N=94)



Twenty-two percent of the students did not do research on solutions to identified needs and opportunities. A large proportion of the students (46%) consulted only one or two persons or experts. Thirty-three percent consulted more than two people or experts, resource materials and existing products. Most of these sources were the same ones that the students consulted when they searched for needs and opportunities. Most of the students (68%) failed to identify and consult the appropriate sources of information on the solutions to the needs and opportunities they were trying to solve.

Many students mentioned old people when they talked about experts. They seemed to have the attitude that the old way of making the products was the better and proper way. Very few students wanted to search for different ways of making the products.

6.3.5 The Ability of Students to Collect Relevant and Sufficient Data on Solutions and Strategies for Needs and Opportunities Identified

The ability of students to collect relevant and sufficient data on solutions and strategies was shown to be limited. The students seemed to be interested mainly in the materials and method of building the products. The types of information collected by the students are reported in Table 6.3.5a

TABLE 6.3.5a
Percentages of Types of Information Collected by Students (n=94)

	Types of information collected by students	%
1	Description of product to be made ---------- ----------	32
2	Description of types of materials needed for the product ----------	30
3	Description of how the investigation was carried out ----------	14
4	Description of problems about the situation ----------	8
5	Questions about materials and about method of making the product ---------	8
6	Description of the materials needed and the method of making the product -	5
7	Description of types of materials needed + how to look after the product ---	3

The students who did not do research on solutions and strategies recorded their own ideas of what they were planning to build in the space provided in the worksheet. Sixty-seven percent of the students described the product to be made and the materials needed for the product. These students were ready to build their products. Thirty percent of the answers were not information related to solutions and strategies, 14% described how the investigation was carried out, 8% raised questions about materials and the method of making the product and another 8% were descriptions of problems related to the situations. These answers indicate that the students were collecting more information about the building of the product than about satisfying needs and opportunities.

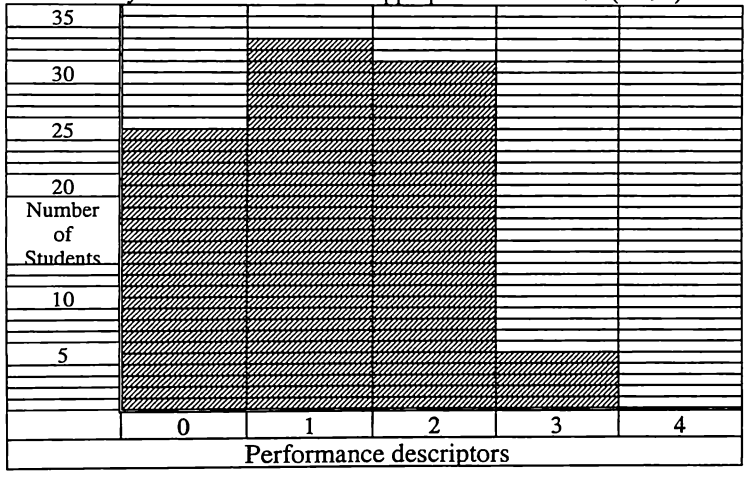
Table 6.3.5a gives the set of performance descriptors that were used to describe the performance of students for this criterion.

TABLE 6.3.5b
Performance Descriptors for Collecting Data on Solutions

Performance Descriptors	
4	Student collects a sufficient amount of appropriate data on solutions to the needs identified.
3	Student collects a very good amount of appropriate data on solutions to the needs identified.
2	Student collects a fair amount of appropriate data on solutions to the needs identified.
1	Student collects a limited amount of appropriate data on solutions to the needs identified.
0	Collects either no data or inappropriate and irrelevant data.

Graph 6.3.5 shows the ability of students to collect relevant and sufficient information on solutions to needs and opportunities identified.

GRAPH 6.3.5
Ability of Students to Collect Appropriate Information (N=94)



Twenty-seven percent of the students described data that was not relevant to the needs and opportunities they had described earlier. Another 35% collected data that was hardly relevant to these needs and opportunities. Although 33% of the students collected a fair amount of appropriate data on needs and opportunities, this data was mainly about the types of materials that would make the products stronger and more beautiful, which were the main improvements they described when they searched for needs and opportunities. Only 5% recorded data that was relevant to the needs and opportunities described earlier.

6.3.6 The Ability of Students to Analyse Data Collected to Identify Solutions to Needs and Opportunities Identified

The ability of students to analyse data collected to identify solutions to the needs and opportunities they had earlier identified needed a lot of improvement. The way in which students summarized solutions collected in research from the information recorded was made more difficult by the fact that the information that most students collected was not to do with solutions to needs and opportunities but was mainly about materials and methods of making the products. The portion of information that the students extracted from the data collected is reported in Table 6.3.6a.

TABLE 6.3.6a
Types of Information Extracted by Students (n=94)

	Solutions and strategies identified	%
1	Mentioned only part of the points in the information collected during research	11
2	Mentioned part of the points in the information collected but raised new points not collected during research	42
3	Mentioned all the points in the information collected	14
4	Mentioned only new points not in the information collected	33

Thirty-three percent of the students mentioned only new points not included in the information collected during the investigation. Another 42% mentioned only some of the information collected in the investigation and went on to mention new points not collected in the investigation. Fourteen percent mentioned all the information collected. Most of the students (89%) missed the purpose of this activity, which was to identify information on solutions and strategies existing in the data collected during investigation. The solutions and strategies to the needs and opportunities that the students described are reported in Table 6.3.6b

TABLE 6.3.6b
Students' Descriptions of Solutions and Strategies (n=94)

	Students' descriptions of solutions and strategies	%
1	Description of the properties and parts of the product to be made	51
2	Description of the nature and materials needed to make the product	27
3	Description of materials needed	8
4	Description of how the product would be made	8
5	Description of materials needed, proper method of using product and how to look after the product	3
6	General statement of how to solve problems	3

Ninety-six percent of the students described the materials needed, the nature of the product to be made and the method of making the product. Very little reference was

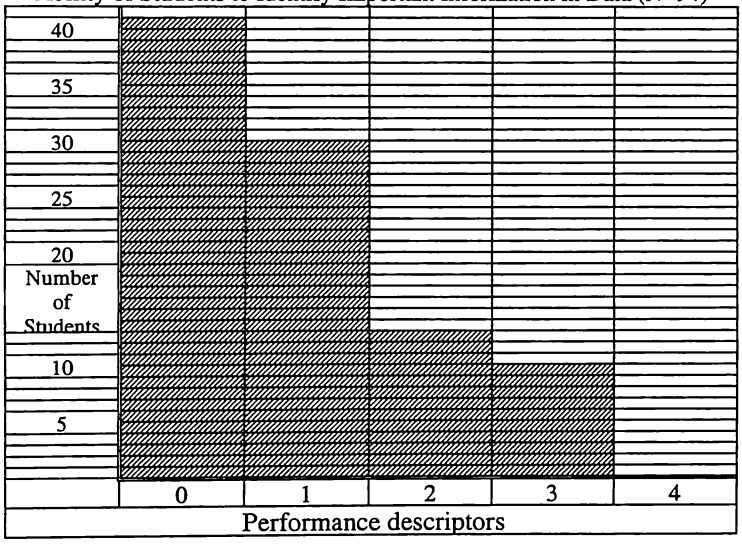
made by the students to the solutions they described regarding the needs and opportunities they had identified. Table 6.3.6c describes the set of performance descriptors that were used to describe the ability of students to identify solutions and strategies from the data collected.

TABLE 6.3.6c
Performance Descriptors for Identifying Solutions and Strategies from Data

Performance Descriptors	
4	Student identifies all the important information on solutions that exist in the data collected.
3	Student identifies most of the important information on solutions that exist in the data collected.
2	Student identifies a fair amount of important information on solutions that exist in the data collected.
1	Student identifies a limited amount of the important information on solutions that exist in the data collected.
0	Student cannot identify any of the important information on solutions that exist in the data collected.

Graph 6.3.6 shows the ability of students to identify the important information on solutions which exist in the data collected.

GRAPH 6.3.6
Ability of Students to Identify Important Information in Data (N=94)



Forty-three percent of the students could not identify the solutions and strategies from the data collected. Another 32% identified only very little information concerning solutions and strategies. Ten percent of the students were able to identify most of the information about the solutions and strategies to the needs and opportunities identified.

A lot of improvement is needed in students' ability to summarise solutions from information recorded during research. Most of the students could not limit their

explanation to what they had recorded. They did not consider it important to follow on from what they had done earlier. This result indicates that the manner in which most students viewed this project was very atomisitc. Most students failed to view that the whole project was made up of the component parts connected together and in a holistic fashion.

6.3.7 The Ability of Students to Identify Factors that could Influence the Making of the Proposed Product to Satisfy Needs and Opportunities Identified

The ability of students to identify the factors that could influence the building of the proposed product to satisfy needs and opportunities identified was shown to be limited. Most of the students (51%) identified only the properties of the materials they could obtain. The factors described by the students are recorded in Table 6.3.7a.

TABLE 6.3.7a
Percentages of Factors Identified by Students (n=37)

	Factors that could affect making of the proposed product	%
1	Properties and types of materials obtained for building the product --	24
2	Properties of materials available + skills in making the product ------	11
3	The way the product is made ----------	8
4	Properties and amount of material available and obtained ----------	8
5	The way the product is used, kept and looked after ----------	8
6	Money available ----------	8
7	Tools available ----------	8
8	Availability of materials required ----------	5
9	Skills in making the product ----------	5
10	No answer or answer not clear ----------	3
11	Tools and materials available ----------	3
12	Time allowed + knowledge about making the product ----------	3
13	Knowing the proper materials for the product ----------	3
14	Tools and materials available + skill involved in making the product	3

Fifty-one percent of the answers mentioned the properties of materials that could be obtained. This is significant because it shows that the quality of the products produced in common practical projects in technical subjects in Tongan schools were limited by the types of materials available in the environment. The quality of products they could produce depended much on the quality of the materials available in the environment. Searching for new materials for building artefacts and new ways of doing things was not strong in students' approach in this project. In a subject called Tongan Craft, the students were encouraged to use local materials found in the environment to build traditional artefacts. Also, in Tongan culture, the

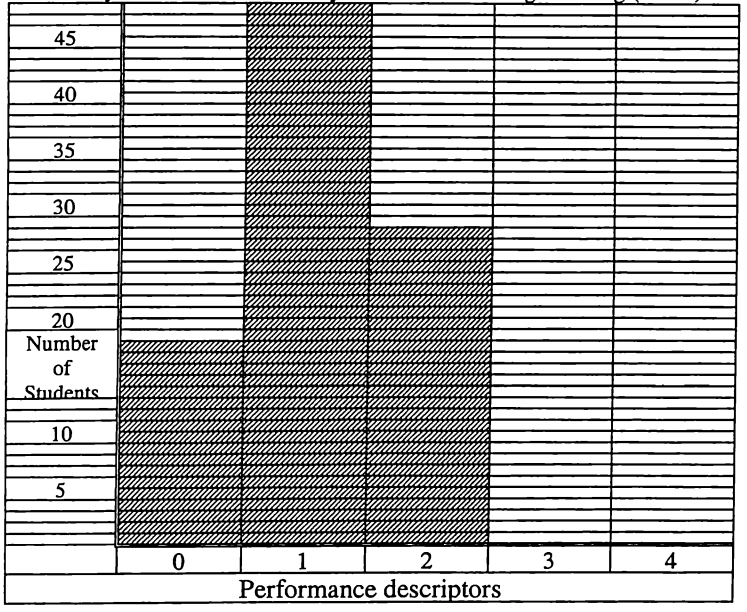
people are encouraged to trust their traditional ways of doing things and discourage searching for changes and imported ways of life. These were factors that seemed to influence the way in which students approached this project. Only 14% mentioned tools as a factor that would influence the building of the product. Only 19% mentioned skills in building, 8% money and 3% mentioned time. These are important factors that would greatly influence the product. However, they were only mentioned by very few students. This shows lack of experience and knowledge in carrying out tasks like this. Table 6.3.7b presents the set of performance descriptors that were used to describe the performance of students on identifying factors that would affect the building of the products.

TABLE 6.3.7b
Performance Descriptors for Identifying Factors Affecting Building of the Product

	Performance Descriptors
4	The student considers a wide range of social, cultural, environmental, legal, time, human, resources, financial and technical factors related to the solutions and strategies
3	Considers a good range of relevant and important factors on most of the above
2	Considers a fair range of relevant and important factors on some of the above
1	Considers a limited range of relevant and important factors on a few of the above
0	Does not consider any factor

Graph 6.3.7 shows the ability of students to identify important and relevant factors that could influence the making and using of the product they were planning to make.

GRAPH 6.3.7
Ability of Students to Identify Factors Influencing Building (N=94)



Nineteen percent of the students could not identify any of the factors that could influence building of the product they were planning to make. Another 51% mentioned only a limited number of important factors. Thirty percent mentioned other factors including money and time. The students were not able to identify many of the factors relating to the building of the products they were planning. The way in which the students answered this question was very general. They could not be more specific because the way in which they described solutions to needs and opportunities was also very general.

6.3.8 The Ability of Students to Identify Knowledge and Skills Required for Making the Product

The ability of students to identify knowledge and skills required for making the product was found to be unsatisfactory. The answers lacked details, mentioning generally the skills in making the product. They did not give the specific skills required in the situations they were working in. Further, the answers concentrated mainly on the skills related to the actual building of the products. The skills related to costing, planning, measurement and using tools were rarely mentioned by the students.

Table 6.3.8a presents the knowledge and skills described by the students to be required for building the products they were planning.

TABLE 6.3.8a
Percentages of Types of Knowledge and Skills Described by Students (n=94)

	Knowledge and skills required that were identified by students	%
1	Skills in preparation of materials and in making the product ---------	42
2	Measurement skills and skills in using tools to make required shape of product ----------	12
3	Ask an expert how to make the product ----------	7
4	Knowing the right types of materials for the product ----------	7
5	Skills in preparation of materials ----------	5
6	Skills in using tools, drawing plans and making the product ---------	5
7	Skills in decorating the product ----------	5
8	Knowing how to measure parts and dimensions of the product ------	5
9	How to draw a plan of the product ----------	2
10	Observe someone making the product and learn from it ----------	2
11	Drawing a plan of product and skills in making it ----------	2
12	Describe the product to be made ----------	2
13	Knowing how to use the product ----------	2
14	Need a modern method of making the product ----------	2

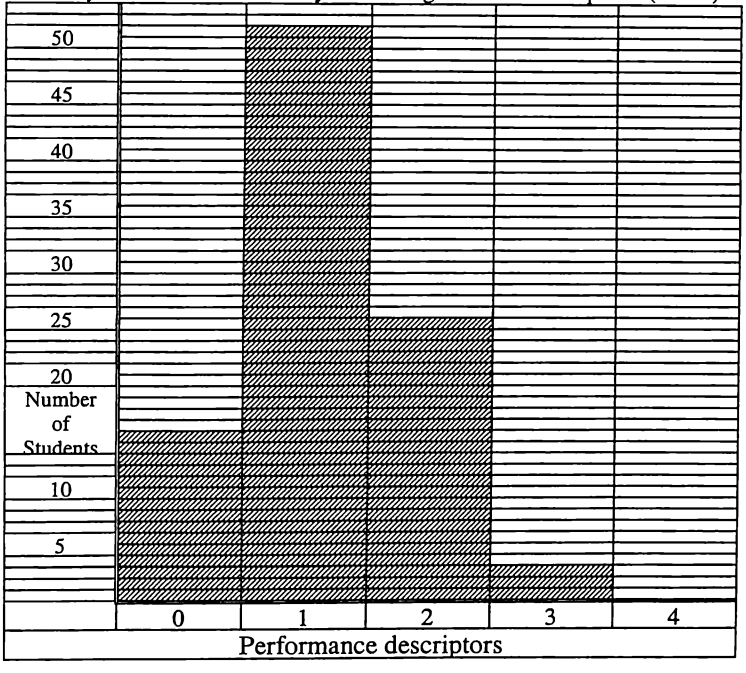
Fifty-four percent of the students suggested appropriate skills in preparing materials and building the products, and knowledge of appropriate materials needed for the products. Seventeen percent suggested skills in using tools to make the product. Seventeen percent mentioned measurement skills and 9% mentioned planning skills. Thirteen percent mentioned no skills or knowledge. The following set of performance descriptors were used to describe the ability of students to identify knowledge and skills required for building the products.

TABLE 6.3.8b
Performance Descriptors for Identifying Knowledge and Skills

	Performance Descriptors
4	Student identifies sufficient skills and knowledge required for the task
3	Student identifies a good number of skills and knowledge required for the task
2	Student identifies a fair number of skills and knowledge required for the task
1	Student identifies a limited number of skills and knowledge required for the task
0	Student cannot identify any of the skills and knowledge required for the task

Graph 6.3.8 shows the ability of students to identify important knowledge and skills required for making the product.

GRAPH 6.3.8
Ability of Students to Identify Knowledge and Skills Required (N=94)



Seventy percent of the students identified only a limited number of skills and knowledge required for building the products. These skills, as shown above, were mainly related to the actual putting together of the product. Only 3% were able to

identify a satisfactory number of appropriate skills and knowledge required for building the products.

Since the factors the students identified that would influence the making of the products were only superficial ones, they found it difficult to consider skills and knowledge they might require to build the products.

6.4 TECHNOLOGICAL CAPABILITY C: PLANNING THE PRODUCTION OF THE SOLUTION

This section reports on the performances of the students in the activities that assessed their ability to plan the production of the solutions they had identified in Section 6.3. Eight assessment criteria were written to cover the main aspects of this technological capability. The results will be presented in the order of the assessment criteria.

6.4.1 The Appropriateness of the Characteristics of the Product Planned by the Students to the Needs and Opportunities Identified

At this stage, the students were expected to be able to describe the characteristics of the products they were planning to make which would satisfy the needs and opportunities they had identified. The results showed that the ability of students to describe the characteristics of the products which would make them appropriate to the needs and opportunities identified was not good. The students' answers are reported in Table 6.4.1a.

TABLE 6.4.1a.
Percentages of Students Giving Each Characteristic (n=94)

	Characteristics described by students	%
1	A general statement about the type of product to be made -	41
2	A general statement about the type with a little detail on materials needed to make the product ----------	32
3	General statement on the type and characteristics with more details on the materials and method of making the product -	27

Twenty-seven percent of the students described the materials needed for the products, the methods of making them and the characteristics that the products were going to have. Seventy-three percent concentrated mainly on describing the types of

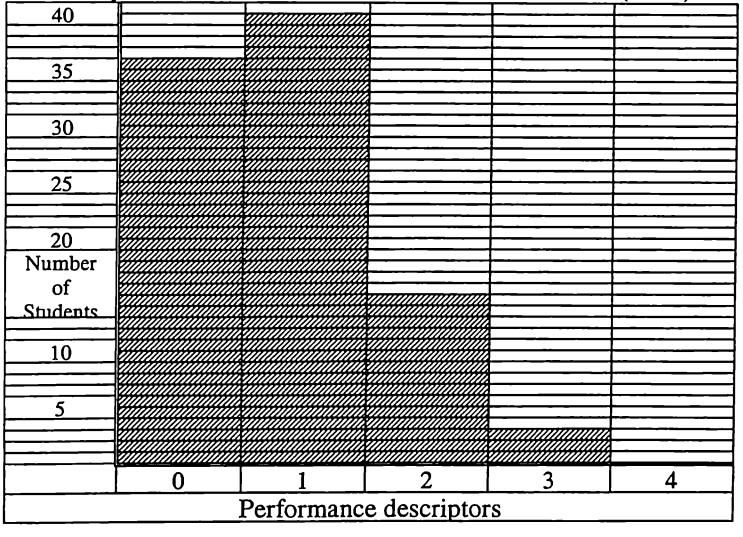
products they were going to make. The students were not specific with the characteristics of the products they were planning to make and very small reference was made regarding the needs and opportunities they were attempting to solve. The relationship of the details of the characteristics described by the students and the solutions they obtained in Section 6.3 was limited. Table 6.4.1b presents the set of performance descriptors that were used to describe the ability of students to describe the characteristics of the products that were appropriate to the needs and opportunities they had earlier identified.

TABLE 6.4.1b
Performance Descriptors for the Ability to Describe the Appropriate Characteristics of Products

	Performance Descriptors
4	Characteristics described are appropriate to all needs and opportunities identified.
3	Characteristics described are appropriate to almost all identified needs and opportunities.
2	Characteristics described are appropriate to a fair number of needs and opportunities identified.
1	Characteristics described are appropriate to a limited number of needs and opportunities identified.
0	Characteristics described are not appropriate to the needs and opportunities identified.

Graph 6.4.1 shows the appropriateness of the characteristics of the products described by the students to the respective needs and opportunities they had identified earlier on.

GRAPH 6.4.1
Ability of Students to Describe Characteristics of Product (N=94)



Characteristics described by 38% of the students were not related to the information they had collected on needs and opportunities. Another 42% percent of the students described characteristics that were hardly appropriate to the needs and opportunities

identified. Only 19% of the students described characteristics that were appropriate to only a fair number of the needs and opportunities they had identified earlier. Very few students seemed to be able to follow on from the results of the previous stages, which exposes students' inability to connect the stages of technological capability together.

6.4.2 The Ability of Students to use Drawing or Explanation to Produce an Appropriate Plan of the Product with Proper Labels and Scales

The plans of the products prepared by the students were very general and lacked appropriate details, labels and scales. The students' answers are reported in Table 6.4.2a.

TABLE 6.4.2a.
Percentages of Students with Types of Plans Prepared

	Characteristics of students' plans of products to be made	%
1	A very rough sketch of the whole product with no labels and no scales ------	22
2	All ingredients needed are named. Amounts needed not given. Brief on the cooking method and cooking time not given----------	16
3	Good sketch of the whole product with no labels and no scales ----------	14
4	Good sketch of the whole product with labels given but no scales ----------	11
5	Very rough sketch of the whole product with labels but no scales ----------	5
6	Rough sketch of the whole product and parts with labels but no scales ------	5
7	Good sketch of the whole product and parts but no labels and no scales ----	5
8	Rough sketch of the whole product with labels but no scales ----------	5
9	Rough sketch of the whole product but no labels and no scales ----------	5
10	Rough sketch of the whole product and parts but no labels and no scales ---	3
11	Good sketch of the whole product and parts with labels and no scales -------	3
12	All ingredients needed are named. Amounts needed are given. Brief on the cooking method and cooking time not given----------	3
13	All ingredients needed are named. Amounts needed not given. Good description of the cooking method and cooking time not given----------	3

For all of the plans drawn by the students (74), none of them had a scale or any mention of the size of the actual product. Forty-five percent of these plans had labels while the other 55% did not. For the twenty students who prepared recipes, only two of them gave the amounts of ingredients needed while the other eighteen did not. They provided only brief and unclear explanations of cooking methods. Fifty-nine percent of the plans drawn were either rough or very rough.

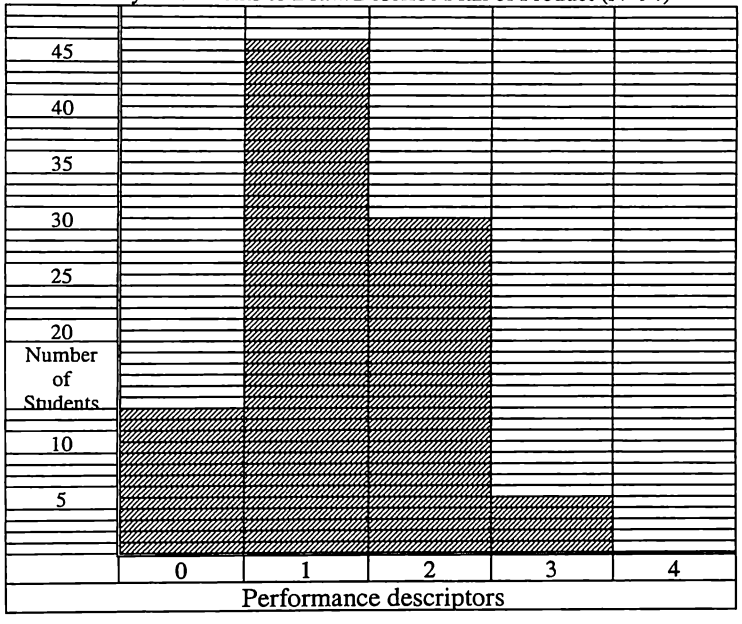
Table 6. 4.2b presents the set of performance descriptors that were used to describe the ability of students to draw or explain a plan of the product.

TABLE 6. 4.2b
Performance Descriptors for Drawing or Explaining Plan of Product

	Performance Descriptors
4	Student uses drawing (or explanation for students who made food) to produce a good plan (or recipe) of the product, with suitable scales and labels (or ingredients and amounts).
3	Student produces a good plan (or recipe) with suitable labels (or names of ingredients).
2	Student produces a poor plan (or recipe) with suitable labels (or names of ingredients).
1	Student produces a poor plan (or recipe) with no labels (or names of ingredients).
0	Student produces an extremely rough plan (or recipe) with no labels (or names of ingredients).

Graph 6.4.2 shows the ability of students to prepare plans of the products they were going to make.

GRAPH 6.4.2
Ability of Students to Draw/Describe Plan of Product (N=94)



Only 5% of the plans and recipes were properly done, giving labels and details of the products they were going to make. Thirty-two percent of the students produced plans that had suitable labels and showed what they were planning to make, but they were roughly prepared. Forty-nine percent produced plans that were roughly made and had no labels, showing very little information on what they were intending to make. The remaining 14% produced plans that were extremely rough and also had no labels. Planning skills were found to be very limited, and it was also observed that planning was not an important part of the students' usual practical project work in Form 4 Industrial Arts and Home Economics courses in Tonga.

6.4.3 The Ability of Students to Ascertain Materials and Tools Needed for the Task

The students did not find it difficult to describe the basic materials and tools required for the tasks they were planning to carry out. However, all the students failed to include some of the materials and tools they required. The students' answers are reported in Table 6.4.3a.

TABLE 6.4.3a.
Percentages of Students Giving Each Description (n=94)

	Materials and tools needed for the task	%
1	Many but not all of materials and tools needed ----------	61
2	Small number of materials and tools needed ----------	11
3	Tools only ----------	11
4	Materials only --------- ----------	11
5	Materials together with descriptions of their characteristics -----	3
6	Meaningless answer ----------	3

Sixty-one percent of the students were able to name most of the materials and tools needed for their tasks. Seventy-three percent of the students did not include a measuring instrument in the tools required. None of the students listed the complete set of tools required for the tasks. Table 6.4.3b presents the set of performance descriptors that were used to describe the ability of students to describe the materials and tools required for building the products.

TABLE 6.4.3b
Performance Descriptors for Describing Tools and Materials Required

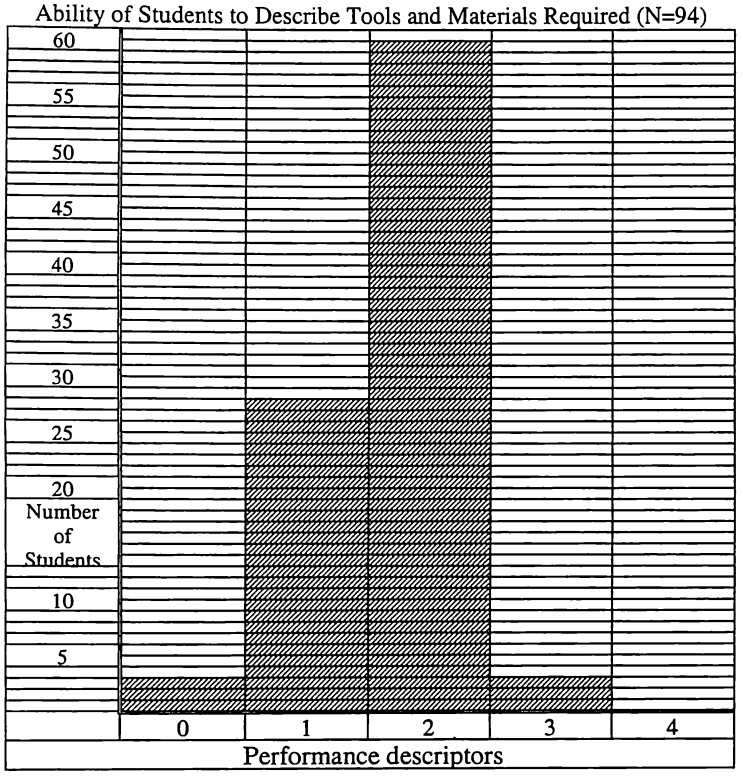
	Performance Descriptors
4	Student lists all tools and materials together with quantities required for the task.
3	Student lists all tools and materials but not with appropriate quantities.
2	Student lists most of tools and materials but not with appropriate quantities.
1	Student lists half of the materials or half of the tools but not with appropriate quantities.
0	Student does not know the right tools and materials needed for the task.

Graph 6.4.3 shows the ability of students to identify materials (with appropriate quantities) and tools required for their respective tasks.

From the graph, 64% of the students knew most of the materials and tools required for their respective tasks and another 3% gave an almost complete list of the materials and tools needed for their tasks. The students concentrated from the

beginning on the materials and the method regarding the building of the product they were working on.

GRAPH 6.4.3
Ability of Students to Describe Tools and Materials Required (N=94)



An important result is that none of the students gave the amount of materials needed for the product. This reflects the nature of the practical classroom work they were accustomed to, in which the students were provided with all the materials they needed and were required almost entirely to do only the final finishing work to the products.

6.4.4 The Ability of Students to Identify the Measurements Needed

Although the answers given by the students were general, most of them (81%) were able to name some of the measurements to be made in building their products. The students' answers are reported in Table 6.4.4a.

TABLE 6.4.4a.
Percentages of Students Giving Things to be Measured (n=94)

	Measurements to be made	%
1	Lengths (amounts) of some of the parts (ingredients) of the product ---	62
2	None to be measured ----------	19
3	Size of the product ----------	14
4	Lengths (amounts) of all parts (ingredients) of the product ---------	5

Eighty-one percent of the students mentioned lengths and sizes of the products. This was different to the results in Section 6.4.2, in which all of the plans drawn by the students had neither scale nor any mention of the sizes of the actual products.
The links between the performances of students in the stages of the project was weak.

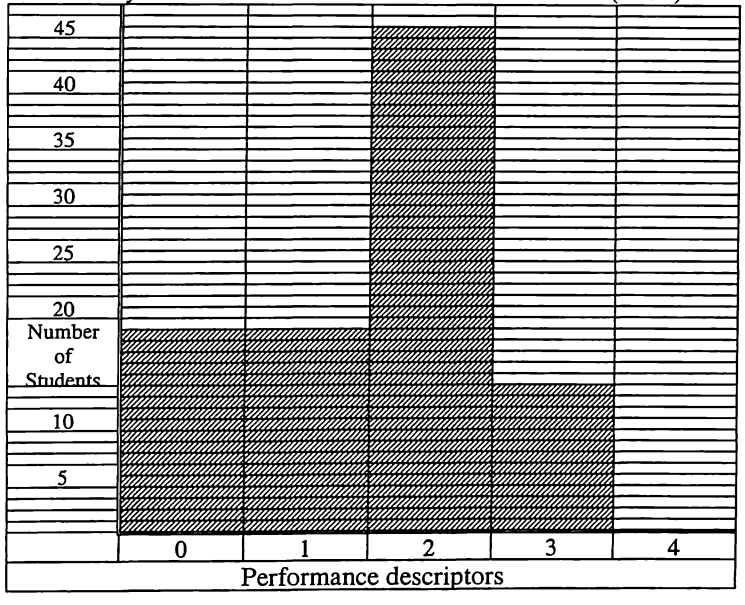
Table 6.4.4b presents the set of performance descriptors that were used to describe the ability of students to describe measurements to be made.

TABLE 6. 4.4b
Performance Descriptors for Describing Measurements to Make

	Performance Descriptors
4	Student identifies all the things that needed to be measured.
3	Student identifies almost all the things that needed to be measured.
2	Student identifies half of the things that needed to be measured.
1	Student identifies one or two of the things that needed to be measured.
0	Student identifies non of the things that needed to be measured.

Graph 6.4.4 shows the ability of the students to identify the things that needed to be measured in making the products they were planning.

GRAPH 6.4.4
Ability of Students to Describe Measurements to Make (N=94)



Fourteen percent of the students identified almost all of the things that needed to be measured in making the products they were planning. Another 67% identified some measurements to be made in building the products they were planning. These results

were contrary to that of Section 6.4.3, in which 73% of the students did not include measuring instruments in their lists of tools required for making the products. These results once again show the atomistic nature with which the students approached the whole project.

6.4.5 The Ability of Students to Determine the Expenses Involved in Making the Products

The expenses that students described to be involved in making the products were limited mainly to the materials they required. The students' answers are reported in Table 6.4.5a.

TABLE 6.4.5a.
Percentages of Students Describing Expenses (n=94)

	Expenses expected by students	%
1	List some of the materials needed but no prices ---------	35
2	List most of the materials but without prices ----------	19
3	No expenses expected ----------	11
4	Almost all materials needed with prices ----------	11
5	A general approximation of total expenses ----------	8
6	Part of materials and tools needed with their prices -----	5
7	Part of materials and tools needed with no prices -------	5
8	All materials and tools ----------	3
9	No answer ----------	3

Seventy-eight percent of the students mentioned materials needed in the expenses they expected in their projects. Only 13% mentioned tools. None of the students mentioned labour, transport, communication, electricity or any of the expenses that usually accompany good quality practical projects. In fact, all of the students who mentioned 'no expenses' commented that they expected to obtain the materials they needed from their homes or from the bush. These students expected no other expenses apart from the materials they needed.

This was similar to the expectations that students had in carrying out project work in a subject called 'Tongan Craft'. The students were expected to use the local materials to make one Tongan traditional artifact. These projects lacked the urge to search for new ways and new materials for building better products.

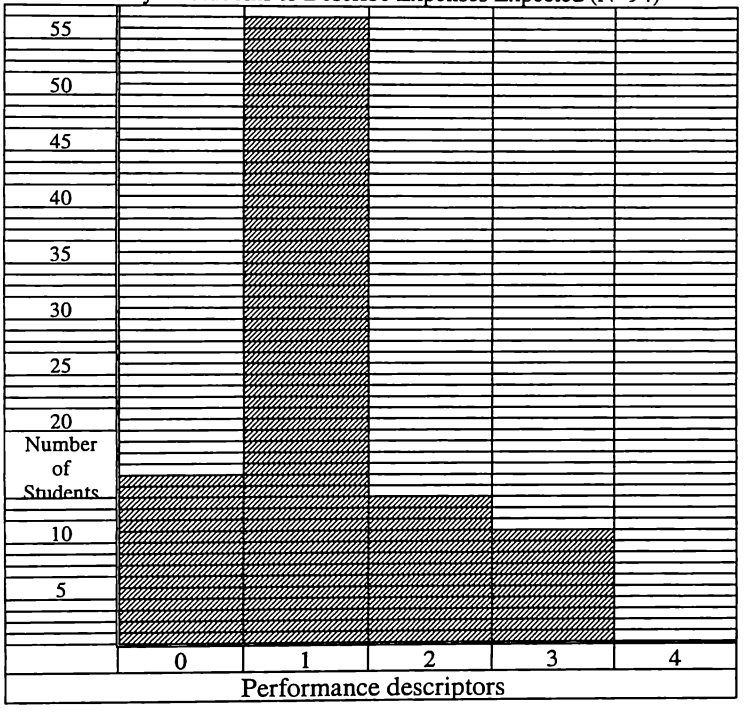
Table 6.4.5b presents the set of performance descriptors that were used to describe the ability of students to describe the expenses involved.

TABLE 6. 4.5b
Performance Descriptors for the Ability to Describe Expenses Expected

	Performance Descriptors
4	Student describes all costs of the materials and expenses involved.
3	Student describes most of the materials to be bought together with their prices.
2	Student describes most of the materials to be bought but without their prices.
1	Student describes one or two of the materials to be bought but without their prices.
0	Student cannot describe costs and expenses involved.

Graph 6.4.5 shows the ability of students to identify the expenses involved in producing the products they were planning to make.

GRAPH 6.4.5
Ability of Students to Describe Expenses Expected (N=94)



Sixty percent of the students were able to name one or two of the materials that needed to be bought for making their products but did not give their prices. Another 13.8% were able to name most of the materials needed for the products but again did not give their prices. Sixteen percent were not able to identify any of the expenses involved in carrying out their tasks. Altogether, 89% of the students did not give the costs of producing their products. The teachers involved explained that the students had never been expected to estimate the overall cost of carrying out a practical project in the Industrial Arts and Home Economic classrooms. They concentrated mainly on building the products.

6.4.6 The Ability of Students to Describe the Appropriate Steps Involved

The students were able to describe only the main parts of the work they were planning to do. The students' answers are reported in Table 6.4.6a.

TABLE 6.4.6a.
Percentages of Students Giving Each Description (n=94)

	Steps in carrying out the task	%
1	Obtain parts required, prepare the parts and put them together making the product ---	38
2	Prepare the parts required, put them together making the product and apply finishing	16
3	Measure parts required, put them together making the product ----------	8
4	Obtain materials needed, measure and cut parts, put them together making the product ----------	8
5	Draw plan, prepare parts, put them together making the product & apply finishing --	5
6	Prepare parts required, put them together making the product ----------	5
7	Prepare parts required, put them together making the product and wrap ----------	5
8	Measure and cut materials, put them together making the product, apply finishing ---	3
9	Obtain tools and materials required, measure and cut, put together making the product and apply finishing ----------	3
10	Buy materials and tools needed, draw plan and make the product ----------	3
11	Description of how to put the parts of the product together ----------	3
12	Description of how to prepare materials needed for the product ----------	3

Forty-nine percent of the students started with obtaining materials and tools needed for the tasks. Twenty-six percent started with preparation of parts. Only 3% started with buying materials, although in Section 6.4.5, 76% of the students included materials in their lists of expenses. Twenty-two percent of the students included measurements as part of the steps in carrying out the tasks they were planning. This differed from the results in Section 6.4.4, in which 81% of the students mentioned some measurements to be made. Again, these results suggest that the links between the sections of the whole project were weak.

Only 8% of the students mentioned planning and none mentioned evaluation or assistance of experts. The main steps of a project in a traditional technical subject do not include planning, evaluation and expert assistance.

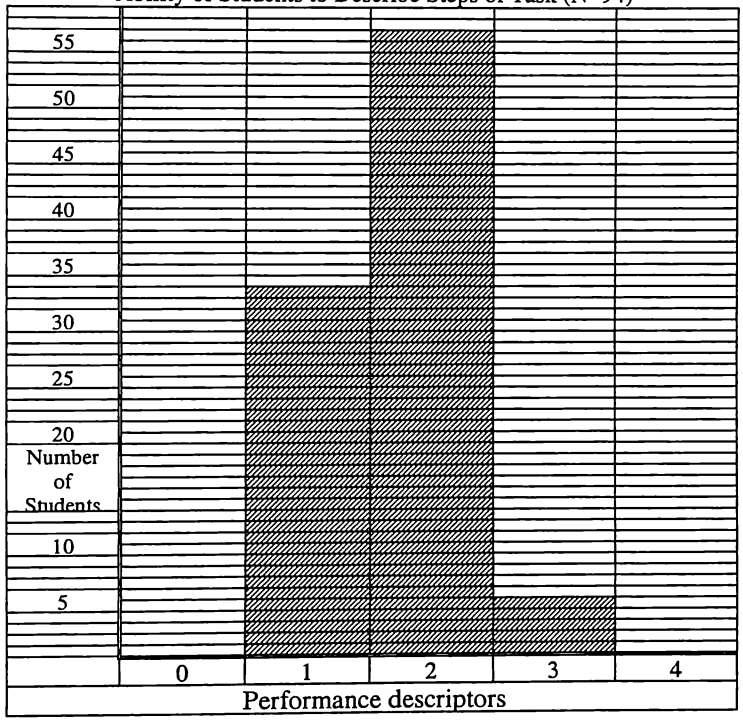
Table 6.4.6b presents the set of performance descriptors that were used to describe the performance of students in explaining the appropriate steps involved in the task.

TABLE 6. 4.6b
Performance Descriptors for the Ability to Describe the Steps involved in Task

	Performance Descriptors
4	Student fully describes in order the steps in carrying out the task.
3	Student describes in order most of the steps involved in carrying out the task.
2	Student describes half of the steps involved in carrying out the task.
1	Student gives one or two of the steps involved in carrying the task.
0	Student cannot describe the steps in carrying out the task.

Graph 6.4.6 shows the ability of the students to describe the steps in carrying out the tasks they were planning.

GRAPH 6.4.6
Ability of Students to Describe Steps of Task (N=94)



Most of the students (60%) were able to name only about half of the steps involved in the tasks they were planning to do and 35% had difficulty in describing these steps. Only 5% were able to describe the details of the steps involved. It was difficult for these students to view the details of the total picture of the work they were planning to do.

6.4.7 The Ability of Students to Identify the Dangers Involved in Carrying out the Tasks

The students did not analyse the situations carefully enough for them to identify the details of the dangers involved in carrying out the tasks they were planning. The students' answers are reported in Table 6.4.7a.

TABLE 6.4.7a.
Percentages of Dangers Involved Described by Students (n=94)

	Dangers involved in carrying out the task	%
1	Using tools	34
2	No dangers expected	12
3	No answer	12
4	Obtaining materials	10
5	Breaking parts while making the product	10
6	Not knowing the right method of using tools	10
7	Careless use of tools	7
8	Meaningless answer	5

Fifty-one percent of the answers mentioned using of tools as a source of danger in carrying out the tasks they were planning. Twelve percent decided there was no danger involved in their tasks, another 12% did not answer the question and 5% of the answers were meaningless. Ten percent of the answers identified climbing coconut trees as one of the dangerous tasks involved and 7% identified carelessness.

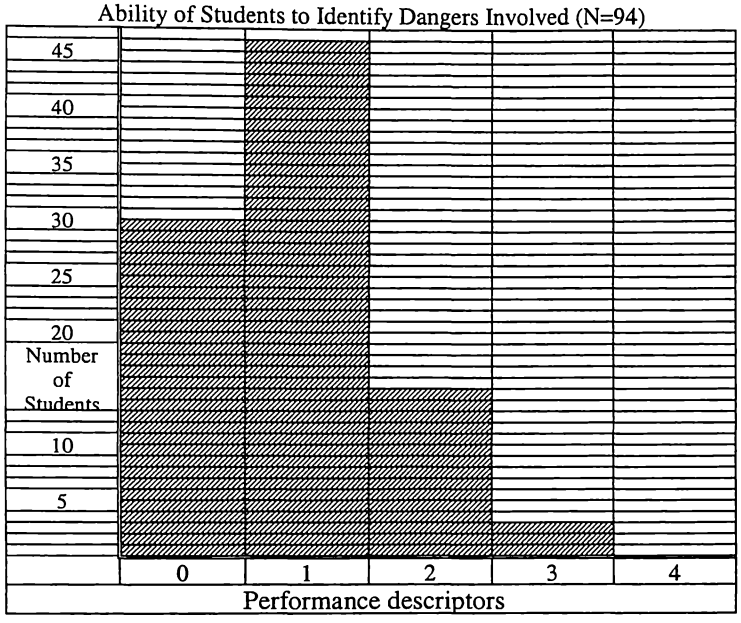
Table 6. 4.7b presents the set of performance descriptors that were used to describe the ability of students to identify dangers involved in producing the product.

TABLE 6. 4.7b
Performance Descriptors for Identifying Dangers Involved

	Performance Descriptors
4	The student can identify all of the possible dangers involved in carrying out the task.
3	The student can identify almost all of the possible dangers involved in carrying out the task.
2	The student can identify half of the possible dangers involved in carrying out the task.
1	The student identifies a limited number of the possible dangers involved in carrying out the task.
0	The student cannot identify any of the possible dangers involved in carrying out the task.

Graph 6.4.7 shows the ability of students to identify the dangers involved in carrying out the tasks they were planning.

GRAPH 6.4.7
Ability of Students to Identify Dangers Involved (N=94)



Thirty-two percent of the students were not able to identify any of the possible dangers involved in carrying out the tasks they were planning and 48.9% identified only a limited number of the possible dangers involved. Three percent were able to identify almost all of the possible dangers.

6.4.8 The Ability of Students to Identify the Assistance Needed from an Expert

Most of the students expected the experts or older people only to show them how to build their products. They did not expect them to carry out any of the work in building their products. The students' answers are reported in Table 6.4.8a.

TABLE 6.4.8a.
Percentages of Students Giving Each Description (n=94)

	Assistance needed from an expert	%
1	Show or teach students how to make the product ----------	30
2	Needed to help do a particular task a student cannot do ----------	27
3	Help to improve the product ----------	11
4	Do the main tasks in preparing materials and making the product -	8
5	Give advice in selecting the right materials for the product --------	5
6	Give advice and carry out a particularly difficult task ----------	5
7	General description of what the expert can do ----------	3
8	No help needed from an expert ----------	3
9	To show the technology of the product ----------	3
10	To teach students how to use the tools ----------	3
11	The teacher will help and no need for an expert ----------	3

Twenty percent of the students identified the difficult tasks that required the help of experts. Forty-seven percent expected the experts to only show or teach them how to make the products and not actually carry out the difficult tasks. Sixty-five percent

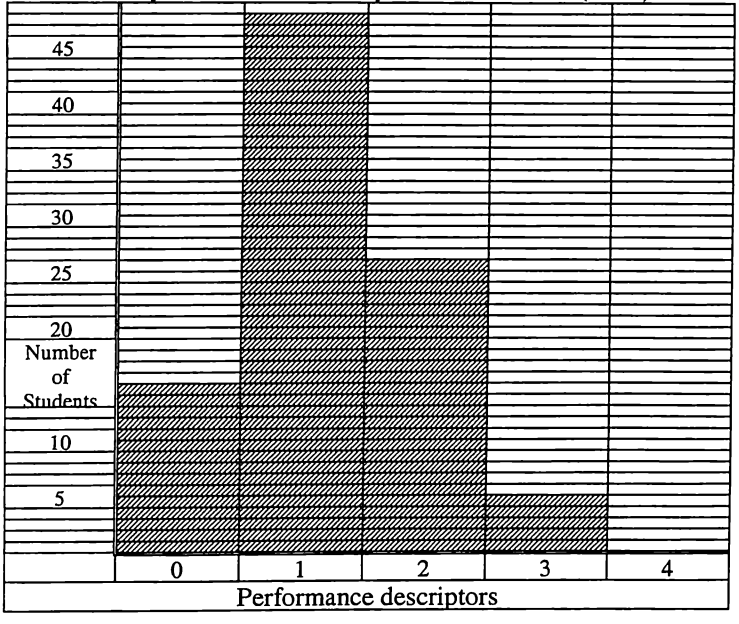
did not expect the experts to carry out any of the tasks involved. They planned to do all the work by themselves. This is a normal expectation in an Industrial Arts or Home Economics piece of practical activity. The students are expected to do all the work in making the products they are required to make. Only 11% mentioned improving the product. The idea of students' actually making the product was more important than the quality of the products the students made. Therefore the quality of the products they made was only as good as the technical skills the students possessed. Thus, satisfying needs and opportunities, the purpose of the project, was not the guiding factor in students' approach. Table 6. 4.8b presents the set of performance descriptors that were used to describe the ability of students to identify assistance needed from experts.

TABLE 6. 4.8b
Performance Descriptors for the Ability to Identify Assistance Needed

	Performance Descriptors
4	The student identifies all the tasks that could best be carried out by an expert.
3	Student explains some of the tasks to be carried out by an expert.
2	Student expects the expert to show or teach them how to make the product.
1	Student is not clear of the tasks to be carried out by an expert.
0	Student cannot see the need for obtaining assistance of experts.

Graph 6.4.8 shows the ability of students to identify the assistance that experts can provide in carrying out the tasks they were planning.

GRAPH 6.4.8
Ability of Students to Identify Assistance Needed (N=94)



Many of the students (67%) were not clear on the tasks to be carried out by experts. These students understood only that they were expected to do all the work in building the product, as they had often been required to do in their normal practical work. Only a very small proportion of the students (5%) stated the sort of tasks that experts should be asked to do in order to build products with appropriate characteristics to the needs and opportunities they had identified earlier.

6.5 SUMMARY OF RESULTS

This section presents the summary of the findings on the performances of students in the planning stages of the technological task. The students performed poorly at these stages. They had not done any work prior to this study on identifying needs and opportunities in a given situation, searching for the best possible solution and planning of production of the solution. However, a very few students were able to follow the guidance provided in the worksheets and performed relatively well. The presentation of the summary will follow the order in which the results were presented.

6.5.1 Identifying needs and Opportunities

The type of questions asked by most of the students (61%) was about the types of materials needed, the properties of the products to be made and the methods of making them. Nine percent of the students did not ask questions but only made statements, explaining the materials needed to make the product, problems and how the product should be made. A very small proportion of the students (2%) asked questions regarding the experts in the field. Only sixteen percent of the students asked about changes and improvements required and about problems of the existing products. No questions were asked about the context of the products, users and time.

The factor mentioned by the highest percentage of the students (40%) was about the properties of the materials available for building the product. Overall, 81% of the students talked about the properties, materials and methods of making the products. Only 19% of the students mentioned the needs of the users, money, tools, time, problems that the product might cause and Tongan culture.

In planning an investigation to collect information on problems, needs and opportunities relating to the products they were going to make, 18% of the answers were not about investigation but were descriptions of materials needed for the products to be made. Another 25% of the answers, although they described investigations to be carried out, were only aimed at finding out methods and materials for making the products. In describing methods of data collection, 71% of the students suggested 'questioning' people. Sixty-two percent of the students described their plans in one or two sentences and in a very general manner. Aims, method of data collection, sources of information, amount and type of information required and method of data analysis were poorly described. The students lacked the appropriate knowledge and skills in planning and carrying out research work in a technological task.

Examining the sources of information the students consulted while searching for information on needs and opportunities, 24% of the students consulted mainly makers and users. Fourteen percent of the students discussed their research questions with members of family. No one consulted existing products, new technology, books and scientific discoveries. Thirty-two percent of the students did not do any research.

In searching for information on needs and opportunities, 32% of the students did not do any research. Another 54% only collected information about the materials that should be used to make the product, the properties the product should have and how the products should be made. Fourteen percent collected information concerning the problems of products, but went on to describe how they should be solved. Only 8% of the students collected information on problems and needs. No data was collected regarding time and context.

When the students were asked to identify needs and opportunities from the information they had collected, all of the students missed the main purpose of this activity. None of them seemed to understand that they were required to identify only the information on needs and opportunities that existed in the data they had collected. Forty-eight percent of the students described new points that were not in

the information they had collected. The relationship between the data collected and needs and opportunities discussed by students was very limited.

Observing the types of needs and opportunities that students identified, it was found that only 16% of those needs and opportunities were related to the functional properties of the products. The rest (84%) only related to the physical properties of the products. In other words, the needs and opportunities that the students identified were only superficial. They were not able to identify the intrinsic needs and opportunities in the given situation.

6.5.2 Searching for the Best Solution of Identified Needs and Opportunities

When the students were asked to describe who, where, why, when and how the product will be used, many of the students (53%) were not able to give specific answers. Forty-six percent were able to describe only why their products would be needed and how their products would be used. The students concentrated more on building the products rather than making decisions on the purposes of their products.

In describing the characteristics that their products should have in order to solve the needs and opportunities they had identified, 33% of the students provided answers that were only descriptions of the properties of the products to be made. Another 28% described the materials needed for the products. These students were ready to build their products at this stage. They had made up their minds on what materials they wanted for their products and how they were going to make them. The relationship between these answers and needs and opportunities identified earlier was weak.

When the students were asked to plan an investigation to collect information on solutions to the identified needs and opportunities, 38% of the students did not plan for an investigation and 35% suggested asking people about the materials or the method for making the product. Time and the amount of information needed were not planned for and no one showed an intention to carry out tests to identify the best solutions.

In carrying out their investigations, 22% did not do research. Fifty-three percent of the students obtained information only from makers and users. Eleven percent obtained information only from home and only 5% consulted existing products. Library, books and new technology were not consulted. Twenty percent of the students did no research.

Examining the types of information the students collected, 67% of the students described the products to be made and the materials needed for the products. Thirty percent gave information not relevant to the needs and opportunities identified.

When the students were asked to describe the best solutions from the information they had collected, 75% came up with new information not included in their data.

When the students were asked to identify the factors that would influence building of the products, 51% of the students mentioned only the properties of the materials available. Only 14% mentioned tools, 19% mentioned skills in building, 8% mentioned money and 3% mentioned time.

When the students were asked to identify knowledge and skills required for building the products, the answers they gave lacked details. They did not give the specific skills required in the situations they were working in. Further, the answers concentrated mainly on the skills related to the actual building of the products. The skills related to costing, planning, measurement and using tools were mentioned by very few students. Fifty-four percent of the students suggested appropriate skills in preparing materials and building the products, and knowledge of appropriate materials required. Seventeen percent suggested skills in using tools to make the product. Seventeen percent mentioned measurement skills and 9% mentioned planning skills. Thirteen percent were not skills or knowledge.

9.3.3 Planning the Production of Solution

When the students were asked to describe the characteristics of the products they were planning to make, 27% included the materials needed in their description. Seventy-three percent gave a general description of the types of products they were

going to make. Eighty-one percent of the students gave some descriptions that were not consistent with the information they had collected earlier.

When the students were asked to make a plan, design or recipe of the products they were going to make, none of the plans drawn had scale or any mention of the size of the actual products. Forty-five percent gave labels to their diagrams. For the twenty students who prepared recipes, only two gave the amounts of the ingredients needed. Explanations of cooking methods were very brief and unclear. Forty-nine percent of the plans drawn were either rough or very rough. Eighty-six percent of the drawings used pencils. Only 5% of the students prepared well-drawn plans, giving labels and details of the products they were going to make.

When the students were asked to describe the materials and tools needed for the project, all of the students missed out one or two of the items required. However, 61% were able to name most of the materials and tools needed. Seventy-three percent of the students did not include a measuring instrument and none gave the amount of materials needed.

When they were asked to describe the measurements needed to be made, 81% of the students were able to identify some measurements to be made while 19 % could not identify any.

For the question about the expenses involved, 78% of students mentioned materials needed. Only 13% mentioned tools. None of the students mentioned labour, transport, communication, electricity or any of the expenses that usually accompany good quality practical projects. In fact, all the students who mentioned 'no expenses' commented that they expected to obtain the materials they needed from their homes or from the bush.

In writing the steps they were going to follow in producing the product, only 22% of the students included measurements, although 76% had earlier identified some measurements to be carried out. Three percent included buying materials although 73% had named some materials or tools that needed to be bought earlier on. Five percent planned to start with drawing a plan, 83% opted to start with obtaining

materials and tools needed. No student mentioned evaluation or assistance of experts. Sixty-four percent of the steps described by students were not complete.

When the students were asked to describe the dangers that they would expect to encounter in their work, 81% had problems identifying the dangers involved and only 3% identified almost all of the possible dangers. Fifty-one percent of the dangers identified were about using tools and those related to obtaining the materials needed. Seven percent identified carelessness.

Asking about the assistance they might need from experts or from older members of the society, 20% of the students identified the difficult tasks that needed help from experts. Forty-seven percent expected the experts to only show or teach them how to make the products and not to actually carry out the difficult tasks. Sixty-five percent did not expect the experts to carry out any of the tasks involved. They planned to do all the work by themselves.

This chapter has presented the results of the assessment of the first three of the six components of students' technological capability that were assessed in this study. These components are related to the planning of the solution (product) to be built. The next chapter will present the results of the assessment of the rest of the components of students' technological capability.

CHAPTER SEVEN

THE EXISTING TECHNOLOGICAL CAPABILITY OF STUDENTS: PRODUCTION, PRESENTATION AND EVALUATION

7.1 INTRODUCTION

Chapter 6 described the results of the assessment of three components of students' technological capability that relate to planning the product to be built. This chapter describes the results of the assessment of students' technological capability that are related to making, presenting and evaluating the solution (product). The students were given two weeks to build the products they had been planning, while the teachers and the researcher observed them throughout the building process. The students were asked at the completion of their products to present them to the remainder of the class. These were tape-recorded by the researcher. The students were also required to evaluate the methods they used as they proceeded through the task and to evaluate the final products when they were completed. The remainder of this chapter reports students' performances on:

- Building the Solution;
- Presentation and Promotion of Ideas, Design and Solution; and
- Evaluation of Progress, Process and Solution.

7.2 BUILDING THE SOLUTION

This section reports the results of the performances of students in the activities that assessed their ability to build the solutions they had planned to satisfy needs and opportunities identified. Seven assessment criteria were written to cover the main aspects of this technological capability. The results will be presented in the order of the assessment criteria.

7.2.1 Using Appropriate Instruments to do Measurement

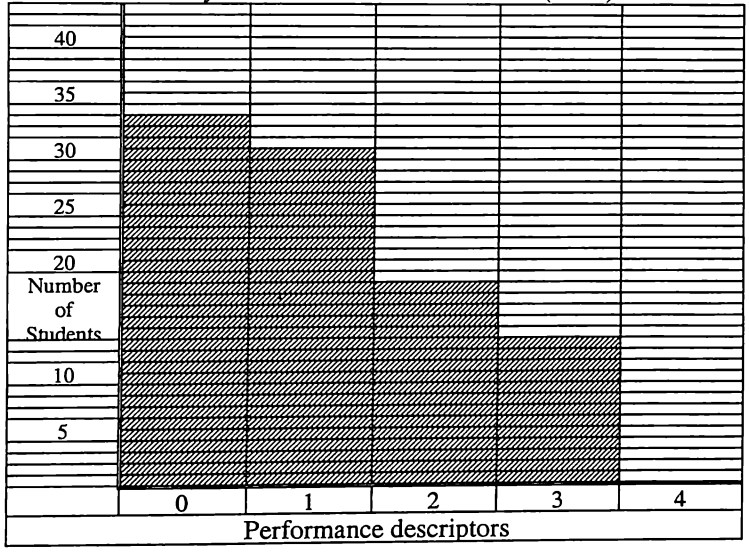
The ability of students to use appropriate instruments to accurately measure required quantities was limited. Most of the students (67%) did not do any measurement, and those who carried out the measurements (19%) did not use the proper instruments. The set of performance descriptors developed to describe the ability of students to do measurement is in Table 7.2.1.

TABLE 7. 2.1
Performance Descriptors for Students' Ability to do Measurement

	Performance Descriptors
4	The student uses appropriate instruments to accurately measure all required quantities.
3	The student uses appropriate instruments to accurately measure some of the required quantities.
2	The student can use only some of instruments to measure some of the required quantities.
1	The student has problems with measuring quantities required.
0	The student does not measure required quantities.

The ability of students to do measurement is shown on Graph 7.2.1.

GRAPH 7.2.1
Ability of Students to do Measurements (N=94)



Thirty-five percent of the students did not record any measurements made or any of the quantities required, in the list of the tasks they carried out. Another 32% recorded only the quantities they required but made no measurement. Only 33% of the students were observed to be making some measurements. However, 19% did not use the proper instruments and only14% used the proper instruments to measure some of the quantities required.

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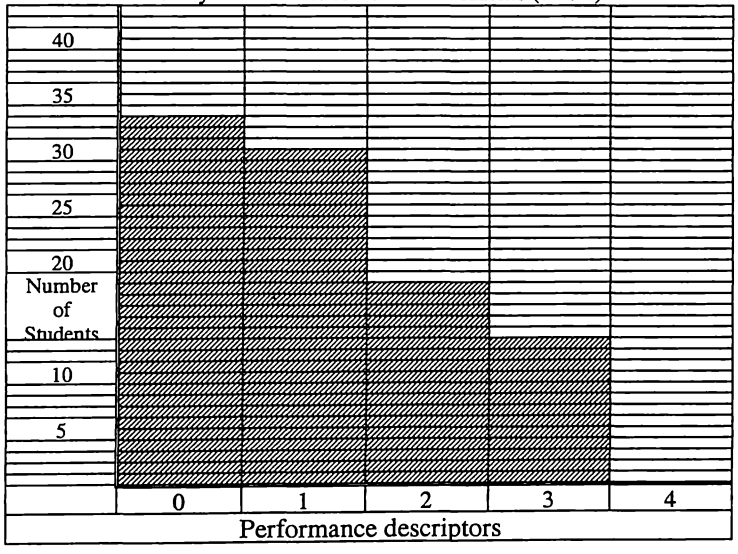


Thirty-five percent of the students did not record any measurements made or any of the quantities required, in the list of the tasks they carried out. Another 32% recorded only the quantities they required but made no measurement. Only 33% of the students were observed to be making some measurements. However, 19% did not use the proper instruments and only14% used the proper instruments to measure some of the quantities required.

In Section 6.4.4, the students were asked to describe the measurements they expected to make in building their products. Eighty-one percent of the students were able to identify at least one measurement to be made. However, in this section, only 33% of the students made some measurements. These results revealed that the students failed to link the stages of the task together. They were not able to view the project holistically. The links between the performances of students in the stages of the project were weak.

It is also important to mention here that the difference between the performances of the groups is evident in this section. All the students (14%) who used the proper instruments to do measurements were from the Industrial Arts Class. Most of them from a group that was building kava-drinking seats, which was technically the most difficult of the tasks. It seemed that measurements were taken only when the students felt it was necessary. For example, the parts of a kava-drinking seat had to fit precisely together, which the students were well aware of, and that was why measurements were taken. On the other hand, the parts of a broom or a fan did not require that same degree of precision in lengths and sizes. Good fans and brooms are made in homes with lengths and sizes of parts not precisely measured. However, lengths of parts are precisely measured when the purposes of the fans and brooms are important. For example, when they are made for particular people or occasions.

Therefore the way in which the students made the products in this project showed that they were not for particular people, occasions or according to pre-prepared plans. They were just making products, like they usually do in their practical work in these technical subjects. So, although the students were required to carry out the planning stages for building the products, very little of the plans were included in the actual building of the products. This once again shows the weakness of the links between the stages of the project.

7.2.2 Using Appropriate Tools to Build Product

The students were able to use many of the appropriate tools in building the products. The teachers only helped them with the more sophisticated power tools to do the difficult parts of the work. However, although the students needed help of teachers,

their performance in this section was generally better than their performances in the earlier stages of the project.

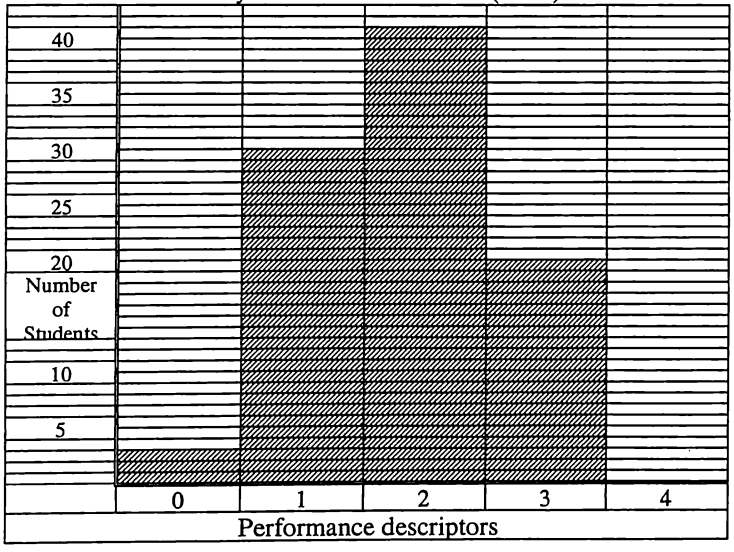
Table 7.2.2 presents the set of performance descriptors that was used to describe the ability of students to use appropriate tools to build the products.

TABLE 7.2.2
Performance Descriptors for the Ability of Students to use Tools

	Performance Descriptors
4	The student is competent in using all the appropriate tools to carry out the work required.
3	The student can use almost all of the appropriate tools to carry out the work required.
2	The student is skillful in using only some of the appropriate tools to carry out the work required.
1	The student has problems in using the appropriate tools to carry out the work required.
0	The student cannot use the appropriate tools to carry out the work required.

The results of the performances of students on using appropriate tools to build the products are shown on Graph 7.2.2.

GRAPH 7.2.2
Ability of Students to use Tools (N=94)



Most of the students (79%) had some difficulty in using some of the tools to perform the work required. The teachers had to help with cutting and preparing parts that the students wanted for their products. In Section 6.4.8, the students were asked to identify the tasks that required the help of experts or older persons and 65% of the students did not expect the experts or older persons to carry out any of the tasks

involved in building the products. These students felt they were required to carry out all the tasks involved in building the products, although they had been asked to identify the work that needed help of older people or experts. Discussions with the teachers revealed that although it was the common practice that they help students to carry out the difficult parts of their projects, most of technical curricula require students to do all the work involved by themselves. The students were encouraged to build their products, not only to learn the skills involved, but also to experience the feeling of being a productive and contributing member of society. An old Tongan saying goes, *'Kovi pe ta ka ko hoto ki'i vaka, ne fataki e maa'imoa kuo lava'*. It means that although the shape of my canoe may not look good, it is my work and has served in tasks commissioned by the king. This feeling of ownership, of being an important, useful and contributing member of society, has helped to make many students in technical classes limit the quality of the products they build to the skills they possess. So although the students were given the freedom to get help from the experts in building their products, they still could not get over the expectations of both the curriculum and the society.

7.2.3 Taking Care of Safety Issues

The ability of students to follow safety precautions in the technical workshop was not good. Most of the students (89%) did not wear the necessary safety gear and handled tools and materials carelessly while working in the workshop.

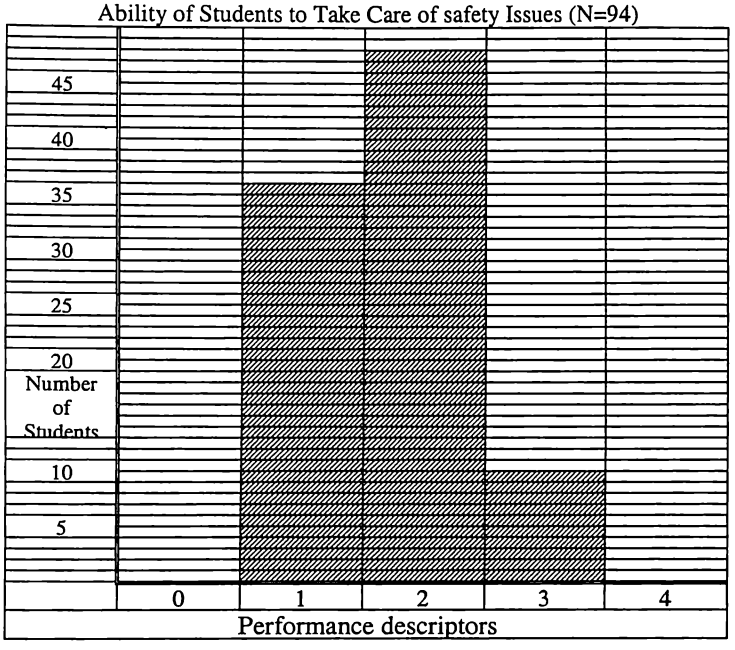
Table 7.2.3 presents the set of performance descriptors that was used to describe the ability of students to work in a safe and appropriate manner in the technical workshop.

TABLE 7.2.3
Performance Descriptors for Students' Practicing Safety Rules

	Performance Descriptors
4	The student wears all the necessary safety gear and handles tools safely while working.
3	The student wears almost all of the necessary safety gear and handles most tools safely while working.
2	The student wears part of the necessary safety gear and handles some of the tools unsafely while working.
1	The student wears very little of the safety gear and is sometimes careless with tools while working.
0	The student does not wear any of the safety gear and at times is dangerous with tools while working.

Graph 7.2.3 shows the performances of the students with regards to safety in the workspace.

GRAPH 7.2.3
Ability of Students to Take Care of safety Issues (N=94)



Many of the students (89%) at times handled tools in an unsafe manner and did not wear all the necessary safety gear during work. Only 11% of the students wore necessary safety gear and handled tools safely during work. The students were working in their school uniform with no aprons, safety glasses or headgear, although they were necessary. The students showed little experience in using tools and machines, especially in the Industrial Arts workshop.

These results show that the students had little experience in doing serious project work in the workshop, the kind of projects that would force them to wear the safety gear.

7.2.4 Organisation of Workspace

At this stage, the students were observed to determine whether they worked in a careful manner and kept the workspace tidy and well organized during and after work. The students tended to leave tidying up to be done at the end of the workshop period. They did not show the habit of working carefully and keeping the workspace organised at all times.

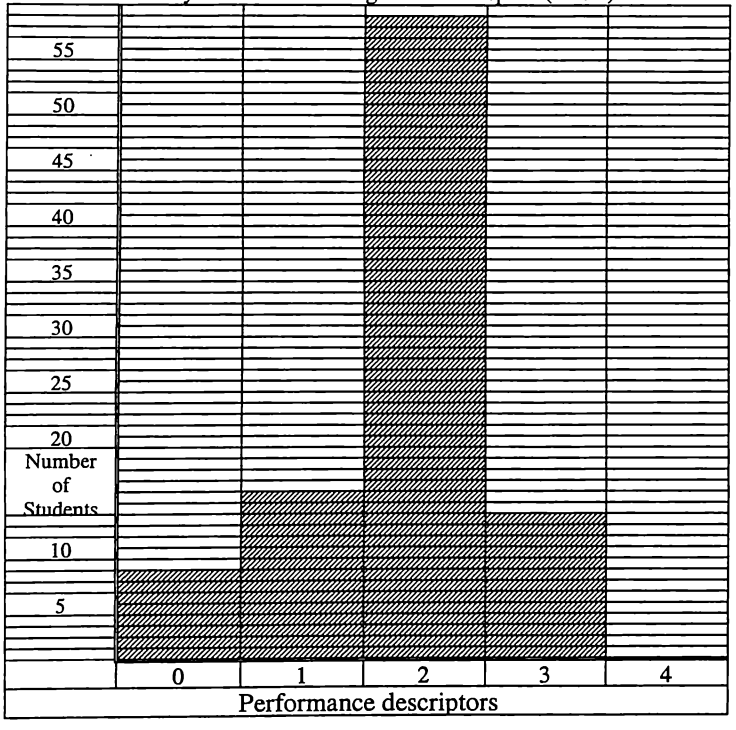
Table 7.2.4 presents the set of performance descriptors used to describe the ability of students to keep the workspace organized all the time.

TABLE 7. 2.4
Performance Descriptors for Organisation of Workspace

	Performance Descriptors
4	The student is always careful and always keeps the workspace tidy and well organized.
3	The student is careful and keeps the workspace tidy and well organized most of the time.
2	The student is careful and keeps the workspace tidy and well-organized half of the time.
1	The student is careless and the workspace is not well-organized most of the time.
0	The student is always careless and does not work in an organized manner.

The ability of the students to keep the workspace organized is shown on Graph 7.2.4.

GRAPH 7.2.4
Ability of Students to Organise Workspace (N=94)



Only 14% of the students were careful and kept the workspace well organized for most of the time. Many of the students (62%) were careful and kept the workspace organized and tidy for half of the time while working. A small proportion of the students (9%) was completely careless and showed no concern about the tidiness of the workspace. The teachers reported that the four week block assigned for their project work was timetabled to coincide with this study, so that the products that the

students were building would be assessed for their project marks. So these students had no workshop experience at this level before this study. The students lacked experience in doing practical work at this level.

7.2.5 Implementation of Plan of Action

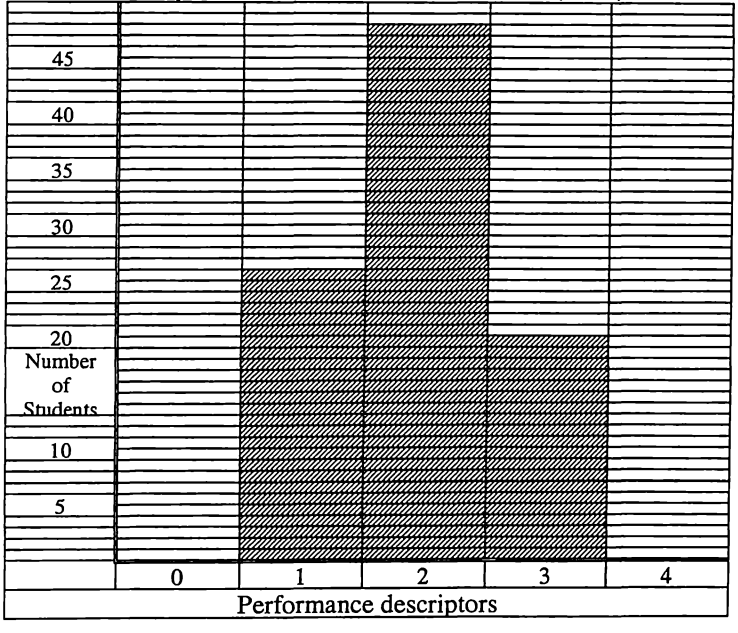
Most of the students (79%) were not able to follow the plans they had prepared earlier. Changes were made because some of the materials they required were not available and some students wanted to make some improvements to the products they had planned. Table 7.2.5 presents the set of performance descriptors that was used to describe the ability of students to follow the plan of action.

TABLE 7.2.5
Performance Descriptors for Following Plan of Action

	Performance Descriptors
4	The student is able to fully implement the whole plan of action.
3	The student is able to follow the main steps of the original plan of action.
2	The student makes minor changes to the original plan of action in order to improve the product.
1	The student has difficulty in following the plan of action.
0	The student does not follow the plan of action.

The ability of students to follow the plan of action is shown on Graph 7.2.5.

GRAPH 7.2.5
Ability of Students to Follow Plan of Action (N=94)



Only 21% of the students were able to follow the main steps of the plans they had prepared. The rest made adjustments to their plans while building the products. Forty-four percent made minor adjustments to the original plans with the intention of improving the products. Twenty-seven percent altered their plans because some of the materials or tools required were not available.

These results point to the fact that the plans students prepared were not thorough and lacked details. The students had not been able to analyse all the factors involved such as materials and tools available, sizes and shapes of products and skills required for building the products while they were preparing the plans.

It also brings into mind the weakness of connection that students made between the stages of the project as they advanced through. Most of the students failed to view the project in a holistic manner. They seemed to treat each stage of the project as a separate occasion and at the same time concentrated mainly in building the products.

7.2.6 Appropriateness of Solution to Criteria

The solutions produced by the students were examined against the criteria they had prepared to determine the appropriateness of the products to the specified criteria. The criteria that students had identified were general and superficial. For example, they identified characteristics like 'making the seat strong and beautiful', 'making a beautiful fan' 'making delicious food'. It was therefore relatively easy for the students to satisfy these criteria. Most of the students (79%) were able to satisfy at least half of the criteria they had identified.

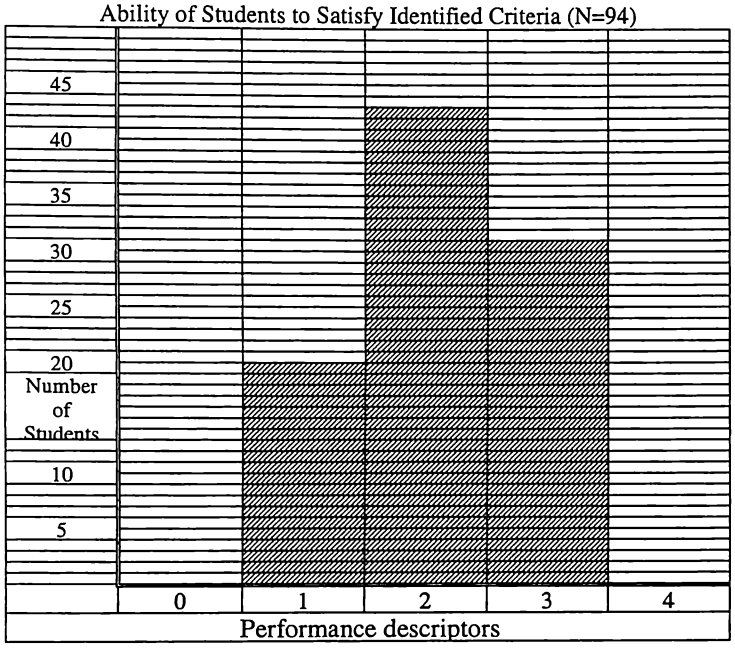
Table 7.2.6 presents the set of performance descriptors that was used to describe the ability of students to satisfy the criteria they had identified.

TABLE 7.2.6
Performance Descriptors for Appropriateness of Solution to Criteria

	Performance Descriptors
4	The work produced by the student is appropriate to its specified criteria.
3	The work produced by the student is appropriate to most of the specified criteria.
2	The work produced by the student meets half of its specified criteria.
1	The work produced by the student meets a limited number of its specified criteria.
0	The work produced by the student is not appropriate to its specified criteria.

The ability of the students to satisfy the specified criteria is shown on Graph 7.2.6.

GRAPH 7.2.6
Ability of Students to Satisfy Identified Criteria (N=94)



Thirty-three percent of the products made by the students were appropriate to most of their respective specified criteria and 46% met half of their specified criteria. Only 21% of the products met less than half of their respective specified criteria. Therefore, in general, the students performed relatively better at satisfying needs and opportunities they had identified than in any of the criteria assessed in this study. The reason behind this is because the criteria that the students had been trying to meet were simple and lacked detailed purposes.

7.2.7 Aesthetic of Solution

The ability of students to build aesthetic products needed a lot of improvement. They lacked the appropriate skills for building good aesthetic products. It was observed that the students were helped by the teachers in carrying out the most difficult tasks, especially when machining was required. However, most of the students had not asked for experts help during the planning of production. They planned to do all the work by themselves. Therefore, the students seemed to be unsure of the level of aestheticism they had wanted their products to have. They had not been able to plan for the details of the quality of the products they were building. The aesthetic of the products was as general as the rest of the criteria they had identified about their products.

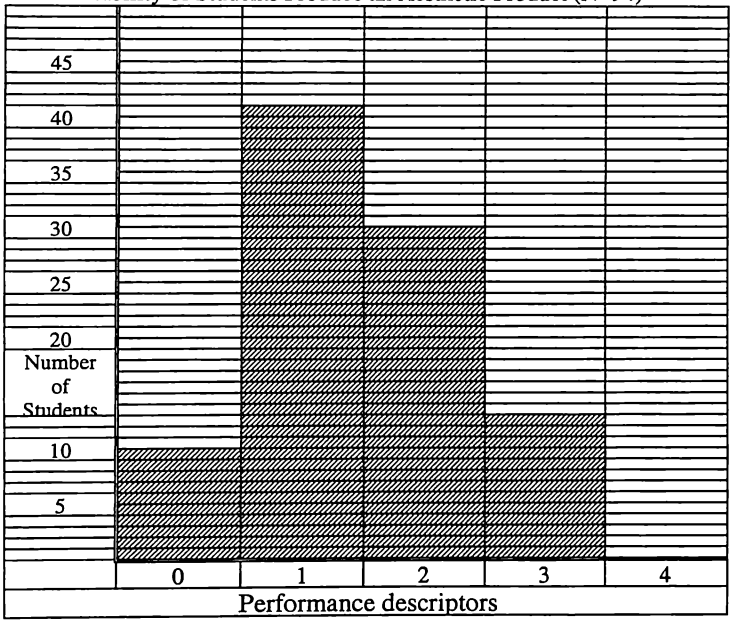
Table 7.2.7 presents the set of performance descriptors that was used to describe the ability of the students to produce an aesthetic product.

TABLE 7.2.7
Performance Descriptors for Producing an Aesthetic Product

	Performance Descriptors
4	The work produced by the student is highly aesthetic.
3	The work produced by the student is very aesthetic.
2	The work produced by the student is moderately aesthetic.
1	The work produced by the student is hardly aesthetic.
0	The work produced by the student is not aesthetic.

The ability of students to produce an aesthetic product is shown on Graph 7.2.7.

GRAPH 7.2.7
Ability of Students Produce an Aesthetic Product (N=94)



Most of the products (54%) that the students produced were not aesthetic. Only 14% of the products made by the students were judged to be very aesthetic and another 32% were moderately aesthetic.

7.3 PRESENTATION OF IDEAS, DESIGN AND PRODUCT

This section reports on the performances of the students in the activities that assessed their ability to write a good report of the project and to present their ideas, design and

product to a group of people. Four assessment criteria were written to cover the main aspects of this technological capability. The results of the performances of students in these four assessment criteria are presented in this section. The results will be presented in the order of the assessment criteria.

7.3.1 Preparation of Report of Technological Activity

Most of the students (60%) found it difficult to prepare a good and complete report of the project. These reports were incomplete and very general. The students lacked the skills in preparing a comprehensive report of a project. They also failed to link the parts of the project together and to view the component parts as a whole unit of work. The main types of reports that students prepared are reported in Table 7.3.1a

TABLE 7.3.1a
Percentages of Types of Reports Prepared by Students (n=94)

	Characteristics of the reports	%
1	Brief description starting from asking certain people how to make the product, materials used and how the product was made	20
2	Brief description of collecting materials needed and making the product	18
3	Detail description of how the product was made	12
4	Very brief description of obtaining materials, making and pricing of product	7
5	A few steps briefing the reasons for this task, buying materials and making the product	7
6	A brief description of reasons for selecting this task	6
7	Detailed account of how the product was made and tested & its uses	6
8	Report is in steps describing materials, making and selling of the product	6
9	Details on collecting information on methods of making product, obtaining materials and making the product	3
10	A few sentences on the sources of information	3
11	A very brief description of how and why the product was being made	3
12	Details on reasons for choosing this task, obtaining information on how to make the product, buying materials, measuring parts and method of making the product	3
13	Detail description of obtaining materials, making, pricing and evaluation of product	3

Sixty percent of the reports were poorly done, too short and very brief. They were less than half a page each and the reporting was very general and missing details such as aims, procedures etc. which should have been included in the report. Eighteen percent of the reports were less than one page, and only 4% were more than two pages. Some of the reports were unclear and difficult to follow, for example, only 17% of the reports were written in steps with sub-headings of some of the stages given. Many reports were not complete, for example, 25% of the reports started with obtaining information and 20% started with describing methods of building the products. Only 5% started with collecting information on needs and problems in the

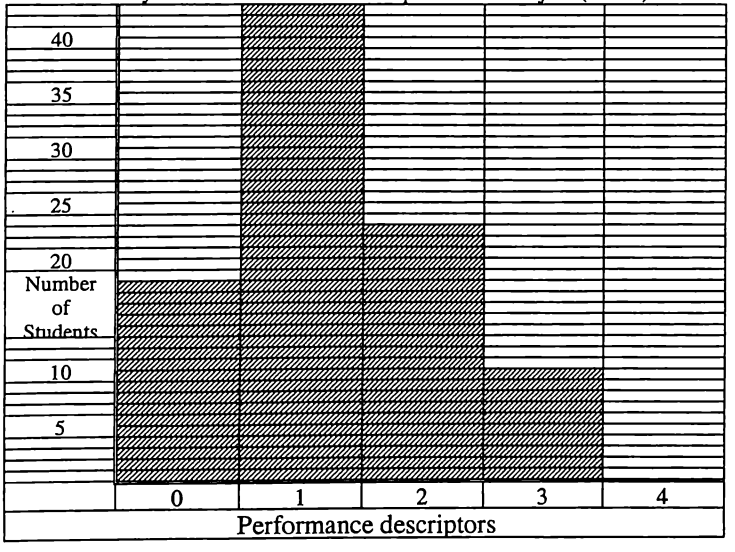
given area. The rest of the reports started at later stages. None of the reports mentioned developing a solution to identified needs and only 5% mentioned evaluation of the product. The following set of performance descriptors was used to describe the performance of the students in preparing the report of the project.

TABLE 7.3.1b
Performance Descriptors for Writing a Report

	Performance Descriptors
4	Report covers all aspects, good order and well organized.
3	Report covers almost all aspects, good order and well organized.
2	Report covers a fair aspects of the project, not in good order and not very well organized.
1	Report omits some important aspects, poor order and also poorly organized.
0	Very poor and unorganized and omits most of the aspects of the project.

The important aspects of the project that should be covered by the reports are: identifying needs and opportunities, developing the best possible solution, planning of production, producing the solution, and evaluation of progress, process and product. Also the important features of the report that were assessed are: the structure of the report, the order of information, clarity of ideas presented and neatness. The graph below shows the ability of students to write a good report of the project.

Graph 7.3.1
Ability of Students to Write a Report of the Project (N=94)



The graph shows that the reports were poorly done. The main topics in the task were not properly covered. The reports missed information on identifying needs and opportunities and development of the best possible solution. They concentrated mainly on how the products were built. Not only that but the structure of report, order

of information, clarity of ideas presented and neatness were also very limited. Only 11% of the reports covered almost all of the aspects of the project, presented ideas in good order and were well organized. Many reports (19%) did not receive any marks because they missed most of the aspects of the project and were poorly organized. Another 46% of the reports covered only about half of the aspects of the project and were fairly organized. These students had not been involved in writing project reports in school prior to this study. They lacked the experience and did not have the skills in preparing and writing of a report.

7.3.2 Explanation of Design, Plan and Outcome of the Project

The students found it difficult to deliver a good explanation in front of the class to report the design, plan and outcome of the project. The presentations made by the students were similar to the types of reports they prepared. They were generally incomplete, short and very general. The students lacked the appropriate skills of doing a presentation to communicate the main ideas behind the design, plan and outcome of a project. The main types of presentations students delivered are reported in Table 7.3.2a

Table 7.3.2a
Percentages of Types of Explanations Students Delivered (n=94)

	Main ideas explained by students	%
1	Reason for doing this task, materials selected, preparation of materials, reason for enjoying the task and how the product is to be sold	31
2	Obtaining materials, preparing materials and making the product	27
3	Obtaining information, preparing materials, making and pricing	16
4	Preparing materials, making the product and pricing	6
5	Reasons for selecting this task and reasons for selecting materials used	4
6	Reason for doing this task, assessing the products and reasons for changing plan of action	4
7	Reason for doing this task, skills learnt, design, problems and making the product	3
8	Planning, collecting materials, making & assessing the product, reasons for adjusting plan	3
9	Reasons for parts of the product, reasons for doing this task, and problems & adjustments made on the plan	2
10	Preparing materials and making the product	2
11	Reasons for shape of product, planning and design, obtaining & preparing materials, making the product, uses of the product, assessment of the product and pricing	2

Most of the presentations (54%) did not cover the range of ideas involved in the design, plan and outcome of the project. These presentations concentrated mainly on describing how the materials were obtained and prepared and how the products were made. Although 46% of the students gave reasons for doing certain tasks, they were mainly simple reasons and lacked detailed purposes and ideas behind plan and design.

For example, some students explained the reason for selecting to make a broom was to sell it to get some money. Only a very few talked about the ideas behind the lengths and sizes of handles or about the ideas behind the number of coconut fronds used in their brooms. The students were required to give an estimate of the price of their products, but only 25% mentioned pricing. The students did not know where to start the presentation. Only 16% of the students started with obtaining information. Also, 92% of the students did not mention anything about evaluation of the product. These results show that the students had limited skills in doing a presentation in front of a group of people. Further, the results reflect the types of activities that the students remembered from the project. Those were the activities that they understood and were interested in. They were interested mainly in building the products. The following set of performance descriptors was used to describe the ability of students to do a presentation:

TABLE 7.3.2b
Performance Descriptors for Doing a Presentation

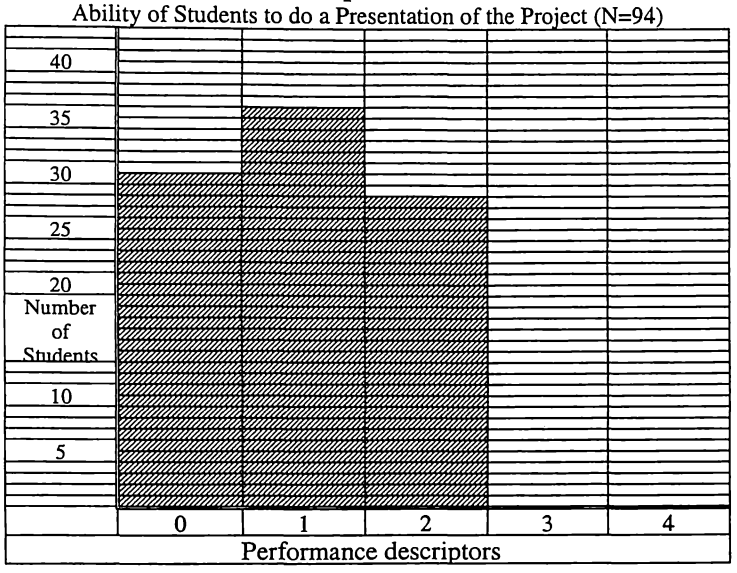
	Performance Descriptors
4	Student clearly covers all ideas underlying the design, plan and outcome.
3	Clearly covers almost all ideas underlying the design, plan and outcome.
2	Covers the main ideas underlying the design, plan and outcome.
1	Covers a small proportion of ideas underlying the design, plan and outcome.
0	Has difficulty explaining the main ideas underlying the design, plan and outcome.

In the set of performance descriptors above, students' presentations were assessed using three criteria: completeness, organization of ideas and confidence in presentation. Completeness refers to the ability of students to cover the main ideas regarding plan, design and product of the project. Organization of ideas refers to the order in which the information was presented. Also, the confidence of the students in front of the class was assessed.

The graph below shows the ability of students to prepare and make a presentation explaining the main ideas behind the design, plan and outcome of the project.

Graph 7.3.2

Ability of Students to do a Presentation of the Project (N=94)



No mark was given to 32% of the students because their presentations were unclear, too short and covered none of the important ideas behind the design, plan and outcome of the project. They had difficulty in explaining the main ideas involved in the project. Another 38% of the students covered only a very minimal proportion of the main ideas behind the design, plan and outcome of the technological task. They were also very unclear of the ideas they were trying to present and found it difficult to talk in front of the class. Some of these students did not take this part of the project seriously and seemed at times to want to make the class laugh. This is a sign of lack of experience in doing a serious presentation in front of a group of people.

7.3.3 Use of Correct Specific Technological Terminology in Report

The students were assessed on their use of the appropriate technological terms in writing the report of the project. There are important technological terms involved in identifying needs and opportunities, searching for and developing the best possible solution, planning of production, producing the solution, presentation and evaluation. The important terms in the component of identifying needs and opportunities include: investigation, interview, data, analysis, factors, inventions, and the word technology itself. In developing the best possible solution, the important terms include: modeling, testing, assessment and evaluation. In planning of production, the important terms include: design, plan, recipe, correct technical terms for materials, parts of products and tools and the appropriate units of measurements. In producing the solution, the important terms include: name of technical processes involved, machining, work

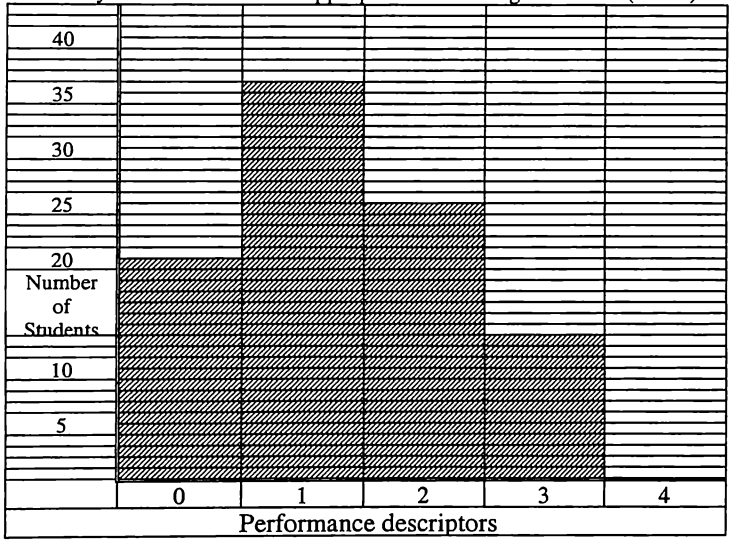
space, organization and finishing. In evaluation, the important terms include: evaluation, testing, improvement and recommendation. The following set of performance descriptors was used to describe the performance of students on using specific technological terms:

TABLE 7.3.3a
Performance Descriptors for Using Technological Terms

	Performance Descriptors
4	Student uses a very wide range (>12) of appropriate specific technological terminology.
3	Student uses a good number (10-12) of correct specific technological terminology.
2	Student uses a fair number (7-9) of specific technological terminology.
1	Student uses a limited number (4-6) of appropriate technological terminology.
0	Student does not use (<4) specific technological terminology

The graph below shows the amount of technological terms the students used in their report.

Graph 7.3.3
Ability of Students to Use Appropriate Technological Terms (N=94)



The students were not familiar with the important technological terms that should be included in the reports. Twenty-one percent of the students used less than four important technological terms in their reports. Another 38% mentioned less than six important terms. These students used mainly general words in writing the reports. For example, instead of using the term 'interview', the students used 'asking people for information'. These results show the students lacked the appropriate knowledge of the proper terms in technology. Not only that, but the students did not seem to consider it important to use the proper technological or technical terms in their reports.

7.3.4 Describing Methods to Promote Selling of Ideas and Product

The ability of students to describe the appropriate methods of promoting the technological ideas behind their design and product was limited. Most of the students (88%) concentrated mainly on promoting the selling of the product by making them beautiful. They wanted the products to be highly aesthetic in order to promote selling. The purposes, which state who, where, when, why and how the product would be used, were not used by the students to promote the selling of the products. The students were not familiar with using ideas to promote the selling of products and relied mainly on the appearance and aesthetic. Table 7.3.2a presents the main types of explanations that the students suggested about ways of promoting the selling of the ideas behind the design and the product.

Table 7.3.4a
Percentages of Methods Explained by Students

	Methods described by students that can promote selling of the products.	%
1	Advertise through shouting, posters, radio, newspapers and TV ----------	9
2	Use good materials and make the product properly ----------	25
3	Use good materials, make the product properly and make the price right ---------	23
4	Advertise materials and uses of the product and make the product beautiful -----	5
5	Make the product properly ----------	17
6	Prepare materials properly with good finishing, make the product beautiful and neat and make the price cheap ----------	9
7	Use good strong materials ----------	3
8	Obtain users needs, make the price cheap, make the product beautiful, make the size large enough and advertise properly ----------	3
9	Decorate properly, and make it to satisfy users needs ----------	3
10	Ask for users needs, make the product good and cheap ----------	3

A large proportion of the students (51%) suggested using good materials to make the product. This suggests that many students expected the selling of the products to depend much on the type of materials they used. Using good materials as a way to promote the selling of a product reflects only a small reliance on the power of advertising and on the ideas behind a good design. Only 17% of the students mentioned advertising as a means of promoting selling of the products. Many students (88%) suggested they would promote the selling of the products by making them beautiful. Aesthetic is one of the main factors that promote the selling of many products in Tonga. The quality of workmanship in Tonga is very low and the products produced locally require a lot of improvement in comparison to the products imported from overseas. Many people in Tonga are easily attracted by the appearance of the products. Very few students (10%) suggested making the characteristics of the

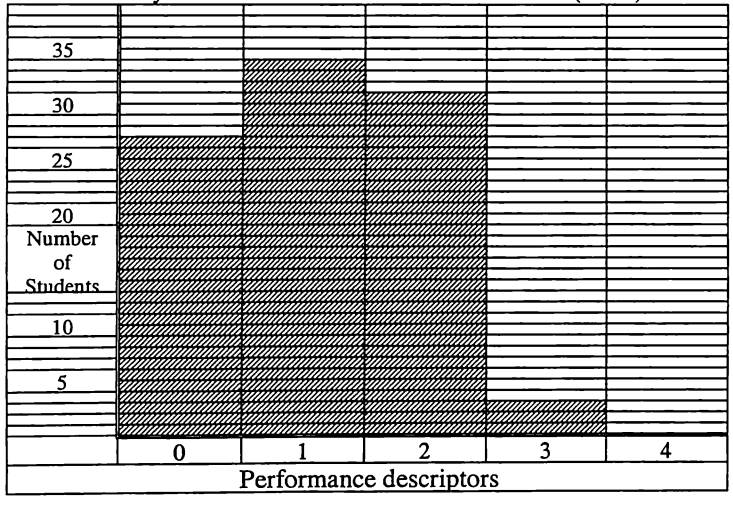
products to meet the needs of the users. Taking little consideration of the needs of the users, consumers and the people as a whole is a reflection of the nature of the Tongan society. The rich and higher classes usually show little consideration to the needs of the rest of the people. The following set of performance descriptors was used to describe the performance of students in promoting ideas and products:

TABLE 7.3.4b
Performance Descriptors for Promoting Ideas and Products

	Performance Descriptors
4	Student explains purposes of product, ideas behind design, needs of users, nature of product, advertising, marketing, pricing, packaging and writing instructions for use.
3	Good range of methods above.
2	Fair range of methods above.
1	Student explains a limited range of methods above.
0	Student explains only one of the above.

The graph below shows the ability of the students to describe the ways of promoting and enhancing the selling of the ideas and the products.

Graph 7.3.4
Ability of Students to Promote Ideas and Product (N=94)



Most of the students (65%) found it difficult to identify the factors that would help to promote the selling of their products. Twenty percent of the students mentioned only one of the ways of improving the selling of the products. Another 36% of the students mentioned only two of the areas which can enhance the selling of the products. Only 3% of the students were able to identify five of the areas that can be used to promote the selling of the products. The students lacked the experience and knowledge related to promotion of the selling of ideas and products.

7.4 EVALUATION OF PROGRESS, PROCESS AND PRODUCT

This section reports the results of the performances of students in the activities that assessed their ability to evaluate their work, progress, process and product as they advanced from one stage to another. Five assessment criteria were written to cover the main aspects of this technological capability. The results will be presented in the order of the assessment criteria.

7.4.1 The Ability of Students to Assess Methods to Identify Improvements Required

The ability of students to assess the methods used to identify improvements required throughout the whole process was limited. The students found it difficult to evaluate the methods used in the project to identify the weaknesses. The main types of improvements that the students identified in the methods they had used in this project are reported in Table 7.4.1a

TABLE 7.4.1a
Types of Improvements Suggested by Students (n=94)

	Types of improvements	%
1	Suggested different materials to be used	26
2	Improvements on properties and method of preparing parts of the product	19
3	Suggested better method of building the product	17
4	No improvement suggested	11
5	Use better tools and machines to improve the product	11
6	Improve overall structure of the product	8
7	Must ask people for better method of building the product	4
8	Improve the plan of the product	4

Although the students were required to assess the methods used throughout the whole project, most of the answers (64%) talked mainly about the materials used and how the products had been built. The methods that the students mentioned in their answers were only those that had been involved in the actual building of the products. None of the students mentioned the methods involved in: obtaining information on needs and opportunities, developing the best possible solution, preparing the project report, presenting ideas and evaluating the methods used and quality of product. The students concentrated mainly on building the products. Another important aspect is that only 4% of the answers mentioned the improvements required on the plans of the products. Although the plans they had designed lacked details and were in need of improvement, most of the students (96%) were not able to single them out. It is likely that the students did not use their plans while they were building their products. It

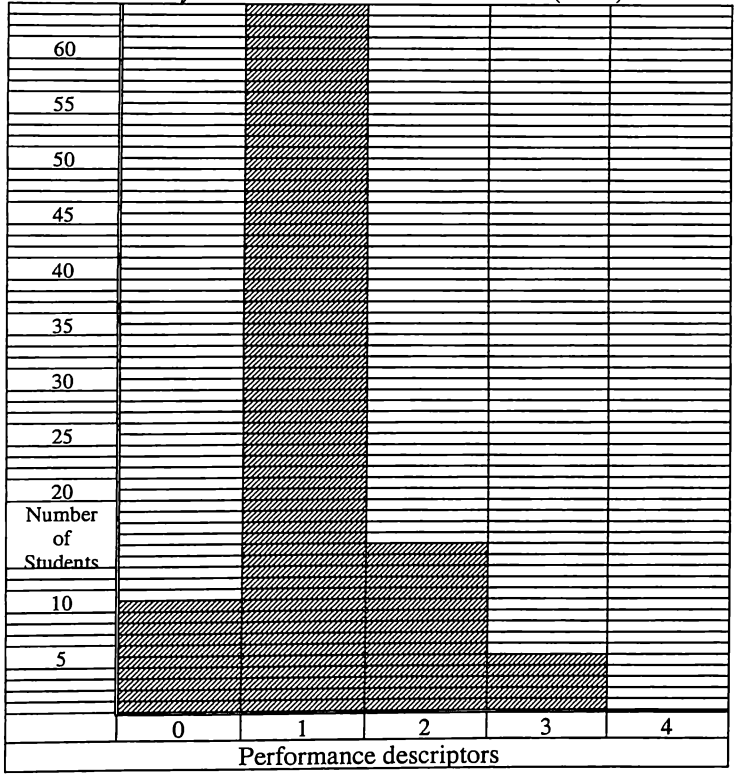
once again shows the weakness of the links between the performances of the students in different stages of the project. Table 7.4.1b gives the set of performance descriptors that was used to describe the performance of students on assessing the methods used to identify the improvements to be made.

TABLE 7.4.1b
Performance Descriptors for the Ability to Assess Methods

	Performance Descriptors
4	The student identifies at least four of the weaknesses of the methods used throughout the whole process.
3	The student identifies three of the weaknesses.
2	The student identifies two of the weaknesses.
1	The student identifies one of the weaknesses.
0	The student cannot identify any of the weaknesses.

Graph 7.4.1 shows the ability of students to assess methods used to identify weaknesses throughout the whole process.

GRAPH 7.4.1
Ability of Students to Assess Methods Used (N=94)



Most of the students (68%) were able to identify only one of the weaknesses in the project that needed improvement. These mainly involved the methods of building the products, tools and materials required and the properties of the products.

Only 5% of the students were able to identify three of the improvements required and 11% were not able to identify any of the weaknesses of the whole project.

7.4.2 The Ability of Students to do Tests in the Development of the Product

Many students (55%) carried out only simple tests in their effort to evaluate the products made. All of the tests were carried out after the plans had been drawn, and it is likely that they were carried out just to make sure that the products held together during the assessment processes.

The main types of tests that students claimed they carried out are reported in Table 7.4.2a

TABLE 7.4.2a
Types of Tests Students Carried Out (n=94)

	Types of Tests	%
1	Tested the appropriateness of the product to the job required ---	43
2	Tested the strengths of parts of the product ----------	21
3	Tested the lengths and size of parts of the product ----------	9
4	Tested the quality of workmanship ----------	9
5	No test carried out ----------	19

Forty-three percent of the tests were carried out by the students when the products were completed. The students tested them to see if they worked. For these tests, none of the students who carried them out mentioned making changes as a result. It therefore seems that the tests were not directed at finding faults so that improvements could be made. Instead, it is more likely that the students used them to see that their products were ready to be used.

Another important point is that all of the tests were held after the plans had been drawn. No test was carried out while the solutions were being planned. Testing involves checking a certain part of a product against a certain set of criteria to determine improvements required. However, because the criteria that students identified for the solutions were superficial, no particular tests were required to determine lengths, strength and weight of the products during the planning activity. Testing was carried out mainly to find out whether the products worked.

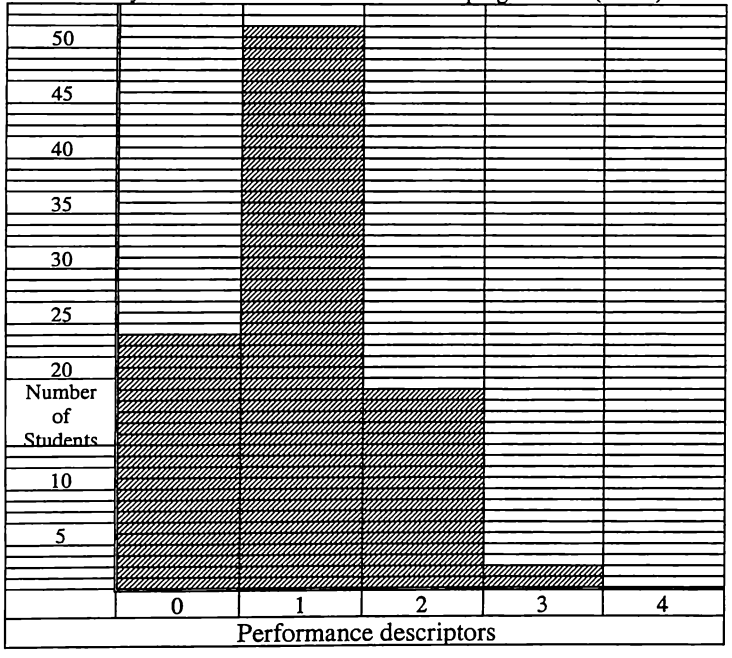
Table 7.4.2b presents the set of performance descriptors that was used to describe the performance of students in carrying out tests to evaluate the properties of the products.

TABLE 7.4.2b
Performance Descriptors for the Ability to do Tests

	Performance Descriptors
4	The student carried out at least four tests to evaluate the properties of the product made and other same products.
3	The student carried out three tests.
2	The student carried out two tests.
1	The student carried out one test.
0	The student carried out no test.

Graph 7.4.2 shows the ability of the students to carry out a consumer-type test to evaluate the products made.

GRAPH 7.4.2
Ability of Students to do Tests in Developing Product (N=94)



Most of the students (54%) carried out only one test and another 25% did not carry out any test to evaluate the properties of the product they produced. Only 2% of the students carried out three tests. The ability of these students to evaluate the products they made was limited. The students were not aware of the importance and value of carrying out tests while developing their products. The students were ignorant about

the benefits that testing can produce if it is properly planned and administered during practical activities in technical subjects.

7.4.3 The Ability of Students to Compare the Plan against the Product to Identify Differences

The students performed poorly in comparing the desired characteristics in the plans against the actual products built to identify the differences. They put more effort towards describing the causes of the differences than towards identifying the manner in which the actual products differed from the planned products. The main types of differences that the students identified when they compared the plans against the products are reported in Table 7.4.3a

TABLE 7.4.3a
Differences Between Plan and Product (n=94)

	Types of answers	%
1	Students were not able to build parts of the product	45
2	No difference between plan and product	19
3	Materials required were not available	11
4	Change of plan (parts) to improve product	10
5	Could not follow procedures planned	5
6	Shape of product	5
7	Poor workmanship due to unavailability of proper tools	5

Forty-five percent of the students identified that the differences had been due to parts of the plans they were not able to complete. Eleven percent identified materials they used were not the ones they had planned for because they were not able to obtain them. Another 15% admitted their products were different from their plans due to their failure to follow the planned procedures, failure to produce the planned shapes of the products and poor workmanship due to unavailability of tools. Altogether, 81% of the answers indicated that they were not able to build what they had planned to do. The students had planned for better products but were not able to build them. These students were not satisfied with the quality of the products they produced. Ten percent of the answers described that they altered their plans to improve their products and they seemed to be satisfied with what they had produced.

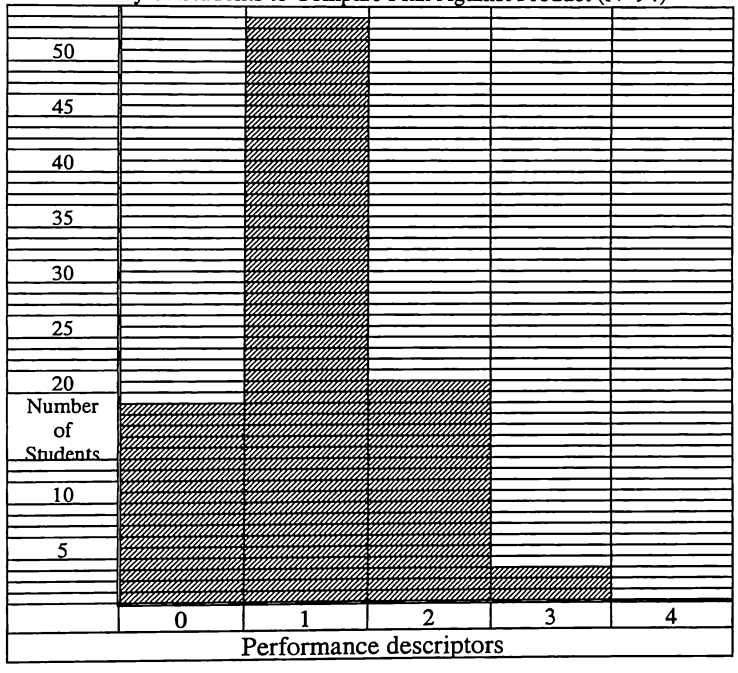
Table 7.4.3b presents the set of performance descriptors that was used to describe the performance of students on this component of technological capability.

TABLE 7.4.3b
Performance Descriptors for the Ability to Compare Plan and Product

	Performance Descriptors
4	The student compared the results against the plan and identified at least four of the differences.
3	The student compared the results against the plan and identified three of the differences.
2	The student compared the results against the plan and identified two of the differences.
1	The student compared the results against the plan and identified one of the differences.
0	The student was not able to identify any of the differences between the plan and the product made.

Graph 7.4.3 shows the ability of students to compare the products planned against the actual products built to identify the differences.

GRAPH 7.4.3
Ability of Students to Compare Plan Against Product (N=94)



Although most of the students' answers (81%) indicated differences between the characteristics of the products they produced when compared with the plans they had drawn, many of the students (56%) were talking about only one of the differences between the plans and the products. Another 19% of the students were not able to identify any of the differences between the plan and the products made and only 3% were able to identify three of the differences between the plans and the products built.

The students seemed to have difficulty in identifying the differences between the plans and the products. It was not difficult for them to obtain the properties of the

products produced, but it was difficult for them to obtain the properties of the plans they had designed, especially when they lacked details of lengths and sizes. So the difficulty that students experienced in identifying differences between plans and products could be highly accounted for by the limited nature of the plans they had prepared.

7.4.4 The Ability of Students to Evaluate the Quality of Products to Identify Improvements Required

The ability of students to evaluate the quality of the products produced to identify improvements required was also limited. The main types of improvements that the students identified regarding the quality of products are reported in Table 7.4.4a

TABLE 7.4.4a
Types of Improvements Identified by Students (n=94)

	Types of improvements	%
1	Identified defects in the product and the method used	34
2	Properties of materials used	25
3	Nothing wrong	19
4	Suggested improvement in overall plan of product	10
5	Lengths of parts of product	7
6	No answer	5

Seventy-six percent of the students were able to identify some improvements to be made on the products. Ten percent mentioned improvements to be made on the plans. The low percentage of answers mentioning plans reflect the small number of students that evaluated the overall plan of the product. Very few students showed a tendency towards assessing the different parts of a product together as a whole. Most of these students failed to make a holistic assessment of the products.

Another important part of students' responses is that most of the answers (76%) were improvements suggested regarding the physical characteristics of the products. None of the answers showed an interest in improving the products in order to be more suitable for a certain type of people, time, place or particular situation. The students evaluated the products mainly at the superficial level. They assessed mainly the strength, shape, size, look, and feel of the products.

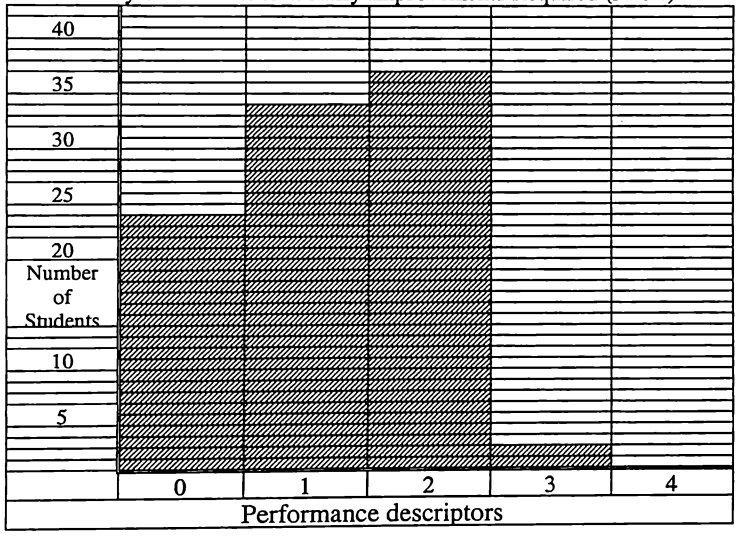
Table 7.4.4b presents the set of performance descriptors that was used to describe the performances of students in assessing products to identify improvements required.

TABLE 7.4.4b
Performance Descriptors for the Ability to Identify Improvements Required

	Performance Descriptors
4	The students identified at least four improvements needed to be made on the product.
3	The students identified three improvements needed to be made on the product.
2	The students identified two improvements needed to be made on the product.
1	The students identified one improvement needed to be made on the product.
0	The students was not able to identify any of the improvements needed to be made on the product.

Graph 7.4.4 shows the ability of students to evaluate the quality of the work produced to identify improvements required.

GRAPH 7.4.4
Ability of Students to Identify Improvements Required (N=94)



Although 76% of the answers identified improvements to be made, 35% mentioned only one and 38% mentioned two improvements. Another 24% were not able to identify any improvement to be made. In general, the students could not find much in their products to be improved.

7.4.5 The Ability of Students to Identify Skills and Knowledge Gained from the Project

The skills and knowledge that students identified they had gained after doing the project were only general ones. They are general skills that could even be learned at

home. Also, the way most of the answers (45%) were expressed was very general, just stating the ability to build the product. The main types of skills and knowledge that the students identified they had gained from this experience are reported in Table 7.4.5a

TABLE 7.4.5a
Types of Skills and Knowledge Gained by Students (n=94)

	Types of skills and knowledge	%
1	General statement about skills in building the product	45
2	Using tools and machines to prepare parts of the product	20
3	Skills in carrying out measurements	7
4	Detail description of putting the product together	7
5	No answer	10
6	Knowledge of proper parts and components of product	5
7	Skills regarding interviewing people	4
8	Traditional technical skills	2

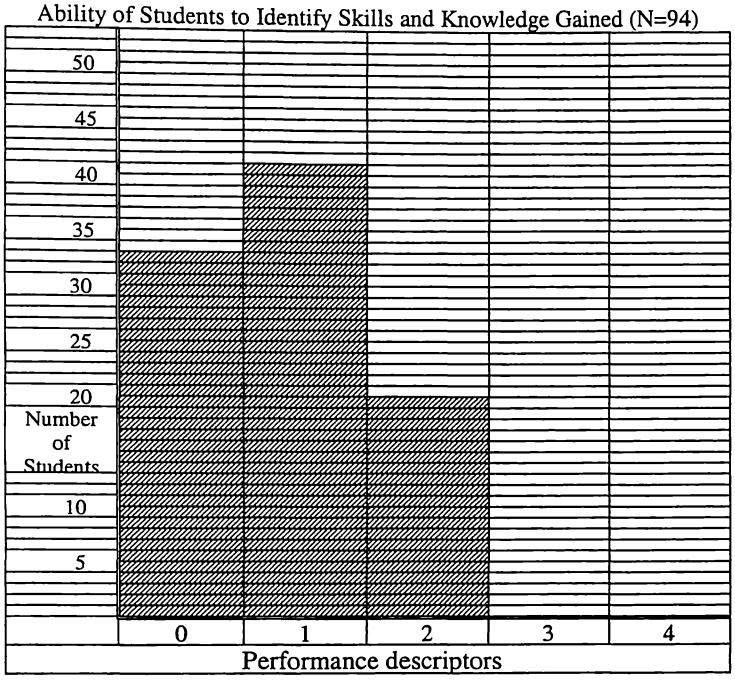
Eighty-six percent of the students concentrated mainly on the skills and knowledge involved in building the products. Only 4% mentioned skills and knowledge involved in interviewing people. None of the students mentioned the more important types of technological skills that this project had hoped the students could learn from this experience. That is, the skills in identifying needs and opportunities, in exploring and developing the best solution for identified needs and opportunities, skills and knowledge involved in planning, reporting and evaluation. The students missed them all and concentrated only on the skills involved in building the products. Table 7.4.5b presents the set of performance descriptors that was used to describe the performance of students in identifying the skills and knowledge gained from this project.

TABLE 7.4.5b
Performance Descriptors for the Ability to Identify Knowledge and Skills

	Performance Descriptors
4	Identified skills in planning, making, presenting and evaluating.
3	Identified skills in three of the above.
2	Identified skills in two of the above.
1	Mentioned common skills.
0	Very general or no answer.

Graph 7.4.5 shows the ability of students to identify skills and knowledge gained from this experience.

GRAPH 7.4.5
Ability of Students to Identify Skills and Knowledge Gained (N=94)



Many students (44%) identified only one skill they had learned during the project and another 35% admitted they had learned no skill at all in this project. These students were not able to identify the skills they had learnt from this project.

7.4.6 The Ability of Students to Make Recommendations and Give Advice Regarding the Best Way of Doing This Project

The ability of students to make recommendations and give advice regarding the best way of doing this project was also limited. The main types of recommendations and advice that the students described are reported in Table 7.4.6a. Fifty-nine percent of the students provided answers that were advice regarding the building of the products. Only 2% gave advice about carrying out interviews and 7% on planning of the products. Not many students were comfortable making recommendations and giving advice on the new types of skills introduced in this project. Seventeen percent of the answers were encouragement to other students, telling them not to be discouraged by the complexity of the products they were going to build.

TABLE 7.4.6a
Types of Answers Provided by Students (n=94)

	Types of answers	%
1	General statement describing the method of building the product--------	44
2	Encouragement to other students regarding building the product---------	17
3	Advice regarding tools and safety issues ----------	11
4	Advice on materials and components for the product ----------	9
5	Advice on planning --------- ----------	7
6	Give details of method of building the product ---------- ----------	4
7	No answer ---------- ----------	4
8	Advice on measurement - ----------	2
9	Advice regarding interviewing people ----------	2

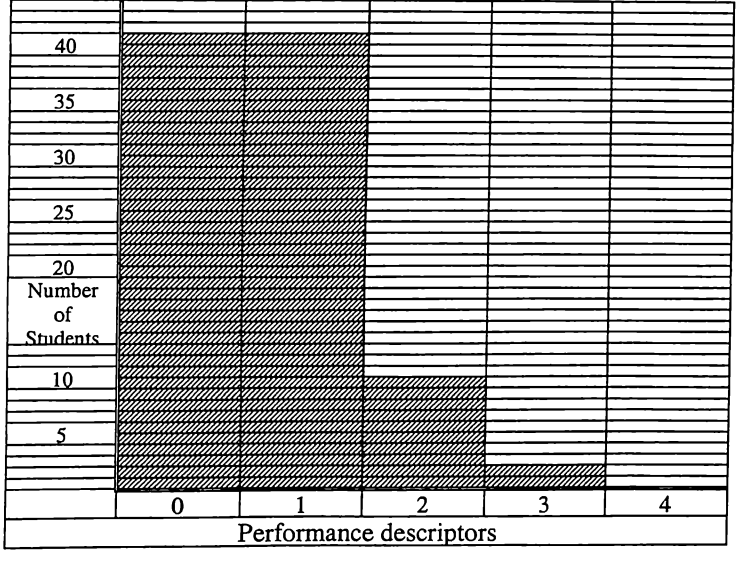
This suggests that some students needed encouragement and better incentives for carrying out a project of this kind. Table 7.4.6b presents the set of performance descriptors that was used to describe the performance of students in making recommendations for improving this project.

TABLE 7.4.6b
Performance Descriptors for the Ability to Make Recommendations

Performance Descriptors	
4	Specific advice regarding planning, building, presenting and evaluating the product
3	Specific advice regarding three of the above
2	Specific advice regarding two of the above
1	General description on how to build the product
0	Very general or no answer

Graph 7.4.6 shows the ability of students to make recommendations and give advice regarding the best way of doing this project.

GRAPH 7.4.6
Ability of Students to Make Recommendations for Improvement (N=94)



Many of the students (44%) were not able to make recommendations about the best way of carrying out this project. Also, another 44% were capable of making only one recommendation. Most of the students (87%) were ignorant of the main aspects that should be taken care of so that a technological project is successful.

7.5 SUMMARY OF RESULTS

This section presents the summary of the findings on the performances of students in the final stages of the project. The presentation of the summary will follow the order in which the results were presented in this chapter.

7.5.1 Building the Solution (Product)

The students were observed while they were building their products and at the same time they were also asked to record all the work they carried out in spaces provided in the worksheets. This summary will follow the seven assessment criteria in this component.

In using appropriate instruments to do measurements, 67% of the students did not do any measurements. Nineteen percent made some measurements but did not use the proper instruments. Only 14% used the proper instruments to carry out measurements. These students were involved in the most difficult technical tasks.

In using appropriate tools to carry out the work required in building the products, 21% of the students were competent in using most of the tools required to carry out the tasks and the rest needed help. Most of the students (79%) had some difficulty in using some of the tools to perform the work required. The teachers had to help with cutting and preparing parts that the students wanted for their products.

In taking care of safety issues, many of the students (89%) at times handled tools carelessly and did not wear all the necessary safety gear during work. Only 11% of the students wore all the necessary safety gear and handled tools safely during work.

These students were working in their school uniform with no aprons, safety glasses or headgear when necessary.

In organisation of workspace, 14% of the students were careful and kept the workspace well organised most of the time. Sixty-two percent had problems with organisation of the workspace. Only14% of the students were careful and kept the workspace well organized for most of the time. A small proportion of the students (9%) were completely careless and showed no concern about the tidiness of the workspace.

In implementing the plan of action, 79% of the students altered the main steps of their plans. Forty-four percent made adjustments to the original plans with the intention of improving the products while 27% altered their plans because of unavailability of materials or tools.

Assessing the appropriateness of the products to the specified criteria, 33% of the products made by the students were appropriate to most of their respective specified criteria. A total of 79% of the students produced products that satisfied at least half of the criteria they had identified.

Assessing the aesthetic of the products, 12% of them were judged to be aesthetic while the rest were not.

7.5.2 Presentation and Promotion of Ideas, Design and the Solution (Product)

In preparing reports of their work, 60% of the reports were poorly done, too short and very brief. Eighteen percent were less than one page and only 4% were more than two pages. Some of the reports were unclear and difficult to follow. For example, only 17% of the reports were written in steps. Many of the reports were incomplete. Only 5% started with collecting information on needs and problems in the given area. No report mentioned anything about developing a solution to identified needs and only 5% mentioned evaluation of the products.

Most of the presentations (54%) did not cover the range of ideas involved in the design, plan and outcome of the project. These presentations concentrated mainly on describing how the materials were obtained and prepared and how the products were built. Although 46% of the students gave reasons for doing certain tasks, they were mainly simple reasons and lacked detailed purpose and ideas behind the plan and design. Only 25% mentioned pricing and 16% started with obtaining information. Also, 92% of the students did not mention anything about evaluation of the product.

In using technological terms in reports, it was found that the students were not familiar with the important technological terms that should be included in the reports. Twenty-one percent of the students used less than four important technological terms in their reports. Another 38% of the students mentioned less than six important terms. These students used mainly general words in writing the reports.

In describing the appropriate methods of promoting the technological ideas behind their designs and products, 88% of the students suggested using good materials to make the products beautiful and strong. Seventeen percent mentioned advertising, 38% suggested making the price right and 10% suggested adjusting the characteristics of the products to meet the needs of the users. Sixty-five percent mentioned only one or two areas of ways for improving selling of the products.

7.5.3 Evaluation of Progress, Process and Solution (Product)

In assessing the methods used throughout the whole task, most of the students (64%) talked about the materials and the methods that should be used in order to improve the products. None of the students mentioned the methods involved in: obtaining information on needs and opportunities, developing the best possible solution, preparing the project report, presenting ideas and evaluating the methods used and quality of the product. The students concentrated mainly on building the products.

In carrying out tests while developing the products, 55% of the students carried out only simple tests in their effort to evaluate the products made. All the tests were carried out after the plans had been drawn, and 43% were carried out when the products were completed. The students tested them to see if they worked. For these tests, none of the students who carried them out mentioned making changes as results.

It therefore seems that the tests were not directed at finding faults so that improvements could be made. Instead, it is more likely that the students used them to see that their products were ready to be used.

In comparing plans against results to identify differences, the students put more effort in describing the causes of the differences than in identifying the manner in which the actual products differed from the planned products. Forty-five percent of the students identified that the differences had been due to parts of the plans they had not been able to complete. Eleven percent identified the materials they used were not the ones they had planned for because they were not able to obtain them. Altogether, 81% of the answers indicated that they were not able to build what they had planned to do. Ten percent described that they altered their plans to improve their products and they seemed to be satisfied with what they had produced.

In evaluating the quality of the products to identify improvements required, 76% of the students were able to identify some improvements to be made on the products. Only 10% mentioned improvements to be made regarding the plans. This is only the portion of students that evaluated the overall plan of the product. Very few students showed a tendency towards assessing the different parts of a product together as a whole. Most of these students (76%) failed to make a holistic assessment of the products. Further, the students could not find much in their products to be improved. For instance, 73% mentioned only one or two improvements to be made. Twenty four percent were not able to identify any improvements to be made.

In identifying skills and knowledge gained from this project the students identified only general skills. Eighty-six percent of the students concentrated mainly on the skills and knowledge involved in building the products. Only 4% mentioned skills and knowledge involved in interviewing people. None of the students mentioned the skills in: identifying needs and opportunities, exploring and developing a solution for identified needs and opportunities, planning the production of the solution, reporting the project and evaluating processes and products. The students concentrated only on the skills involved in building the products.

In making recommendations regarding the best way of doing this project, 59% of the students provided answers that were advice regarding building of the products. Only 2% gave advice about carrying out interviews and 7% on planning of the products. Seventeen percent of the answers were encouragement to other students, telling them not to be discouraged by the complexity of the products they were going to build. Many of the students (44%) were not able to make recommendations about the best way of carrying out this project. Also, another 44% were capable of making only one recommendation.

This chapter has presented the results of the assessment of the last three of the six components of students' technological capability that were assessed in this study. These components are related to the building, presenting and evaluation of the solution (product). The next chapter will present the relationships between the performances of the students in the various components of the task.

CHAPTER EIGHT

RELATIONSHIPS BETWEEN STUDENTS' PERFORMANCES

8.1 NTRODUCTION

The last two chapters presented the performances of the students in each of the six components of technological capability assessed. This chapter describes the relationships between the performances of students in these components. These relationships will be examined in order to determine: the total technological problem solving process that the students proceeded through while carrying out the technological activity; the relationship between their performances in the other components to the quality of the products produced; and the relationship between their perceptions of technology and technological capability. These relationships are important in this study because they can help to show the total picture of Tongan students' existing technological capability. They also can show the process that the students took in building the products they chose to make.

Kimbell (1994) believes that the assessment of technological capability should be carried out holistically. Kimbell, Stables, Wheeler, Wosniak and Kelly (1991, in Kimbell, 1994) argue that 'Making holistic judgements involves subconsciously teasing a piece of work apart to look for evidence of important qualities ... but more importantly ... putting it all back together again to see how effectively the individual elements work together' p. 198. This study has tried to adopt this holistic approach towards assessment of students' existing technological capability. However, instead of subconsciously teasing the piece of work apart to look for evidence of important qualities, this study employed assessment criteria to consciously tease the components of the task apart to identify the important qualities in students' performance. Putting the components together to see how effectively the individual components work together is the main purpose of this chapter. This is done through the analysis of the relationships between the performances of the students in the components of the task.

The students had been taught in Industrial Arts and Home Economics the manual skills relating to making the common important household artefacts in Tonga. Assessment in these technical subjects concentrated mainly on the quality of products the students made. This study considered it important to examine the whole process the students went through in making the products. The aim is to identify the existing ability of students to build an artefact to satisfy a certain need or opportunity in a given situation, or in other words, to identify their existing technological capability. This aim could be achieved by analyzing the following components of technological capability: A. Identifying needs and opportunities in a given situation; B. Searching for and developing the best possible solutions for the needs identified; C. Planning for the production of the solutions developed; D. Carrying out the plan of action and building the product (solution developed); E. Presenting the ideas behind the product and the product itself to the rest of the class; and F. Evaluating their methods and results as they proceeded through the project. A person that is able to connect these stages together will make a product that is appropriate to the needs identified in a given situation. Behaviors of these relationships together with weaknesses in students' performances will be identified and documented. The existing links between students' performances in the components of the task and the quality of product will also be examined and recorded. Further, relationships between students' perceptions of technology and their existing technological capability will also be investigated and documented.

The Pearson Product Moment of Coefficient of Correlation ***r*** (or correlation coefficient) will be used to assist the explanation of the relationships between the performances of the students in the stages of the project. Correlation coefficient ***r*** is a direct measure of the strength of the linear (straight line) relationship between two variables, ranging from −1.00 to +1.00. The correlation coefficient ***r*** is positive when one variable increases as the other variable increases. It is zero when there is no systematic tendency for one variable to vary with the other, and is negative when an increase in one variable corresponds to a decrease in the other variable. In this analysis, only the positive statistically significant correlations will be discussed in

order to clarify the possible paths that the students might have taken in building the products. The remainder of this chapter reports the following:

8.2 Links between Performances of Students on Components of Technological Capability;
8.3 Links between the Performances of Students on Components Technological Capability and the Quality of Product;
8.4 The relationship between Students' Perceptions of Technology and their Existing Technological Capability; and
8.5 Summary of Results.

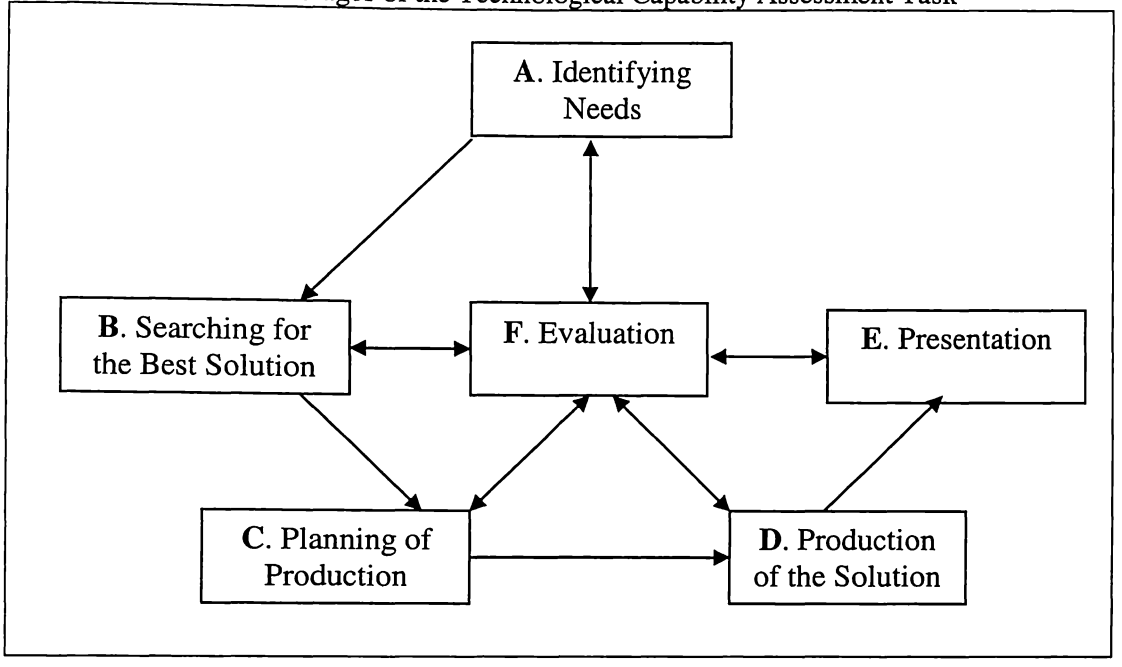
8.2. LINKS BETWEEN THE PERFORMANCES OF STUDENTS ON VARIOUS COMPONENTS OF TECHNOLOGICAL CAPABILITY

This section presents the characteristics of the links between the performances of students in the six components of technological capability assessed. These links will be used to estimate the problem solving pathways that the students went through in carrying out the activity.

At the beginning of the assessment of students' existing technological capability, the students were introduced to the project and it was explained what they were expected to do. They were given the diagram in Fig 8.2 and told that they were to choose to build one artefact from three choices. They were to follow the stages given in the project and to finish their work in five weeks. They were also told that the aim of this project was to assess their existing technological capability. Figure 8.2 shows the stages of the project that the students went through. The process that the students went through was fixed.

The procedure was laid out in the worksheets that guided the students. The stages of the technological task were arranged in such a way that the technological problem solving process that the students followed started from identifying needs and ended with presentation. They were also required to evaluate their methods and results throughout the whole stages of the project. This would enable an exploration of what the students were capable of doing in each step of the project.

FIGURE 8.2
The Main Stages of the Technological Capability Assessment Task



The students were required to follow the above stages because in the pilot study of the analysis of students' existing technological capability in Tonga, none of the students involved searched for solutions or planned for production. All of them went straight to producing the products they had chosen to build. Also, none of them evaluated their methods and results. It was therefore deemed necessary to require and guide the students to go through the components of the project so that the process they used to solve the technological problems could be determined. Their performances in these components could then be pieced together, so that a total picture of their existing technological capability could be approximated. This total picture would then show the ability of the students to view the project holistically and reveal the weaknesses in their technological capability.

It would be inaccurate to use only the correlation coefficients to describe the links between the performances of the students in the components of the project because of the small number of students involved. It is understood that fairly large correlation coefficients can occur easily by chance in a very small sample. This project was unable to include a large number of students in the study. This was due to the practical nature of the project and the need for close observation and

interviewing of the students. Therefore, to get a more complete picture of the relationships between the performances of the students in the various components of the project, the marks they obtained in each stage will be presented and explained. This will help to identify the way in which the students tackled the task. The positive significant correlation coefficients between the performances of the students in the stages of the project will also be given to assist in showing any possible relationships that existed between the performances of the students. A pathway diagram similar to the one shown above for each group will be provided and will show the positive and significant correlation coefficients between the components. This will be used to assist in explaining the paths that students actually took while carrying out the tasks.

Cohen (2001) created a convenient table for determining whether a correlation coefficient (***r***) is statistically significant or not. He performed ***t*** tests for the common alpha levels (.10, .05, .02, & .01) and obtained critical values for ***r*** for different combinations of alpha and degree of freedom (df = N-2). The critical values of ***r*** become larger as alpha gets smaller and also as the sample size decreases. Only the correlation coefficients that are greater than half of the critical values and positive will be shown in the diagrams, in order to help explain the relationships between the performances of the students in the components. It was decided to show the correlation coefficients below the statistically critical value down to half of the actual critical value in each case. This is to allow for any educationally significant relationships that might not be statistically significant enough to show up.

The relationships between the performances of the individual groups will be presented first and the relationships between the performances of the whole group of students involved in this study will follow.

8.2.1 Group 1 – Home Economics Brooms

This section presents results for the Home Economics girls who made brooms. The results show the relationships between students' performances on the various aspects of the task. The Home Economics students, including the girls in this group, worked in pairs. The first pair was coded HEB1, where HE stands for home

economics, B stands for broom and 1 stands for the first pair. There were eight pairs of girls in this task, but pair numbered 5 did not complete the work and were left out. The marks that the students of this group obtained in each component of the task are given in Table 8.2.1. The number in the bracket beside each mark is the order of the mark in each component, from highest to lowest. The relationship between two components is high if the order of students' marks stays the same from one of the components to the other. The relationship between the components is weak if the order changes from one component to the other.

Examining the relationship between the orders of the marks between components A and B, only students HEB2 and HEB8 had the same rank orders. The rest of the students had different orders, which suggested that the link between these two components was weak for this group. Between components B and C, again only two had the same rank order, and between C and D, only HEB7 kept the same order. This trend continued on for the rest of the components. This means that the links between the performances of this group in the components of the task were weak.

TABLE 8.2.1
Marks of Group 1 in Each Component

	Results in Each Component (%)						
Code	A	B	C	D	E	F	Ave
HEB1	39(1)	31(2)	16(7)	54(1)	56(1)	33(2)	38(1)
HEB2	21(5)	22(5)	25(5)	39(3)	19(6)	38(1)	27(4)
HEB3	39(1)	19(7)	25(5)	21(6)	31(2)	29(3)	27(4)
HEB4	21(5)	25(4)	28(4)	21(6)	31(2)	29(3)	26(7)
HEB6	36(3)	31(2)	38(1)	29(4)	31(2)	25(6)	32(2)
HEB7	29(4)	38(1)	31(2)	50(2)	19(6)	21(7)	31(3)
HEB8	21(5)	22(5)	31(2)	25(5)	31(2)	29(3)	27(4)

For the marks in components A and B, the most pronounced changes in the order are of the marks of students HEB3 and HEB7. Students HEB3 dropped from 1st in component A to 7th in B, while HEB7 improved from 4th in component A to 1st in B. In component A, students HEB3 were able to identify and consult appropriate sources of information on needs and opportunities, were able to collect relevant and sufficient information on needs and opportunities and were also good at analysing data to identify needs and opportunities. However, in component B, these students did not obtain the same results. They seemed to have had some ideas about the solutions to the needs and opportunities they had identified in component A and did not want to do the activities in searching for the solution. Instead, they wanted to

continue immediately and build the product. This represents one of the causes of the weaknesses of the links between components A and B. Some students identified only simple and common needs and opportunities with very obvious solutions that they felt they did not have to do further research for the best solutions.

Students HEB7 did not do well in component A, especially in planning an investigation for gathering data on needs and opportunities and analyzing data collected to identify needs and opportunities. In component B, these students showed much improvement after the experience in component A. They scored much better in describing the types of information they needed in order to solve the problems they had identified and also on identifying the best solutions from collected data. They seemed to have benefited from the experience and performed better in the next step. Therefore these students represent another cause of the weaknesses of the link between components A and B. That is, some of the students benefited more from the experience than the rest and caused a noticeable change in the order of the marks.

The most obvious changes in the order of the marks between components B and C are in the marks for students HEB1 and HEB8. Students HEB1 dropped from 2^{nd} in component B to 7^{th} in C, while students HEB8 improved from 4^{th} in B to 2^{nd} in C. In component B, students HEB1 did well in consulting the appropriate sources of information on solution to needs and opportunities, collecting relevant information on solutions, identifying solutions from data collected and identifying factors that would influence the building of the solution. It seems that these students were confident of what they were going to build. However, in component C, these students failed to do well in explaining the characteristics of the product to be built, drawing an appropriate plan of the product, identifying measurements to be made, determining the expenses involved and identifying the dangers involved in building the product. Most of these skills are different from those involved in component B, and do not depend on the results of students' performances on component B. These students needed to be taught how to draw an appropriate plan of a product to be built, determining expenses and measurements to be made and analyzing the project

to identify dangers involved. This result shows students' lack of knowledge and experience in carrying out a project of this type.

Students HEB8 did not do well in component B on collecting information on solutions and identifying appropriate solutions from collected data. These students were not sure of the solutions they were going to build. However, in component C, these students did well in determining the expenses involved and describing the appropriate steps in building the product. Again the difference in the skills required to carry out components B and C showed up in the performances of students HEB8. They needed to be taught the skills required to perform the tasks in these components in order to improve the link between them.

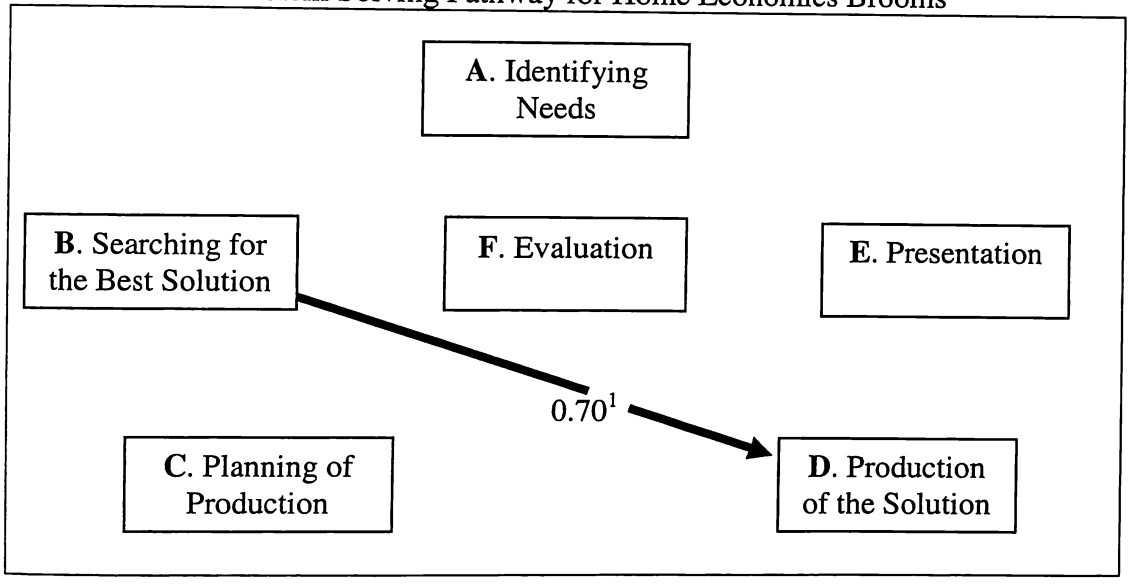
The most obvious changes in the order of the marks between components C and D are in the marks of students HEB1 and HEB6. Students HEB1 improved from 7^{th} in component C to 1^{st} in D, while students HEB6 dropped from 1^{st} in component C to 4^{th} in D. In component C, students HEB1 performed poorly in explaining the characteristics of the product to be built, drawing an appropriate plan of the product, identifying measurements to be made, determining the expenses involved and identifying the dangers involved in building the product. However, in component D, they did much better in using appropriate tools to do work required, keeping the workspace tidy and well organized and producing a product that was appropriate to specified criteria.

In component C, students HEB6 did well in naming of materials and tools required, identifying measurements to be made, explaining steps of the project identifying dangers involved in work. In component D, they did badly in using instruments to do measurements, using tools to do work and keeping the workspace tidy and well organized. It can be recognized that much of the skills required for carrying out components C and D are independent of each other. That is, the students did not have to do well in C in order to do well in D. Therefore, a strong link between these components means that the students were capable of carrying out all of the tasks required in both components. Students' lack of skills results in a weak link between the components. These students represent one of the causes of the weakness of the

links between the components of the project, that is, the lack of appropriate skills to do work required.

The nature of the links between the performances of the students in this group on the various components of the project can be clarified by using the correlation coefficients between the performances of students. Figure 8.2.1 presents the links between the performances of this group using the correlation coefficients. The only significant and positive correlation coefficient was the relationship between searching for the best solution and production. This indicates that the students of this group concentrated mainly on the production of the solutions they identified. The rest of the correlation coefficients between the components were below 0.25, which indicates that the students performed the stages of the task almost separately and concentrated mainly on the building of the solution.

FIGURE 8.2.1
Problem Solving Pathway for Home Economics Brooms



The students in this group were all girls, and Tongan girls know how to make brooms. They were familiar with the common problems of Tongan brooms. Therefore, the students might have found this task very easy, and did not see the

[1] Significant correlation coefficient (critical value) for a sample size of 16, alpha value of 0.05, using two-tailed t test, is 0.50 (Cohen, 2001, p.695).

need to identify needs or carry out proper planning and evaluation in order to be able to make a broom.

This group had problems with the relationship between identifying needs and searching for the best solution, searching for the best solution and the planning of production, the planning of production and production of the solution, production of the solution and the presentation. The only significant and strong correlation coefficient was that between searching for the best solution and production of the solution. This suggests that the students who were good at production of the solution were the students who had done well in searching for the best solution. These students did not do well in the planning of production, which means they found the best solution and went straight to production of the solution. This result shows that there is a need to teach these students to appreciate the importance of preparing a good plan for production before they build the product. It also shows the need to upgrade the nature of the task that the students are involved in so that they find it easier to see the need for proper planning before production.

8.2.2 Group 2 – Home Economics Fans

This section presents results for the Home Economics girls who made fans. The students in this group worked in pairs. The first pair was coded HEF2, where HE stands for Home Economics, F stands for fan and 2 stands for the second pair of students. There were eight pairs of girls in this task, but pair number 1 did not complete the work and was left out. The results show the relationships between students' performances on the various aspects of the task. The relationship between the orders of the marks in consecutive components was generally weak. Between components A and B, only students HEF2 and HEF6 retained the same order. Students HEF3 and HEF6 retained the same order between components B and C and none of the students had the same order between components C and D. This shows that the way students performed in a particular component was not affected much by their performance on the previous component.

The marks that the students of this group obtained in each component of the task are given in Table 8.2.2.

TABLE 8.2.2
Marks of Group 2 in Each Component

	Results in Each Component (%)						
Code	A	B	C	D	E	F	Ave
HEF2	21(5)	19(5)	34(2)	64(1)	44(3)	38(1)	37(2)
HEF3	25(1)	28(2)	34(2)	43(3)	38(4)	13(7)	30(3)
HEF4	21(5)	22(4)	25(6)	39(4)	31(5)	21(3)	27(4)
HEF5	7(7)	19(5)	31(4)	29(6)	50(1)	21(3)	26(6)
HEF6	25(1)	38(1)	41(1)	61(2)	50(1)	33(2)	41(1)
HEF7	25(1)	25(3)	31(4)	36(5)	31(5)	17(6)	27(4)
HEF9	25(1)	19(5)	13(7)	29(6)	31(5)	21(3)	23(7)

The most noticeable changes in the order of the marks between components A and B were found in the marks of students HEF5 and HEF9. Students HEF9 dropped from 1st in component A to 5th in B, while students HEF5 improved from 7th in A to 5th in B. Students HEF9 performed relatively well in component A in identifying factors that would influence the situation, collecting relevant and sufficient data on needs and opportunities, and analyzing data to identify needs and opportunities. However, in component B, they did very poorly in describing who, when, where, why and how the product would be used, describing a plan of an investigation to collect solutions on identified needs and also on consulting appropriate sources of information on solutions. These students represent those who identified needs and opportunities that had evident solutions that they did not have to do research in order to find out. They contributed to the weakness in the relationship between components A and B. In component A, students HEF5 did not do the investigation to identify needs and opportunities and obtained no marks for that part. However, in component B, these students were able to describe the types of information they needed to obtain to solve needs and opportunities. It seemed that they had knowledge of some problems about fans before, and they wanted to do an investigation to identify solutions for these problems. This accounted for part of the problems of the relationships between the performances of the students in the components of the task.

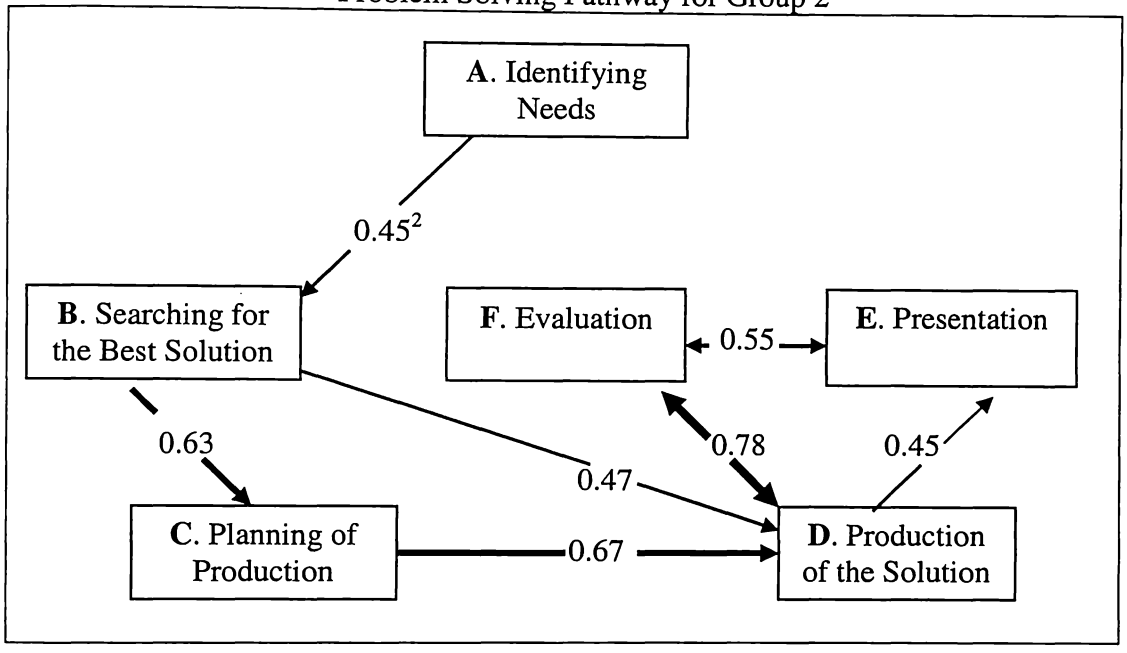
Between components B and C, the most pronounced changes in the order of the marks were observed in students HEF2 and HEF9. Students HEF2 improved from 5th in component B to 2nd in component C, while students HEF9 dropped from 5th in component B to 7th in C. Students HEF2 performed badly in component B in

describing the types of information needed for the solution, identifying appropriate sources of information for the solution, identifying the appropriate solution from the data collected and identifying factors that would influence the building of solution. In component C, these students did relatively better in drawing the plan of the product, identifying measurements to be made and determining tools and materials required for the work. Students HEF9 performed relatively well in component B in collecting information on solutions, identifying solutions from the data collected and identifying factors that would influence the building of the product. In component C, these students performed poorly in drawing the plan of the product, identifying measurements needed to be made, determining the expenses involved and identifying dangers involved in the work. Some of the skills mentioned above in components B and C are separate. The students had to perform well in all of the skills for the relationship to be high. Therefore the weakness of the relationship would suggest that the students lack the proper skills for carrying out the tasks required in both of these components.

For components C and D, the most pronounced changes in the order of the marks were those of students HEF4 and HEF5. Students HEF4 improved from 6^{th} in component C to 4^{th} in component D, while student HEF5 dropped from 4^{th} in component C to 6^{th} in D. In component C, students HEF4 performed poorly in identifying measurements to be made, determining expenses involved, explaining the steps in building the product and identifying dangers involved in the work. In component D, these students performed relatively well in keeping the workspace tidy and well organized, implementing the plan of action and producing the product with characteristics relevant to identified needs. Students HEF5 performed well in drawing a plan of the product, explaining the appropriate steps in building the product and identifying the assistance needed from experts in the field. However, in component D, they performed poorly in using appropriate instruments to do measurement, taking care of safety issues, keeping the workspace tidy and well organized and producing the product with characteristics relevant to identified needs.

Inspecting the correlation coefficients between the performances of the students in the various components of the task reveals more about the relationships between the performances of students. Figure 8.2.2 presents the correlation coefficients between the performances of the students in the various components of the task for this group. The correlation coefficients that are equal or greater than half of the critical value for this group are shown.

FIGURE 8.2.2
Problem Solving Pathway for Group 2



The relationships between the performances of the students in this group on the components of the task were better than the previous task. Although the solutions that the students developed were weakly related to the problems they identified, the planning of production related well to the solution developed. Also, the production of the solution related well to the planning they prepared. The challenge that the students of this group confronted in making a fan could have been higher than that afforded by the previous task undertaken by the students of the first group. It is less complicated to make a broom than to make a fan in Tonga. A broom is a household object in Tonga, and almost every Tongan girl has seen or helped her mother make a broom. A fan is not very common in Tongan homes and not many women can

[2] Significant correlation coefficient for a sample size of 16, alpha value of 0.05, using two-tailed t test, is 0.50 (Cohen, 2001, p.695).

make a fan. Therefore, it seems that this group had to follow more closely to the stages of the activity in order to be able to make a reasonable fan.

8.2.3 Group 3 – Home Economics Food for the Canteen

This section presents results for the Home Economics girls who made food for the school canteen. The results show the relationships between students' performances on the various aspects of the task. The students in this group also worked in pairs. There were eight pairs of girls working in this task. The first pair was coded HEC1, where HE stands for Home Economics, C stands for canteen and 1 stands for the first pair. Almost all of the relationships between the marks the students obtained in the consecutive components of the task were weak. Between components A and B, none of the students had the same order for their marks. Only students HEC5 had the same order for the marks in components B and C. Between components C and D, only students HEC2 had the same order, and in components D and E, only students HEC5 had the same order in the marks. This means that generally, the students who had done well in one component did not continue to do so in the next component, suggesting weakness in the relationships between consecutive components. The marks that the students of this group obtained in each component of the task are given in Table 8.2.3.

TABLE 8.2.3
Marks of Group 3 in Each Component

	Results in Each Component (%)						
Code	A	B	C	D	E	F	Ave
HEC1	36(1)	28(2)	41(2)	43(3)	56(1)	21(4)	37(1)
HEC2	18(6)	25(3)	25(6)	39(6)	19(7)	29(2)	26(7)
HEC3	18(6)	13(7)	38(3)	39(6)	31(4)	33(1)	29(4)
HEC4	32(2)	34(1)	22(8)	71(1)	38(3)	25(3)	37(1)
HEC5	14(8)	22(4)	28(4)	46(2)	50(2)	21(4)	30(3)
HEC6	25(5)	16(6)	47(1)	43(3)	25(5)	17(6)	29(5)
HEC7	29(3)	22(4)	25(6)	43(3)	25(5)	17(6)	27(6)
HEC8	29(3)	13(7)	28(4)	36(8)	13(8)	8(8)	21(8)

The most pronounced changes in the order of the marks between components A and B were the marks of students HEC2 and HEC8. HEC2 improved from 6th in component A to 3rd in component B, while students HEC8 dropped from 3rd in component A to 7th in B. Students HEC2 did not do well in asking important questions about a given situation, describing a plan of an investigation and also in consulting appropriate sources of information on needs and opportunities. In

component B, students HEB2 did better at describing the plan of an investigation to collect information on the best solution to needs identified. This was an improvement after the experience in component A regarding writing a plan of an investigation. This improvement changed the order of students' marks in B compared to A, and represents one of the causes of the weaknesses of the relationships between the performances of students in the consecutive components of the project. That is, some students made some improvements because of the experience they learned during the project. This supports the idea that these students need to be taught the skills in carrying out the various components of technological capability.

Students HEC8 started off relatively well in component A, especially in identifying factors relevant to the situation and asking important questions about the situation. However, they did not do well in consulting appropriate sources of information for needs and opportunities and also in collecting relevant information on needs and opportunities. These weaknesses continued and showed up again in their performance in component B. They were not able to identify and consult the appropriate sources of information on solutions to needs identified, which nullified their ability to identify best solutions to identified needs and opportunities and also their ability to identify factors that influenced building of the solution. Consulting appropriate sources of information is one of the continuous skills. Continuous skills are those that are required to carry out tasks which results affect the performances of students in the other component components. For example, the skill in determining the scale of a design in the planning stage will affect building of the product in the next stage. Discrete skills are those that are required to carry out the tasks local to a particular component; the results of these local tasks do not affect the performances of the students in the other components of the task. Students HEC8 performed well in the discrete skills in component A but badly in the continuous skills. This resulted in a drop in the order of marks between components A and B, which represents one of the causes of the weaknesses of the links in students' performances. Learning the continuous skills is one of the new and strong aspects emphasized by the new Technology Education curriculum. Students who are good at the continuous skills are able to look at a task in a more holistic way, and are able

to build a product that can satisfy a particular need or opportunity. So, weakness of links between the components of the task will occur when students have good discrete skills but bad continuous skills.

Between components B and C, the most noticeable changes in the order of marks were those belonging to students HEC4 and HEC6. Students HEC4 dropped from 1st in component A to 8th in B, while students HEC6 improved from 6th in component B to 1st in A. In component B, students HEB4 did relatively well in describing a plan of investigation to collect information on solutions to need identified, consulting appropriate sources of information on solutions and collecting relevant and sufficient information on solutions to needs identified. In component C, students HEB4 performed badly in planning a product with characteristics appropriate to the needs identified, identifying measurements that needed to be made, identifying dangers involved in building the product and in identifying assistance needed from experts in the field. Students HEB4 represent students who performed well in identifying needs and opportunities and searching for the best solutions for the needs identified, and then immediately moved on to build the product without proper consideration of planning. Since they were successful in determining the solutions for the problems, they found it difficult to spend time in doing proper planning for production.

Students HEB6 started off badly in component B, especially in determining who, when, how, why and where the product will be used, describing a plan of an investigation for information on the solution, identifying solutions from information collected and identifying knowledge and skills required for building the product. But in component C, these students did relatively better at determining materials and tools required for the work, identifying measurements needed to be made, determining the expenses involved, explaining the appropriate steps of building the product and identifying dangers involved in the work. These students proved that they could do well in planning although they had not done well in identifying needs and opportunities and searching for the best solution. They did very well in the discrete skills in planning. This represents another cause of the weaknesses of the

links between students' performances in the components. That is, the students performed well in the discrete skills but badly in the continuous skills.

Between components C and D, the most prominent changes in the order of the marks were that for students HEC4 and HEC8. Students HEC4 improved from 8th in component C to 1st in component D, while students HEC8 dropped from 4th in component C to 8th in D. In component C, students HEC4 did badly in drawing the plan of the product, identifying the measurements needed to be made, explaining the steps involved in building the product, identifying dangers involved in work and determining assistance needed from experts in the field. In component D, these students performed well in using tools to do work required, taking care of safety issues, keeping the workspace tidy and well organized, implementing a plan of action, producing a product with characteristics appropriate to specified criteria, and producing an aesthetic product. Students HEC4 represent the type of students that are better at building a product than explaining it. They found it difficult to explain what they were going to build, but were very skilful in building the product. This represents one of the causes of the weaknesses of the links between the performances of students.

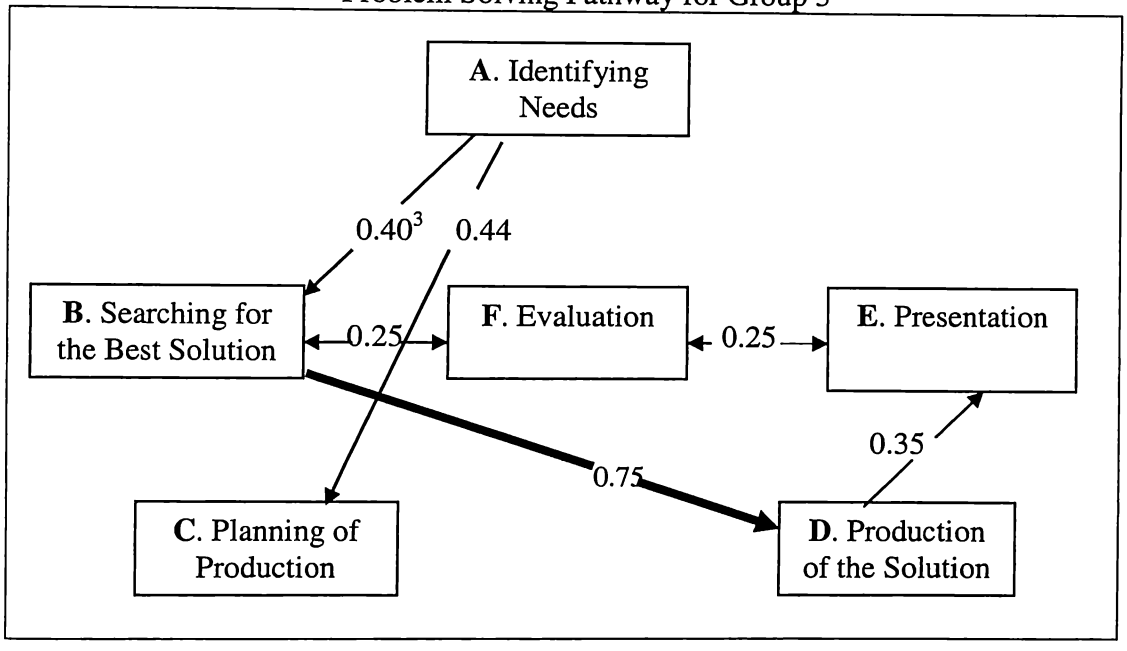
In component C, students HEC8 performed relatively well in determining materials required for the product and describing the expenses involved. However, in component D, these students did badly in using appropriate instruments to do measurement, using tools to perform work and producing the product with characteristics appropriate to specified criteria. These students were opposite of students HEC4. They found it easy to explain what they were going to do and to describe the nature of the product, but did not have the skills to build the product they had planned. They represent one of the causes of the weaknesses of the relationships between the performances of the students in the components of the task.

The nature of the links between the performances of the students in this group on the various components of the project can be clarified by using the correlation coefficients between the performances of students in the various components of the

project. Figure 8.2.3 presents the links between the performances of this group using the correlation coefficients.

The way this group tackled the task was similar to the group of girls that made brooms. They seemed to have produced the product from the solution they developed. No relationship existed between production and planning and also between planning and the solution developed. Planning of production was related to the needs identified, but was never used in the production of the solution. Evaluation was also weakly related to the rest of the components. It seems that the students in this group concentrated mainly on the production of the solution they developed and did not take care of the rest of the stages of the activity.

FIGURE 8.2.3
Problem Solving Pathway for Group 3



The students seem to have found this task easy, they saw no need for proper planning of production. The main types of food the students made were pancakes and sandwiches, which were easy to make. They identified the problems with the food in the school canteen to be lack of variation. They found that the students of the school wanted other types of food beside the buns that they were selling in the

[3] Significant correlation coefficient (critical value) for a sample size of 16, alpha value of 0.05, using two-tailed t test, is 0.50 (Cohen, 2001, p.695).

canteen everyday. So the students of this group wanted to make cheap food to replace buns and they opted for the cheapest food that they knew how to make.

These students managed to relate the development of the solution to the needs they identified, but were not able to continue on and base their planning on the solution they developed. Instead, they went ahead and produced the solution they found.

8.2.4 Group 4 – Industrial Arts Brooms

This section presents results for the Industrial Arts boys who made brooms. The results show the relationships between students' performances on the various aspects of the task. The Industrial Arts students, including the students in this task, worked in groups of three. The first group was coded IAB1, where IA stands for Industrial Arts, B stands for broom and 1 stands for the first group. There were five groups that were working in this task. The marks that each group in this task obtained in each component of technological capability are given in Table 8.2.4. The relationship between the orders of the marks in components C and D was close. Students IAB1 and IAB3 kept the same orders and the rest had only close changes. Large changes in the orders of the marks were observed between components A and B, B and C, and D and E. This suggests that the relationship between the performances of the students in this task in components C and D was the highest.

TABLE 8.2.4
Marks of Group 4 in Each Component

	Results in Each Component (%)						
Code	A	B	C	D	E	F	Ave
IAB1	32(1)	34(1)	34(3)	43(3)	13(2)	25(2)	30(2)
IAB2	14(5)	31(2)	22(5)	39(4)	13(2)	17(5)	23(4)
IAB3	25(3)	22(3)	41(1)	50(1)	38(1)	38(1)	35(1)
IAB4	21(4)	16(5)	31(4)	36(5)	13(2)	21(4)	23(4)
IAB5	32(1)	19(4)	38(2)	50(1)	13(2)	25(2)	29(3)

Between components A and B, the most pronounced changes in the orders of the marks occurred with students IAB2 and IAB5. Students IAB2 improved from 5th in component A to 2nd in B, while students IAB5 dropped from 1st in component A to 4th in B. Students IAB2 did poorly in component A in describing a plan of investigation, collecting important information on needs and opportunities, and identifying needs intrinsic in the situation. However, in component B, these students did well in collecting important information on solutions, identifying best solutions

from the data collected and identifying factors that would influence the building of solutions. These students improved their performances after the experience in component A. Students IAB5 did relatively well in component A in consulting appropriate sources of information on needs and opportunities, and collecting relevant and sufficient information on needs and opportunities. In component B, these students did badly in describing a plan of an investigation of solutions, identifying important solutions from the data collected, and identifying factors that would influence the building of the product. These students had shown in component A that they were good at searching for information. This drop of results in component B suggests that they did not want to do part B. They wanted to proceed straight on to the building of the product using the information they had obtained while searching for needs and opportunities.

Between components B and C, the largest changes in the orders of the marks were observed with students IAB2 and IAB3. Students IAB2 did relatively well in component B in collecting important information on solutions, identifying best solutions from the data collected and identifying factors that would influence the building of solutions. In component C, these students did poorly in drawing the plan of the product, identifying materials and tools needed for the work and identifying dangers involved in building the product. These students were able to obtain important information on solutions but failed to develop a good plan. Lack of appropriate skills in carrying out tasks required is one of the causes of the weaknesses of this link. Students IAB3 did poorly in component B on stating who, where, why, when and how the product would be used, identifying factors that would influence the building of the product and identifying knowledge and skills required for the work. In component C, these students performed relatively well in planning the product with characteristics relevant to the identified needs, identifying materials and tools required for work, explaining the appropriate steps involved in building the product and identifying dangers involved in work. The strength of these students was mainly on building the product. They showed lack of confidence in determining the purpose of the product and consideration of factors that would influence the building of the product. This is a reflection of what they were commonly doing in Industrial Arts practical work. The students were asked to build

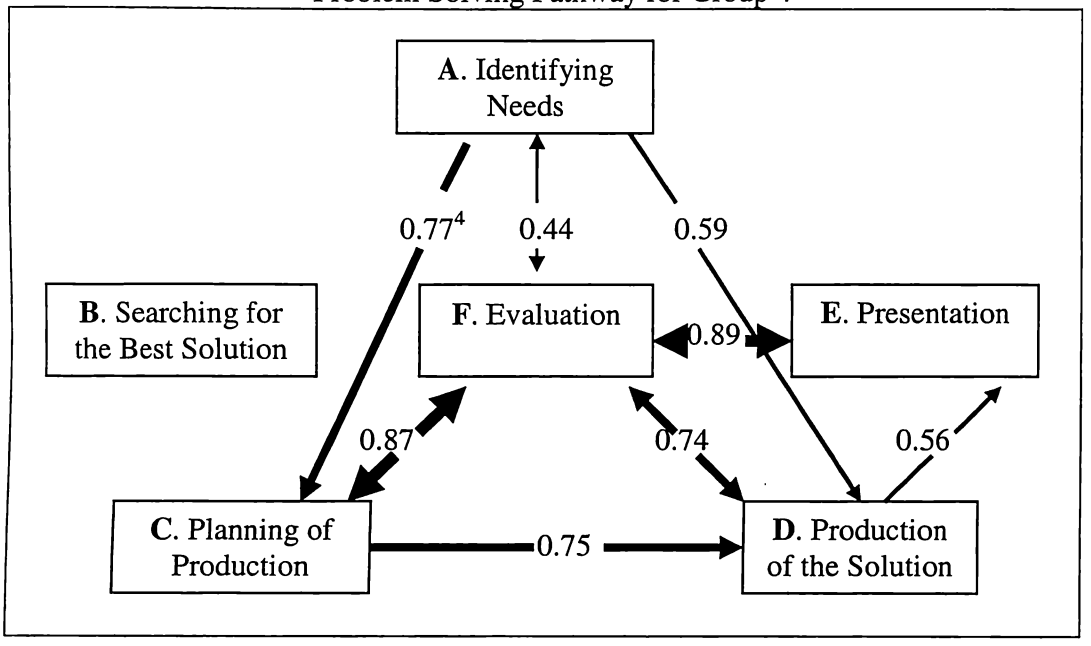
a product as the practical part of the course. Building the product for whom and for what purpose was not emphasized in the Industrial Arts and Home Economics practical work. This represents one of the causes of the weaknesses of the relationships between the performances of the students in the components of the task.

Between components C and D, the changes in the orders of the marks were not much. However, weaknesses of the relationships could be observed in students IAB4 and IAB5. Students IAB4 dropped from 4th in component C to 5th in D, while students IAB5 improved from 2nd in component C to 1st in D. Students IAB4 performed relatively well in component C in identifying measurements to be made, identifying dangers involved in work and identifying assistance needed from experts in the field. However, in component D, they did badly in taking care of safety issues, keeping the workspace tidy and well organized and producing an aesthetic product. This shows lack of experience in building products in a workshop. This is one of the causes of the weaknesses of the links between components of the task. Students IAB5 did badly in component C in drawing the plan of the product, identifying materials and tools needed for the work and identifying dangers involved in building the product. In component D, they did relatively well in taking care of safety issues, producing a product with characteristics appropriate to the specified criteria and producing an aesthetic product. They seemed to lack experience in the planning of production. They were good at the actual building of the product.

More information on the relationships between the components is exposed using the correlation coefficients between the various components of the task. Figure 8.2.4 presents the problem solving process pathway for this group. This group of boys approached this task of making a broom differently from the group of girls who made brooms. The boys did not search for the solutions of the needs they had identified, and also, they did not plan for the production of the solutions they developed. They identified the needs and problems regarding the brooms in Tonga and they went ahead and planned for the production of the brooms. They continued

well from the plan to the production of brooms and reasonably well to presentation. Evaluation was well related to planning, production and presentation.

FIGURE 8.2.4
Problem Solving Pathway for Group 4



The Tongan boys were not as familiar as the girls with the problems relating to the making and use of brooms. They also have much less experience than the girls in making brooms. So it is likely that these boys found this task more difficult than the girls. Thus they had to plan well before they could make a broom. It can be observed in the diagram above that the boys related their planning well to the needs identified and also their production of solutions was well related to their planning. Evaluation was also highly related to the rest of the components.

8.2.5 Group 5 – Industrial Arts Wooden Pillows

This section presents results for the Industrial Arts boys who made wooden pillows. The results show the relationships between students' performances on the various aspects of the task. The students in this task also worked in groups of three. The first group was coded IAW1, where IA stands for Industrial Arts, W stands for wooden pillow and 1 stands for the first group. There were six groups working on this task

[4] Significant correlation coefficient for a sample size of 15, alpha value of 0.05, using two-tailed t test, is 0.51 (Cohen, 2001, p.695).

but group IAW3 did not complete the task and was left out. The marks that the students of this group obtained in each component of the task are given in Table 8.2.5. The changes in the orders of the marks are more recognizable between components B and C and between C and D. This means that the relationships between these components were weaker than the others. Changes in the orders of the marks between components A and B and between D and E were not much, indicating better relationships between the components.

TABLE 8.2.5
Marks of Group5 in Each Component

	Results in Each Component (%)						
Code	A	B	C	D	E	F	Ave
IAW1	32(1)	16(3)	34(3)	43(2)	19(3)	17(4)	27(3)
IAW2	7(5)	16(3)	22(5)	32(4)	19(3)	17(4)	19(5)
IAW4	21(3)	19(2)	34(3)	39(3)	25(2)	38(1)	29(2)
IAW5	18(4)	13(5)	38(2)	29(5)	19(3)	25(2)	23(4)
IAW6	29(2)	22(1)	47(1)	46(1)	31(1)	25(2)	33(1)

Between components A and B, the changes between the orders of the marks were not much. However, the most noticeable changes were those of students IAW1 and IAW2. Students IAW1 dropped from 1st in component A to 3rd in component B, while students IAW2 improved from 5th in component A to 3rd in component B. Students IAW1 did relatively well in component A in asking important questions about a given situation, consulting appropriate sources of information on needs and opportunities, analyzing the collected data to identify needs and opportunities and identifying needs and opportunities intrinsic in the situation. In component B, these students did poorly in stating who, where, why, when and how the product would be used, describing a plan of investigation to collect information on solutions, collecting relevant and sufficient information on solutions and identifying the best solutions from the collected data. It seems that these students did not want to search for solutions. Instead, they wanted to build the product using the information on needs and opportunities they obtained. Students IAW2 did poorly in component A in asking important questions about a given situation, consulting appropriate sources of information on needs and opportunities, collecting relevant and sufficient data on needs and opportunities and analyzing the collected data to identify needs and opportunities. In component B, these students performed relatively well in describing the type of information needed for solutions, collecting relevant and sufficient information on solutions and identifying knowledge and skills required

for building the product. These students seemed to have benefited from the experience in the research work in component A. This is one of the causes of the weaknesses of the relationships between the components.

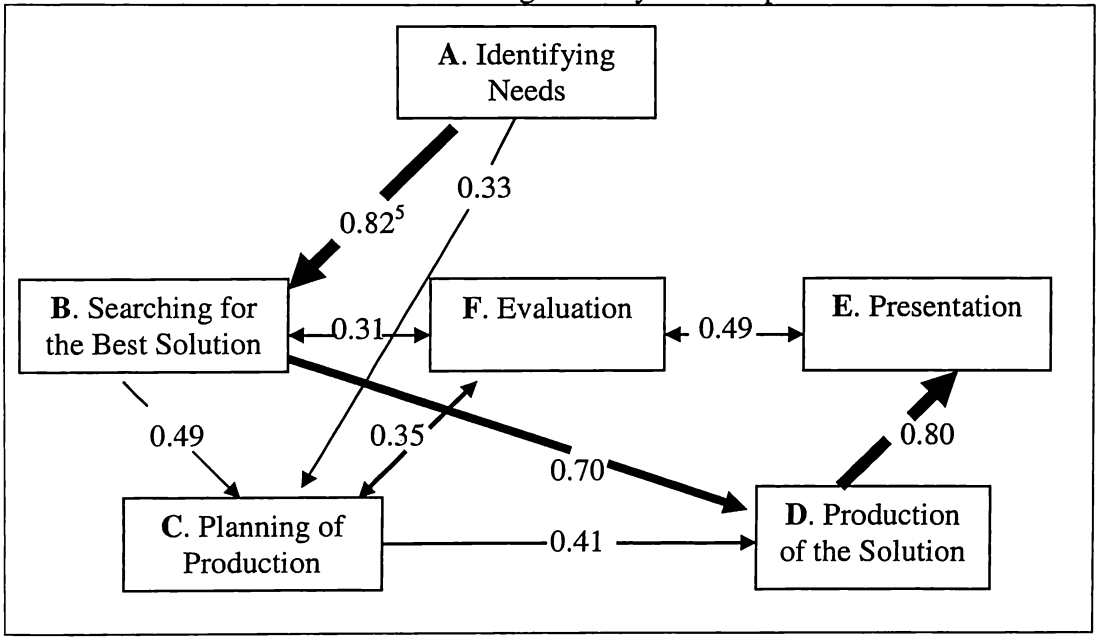
Between components B and C, the most obvious changes in the orders of the marks were those of students IAW2 and IAW5. Students IAW2 dropped from 3rd in component B to 5th in C, while students IAW5 improved from 5th in component B to 2nd in C. Students IAW2 performed relatively well in component B in describing the type of information needed for solutions, collecting relevant and sufficient information on solutions and identifying knowledge and skills required for building the product. In component C, these students did poorly in planning a product with characteristics appropriate to needs identified, determining materials and tools needed for work and identifying assistance required from experts in the field. The skills involved were separate and the very low marks the students obtained suggest that the students needed to be taught the skills involved in these components. Students IAW5 did badly in component B in stating who, where, why, when and how the product would be used, describing the types of information needed for solutions, describing a plan of investigation for information on solutions, collecting relevant and sufficient information on solutions and identifying the best solutions from the data collected. In component C, these students did relatively well in determining materials and tools needed for the task, determining expenses involved and explaining the steps involved in building the product. These students seemed to be concentrating mainly on building the product.

Between components C and D, the most pronounced changes in the orders of the marks were those of students IAW2 and IAW5. Students IAW2 improved from 5th in component C to 4th in D, while students IAW5 dropped from 2nd in C to 5th in D. Students IAW2 performed poorly in component C in planning a product with characteristics appropriate to needs identified, determining materials and tools needed for work and identifying assistance required from experts in the field. In component D, these students performed relatively well in using appropriate instruments to measure required quantities, taking care of safety issues and keeping the workspace tidy and well organized. However, they did not do well in using tools

to perform the work required, building a product with characteristics appropriate to specified criteria and producing an aesthetic product. These results suggest that these students lacked the appropriate skills to carry out these activities. Students IAW5 performed relatively well in component C in determining materials and tools needed for the task, determining expenses involved and explaining the steps involved in building the product. However, in component D, these students did not do well in using appropriate instruments to do measurements, using appropriate tools to perform work required, taking care of safety issues, producing a product with characteristics appropriate to specified criteria and producing an aesthetic product. These students knew what they were required to do but failed to do it. They seemed to know the steps in building the product but lacked the appropriate skills, helping to make the relationship between the components weak.

Further analysis of the relationships between the performances of this group in the components of the task is carried out using the correlation coefficients between the components. Figure 8.2.5 presents the correlation coefficients between the marks the students obtained in the various components of the task.

FIGURE 8.2.5
Problem Solving Pathway for Group 5



[5] Significant correlation coefficient (critical value) for a sample size of 15, alpha value of 0.05, using two-tailed t test, is 0.51 (Cohen, 2001, p.695).

This group of students recognized the need to carry out a proper search for solutions to identified needs more so than the boys who made brooms. The highest correlation coefficient was that between identifying needs and searching for the best solution. Their planning also related better to the solutions they developed than the previous group. A positive relationship was also observed between production of the solution and planning of production. However, the relationship between production of the solution and searching for the best solution was very strong, suggesting that the students tended to base their building of products more on the solutions they identified. The strong relationships suggest that this group identified needs, searched for the best solution, build the products, presented them to the class, with some evaluation while searching for the best solution, planning and presentation.

8.2.6 Group 6 – Industrial Arts Kava Drinking Seats

This section presents results for the Industrial Arts boys who made a kava drinking seat. The results show the relationships between students' performances on the various aspects of the task. The students in this task also worked in groups of three. The first group was coded IAS1, where IA stands for Industrial Arts, S stands for seat and 1 stands for the first group. There were five groups of students working on this task. The marks that the students in this task obtained in each component of the task are given in Table 8.2.6. Very small changes could be observed in the orders of the marks between components A and B and between C and D, indicating strong relationships between the performances of this group in these components. Larger changes in the orders of the marks could be observed between components B and C and between D and E, suggesting weaker relationships in the performances of this group in these components.

TABLE 8.2.6
Marks of Group 6 in Each Component

	Results in Each Component (%)						
Code	A	B	C	D	E	F	Ave
IAS1	32(2)	38(2)	34(4)	57(3)	19(3)	29(4)	35(4)
IAS2	29(3)	22(5)	44(3)	50(4)	50(2)	46(2)	40(2)
IAS3	18(5)	28(3)	47(2)	68(1)	19(3)	42(3)	37(3)
IAS4	21(4)	28(3)	19(5)	39(5)	6(5)	29(4)	24(5)
IAS5	54(1)	53(1)	59(1)	68(1)	56(1)	54(1)	57(1)

Between components A and B, the changes between the orders of the marks were not much. However, the most noticeable changes were those of students IAS2 and

IAS3. Students IAS2 dropped from 3rd in component A to 5th in component B, while students IAS3 improved from 5th in component A to 3rd in component B. Students IAS2 performed relatively well in component A in describing a plan of investigation to collect information on needs and opportunities, consulting appropriate sources of information on needs and opportunities and analyzing the data collected to identify needs and opportunities. In component B, these students did not perform well in describing who, where, why, when and how the product would be used, describing a plan of investigation to collect information on solutions, identifying best solutions from the data collected and identifying knowledge and skills required for making the product. These students seemed to have found needs and opportunities with evident solutions. They therefore did not want to do another search for solutions but wanted to continue and build the product, adding to the weakness in the relationships between components A and B. Students IAS3 performed poorly in component A in describing a plan of investigation to collect information on needs and opportunities, collecting relevant and sufficient data on needs and opportunities and analyzing data to identify needs and opportunities. In component B, these students performed relatively well in describing the types of information needed for solutions, collecting relevant and sufficient information on solutions and identifying knowledge and skills required for building the product. These students benefited from the experience and performed better in component B, contributing to the weakness in the relationship between components A and B.

Between components B and C, the changes between the orders of the marks were more recognizable than those between A and B. The most noticeable changes were those of students IAS2 and IAS4. Students IAS2 improved from 5th in component B to 3rd in component C, while students IAS4 dropped from 3rd in component B to 5th in component C. Students IAS2 did not perform well in component B in describing who, where, why, when and how the product would be used, describing a plan of investigation to collect information on solutions, identifying the best solutions from data collected and identifying knowledge and skills required for making the product. In component C, these students performed relatively well in planning the product with characteristics appropriate to the needs identified, determining materials and tools needed for work and identifying assistance required from experts in the field.

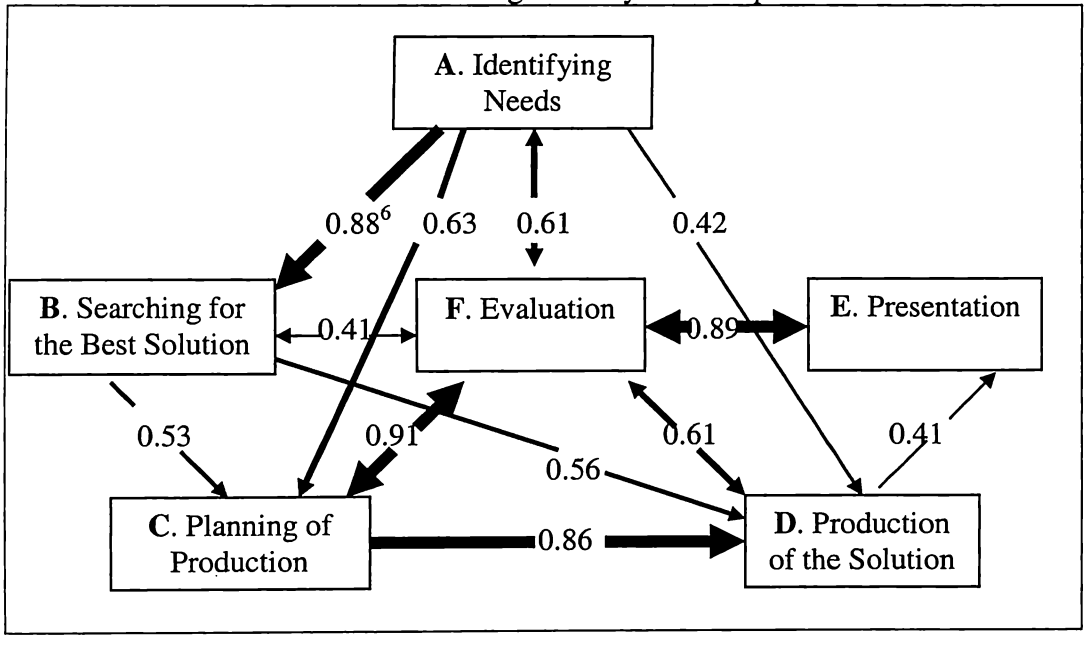
Although these students showed relatively good skills in planning for production, they lacked the appropriate skills involved in searching for the best solution. This lack of skills contributed to the weakness of the relationships between components B and C. Students IAS4 performed relatively well in component B in describing an investigation to collect information on solutions, consulting appropriate sources of information on solutions, identifying factors that would influence the building of the product and identifying knowledge and skills required for building the product. In component C, these students performed poorly in planning the product with characteristics appropriate to needs and opportunities identified, drawing a plan of the product, determining materials and tools required for work, identifying dangers involved in building the product and identifying assistance needed from experts in the field. These students seemed to be ready to build the product after component B. They did not want to do the planning part of the project which contributed to the weakness of the relationship between these components.

Between components C and D, the changes between the orders of the marks were not as much as the last pair. However, the most pronounced changes were those of students IAS1 and IAS2. Students IAS1 improved from 4th in component C to 3rd in component D, while students IAS2 dropped from 3rd in component C to 4th in component D. Students IAS1 performed poorly in component C in planning the product with characteristics appropriate to the identified needs and opportunities, identifying measurements needed to be made, explaining the steps in building the product and identifying assistance needed from experts in the field. In component D, these students performed relatively well in using appropriate instruments to do measurements, fully implementing the plan of action and producing a product with characteristics appropriate to specified criteria. These students seemed to be the same as those who did not see the importance of doing proper planning for production. These students concentrated mainly on building the product, contributing to the weakness of the relationship between these components. Students IAS2 performed relatively well in component C in planning the product with characteristics appropriate to the needs and opportunities identified, drawing a plan of the product, determining materials and tools required for work, identifying dangers involved in work and identifying assistance required from experts in the

field. These students performed poorly in component D in terms of using appropriate instruments to do measurements, using appropriate tools to perform work required and fully implementing the plan of action. These students were not able to carry out what they planned to do. They seemed to know what to do but lacked the appropriate skills to carry out what they had planned. This lacking of appropriate skills contributed to the weakness of the relationship between these components.

The correlation coefficients between the marks the students obtained is presented to enhance the description of the relationships between the performances of this group in the components of the task. Figure 8.2.6 presents the correlation coefficients between the performances of this group in the components of the task.

FIGURE 8.2.6
Problem Solving Pathway for Group 6



The correlation coefficients between the performances of this group on the components of the task were the highest of all the groups. The relationships between evaluation and the rest of the components were also better. This was the most difficult task. The students had to do better preparation and planning before they

[6] Significant correlation coefficient (critical value) for a sample size of 15, alpha value of 0.05, using two-tailed t test, is 0.51 (Cohen, 2001, p.695).

could build the seat. They had to: search for best materials to use; search for the best shape and size; draw a plan; do measurements; use the machines to do the cuttings; nail the parts together; and do the finishing. These challenges were higher than those afforded by the rest of the tasks carried out by the other groups. Because the challenges were higher in this task, it seems that this helped the students to link the parts of the task better than the rest of the groups.

This result is significant because it shows that the nature of the task is a major factor that influences the way in which the students advance through the problem solving process. It suggests that the affordance of the task must be right before the students can carry out the components in a holistic fashion. It has been shown that when the tasks are too easy or too common, the students tend to concentrate mainly on building the products and carry out the components as if they were separate activities. Building a kava drinking seat is a technological task that has been shown to have high affordance in a Tongan secondary school Industrial Arts class. It provided adequate challenge and incentive that kept these students closely following the main stages of the technological capability pathway, thus performing the task in a holistic way.

8.2.7 Whole Group of Students Involved in this Study

This section presents results for the whole group of students involved in the study. The results show the relationships between students' performances on the various aspects of the task. The results of the performances of the groups in the stages of the project are given in Table 8.2.7. The highest average for the whole group was that for capability D, production of the solution. This suggests that the students mainly concentrated on building the products. They did not do well in identifying needs (A), and searching for the best solution (B). The relationships between the orders of marks between consecutive components were generally low. The largest changes were observed between components B and C, and between D and E. The changes of the orders of the marks between components C and D were also high. These results suggest that the relationships between the performances of students in searching for the best solutions and the planning of production, the planning of production and producing the product, and producing the product and presentation were weak. The

smallest changes in the orders of the marks were observed between components A and B, in which three groups kept the same orders and the changes in the orders were small. This result suggests that the relationship between the performances of students in identifying needs and opportunities and searching for the best solutions was the strongest. It should also be mentioned here that this analysis of the relationships between the performances of the groups in the components of the task looks at a more general picture of the results which the analysis of the individual groups can not do.

TABLE 8.2.7
Marks of Groups in Each Component

Groups		Results in Each Component (%)						
		A	B	C	D	E	F	Ave
1	Girls - Brooms	30(2)	27(2)	28(6)	34(6)	31(3)	29(2)	30(2)
2	Girls - Fans	21(5)	24(3)	30(5)	43(4)	39(1)	23(5)	30(2)
3	Girls - Canteen	25(3)	21(5)	32(4)	45(2)	32(2)	21(6)	29(4)
4	Boys - Brooms	25(3)	24(3)	33(3)	44(3)	18(6)	25(3)	28(5)
5	Boys - Pillows	21(5)	17(6)	35(2)	38(5)	23(5)	24(4)	26(6)
6	Boys - Kava Seats	31(1)	34(1)	41(1)	56(1)	30(4)	40(1)	39(1)
All		25	24	32	43	30	27	30

The largest changes in the orders of the marks belonged to groups 2 and 3. Group 2 improved from 5th in component A to 3rd in B, while group 3 dropped from 3rd in component A to 5th in B. Group 2 performed poorly in component A in consulting appropriate sources of information on needs and opportunities, collecting relevant and sufficient data on needs and opportunities and identifying needs and opportunities intrinsic in the situation. However, in component B, this group performed relatively well in describing the types of information needed for solutions, consulting the appropriate sources of information on solutions and strategies and identifying knowledge and skills required for building the product.

The improvement in the results of group 2 in consulting the appropriate sources of information suggested that these students benefited from the experience they had in component A, contributing to the weakness of the relationships between these two components. Group 3 did relatively well in component A in asking important questions about a given situation, identifying factors relevant to a given situation, collecting relevant and sufficient data on needs and opportunities and identifying needs and opportunities intrinsic in the situation. In component B, this group performed poorly in stating who, where, why, when and how the product would be

used, describing the types of information needed for solutions, consulting the appropriate sources of information on solutions and identifying solutions from the data collected. This group seemed to have found needs and opportunities that were too difficult to solve. They were able to identify important needs and opportunities in the situation, but they were not able to find the right sources of information for the solutions to the problems and could not determine the types of information they needed in order to solve the problems they had identified. This result shows that students lacked experience and knowledge in determining the right types of problems to work on, which contributed to the weakness of the relationship between these components.

Between components B and C, the largest changes in the orders of the marks were those of groups 1 and 5. Group 1 dropped from 2nd in component B to 6th in C, while group 5 improved from 6th in component B to 2nd in C. Group 1 performed relatively well in component B in consulting appropriate sources of information for solutions, identifying the best solutions from data collected and identifying factors that would influence the building of solutions. In component C, this group performed poorly in a planning product with characteristics appropriate to the identified needs and opportunities, determining materials and tools required for work, determining expenses involved and identifying dangers they would expect in building the product. This group seemed to have wanted to go straight from searching for the best solutions to building the product without carrying out proper planning. This was one of the causes of the weakness between these two components. Group 5 performed poorly in component B in stating who, where, why, when and how the product would be used, planning an investigation to collect information on solutions, collecting relevant and sufficient information on solutions and identifying the best solutions from the collected data. In component C, this group performed relatively well in determining materials and tools required for work, identifying measurements needed to be made, explaining the appropriate steps in building the product and identifying dangers involved in the production.

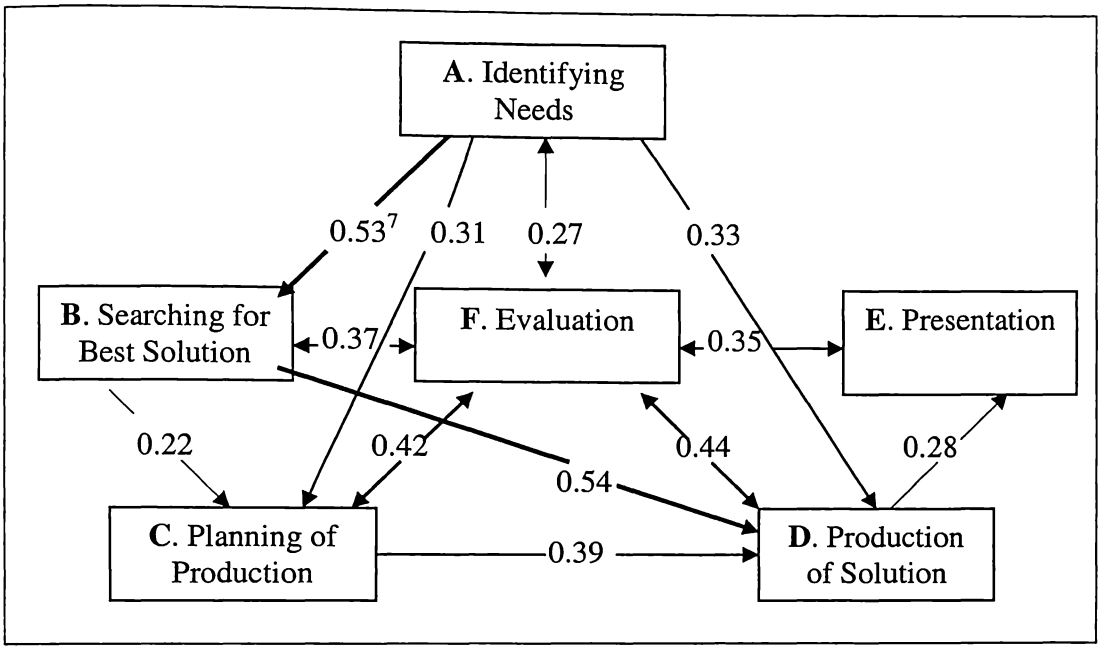
Between components C and D, the largest changes in the orders of the marks were those of groups 3 and 5. Group 3 improved from 4th in component C to 2nd in D,

while group 5 dropped from 2nd in component C to 5th in D. Group 3 performed poorly in component C in planning a product with characteristics appropriate to the needs identified, identifying dangers involved in building the product and identifying assistance required from experts in the field. In component D, this group did relatively well in taking care of safety issues, keeping the workspace tidy and well organized, implementing the plan of action and producing a product with characteristics appropriate to specified criteria. Group 5 performed relatively well in component C in determining materials and tools required for work, identifying measurements that needed to be made, explaining the appropriate steps in building the product and identifying dangers involved in work. In component D, this group performed poorly in using appropriate tools to do work, full implementation of the plan of action, producing a product with characteristics appropriate to specified criteria and producing an aesthetic product. This group failed to produce what they were able to explain. They represent the types of students who were good at explaining things but not as good at building them with their hands, contributing to the weakness of the link between these two components.

The correlation coefficients between the marks the students obtained will be presented to provide a more complete picture of the relationships between the performances of the students in the components of the task. Figure 8.2.7 presents the correlation coefficients between the performances of the whole students involved in this study in the components of the task.

The links between the performances of the students in the components of the project were weak, indicating that the students performed each component almost separately from the rest of the components. It seemed that they were not able to view the components of the project holistically. The lowest correlation coefficient was between searching for the best solution and the planning of production. This indicates that the students did not relate much of their planning to the solutions they developed. The relationship between production and presentation was also very low, indicating that the students were not able to present properly what they had produced. The link between planning and production was also very low and so too the link between identifying needs and opportunities and evaluation.

FIGURE 8.2.7
Problem Solving Pathway for the Whole Students Involved



The highest correlation coefficient was that between searching for the best solution and production, which was 0.54. The second was between identifying needs and opportunities and searching for the best solution, which was 0.53. The general path that shows using the correlation coefficients is that the students searched for the best solutions for the identified needs, and then proceeded straight to production.

Relationships between evaluation and the rest of the components were relatively high. This indicates that the students performed appropriate evaluation of their progress and work as they proceeded through the project.

[7] Significant correlation coefficient (critical value) for a sample size of 95, alpha value of 0.05, using two-tailed t test, is 0.21 (Cohen, 2001, p.695).

8.3 LINKS BETWEEN THE PERFORMANCES OF STUDENTS ON SIX COMPONENTS OF TECHNOLOGICAL CAPABILITY ASSESSED AND THE QUALITY OF THE PRODUCT

This section presents the relationships between the performances of the students on the six components of technological capability assessed and the quality of the product they produced. This study believes it is important to identify the components of technological capability that correlate strongly with the quality of the product produced by Tongan students. One of the important purposes of Technology Education is the production of a good quality product. A good quality product is one that not only has characteristics which are appropriate to pre-specified criteria, but is also very aesthetic. Factors that contribute to the production of a good quality product are important to the development of Technology Education curricula. An assumption has been made in many Technology Education curricula states that a good quality product results from proper execution of the design cycle. In other words it is assumed that a good quality product is an outcome of the work of a technologically capable person. A technologically capable person is one that has mastered the skills in identifying needs and opportunities in a given situation, searching for and developing the best possible solutions and strategies for identified needs and opportunities, planning the production of solutions developed, building of solutions, presenting the ideas behind solutions to a group of people and evaluating the process and results as progress is made. It also enables the person to view the total design cycle in a holistic fashion. The results of this section will add more light to this situation. Further important information that is documented in this section is the causes of the weaknesses of the relationships between the performances of the students in the components of the task and the quality of products they produced. It is important to find out the total picture of the present situation in Tonga, because no research has been done in this area in Tonga. Also, there has been no information about Tongan students' technological capability available in literature.

This section will analyse the nature of the relationships between the performances of the students in the components of the project and the quality of products. The

analysis will only consider the relationships between the performances of tasks groups, and not of the pairs and smaller groups as in the previous section. This is to create a better view of the effects of the tasks on the relationships between each technological capability component and the quality of the product produced. The analysis will use the orders of the marks the students obtained in each component and the orders of the marks for the quality of the product they produced. These orders will be examined to determine the groups that retained the same orders between each component and the quality of product and those that had changes. Large changes in the orders of the marks between each component and quality of product suggest a weak relationship, while small changes in the orders suggest a stronger relationship. Also, difference between the marks the students obtained for each component and those for quality of the product are examined. Large differences of marks indicate a weak relationship. Further analysis of these relationships will be carried out using the Pearson Product Moment of Coefficient of Correlation ***r***. The relationships between the performances of the groups in component A will be presented first and the rest of the components will follow.

8.3.1 Identifying Needs and Opportunities and the Quality of the Product

The relationship between the performances of students in identifying needs and opportunities and the quality of the product depended on both the aesthetic of the product and on the ability of the students to build products to satisfy needs and opportunities identified. This is the ability to build something that could serve a particular purpose, one of the main differences between the traditional technical subjects and the new approach provided through Technology Education. The new approach encourages building artefacts that can serve a purpose in the community. The students are assisted to obtain appropriate knowledge and skills to develop products, systems and environments, in order to meet needs and opportunities existing in a particular social context. So the ability of the students to build a product that meets the identified needs and opportunities is one of the ingredients of a technologically capable person. Further, the appropriateness of the product to the specified needs and opportunities is one of the characteristics of a good quality product. So, the push by Technology Education for good quality products requires the relationships between the performances of the students in identifying needs and

opportunities and the quality of the products to be high. A low relationship would be a signal of a need for the development of Technology Education for Tonga. Table 8.3.1 presents the groups' marks and their orders (in brackets) for identifying needs and opportunities and quality of the product, together with the differences between the marks that each group obtained for identifying needs and opportunities and for the quality of the product.

TABLE 8.3.1
Marks of Groups for Identifying Needs and Quality

Group		A. Identifying Needs/Opportunities (%)	Quality (%)	Difference in marks
1	Girls - Brooms	30(2)	36(5)	6
2	Girls - Fans	21(5)	47(3)	26
3	Girls - Canteen	25(3)	47(3)	22
4	Boys - Brooms	25(3)	53(2)	28
5	Boys - Pillows	21(5)	28(6)	7
6	Boys - Kava Seats	31(1)	63(1)	32
All		25	45	20

Groups 3 and 6 had the same orders of marks for component A and the quality of the product. Changes were observed in the rest of the groups, indicating a weak relationship between identifying needs and opportunities and the quality of the product. The most obvious changes between the orders of the marks in identifying needs and opportunities and the quality of the product were those of groups 1 and 2. Group 1 dropped from 2nd in identifying needs and opportunities to 5th in the quality of the product while group 2 improved from 5th in identifying needs and opportunities to 3rd in the quality of the product. Group 1 performed relatively well in asking important and relevant technological questions about a given situation, consulting appropriate sources of information for needs and opportunities, collecting relevant and sufficient data on needs and opportunities and analyzing the data collected to identify needs and opportunities. They performed badly in the quality of the product in terms of producing an aesthetic product. These students were able to build the product to satisfy the needs and opportunities they had identified, but laced the appropriate skills to build an aesthetic product. Thus the inability of this group to use good materials and appropriate tools to build a good looking product contributed to the weakness of the relationship. Group 2 performed poorly in component A in describing a plan of investigation to collect information on needs and opportunities, collecting relevant and sufficient information on needs and opportunities and analyzing the data collected to identify important needs and

opportunities. For the quality of the product, this group performed satisfactorily in building a product with characteristics appropriate to the needs and opportunities identified. However, they performed poorly in producing an aesthetic product. These Home Economics girls who were making fans found it difficult to identify needs and opportunities relating to fans. However, they were able to build the products with characteristics appropriate to the needs and opportunities they had identified. This was due mainly to the fact that the needs and opportunities identified by this group were simple and easy to identify. This contributed to the weakness of the relationship between identifying needs and opportunities and the quality of the product. Groups 3 and 6 were the main causes of the strength of the relationship. These students were able to build products which not only were aesthetic but also had characteristics that were appropriate to the needs and opportunities they had identified. Differences between the marks obtained by the students for identifying needs and opportunities and the quality of the product were considerable. The students performed much better in the quality of the product, but this reflected the types of practical projects that these students had been doing in technical subjects. They had never learned to identify needs and opportunities in a given situation. Therefore, this large difference in the marks the students obtained for these components contributed to the weakness of the relationship.

8.3.2 Searching for the Best Solutions and the Quality of the Product

The relationship between the performances of students in searching for the best solutions and the quality of the product depended on the ability of the students to build the best solutions they had developed in their investigation. This relationship would be strong if the groups who had performed well in searching for the best solutions continued to do well in building the product. This would mean that the groups kept the same orders of the marks they obtained in both searching for the best solutions (technological capability component B) and the quality of the product. Changes in the orders of the marks obtained by the groups in searching for the best solution and quality of the product would cause the weakness of the relationship. Table 8.3.2 presents the marks and the orders of the marks (in brackets) that each group obtained for searching for the best solutions and the

quality of the product, together with the differences between the marks that each group obtained for searching for the best solutions and for the quality of product.

TABLE 8.3.2
Marks for Searching for the Best Solution and Quality of the Product

Group		B. Searching for Best Solution (%)	Quality (%)	Difference in marks
1	Girls - Brooms	27(2)	36(5)	9
2	Girls - Fans	24(3)	47(3)	23
3	Girls - Canteen	21(5)	47(3)	26
4	Boys - Brooms	24(3)	53(2)	29
5	Boys - Pillows	17(6)	28(6)	11
6	Boys - Kava Seats	34(1)	63(1)	29
All		24	45	21

Three groups, groups 2, 5 and 6 had the same orders of marks for searching for the best solutions and the quality of the product. Changes were observed in the rest of the groups. Three groups keeping the same order of marks indicates that the quality of the product related better to this component than to identifying needs and opportunities, in which only two groups kept the same orders of marks. The most obvious changes between the orders of the marks in searching for the best solutions and the quality of the product were those of groups 1 and 3. Group 1 dropped from 2nd in searching for the best solutions to 5th in the quality of the product while group 3 improved from 5th in searching for the best solutions to 3rd in the quality of the product. Group 1 performed relatively well in consulting appropriate sources of information on solutions, identifying the best solutions from the data collected and identifying the factors that would influence the building of the solutions. They performed badly in the quality of the product in terms of producing an aesthetic product. This group represents the type of students that are good at the thinking part of a project but perform poorly in the practical skills. They lacked the manual skills that would allow them to build the solutions they had developed. Another part of this problem was caused by students who developed solutions that would be difficult to build. They identified solutions that included materials that were difficult to obtain and parts that were difficult to build. They ended up with products that did not match the solutions they had developed in their investigation, contributing to the weakness of the relationship. Group 3 performed badly in stating who, where, why, when and how the product would be used, consulting appropriate sources of information on solutions and identifying the best solutions from the data collected. However, they performed relatively well in the quality of product in both building a

product with characteristics appropriate to specified criteria and building an aesthetic product. This group represents the students that identified common needs and opportunities with evident solutions that did not require further investigations for solutions. These students seemed to want to move straight from identifying needs and opportunities to building solutions. This was one of the weaknesses of the relationships between the performances of students in searching for the best solutions and the quality of the product. Another factor that contributed to the weakness of the relationship was the large differences between the marks the students obtained for searching for the best solution and the quality of the product. The students did much better in the quality of the product.

8.3.3 Planning of Production and the Quality of the Product

The relationship between the performances of students in the planning of production and the quality of the product depended on the ability of the students to build the plan they had prepared. This relationship would be strong if the groups who had performed well in the planning for production continued to do well in producing a good quality product. This would mean that the groups kept the same orders of the marks they obtained in both the planning of production (technological capability component C) and the quality of the product. Changes in the orders of the marks obtained by the groups in the planning of production and the quality of product would indicate that the relationship was weak. Table 8.3.3 presents the marks and the orders of the marks (in brackets) that each group obtained for the planning of production and the quality of the product, together with the differences between the marks that each group obtained for the planning of production and for the quality of the product.

TABLE 8.3.3
Marks for the Planning of Production and the Quality of the Product

Group		C. Planning of Production (%)	Quality (%)	Difference in marks
1	Girls - Brooms	28(6)	36(5)	8
2	Girls - Fans	30(5)	47(3)	17
3	Girls - Canteen	32(4)	47(3)	15
4	Boys - Brooms	33(3)	53(2)	20
5	Boys - Pillows	35(2)	28(6)	-7
6	Boys - Kava Seats	41(1)	63(1)	22
All		32	45	13

Group 6 was the only group that kept the same orders of marks for the planning of production and the quality of the product. Changes were observed in the rest of the

groups. This indicates that the quality of the product related better to searching for the best solution (the last component) than to the planning of production. The most obvious changes between the orders of the marks in the planning of production and the quality of the product were those of groups 2 and 5. Group 2 improved from 5th in the planning of production to 3rd in the quality of the product, while group 5 dropped from 2nd in planning of production to 6th in the quality of the product. Group 2 performed badly in the planning of production, planning a product with characteristics appropriate to the needs identified, identifying measurements to be made, determining expenses involved in building the product and identifying dangers involved in work. For the quality of the product, they performed relatively well in both building a product with characteristics appropriate to specified criteria and building an aesthetic product. These students did not do well in planning but managed to do well in the building of the product. They represent students who saw no reason for planning, simply because they knew very well what they were going to build, thereby contributing to the weakness of the relationship. Group 5 did relatively well in the planning of production in determining materials and tools required for the task, identifying measurements needed to be made, describing the steps involved in building the product, and identifying dangers involved in work. For the quality of the product, they did badly in both building a product with characteristics appropriate to specified criteria and building an aesthetic product. These students performed well in planning, but did not have the appropriate skills to implement what they had planned to produce a good quality product, which contributed to the weakness of the relationship. Also, large differences between the two sets of marks, as observed in the previous components, were also observed between the planning of production and the quality of the product. This is another factor that contributed to the weakness of this relationship.

8.3.4 Production and the Quality of the Product

The relationship between the performances of students in production of the product and the quality of the product depended on the experience and manual skills that students had for building the product they had planned. This relationship was strong if the groups who had performed well in the various aspects of the actual building of the product continued to do well in producing a good quality product. This would

mean that the groups kept the same orders of the marks they obtained in both the production of the solution (technological capability component D*[8]) and the quality of the product. Changes in the orders of the marks obtained by the groups in the production of the solution and the quality of the product would indicate that the relationship was weak. Table 8.3.4 presents the marks and the orders (in brackets) of the marks that each group obtained, together with the differences between the marks for the production of the solution and for the quality of the product.

TABLE 8.3.4
Marks for the Production of the Solution and the Quality of the Product

Group		D*. Production of Solution (%)	Quality (%)	Difference in marks
1	Girls - Brooms	34(6)	36(5)	2
2	Girls - Fans	41(4)	47(3)	6
3	Girls - Canteen	44(2)	47(3)	3
4	Boys - Brooms	40(5)	53(2)	13
5	Boys - Pillows	42(3)	28(6)	-12
6	Boys - Kava Seats	54(1)	63(1)	9
All		43	45	2

Group 6 was the only group that kept the same orders of marks for production of the solution and the quality of the product. Although changes were observed in the rest of the groups, they were smaller than the changes observed between the other components and the quality of the product. The marks that the students obtained were also closer between the quality of the product and the production of the solution than with any of the other components. This indicates that the quality of the product related better to the production of the solution than to any of the first three components. The most obvious changes between the orders of the marks in the production of the solution and the quality of the product were those of groups 4 and 5. Group 4 improved from 5th in the production of the solution to 2nd in the quality of the product, while group 5 dropped from 3rd in the production of the solution to 6th in the quality of the product. Group 4 performed poorly in the production of the solution in terms of using appropriate instruments to do measurements, taking care of safety issues and keeping the workspace tidy and well organized. For the quality of the product, these students performed well in building a product with characteristics appropriate to specified criteria but poorly in building an aesthetic product. These students concentrated mainly on building the product. They did not care about the condition of the workspace or about the safety issues. They lacked

[8] D* is technological capability component D minus the criteria for quality of product.

that experience, causing weakness of the relationship. Group 5 performed relatively well in the production of the solution in terms of using appropriate instruments to do measurements, taking care of safety issues and keeping the workspace tidy and well organized. For the quality of the product, these students performed poorly in both building a product with characteristics appropriate to specified criteria and in building an aesthetic product. These students did not have the skills required for the actual making of the product. They were careful of the workspace and other organizational matters, but did not have the appropriate skills in using tools to build the product they had wanted to build. This added to the weakness of the relationship.

8.3.5 Presentation and the Quality of the Product

The relationship between the performances of students in presentation of ideas behind the design, plan and outcome and the quality of the product depended on the ability of the students to write a good report and do a clear presentation of the work they had done. The relationship between students' ability to convey to the others the process they had gone through and the quality of the product they had produced is what is being examined in this section. This relationship would be strong if the groups who had been doing well in producing a good quality product continued to do well in telling others about the ideas behind the design, plan and outcome. This would mean that the groups kept the same orders of the marks they obtained in both presentation (technological capability component E) and the quality of the product. Changes in the orders of the marks obtained by the groups in the presentation and the quality of the product would indicate the weakness of the relationship. Table 8.3.5 presents the marks and the orders of the marks (in brackets) that each group obtained for the presentation and the quality of the product, and also the difference between the two sets of marks.

TABLE 8.3.5
Marks for Presentation and Quality of the Product

Group		E. Presentation (%)	Quality (%)	Difference in marks
1	Girls - Brooms	31(3)	36(5)	5
2	Girls - Fans	39(1)	47(3)	8
3	Girls - Canteen	32(2)	47(3)	15
4	Boys - Brooms	18(6)	53(2)	35
5	Boys - Pillows	23(5)	28(6)	5
6	Boys - Kava Seats	30(4)	63(1)	33
All		30	45	15

None of the groups kept the same orders of marks for the presentation and the quality of the product. Changes were observed in all of the groups. This indicates that the quality of the product related better to all of the other components than to the presentation. The most obvious changes between the orders of the marks in the presentation and the quality of the product were those of groups 1 and 4. Group 1 dropped from 3rd in the presentation to 5th in the quality of the product, while group 4 improved from 6th in the presentation to 2nd in the quality of the product. Group 1 performed relatively well in the presentation in terms of preparing a good report of the technological activity, in using appropriate specific technological terminology in writing the report and in the presentation of the project to the class. For the quality of the product, they performed poorly in building a product with characteristics appropriate to specified criteria. These students knew what they were trying to build and understood the ideas behind their products but did not have the right skills to build the product. They were better at talking about their products than building them, contributing to the weakness of the relationship. Group 4 performed poorly in the presentation in terms of preparing a good report of the technological activity, in using appropriate specific technological terminology in writing the report and in the presentation of the project to the class. For the quality of the product, these students performed relatively well in both building a product with characteristics appropriate to specified criteria and in building an aesthetic product. Group 1 students were all girls and they knew about brooms better than the boys in group 4. The girls were able to present their ideas behind the brooms better than the boys, who knew less about brooms and were less talkative, especially in front of other people. However, the boys worked harder than the girls and in consequence, produced better quality brooms. Large differences between the two sets of marks indicated weakness of the relationship.

8.3.6 Evaluation and the Quality of the Product

The relationship between the performances of students in the evaluation and the quality of the product depended on the ability of the students to evaluate and improve their methods as they proceeded through the project. The relationship between students' ability to evaluate and improve their work and the quality of the product they produced is examined in this section. This relationship would be strong

if the groups who had understood the purposes of the various aspects of the task continued to do well in producing a good quality product. This would mean that the groups kept the same orders of the marks they obtained in both the evaluation (technological capability component F) and the quality of the product. Changes in the orders of the marks obtained by the groups in the evaluation and the quality of the product would indicate weakness of the relationship. Table 8.3.6 presents the marks and the orders of the marks (in brackets) that each group obtained for the presentation and the quality of the product, together with the difference between the sets of marks.

TABLE 8.3.6
Marks for Evaluation and Quality of the Product

Group		F. Evaluation (%)	Quality (%)	Difference in marks
1	Girls - Brooms	29(2)	36(5)	7
2	Girls - Fans	23(5)	47(3)	24
3	Girls - Canteen	21(6)	47(3)	26
4	Boys - Brooms	25(3)	53(2)	28
5	Boys - Pillows	24(4)	28(6)	4
6	Boys - Kava Seats	40(1)	63(1)	23
All		27	45	18

Group 6 was the only group that kept the same orders of marks for the evaluation and the quality of product. Changes were observed in the rest of the groups. This indicates that the quality of the product related better to the evaluation than to the presentation (the previous component). The most obvious changes between the orders of the marks in the evaluation and the quality of the product were those of groups 1 and 3. Group 1 dropped from 2nd in the evaluation to 5th in the quality of the product, while group 3 improved from 6th in the evaluation to 3rd in the quality of the product. Group 1 performed relatively well in the evaluation in terms of assessing methods used to identify strengths and weaknesses throughout the whole process, carrying out tests to evaluate the product made and evaluating the quality of the product to identify the improvements required. For the quality of the product, these students performed poorly in building an aesthetic product. They seemed to lack the appropriate skills required and did not manage to obtain good parts for building beautiful and good looking brooms. Group 3 performed poorly in evaluation in terms of carrying out tests to evaluate the product made, comparing the plan against the product to identify differences and identifying skills and knowledge gained from this project. For the quality of the product, these students

performed relatively well in both building a product with characteristics appropriate to specified criteria and in building an aesthetic product. Most of group 3 students found it difficult to show their skills in the evaluation of this task. Most of them made pan-cakes and sandwiches. They were familiar with them and did not have to do tests to tell when they were cooked or to find out about their tastes. So the nature of this task influenced the ability of the students in this group to show what they were truly capable of in the evaluation. Therefore, it is not surprising that these students managed to produce good quality products although they had not shown good ability in the evaluation.

8.3.7 Overall Results and the Quality of the Product

The relationship between the overall performances of students in the components of the task and the quality of the product depended on the ability of the students to work thoroughly throughout the whole design cycle and eventually produce good quality products. The relationship between students' overall performance in the task and the quality of the product they produced is examined in this section. This relationship would be strong if the groups who had performed well right throughout the whole project continued to do well in producing a good quality product. This would mean that the groups kept the same orders of the marks they obtained in both the overall average and quality of the product. Many changes in the orders of the marks obtained by the groups in overall average and the quality of the product would indicate that the relationship was weak.

Table 8.3.7 presents the marks and the orders of the marks (in brackets) that each group obtained for overall average and the quality of the product, together with the differences between the two sets of marks.

TABLE 8.3.7
Marks for Overall Average and the Quality of the Product

Group		Overall Average (%)	Quality (%)	Difference in marks
1	Girls - Brooms	30(2)	36(5)	6
2	Girls - Fans	30(2)	47(3)	17
3	Girls - Canteen	29(4)	47(3)	18
4	Boys - Brooms	28(5)	53(2)	25
5	Boys - Pillows	27(6)	28(6)	1
6	Boys - Kava Seats	38(1)	63(1)	25
All		30	45	15

Groups 5 and 6 kept the same orders of marks for the overall average and the quality of the product. Also, the changes for the orders of marks for groups 2 and 3 were very small. The only significant changes in the orders of the marks were those for groups 1 and 4. This small change means that the relationship between the overall average marks of the students related better to the quality of the product than most of the components.

Group 1 dropped from 2nd in overall average to 5th in the quality of the product, while group 4 improved from 5th in overall average to 2nd in the quality of the product. Group 1 performed relatively well in identifying needs and opportunities, the production of the solution and the presentation. They performed poorly in the quality of the product in terms of producing an aesthetic product. These girls represent those students who did not have the proper skills to build a good looking product. They understood what they wanted to build but lacked the skills to make their brooms beautiful. This was one of the causes of the weakness of the relationship. Group 4 performed poorly in searching for the best solution, the presentation and the evaluation. They performed relatively well in producing a product with characteristics appropriate to specified criteria and producing an aesthetic product. These boys represent the type of students that concentrated mainly on building the product. They gave little consideration to the purposes of the product such as where, when, how and why their product would be used.

8.4 RELATIONSHIP BETWEEN STUDENTS' PERCEPTIONS OF TECHNOLOGY AND THEIR EXISTING TECHNOLOGICAL CAPABILITY

All the effort that has been carried out to establish the relationship between students' perceptions of technology and their existing technological capability yielded no result. All of the students involved in this study were required to complete the three instruments used for assessing perceptions of technology: the writing/drawing activity; the Technology Education questionnaire; and the picture quiz. The responses of the students in these instruments were analysed and the results were recorded in order to explore the relationship between their perceptions of technology and their existing technological capability. A variety of tests were

carried out using the results from the perceptions instruments and the results from their performances in the technological capability task.

The following tests have been carried out to determine if the relationship between students' perceptions of technology and existing technological capability existed or not:

8.4.1 Students' total score and the number of pictures selected

The total scores that the students obtained from the technological capability task were correlated against the number of pictures they selected to be related to technology from the picture quiz. The number of pictures that the students selected in the picture quiz was considered to represent the type of perceptions that the students held about technology. The resulting correlation coefficient was zero.

8.4.2 Students' total score and the number of ideas mentioned

The number of ideas that the students provided in the writing/drawing activity varied accordingly to their age. The Form 1 students provided fewer ideas about technology than the Form 6 students. It was therefore decided that the number of ideas that the students identified about technology represents their perceptions of technology. A correlation test was carried out between students' total scores in the technological capability task and the number of ideas they mentioned in the writing/drawing activity. The resulting correlation coefficient for this test was again zero.

8.4.3 Students' total score and the type of ideas mentioned

The type of ideas the students mentioned in the writing/drawing activity and the reasons they provided for their selection of pictures to be related or not related to technology in the picture quiz were identified. These results were used to give students a category number (the students were categorised under the categories of students' perceptions of technology in chapter 5 section 5.5.1). These numbers were considered to represent students' perceptions of technology and were correlated against their total scores from their performance on the technological task. The resulting correlation coefficient was again zero, suggesting there was no

relationship between students' perceptions of technology and their existing technological capability.

8.5 SUMMARY OF RELATIONSHIPS

This section presents the summary of the results of the study of the relationships between the performances of the students in the task. The summary of the relationships between the performances of students in the components of the task is presented first, followed by the relationships between students' performances in the components of the task and the quality of their final products.

Problem solving process for group 1 – Home Economics brooms

The only significant and positive correlation coefficient was the relationship between searching for the best solution and the production. This indicates that the students of this group concentrated mainly on the production of the solutions they identified and performed the stages of the task almost separately.

Problem solving process for group 2 – Home Economics fans

The path this group followed was from searching for the best solution to the planning of the production, and from the planning of the production to the production of the solution. The evaluation of the production of the solution was strong. This path is different from the path taken by the previous group. The challenge that the students of this group confronted in making a fan was higher than that afforded by making a broom. It seems that this group had to follow more closely to the stages of the activity in order to be able to make a reasonable fan.

Problem solving process for group 3 – Home Economics food for the canteen

This group tackled tasks in a similar way to the group of girls that made brooms. They produced the product from the solutions they developed and not from planning. This group concentrated mainly on the production of the solution they developed. These students seem to have found this task so easy, that they saw no need for proper planning of the production.

Problem solving process for group 4 – Industrial Arts brooms

This group of boys approached this task differently from the group of girls who made brooms. The boys identified the needs and problems regarding the brooms in Tonga, which the girls missed, planned for the production and produced the brooms. It is likely that the boys found this task more difficult than the girls, so they had to plan well before they could make the brooms.

Problem solving process for group 5 – Industrial Arts wooden pillows

The path this group followed was from identifying needs to searching for the best solution, from searching for the best solution to the production, and from the production to the presentation. This path is different from the path taken by the previous group. It was easier for this group to build the wooden pillows than for group 4 to build the brooms.

Problem solving process for group 6 – Industrial Arts kava drinking seats

The relationships between the performances of this group on the components of the task were the highest. The relationships between the evaluation and the rest of the components were also better. This was the most difficult task. The affordance of this task was the highest. This helped to make the students perform this task in a holistic fashion.

Problem solving process - All Students Involved

The general path that the students involved in this study took was from identifying needs to searching for the best solution and from searching for the best solution to the production of the solution. The evaluation was highest related to the production of the solution.

Links between the Performances of Students on the Components of Technological Capability and the Quality of the Product

The component that was found to have the highest relationship with the quality of the product was the production of the solution. This was followed by searching for the best solution. The presentation was the component that had the weakest relationship with the quality of the product.

The relationship between students' perceptions of technology and their existing technological capability

The tests that were carried out to investigate the relationship between students' perceptions of technology and their existing technological capability showed there was no relationship existed. All the correlation coefficients for the relationship were zero. This means that the perceptions of technology of the students who were involved in this study and their existing technological capability did not relate to one another.

This chapter has presented the relationships between the performances of students in the components of the task. Chapter 9 will present discussions of the main findings, conclusions and implications of this study.

CHAPTER NINE

DISCUSSION, CONCLUSIONS AND IMPLICATIONS

9.1 INTRODUCTION

This chapter discusses the results and presents the conclusions and implications of this study. Discussion will focus on the results obtained for students' perceptions of technology and students' existing technological capability. The aim is to answer the research questions formulated at the beginning of this study. Each of sections 9.2 to 9.6 discusses the answers to one of the five research questions in this study. Comparison between the results of this study with results of similar studies on students' perceptions of technology and students' existing technological capability in other countries will be made throughout this chapter. This is to determine the situation of the research with Tongan students in relation to other studies. This chapter discusses the following:

9.2 Students' Perceptions of Technology;
9.3 Students' Existing Technological Capability;
9.4 Relationships between the Performances of Students;
9.5 Relationships between Components and Quality of Final Products;
9.6 Relationship between Students' Perceptions of Technology and Their Existing Technological Capability;
9.7 Conclusions; and
9.8 Implications.

9.2 STUDENTS' PERCEPTIONS OF TECHNOLOGY

This section discusses the results of the study of the perceptions of technology held by Tongan secondary school students. Three instruments, a writing/drawing activity, a technology questionnaire and a picture quiz, were used to collect information on students' ideas about technology. The results from these three instruments will be combined and used to identify the perceptions that these students hold about

technology. Discussions will be made in the light of results of similar studies carried out in other countries and also in the context of Tonga and Tongan schools. The main ideas held by the students about technology will be discussed first. This will be followed by comparisons of perceptions of younger students (Form 1 students) against the mature students (Form 6 students). Finally, a comparison of the perceptions of male against female students will be presented.

9.2.1 Types of Perceptions of Technology Identified

The results obtained using the three instruments showed that Tongan secondary school students have a wide range of ideas about technology. The types of ideas that students have about technology, the nature of these ideas and their attitudes towards technology are discussed below. Many of the previous studies on students' perceptions of technology used the Pupils' Attitudes Towards Technology (PATT) questionnaire (Raat, de Klerk Wolters and de Vries, 1987) or a modified form of it. A perception of technology is also considered in this study to include both ideas about technology and attitudes towards technology. Attitudes include interest in technology and awareness of the effects of technology in society. The main ideas about technology will be presented first and the attitudes towards technology will follow.

(a) Students' Main Ideas About Technology

This study revealed that Tongan secondary school students have a large variety of ideas about technology. A similar result was found by Rennie and Jarvis (1995a) in England and Western Australia.

In the writing/drawing activity, the Tongan students mentioned 25 different ideas that could be categorized about technology. Another category, 'other', accounted for by 26% of the students, were ideas that could not be categorized into one of the 25 categories identified. Each of the ideas included in the 'other' ideas was only mentioned by a small proportion of the students. Some of these ideas were wrong and some did not make much sense. For example, some young students confused technology with theology, a word that they were more familiar with. They answered that technology was the study of the Bible and God. Some other students related technology to the word sociology, a word they had encountered in the subject Social

Studies. They referred to technology as the study of the structure of Tongan society. Some confused it with Biology and described it as the study of plants and animals. It has been shown that not only the ideas about technology were unknown to most students in Tonga but also the word itself was new to them. The ideas that the students provided about technology are categorized as follows:

(i)Technology as Process

The students gave four ideas that belong to this category.

- *Technology as change and development*

The idea of technology that was mentioned by the largest percentage (48.9%) of the students involved in this study in the writing/drawing activity was one of change and development. Change and development was also given by the highest percentage of students in the picture quiz as the reason for selecting pictures as relating to technology. Thirty-three percent of the reasons given for selecting pictures as relating to technology stated this idea. These students thought that technology referred to changes and development that were taking place in their environment. The examples they used included new houses replacing the old ones, the new types of vehicles replacing the old types, the new types of food replacing the old ones and the new types of medicines taking the place of the traditional herbal ones. They related technology to new human-made products replacing the older and traditional ones. This view is similar to the one identified in the PATT study (Raat, de Klerk Wolters and de Vries, 1987) in the sense that technology was about new artifacts. However, the students of this study emphasized more the idea of development. The word 'fakalakalaka' means development and was the most frequently stated term relating to technology. The idea of change, then was used by many students to clarify what they meant by development.

At the time of this study, technology education did not exist in Tonga. The word technology was still very new to these islands. The only chance that most of the students would have had of hearing the use of the word technology was from radio and television advertisements. Through these modes, the term technology was used to inflict the idea of modern artifacts and better ways of doing things arriving in the country. This created the idea held by many students that

technology was bringing modern and better things into the islands from overseas, the idea of change and development.

- *Technology as new discoveries, new ideas and new ways of doing things*

The next popular idea in the writing/drawing activity, mentioned by 18.5% of the students involved in the study referred to technology as new discoveries, ideas and new ways of doing things. In the technology education questionnaire, 75% of the students agreed that technology referred to inventing new ways of doing things. Also in the picture quiz, high percentages of students selected the more recent artifacts to be related to technology because they were new ways of doing things. These students did not emphasize the natures of the artifacts as in the ideas above. This idea was about process, the new discoveries and ideas involved in methods of doing something. They talked about the methods of baking bread, of keeping time and of building houses as examples of what they understood about the term technology. It is also interesting to note that the students did not mention anything related to the design process. None of the students mentioned anything about design or planning something as related to technology. This is contrary to the results of a similar study carried out by Rennie and Jarvis (1995a) of students' perceptions of technology in England and Western Australia. They reported that most students' ideas about technology were related to the design process. This discrepancy could be due to the fact that at the time of the study, no technology education existed in Tonga, so the students would not have known about the design process. However, some of these students thought along the same line and viewed technology as new ways of doing things.

- *Technology as an effort to make work easier*

This idea was mentioned by 12% of the students in the writing/drawing activity. This is another idea that did not view technology as artifacts. It is closer to the idea of technology as new ways of doing things. This idea was given by mostly mature students. They observed the effects of new machines, tools, vehicles and boats and concluded that they represented an effort to make work easier.

- *Technology as involving design (Problem Solving)*

In the writing/drawing activity, none of the students related technology to design. The idea of change and development was too strong and also, there was no technology education in Tongan schools at that time. However, in the technology questionnaire, the students were prompted with the idea of technology as design. The result was positive. Fifty-seven percent of the students agreed that technology involves designing solutions to problems and 63% agreed that in technology there are opportunities to design new products. On the same line, 75% of the students agreed that technology means inventing new ways of doing things. In fact, for all of the five items that related technology to the idea of the design process, more than half of the students agreed with each of them. This result is similar to that reported by Rennie and Jarvis (1995a) about students' perceptions of technology in England and Western Australia.

(ii)Technology as Artefacts

The students provided seven ideas that belonged to this category. They are:

- *Technology as modern, better and newer tools*

The next popular idea in the writing/drawing activity was that technology referred to modern, better and newer tools and machines. This idea was given by 22.9% of the students in the writing/drawing activity. In the picture quiz, modern pieces of equipment like 'computer', 'telephone', 'clock' were selected by more than 80% of the students while the older items like 'hand axe', 'knife' and 'cup' were selected by less than 50% of the students. The most frequently stated reason (33.1%) for the selection of items related to technology in the picture quiz was that of change and development. This idea of modern equipment was used together in students' explanation of the idea of change and development. Many students viewed that modern, better and newer tools were taking the place of the older ones. They claimed that items like clock, telephone, computer were modern, better and newer items replacing the old tools.

- *Technology as machines and engineering*

In the writing/drawing activity, 18.5% of the students referred to technology as machines and engineering. In the picture quiz, 4.9% of the students selected pictures as related to technology because they were machines. The word

technical is a similar term to technology but was a more familiar term in Tongan schools at the time of the study. Technical buildings housed the Industrial Arts and Home Economics practical rooms in many schools. In some schools, the technical building contained machines for the Industrial Arts and other technical courses like mechanical repairs, basic plumbing and carpentry for students who took life skills courses.

- *Technology as goods imported from overseas*

This idea was mentioned by 14.3% of the students in the writing/drawing activity. It was also mentioned by 17.1% of the students in the picture quiz as the reason for selecting pictures as related to technology. This idea could have developed from the fact that almost all of the new changes and developments in the environment, modern machines, new ideas and new ways of doing things are imported from outside of the islands. Some people including many students have the attitude that all good things came from overseas. They have coined the idea that technology is not produced in Tonga but imported from the developed countries.

- *Technology as vehicles and boats*

This idea was mentioned by 12.3% of the students in the writing/drawing activity. These students viewed technology as things that impressed them most. They thought of the modern types of cars, trucks, vans and boats that arrived in the islands. They were fascinated by the look and shape of these new forms of transportation and they were the dream of their lives.

- *Technology as electrical appliances*

This idea was mentioned by 10.3% of the students in the writing/drawing activity. In the technology questionnaire, 44% of the students also agreed that there would be no technology without electricity. Further, 4.18% of the students selected pictures in the picture quiz to be related to technology because they used electricity. Many of these students were from places and homes that did not have an electricity supply. They thought that technology was something modern that they did not have. They thought about modern electrical appliances such as televisions, computers, fridges and stoves as representing technology and

development. They therefore concluded that technology had a strong relationship with electricity. A similar study by Rennie and Treagust (1987) found that 14% of the students involved agreed that technology always had to do with electricity.

- *Technology as Human-made*

Some of the students described technology to be everything that was made by people. Technology as artifacts was a common perception of technology found in previous studies in many countries (Raat, de Klerk Wolters and de Vries, 1987, Rennie and Jarvis, 1995a). However, in this study, only a very small proportion of the students referred to technology as something made by people. In the writing/drawing activity, only 5.6% of the students stated that they thought technology referred to the things made by people. Clothing was given as an example of the things made by man to be technology. In the picture quiz, only 2.2% of the students selected pictures as related to technology because they were man made. Making of modern products was a process that did not happen in Tonga. Some students thought that technology was imported from overseas. They only saw the arrival of new products from overseas. Families which had members working overseas had better and modern things. Therefore, the actual building of new products in Tonga was not regarded as technology as much as products arriving from overseas. So, many students were not able to see technology as something made by man as in other countries.

- *Technology as useful things (safe and not dangerous)*

The idea that technology was about useful things, safe and not dangerous was not mentioned by any of the students in the writing/drawing activity. However, in the picture quiz, 26.9% of the students mentioned this idea as the reason for selecting pictures related to technology. They thought that technology referred to things that are useful to man. A similar idea was mentioned in the pictures of a gun and a volcano. Some students (7.2%) decided they were not related to technology because they were dangerous to man. Also in the questionnaire, 52% of the students agreed that invention in technology does more good than harm, 53% agreed that technology brings more good things than bad things and 53% agreed that technology makes the world a better place to live in. These students showed positive attitudes towards technology. Their views of technology were

limited only to the good things about change and development. They failed to view the bad effects that technology might produce.

(iii) Technology as related to computer

The next popular idea about technology was that it is related to computers. This was mentioned by 29.2% of the students in the writing/drawing activity. In the technology questionnaire, 81% of the students agreed that technology mainly concerned computers and similar equipment. Also in the picture quiz, the most popular item, selected by 96% of the students involved as being technology, was the computer. At the time of the study, each of the schools involved in the study had a computer laboratory. The students knew about computers but they were not aware of the connection between computers and technology. Terms like computer technology and information technology, that that link computers and technology in many places, were almost unheard of in Tonga at the time of the study. The main reason why many students selected 'computer' to be related to technology in the picture quiz was that it was a modern and useful piece of machinery.

The percentages of students that mentioned 'computer' as being related to technology in the writing/drawing activity, selected 'computer' as being related to technology in the picture quiz, and agreed that 'computer' was related to technology in the questionnaire were different. This inconsistency in students' answers in the three instruments suggests that the students were unsure of the relationship between the term technology and computer. This indicates a limited perception of technology. This is consistent with the results of the PATT study (Raat, de Klerk Wolters and de Vries, 1987) which stated that students have limited concepts of technology. The PATT study in Australia and England (Rennie, 1987) also reported similar results, stating that many students did not have an understanding of technology.

(iv) Technology as science

In the writing/drawing activity, 8.4% of the students related technology to science and scientific development. This result is similar to that of a study in New Zealand reported by Burns (1992) which shows that 16% of the students referred to technology as a scientific process. However, these results are lower than the results

of a similar study in Australia by Rennie and Jarvis (1995b), which found that a significant proportion of the children confused technology with science or with acquiring knowledge or learning. Data collected in Tonga was from Forms 1 – 6 (12 – 17 year old) students. The study in New Zealand collected data from Form 3 (14 year old) students, and the study in Australia obtained data from primary school students. These results show that the younger students tend to confuse technology with science but recognize the difference as they become older and enter higher classes in schools.

(b) Students' Attitudes Towards Technology

The attitudes that students had about technology are expressed in two ways. First is the students' interest in technology, and second is the students' awareness of the effects of technology in society.

(i) Interest in technology

In the questionnaire, five items examined the interest of students in technology. The results showed that most of the students involved in this study showed interest in technology. In the questionnaire, 72% of the students agreed that they were interested in technology. Seventy-three percent of the students agreed that they would like to learn more about technology. For the five items examining interest in technology, an average of 67% of the students agreed with the items. This result is in line with results of similar studies in other countries.

(ii) Social aspects of technology

Five items in the second part of the questionnaire examined the attitude that the students had about the effect of technology on society. The percentages of students agreeing with the items on the social aspects of technology were relatively low, in comparison to the percentages of students agreeing with the items on interest in technology. Further, the percentages that chose the undecided column were relatively high in the items about the social aspects of technology. For example, 37% marked the undecided column for the item that suggested technology was needed by everybody, 27% were undecided that it was worth spending money on technology, and 30% were not sure that technology brought more good things than

bad things. These results suggest that although the students were interested in technology, many were not sure and had limited ideas of its effect on society.

9.2.2 Comparison of Perceptions of Form 1 and Form 6 Students

The following discussion will examine the difference between the perceptions that Form 1 (12 year old) students had about technology and those of Form 6 (17 year old) students.

(i) Form 1 students had a larger range of ideas about technology than Form 6 students

In the writing/drawing activity, the range of ideas provided by the Form 1 students was larger than those provided by the Form 6 students. The Form 6 students concentrated more on the 10 most popular ideas related to technology. The highest percentage of Form 1 students (44.5%) mentioned the 'other' ideas. These were the ideas that could not be categorized into any of the 25 ideas that were decided in this study to be related to technology. The 'other' ideas were either meaningless or wrong ideas about technology. The Form 6 students seemed to have a better idea about technology than the Form 1 students. The wide range of ideas provided by the younger students might have been due to lack of understanding of the term technology. There is no Tongan word for technology, except for the translation of the term to 'tekinolosia'. The term was new and the ideas behind it are also new to Tonga and especially to the younger children.

(ii) Form 6 students provided more ideas about technology

In the writing/drawing activity, the percentage of Form 6 students mentioning each of the 12 most popular ideas about technology was higher than the percentage of Form 1 students except for the 'other' ideas. This indicates that the Form 6 students provided more ideas about technology than the Form 1 students. The Form 1 students managed to give an average of only one idea about technology. This result means that the Form 6 students knew more about the meaning of technology than the Form 1 students. This also indicates that the mature students had a broader view of technology than the younger students. This is in line with a result of the study by Jarvis and Rennie (1998) in England and Western Australia, which reported that

children's conceptual development of technology was mainly age-related and older children were more likely to use several concepts in their explanation of technology.

(iii) Form 6 students agreed more with technology as design

In the technology questionnaire, Form 6 students' and Form 1 students' mean scores for all of the items about technology as a design process were found to be significantly different. Form 6 students agreed more with the involvement of design in technology. This indicates that the Form 6 students had a better understanding of the relationship between technology and design. Once again, this result also points to Form 1 students' lack of knowledge of the ideas related to technology.

(iv) Form 6 students were more interested in technology and knew more about the effects of technology on society

In the second part of the questionnaire, five items examined the interest of students in technology and another five items examined students' awareness of the effects of technology on society. It was found that the mean scores for the Form 6 students for six of the ten items were significantly smaller than the mean scores for the Form 1 students. This means that generally, Form 6 students were more interested in technology and more aware of the effect of technology in society than the Form 1 students. The graph of item mean scores for interest in technology and social aspect of technology in Figure 5.1 shows that the mean scores decrease as the form increases. This means that the students tended to be more interested in technology and aware of the effects of technology on society as they matured. The difference between the mean scores for Form 1 and Form 6 students was not significant for the items that suggested: technology has brought more good things than bad things; I would like a career in technology; I would like to read books and magazines about technology; and inventions in technology are doing more good than harm. The results for these items show that some of the Form 6 students were as confused as the Form 1 students about the some of the effects of technology on society and also on what is involved in technology. It reflects the limited perception of technology.

In the picture quiz, Form 6 students selected more pictures as related to technology than Form 1 students, except for pictures of old items and pictures of an ''ovava' tree and 'volcano'. The idea mentioned by the highest percentage (50%) of Form 6

students was of 'change and development', but was only mentioned by 17% of the Form 1 students. The Form 1 students favoured 'usefulness' of objects while selecting pictures as related to technology, but this was mentioned by only 15% of Form 6 students. Form 6 students also selected a higher number of pictures (average=12.80 compared to 9.9 in Form 1)

9.2.3 Comparison of Perceptions of Male and Female Students

This section compares the perceptions of male and female students in this study about technology. The performances of the students in the three instruments will be used to determine the differences between their perceptions.

(i) A higher proportion of boys viewed technology as change and development

In the writing/drawing activity, the proportion of boys mentioning technology as the coming of modern tools, machines and ways of doing things to replace the old ones was higher than the proportion of girls. The proportion of boys mentioning that technology was related to computers was also higher than that of the girls. Fifty-seven percent of the boys viewed technology as about change and development compared to only 43.8% of the girls. A high percentage of the boys referred to technology as related to computers compared to 25.3% of the girls. Also, 22.2% of the boys considered technology as new discoveries, new ideas and new ways of doing things compared to 16.3% of the girls. The boys had stronger ideas about technology as being modern tools, computers, new types of machines and new ways of doing things. They were more fascinated by the new developments that accompanied computerized tools and machines. Many of the boys thought that this was what technology was all about. A similar pattern was observed in the results of the picture quiz. Giving reasons for selecting pictures relating to technology, 39.9% of the boys mentioned change and development compared to 28.6% of the girls.

(ii) A higher proportion of girls viewed technology as new things in the island

This idea referred to technology as things imported into Tonga. Technology was produced overseas. This idea was mentioned by a higher proportion of the girls. In the writing/drawing activity, 18.2% of the girls referred to technology as new things in Tonga, imported from overseas. This was mentioned by only 8% of the boys. Also in the picture quiz, 20.5% of the female students selected pictures as related to

technology because they were new to Tonga. This reason was mentioned by 11.9% of the boys.

(iii) Boys were more interested in technology than girls

In the questionnaire, the boys were more interested in technology than girls. A higher proportion of boys agreed with the item that suggested that 'I am interested in technology' as opposed to the girls' percentage. It was found that the boys' mean score for this item was significantly less than the mean score for girls. This means that the boys agreed more with the idea than the girls. This result is in line with the results of the PATT study in Western Australia (Rennie, 1987) about students' interest in technology. It was found that boys generally were more interested in technology than girls. A similar result was found in New Zealand (Burns, 1992) which showed that boys were more interested in technology than girls.

9.3 STUDENTS' EXISTING TECHNOLOGICAL CAPABILITY

Discussion of students' existing technological capability will be made in two parts. This section discusses the level of performance of students in each of the technological capability components assessed. In Section 9.4, the relationships between the performances of students in the various aspects of the task will be discussed. The order of discussion will follow the six components of technological capability assessed in this study.

9.3.1 Identifying Needs and Opportunities

This component assessed students' knowledge and skills in: asking important and relevant technological questions about a given situation; identifying factors relevant to and influencing the given situation; describing a plan of an investigation for gathering data on needs and opportunities; consulting appropriate sources of information on needs and opportunities; collecting relevant and sufficient data on needs and opportunities; analysing data collected to identify the existing needs and opportunities; and identifying needs and opportunities intrinsic in the situation. The students performed very badly in this area. The students' overall average mark for this component was second to the lowest.

The following factors have been shown to be responsible for the unsatisfactory performance of students in this area.

(i) Students lacked appropriate knowledge, skills and experience for this area

The students have been shown to lack the knowledge, skills and experience in carrying out the activities required in this part. For example, they lacked the skills in planning an investigation for a technological task. Aims, method of data collection, sources of information, amount and type of information needed and method of data analysis were poorly described. Further, the language that students used showed they knew very little about doing research work. For example, in describing the method of data collection, 71% of the students used the general expression 'questioning people' instead of using a more specific expression like 'interviewing experts or users'. Sixty-two percent of the students described their plans in one or two sentences and in a very general manner. The students were also unable to analyse the situation to identify the factors that would influence the task. Only a small proportion of the students (19%) mentioned factors related to social, cultural, environmental, financial, needs of customers and time. The sources of information the students consulted while searching for information on needs and opportunities indicated a lack of experience and knowledge of doing research work. Twenty-four percent of the students consulted mainly makers and users. Fourteen percent of the students discussed their research questions with members of family. No one consulted existing products, new technology, books and scientific discoveries. Discussions with teachers revealed that these students had never had any experience in doing research work of this sort, not only in technical subjects but also in the other subjects. This result is consistent with Jones (1997a) who reports that the strategies, skills and knowledge students bring to a technological task are often not appropriate.

(ii) Students concentrated mainly on building the products

Students' performance in this area was unsatisfactory because they concentrated mainly on building the products. Jones and Carr (1993b) found that what students expect to do in a technological task strongly influences the way they perform in that task. In this present study, the students were expecting to build the products they had been assigned to work on. Their concentration on building the products showed up

in their responses to the activities required in this component. For example, when they were asked for the types of questions that should be asked to identify needs and opportunities in their respective area, most students (61%) asked questions about the types of materials needed, the properties of the products to be made and the methods of making them. Only 2% asked questions about the makers of the products or the experts in the field. In identifying factors that might affect the situation, a large proportion of students (81%) only talked about the properties, materials and methods of making the products. In collecting appropriate information on needs and opportunities, 54% collected information mainly on the materials, the properties of the products and the method of building the products.

(iii) Classroom culture affected students' performances

Students' performances in this component have been shown to be influenced by what they had been doing in their project work in technical subjects. The students had never been required to identify needs and opportunities in a given situation before this project. They had been accustomed to being provided with details of products to be made and asked to produce one. When they were asked to describe a plan of an investigation to identify needs and opportunities, 18% of the answers were not about investigation but were descriptions of materials needed for the products to be made. Another 25% of the answers, although they described investigations to be carried out, were only aimed at finding out methods and materials for making the products. Jones (1997a) reports that classroom cultures greatly affect the performance of students in a technological task.

(iv) Tongan culture affected students' performances

The way in which children are raised in Tongan families influenced their performances in this component. For example, when the students were required to state important and appropriate questions that should be asked in order to identify needs and opportunities in their respective area, 9% of the students did not ask questions but only made statements, explaining the materials needed to make the product, problems and how the product should be made. Only 16% of the students asked about changes and improvements required and about problems of the existing products. No questions were asked about the context of the products, users and time. The students were not good at asking questions. The effect of culture on children's

education was reported by Rensburg, Ankiewicz and Mybyrgh (1999) in a study of students' perceptions of technology in South Africa (refer to Chapter 3). In Tonga, children are not encouraged to talk or ask questions when their elders are present. It is regarded as disrespect for children to ask many questions. This is an area that needs to be improved.

9.3.2 Searching for Best Solution of Identified Needs and Opportunities

This section assessed the ability of students to: state (a)who will use the product, (b)where, (c)why, (d)when and (e)how will the product be used; clearly describe the types of information needed to be obtained in order to solve identified needs and opportunities; describe a plan of an investigation to collect information on solutions to the identified needs and opportunities; consult appropriate sources of information on solutions and strategies for the identified needs and opportunities; collect relevant and sufficient information on solutions and strategies for the identified needs and opportunities; identify solutions and strategies relevant to the needs and opportunities; identify the factors that influence making of the solution; and identify knowledge and skills required for making the solution. The students' overall average mark for this component was the lowest. The students performed worst in searching and developing best solutions for identified needs and opportunities. The performances of students showed the following characteristics.

(i) Students lacked purpose and inventiveness

Students' responses in the worksheets and interview showed many of them were not sure of the purposes of their products. The students concentrated more on building the products rather than trying to establish the purposes of their products. For example, when the students were asked to describe who, where, why, when and how will the product be used, many of the students (53%) provided answers that were general. When they were asked to describe the characteristics that their products should have in order to solve the needs and opportunities they had identified, 33% described only the properties of the products to be made and 28% described the materials needed for the products. These students were ready to build their products at this stage. They had made up their minds on what materials they wanted for their products and how they were going to make them. They were not interested in who would use their products, the reason for using them, or the time and method of using

their products. They were not building products for certain people, place or time. They were just building products like the existing ones. They lacked purpose as they carried out this technological task.

The degree of inventiveness showed by the students was low. Tongan culture is very structured and conservative. Departing from the norm is not encouraged. This character showed up in the way these students built their products. The students tried to make sure that their products were the same as the traditional types. Many of them went to the old people for information on how to build their products and they did not search for new materials but tried to use the materials that that had been traditionally used for building these products in Tonga.

(ii) Inappropriate attitudes towards using research results for planning and building

Students' tendency to use the results of research for planning and building the products was lacking. Many of them did not want to do the investigation part of the task. They did not appreciate the importance of obtaining information to assist in developing the best possible solutions for the identified needs and opportunities. They did poorly in investigating the existing needs and opportunities in their respective situation and also did poorly in investigating the best possible solutions for needs and opportunities.

When they were asked to plan an investigation to collect information on solutions to the identified needs and opportunities, 38% of the students did not plan for the investigation and 35% suggested asking people about the materials or the method for making the product. Decisions regarding time and the amount of information required were not made in any of the plans and no one showed an intention to carry out tests to identify the best solutions. In carrying out their investigations, 22% did not do research. Fifty-three percent of the students obtained information only from makers and users. Eleven percent obtained information only from home and only 5% consulted existing products. Library, books and new technology were not consulted. It is evident that the students did not consider searching for information to assist in developing solutions as an important part of the task.

(iii) Students' ability to identify factors was limited

The ability of students to identify factors that would influence making and using the products was limited. Identifying factors is a high level skill. It requires understanding of the detail of the whole task and comprehension of knowledge and skills involved in a particular area. When the students were asked to identify the factors that would influence the building of the products, 51% of the students mentioned only the properties of the materials they could obtain. Only 14% mentioned tools, 19% mentioned skills in building, 8% mentioned money and 3% mentioned time. This skill needs to be properly taught to students in technology education because it is important for carrying out a technological task.

9.3.3 Planning the Production of the Solution

This component assessed the ability of students to: plan a product with characteristics appropriate to the needs and opportunities identified; draw or describe an appropriate plan or recipe of the product with proper labels and scales; ascertain materials (with quantities required) and tools needed for the task; identify the measurements that needed to be made in making the product; determine the expenses involved in making the product; explain the appropriate steps in carrying out the task; identify the dangers involved in carrying out the task; and identify the assistance needed from an expert or from an older person for carrying out the task.

The students performed relatively well in this section. The students' overall average mark for this component was the second to the highest. The following characteristics showed up in students' responses.

(i) Students tended to perform the task in an atomistic manner

The ability to view the various components of a task as a whole unit is a very important aspect of students' technological capability. They should be able to make connections between the components of a task in order to work in a holistic manner. The results of this part show that the students failed to perform the components of the task in a holistic way. For example, when they were asked to describe the characteristics of the products they were planning to make, 81% of the students gave descriptions that were not consistent with the information they had collected earlier. Seventy-three percent gave only a general description of the types of products they were going to make. The students did not include the results from the earlier stages

of the task in planning the products. This result is similar to that reported by Jones (1997) who found that the links between the performances of the students in parts of the technological task, for example, research results and model making did not exist.

Another example is that, when the students were required to write the steps they were going to follow in producing the product, only 22% of the students included measurements as part of the steps in carrying out the tasks, although 81% had earlier identified some measurements to be carried out. Only 3% of the students included buying materials as part of the steps in carrying out the tasks although 73% had named some materials or tools that needed to be bought earlier on. Five percent planned to start with drawing a plan, 83% opted to start with obtaining materials and tools needed. No student mentioned evaluation or assistance of experts. It is evident from these results that most students viewed the task in an atomistic way.

(ii) Students lacked skills in planning for the production of the solution

Most students lacked the appropriate skills required for the production of the solution. For example, when they were asked to make a plan, design or recipe of the products they were going to make, none of the plans had scale or any mention of the size of the actual products. Only 45% gave labels to their diagrams. For the students who prepared recipes, only 10% gave the amount of the ingredients needed and cooking methods were briefly described. One would find it very difficult to produce any of the products intended in the plans produced by the students.

(iii) Students failed to attend to the detail of the task

The students described their plan in a general manner and the plan lacked detail. For example, when they were asked to write down the materials and tools required, all of the students missed out one or two of the items required. Although 61 % named most of the materials and tools needed, 73% did not include a measuring instrument and none of the students gave the amount of materials required.

When they were asked to describe the expenses involved, 78% of the students mentioned only materials needed. Only 13% mentioned tools. None of the students mentioned labour, transport, communication, electricity or any of the expenses that usually accompany good quality practical projects. All of the students who

mentioned 'no expenses' commented that they expected to obtain the materials they needed from their homes or from the bush. Most students failed to include in their plans the whole detail of the task. A similar result was reported by Fleer (2000), who found that the students were unable to provide the appropriate details of their products in their plans.

(iv) Effect of classroom culture

Classroom culture influenced the performance of students in this component. In a normal practical work in technical subjects in Tonga, the students were expected to do all the work involved in building a product. In this component, when the students were required to identify the assistance they might need from experts or from older members of the society, 20% of the students identified the difficult tasks that needed help of experts. Forty-seven percent expected the experts to only to show or teach them how to make the products and not to actually carry out the difficult tasks. Sixty-five percent did not expect the experts to carry out any of the tasks involved. They planned to do all the work by themselves.

9.3.4 Building the Solution (Product)

This component assessed students' ability to: use appropriate instruments to measure required quantities accurately; use appropriate tools to perform work required effectively; wear necessary safety gear and use tools safely while working; work in a careful manner and keep the workspace tidy and well organized during and after work; fully implement the plan of action; produce the product with characteristics appropriate to pre-specified criteria; and produce an aesthetic product. The students performed best in this component. The students' overall average mark for this component was the highest. Students' responses to various requirements in the task showed the following characteristics:

(i) Inappropriate attitude towards accuracy and precision

The students did not consider measurement as an important part of building the products. For example, 67% of the students did not do any measurement while 33% carried out some. Nineteen percent made some measurements but did not use the proper instruments and only 14% used the proper instruments for measurement.

This result is a reflection of the general attitude towards measurement in the field of building and construction in Tonga. Most buildings and construction work in Tonga are simple and small and there are few instances in which there is a need for people to be extremely precise when dealing with measurements. Children bring this attitude to their practical work in technical classrooms.

(ii) Students were not serious about safety

Observing students' consideration of safety in the workplace, many of the students (89%) at times handled tools in an unsafe manner and did not wear all of the necessary safety gear during work. These students were working in their school uniform with no aprons, safety glasses or headgear when necessary. Only 11% of the students wore necessary safety gear and handled tools safely during work. This result demonstrates a lack of awareness of the proper ways of working with new machines and equipment. These students were not familiar with the possible hazards that accompany modern electrical appliances and tools in technical classrooms. This is a reflection of the gap between skills required to operate modern tools and machinery imported from developed countries and the level of skills and knowledge existing in Tonga. There is a need to identify appropriate strategies that can assist technology transfer into the third world countries (Lewis, 2000).

(iii) The issue of quality versus own work

The students tended to consider it more important to build the products by themselves than to ask for others' help to build better quality products. For example, although the students were allowed to seek for expert help to improve the quality of their products, 65% did not seek for outside help. At the same time, only 21% were competent in using most of the tools required to carry out the tasks and the rest needed help. The teachers had to help with cutting and preparing parts of what the students wanted for their products. Further, assessing the aesthetic of the products, only 12% of them were judged to be aesthetic while the rest were not. Two factors have been identified to be the main possible causes of this effect. First is the requirement of the curriculum. Most technical curricula require students to build the products by themselves in order to learn the skills involved. Second is the feeling of ownership and of being a contributing member of society. Children are encouraged to contribute and participate in social activities.

(iv) Difficulty in following the plan of action

The students in this study found it difficult to follow the plan they had earlier prepared. Most of the students (79%) altered the main steps of the plan. Forty-four percent made adjustments to the original plan with the intention of improving the products while 27% altered their plans because of the unavailability of materials or tools. This result is similar to the result of a study by Fleer (2000) who found that many children changed their minds between conceptualization stage and construction stage of a technological task.

9.3.5 Presentation and Promotion of Ideas, Design and Solution (Product)

This section assesses the ability of students to: prepare a good report of the technological activity; explain the design, plan and outcome of the project to a selected group of people; use appropriate specific technological terminology in writing the report of the project; and describe the appropriate methods of promoting the technological ideas and product produced. The following results were observed:

(i) Students lacked skills in reporting

The students were asked to prepare reports of their work. The reports were poorly done and too short. Sixty percent of the reports were less than half a page each and the reporting was very general and missed details such as aims, procedures etc., which should have been included. Eighteen percent of the reports were between half a page and one page, and only 4% were more than two pages. Many reports were unclear and difficult to follow. Only 17% of the reports were written in steps with sub-headings and many of the reports were incomplete. Results of the interview revealed that writing reports was never a part of practical work in technical classes.

(ii) Reports showed concentration on building the products

Students' concentration on building the products was observed throughout all of the components of the task. Many of the students (55%) did not include the planning stages of the task in their reports. Only 25% of the reports started with obtaining information, 20% on how to make the products and only 5% started with collecting information on needs and problems in the given area. The rest of the reports started on later stages and concentrated mainly on materials used and how the products

were produced. No report mentioned anything about developing a solution to identified needs and only 5% mentioned evaluation of the product.

(iii) Students lacked ideas behind design and planning

The students showed little understanding of ideas behind design and planning. Most of the presentations (54%) did not cover the range of ideas involved in design, plan and outcome of the project. Students' presentations concentrated mainly on describing how the materials were obtained and prepared and how the products were made. Some students (46%) gave reasons for performing certain tasks, but they were mainly simple reasons and lacked detailed purposes and ideas behind the plan and design. The students were required to give an estimate of the price of their products, but only 25% mentioned pricing. It was found that the students were not familiar with the important technological terms that should be included in the report. Fifty-nine percent of the students used less than six important technological terms in their whole reports. When the students were asked to describe the appropriate methods of promoting the technological ideas behind the design and product, 88% suggested using good materials to make the product beautiful and strong. Only 10% suggested making the characteristics of the products satisfy the needs of the users. Sixty-five percent of the students mentioned two areas of ways of improving selling of the products. These results show that the students had little consideration of the ideas behind the design and planning of their products.

9.3.6 Evaluation of Progress, Process and Solution (Product)

This section assessed the ability of students to: assess methods used to identify strengths and weaknesses throughout the whole process; carry out tests to evaluate the product made and other same products; compare the desired results in the plan against the products made to identify differences; evaluate the quality of the work produced to identify improvements needed to be made; identify skills and knowledge gained from this project; and make recommendations and give advice regarding the best way of doing this project. The main findings are reported below.

(i) Students' ability to evaluate was limited

When the students were required to assess the methods used throughout the whole task to identify weaknesses and strengths, most of the students (64%) described materials and the building method that should be used in order to improve the

product. None of the students evaluated the methods of obtaining information on needs and opportunities, the methods involved in developing the best possible solutions, preparation of reports, presentation and evaluation. Only 10% of the answers mentioned improvements to be made on the plan. None of the answers wanted to improve the product in order for it to be more suitable to a certain type of people, time, place or a particular situation.

The factor that the highest percentage of the students (40%) mentioned that would influence building and using the product was the properties of the materials available.

(ii) Students concentrated mainly on building the products

Students' evaluation of methods and results showed they concentrated mainly on building the products. When they were asked to identify skills and knowledge they gained after doing the task, 86% of the students concentrated mainly on the skills and knowledge that were involved in building the product. Only 4% mentioned skills and knowledge involved in interviewing people. None of the students mentioned the skills in identifying needs and opportunities, in exploring and developing a solution for identified needs and opportunities, skills and knowledge involved in planning, reporting and evaluation. The students missed them all and concentrated only in the skills involved in building the products.

When the students were asked to make recommendations and give advice regarding the best way of doing this project, 59% of the students provided answers that were advice regarding the building of the products. Only 2% gave advice about carrying out interviews and 7% on the planning of the product. Seventeen percent of the answers were encouragement to other students, telling them not to be discouraged by the complexity of the products they were going to build. Many of the students (44%) were not able to make recommendations about the best way of carrying out this project. Also, another 44% made only one recommendation.

(iii) Testing and development of the solution was not evident

The students were observed to check whether they carried out tests to evaluate and improve the products they were building. The tests that most students (55%) carried

out were only simple ones. Forty-three percent of the tests were carried out by the students when the products were completed. It is likely that the students tested their products to see if they worked because none of the students mentioned making changes based on the results of testing. Another important result is that all of the tests were held after the plans had been drawn. No test was carried out during the exploration and development of the solution phase. Testing involves checking a certain part of a product against a certain set of criteria to determine improvements required. However, because the criteria that students identified for the solutions they were planning to develop were superficial, no particular tests were required to determine lengths, strength and weight of the products during the planning activity. Testing was carried out mainly to find out whether the product worked and was not used for development of a better product.

Since no changes were made as results of the tests, and since the tests were carried out after the plans of the final products had been drawn, it is likely that the tests were carried out because of the requirement of the task. Results from the interviews reveal that the students had never been involved in projects that required testing and improvement as part of the product development.

(iv) Students found it difficult to evaluate their own work

When the students were asked to compare their products against the plans to identify differences, 81% of the answers indicated that they were not able to build what they had planned to do and they tried to justify the differences between their plans and products. Forty-five percent identified the differences to be due to parts of the plans they were not able to build. Fifteen percent identified materials they used were not the ones they had planned for because they were not able to obtain them. Another 15% admitted their products were not as good as they had planned for due to their failure to follow planned procedures, failure to produce the planned shape of the product and inadequate workmanship due to unavailability of tools.

9.4 RELATIONSHIPS BETWEEN THE PERFORMANCES OF STUDENTS

This section discusses the relationships between the performances of students in the various aspects of the task. Examining the relationships between the performances

of the students in the various components of the task was considered important in this study. The relationships showed the pathways that the students took while proceeding through the task. They were explored to help draw a picture of students' technological capability. One aspect of students' technological capability is their ability to perform a technological task in a holistic fashion (Kimbell, 1994). This discussion will examine: the nature of the links between the performances of students; the causes of the weaknesses of the links; the influence of task affordance on the performances of the students; the effect of types of skills involved in the quality of students' final products; and the evaluation, total scores and the quality of the final products.

9.4.1 Nature of links between the performances of students

The overall problem solving pathway that all the students followed was presented in Section 8.2.7. Figure 8.2.7 gave the correlation coefficients between the performances of the students in the various components of the task. The correlation coefficients were low and varied. This indicates that the students linked some components together better than others. Some links were weaker and some were stronger. This section discusses the nature of the links between students' performances.

(i) The stronger links

The highest correlation coefficient between the performances of the whole group of students involved in this study in the various components of the task was that between searching for the best solution and the production of the solution. This means that most of the students, after identifying the solution to identified needs and opportunities, proceeded straight to building the product, overlooking the component planning for production. This result is no surprise, since practical work in technical classes in Tonga is comprised mainly of instructions regarding the characteristics of products that the students have to build. Assessment of these projects is based primarily on the quality of students' final products. In this present study, although the students were guided by the worksheets to go through the main stages of the technological capability assessment task (see Figure 8.2.1), the effect of classroom culture was stronger. The students concentrated mainly on building the solutions they obtained.

The relationship with the second highest correlation coefficient between the performances of students was between identifying needs and opportunities and searching for the best solution. This link was expected to be high since both components involve investigations. They involve similar activities and require similar skills. However, although this link was the second highest, relatively high in comparison to the other links in this study, its correlation coefficient value of 0.53 is not a strong relationship. This means that there is much room for improvement regarding the links between the performances of students in a technological task.

The first and second highest correlation coefficients between the performances of the students showed the path that most students took in performing this task. The students identified needs and opportunities, searched for the best solutions for the identified needs and opportunities and proceeded straight to building the products. There is a great deal of improvement that can be made regarding the problem solving pathway that Tongan secondary school students follow in carrying out a technological task.

(ii) The weaker links

The weakest link between the performances of the students in the components of the task was between searching for the best solution and the planning of the production. This indicates that the students in this study performed worst in the planning of the production using results from searching for the best solution. This means that the students did not see planning as an important part of the task. It seems that the students knew what they wanted to build after searching for the best solution and saw no need to design the product or plan for production. This result is another reflection of what the students have done in their practical work in technical subjects. Planning and design have never been emphasized in technical subjects in Tonga. Further, planning and design have not been a significant part of the Tongan traditional building and construction system. The students in this study had no previous experience in producing a plan and design of an artifact using research results or in building an artefact from a design or plan.

The second weakest link was between the production of the solution and the presentation. In presentation, the students were required to prepare a report of the project and to present the ideas behind the design, plan and outcome to the class. The weakness of this link means that the students were not able to prepare good reports of their work and also were not able to explain the important ideas behind their products. Two main reason seemed to have accounted for the weakness of this link. First is students' lack of experience, knowledge and skills in preparing reports and making presentations. Second, the students did not fully understand the task as a whole and did not know the important ideas behind their designs, plans and outcomes. The students need to learn the appropriate knowledge and skills in the various components of a technological task in order to appreciate the ideas behind the task as a whole and to be able to develop important ideas and purposes in building a technological product.

9.4.2 Causes of the weakness of links between students' performances

The nature of the links between the performances of the students in the various components of the task was explored in Chapter 8. The order of the marks the students obtained in each component and the correlation coefficients between the marks were used to determine the nature of the links between the performances of the students. The causes of the weaknesses between the performances of the students are discussed in this section.

(i) Simple needs and opportunities identified

Most of the students identified needs and opportunities in the situation they were assigned to work in that were too simple and superficial. Thus, they continued on to identify criteria for their products that were again simple and shallow. They therefore tended to overlook the importance of going through all the components of the task and concentrated mainly on building the final products. Most of the students skipped planning and went straight on to building the products. This contributed to the weakness of the links between their performances on the components of the task.

(ii) Some students benefited more than others from the task

The experiences that the students obtained from each component of the task varied. Some students gained more from each component than the rest, contributing to the

weakness of the links. For example, some students learned a lot more about doing an investigation from the experience of identifying needs and opportunities than the rest. This showed up well when they carried out the investigation part of the second component, searching for the best solutions. They gained more marks than the rest of the students and caused a significant change in the orders of the marks for searching for the best solution. This shift in the orders of the marks lowered the value of the correlation coefficient between the performances of the students in identifying needs and opportunities and searching for the best solutions. This lowered the strength of the links between the performances of students.

(iii) Students lacking appropriate skills

The marks that the students obtained for their performances in the components of the task were very low. This indicates that they lacked knowledge and appropriate skills required for performing most of the activities in the task. These students had never had any prior experience in carrying out a technological task that involved thorough planning, reporting and evaluation. The kind of practical work they were accustomed to in technical classes only involved building a product with given criteria. They lacked skills in researching, developing solutions, designing and planning production, reporting and presentation, and evaluation. This lack of skills resulted in weaker links between their performances.

(iv) Students familiarity with products

It has been shown that when the students were too familiar with the product they selected to work on, they tended to concentrate on building the product and overlooked the importance of the other components. For example, the group of girls who made brooms were more familiar with brooms than the group of boys who worked on the same product. The links for the performances of the girls were weaker than those for the boys. The girls concentrated mainly on making the broom and missed identifying needs and opportunities, planning, presentation and evaluation.

(v) Disparity between thinking and making

Some students were good at the planning and thinking part of the task but performed poorly in building what they had planned. They were not able to produce what they

had designed and planned to do. They were better at making decisions about the characteristics of the products they were going to build than at the actual building of the products. They lacked the appropriate skills required in using machines and tools to prepare materials and construct the products. At the same time, there were students who were not good at the planning stages of the task but performed better in the production component. They were not able to identify needs and opportunities, to search for the best solutions, or to do the design and planning of products. However, the products they produced were much better and contributed to the weakness of the links between the performances of students. This has been the common characteristics of most of the students who have opted to do the technical subjects. They were students who were not successful with the academic subjects. They turned to the technical subjects and found themselves better with their hands than their minds.

(vi) Failure to view the task holistically

Many of the students involved in this study failed to connect the components of the task together. They were not able to follow the links presented in the instructions for the task and ended up performing each component almost separately. The activities that the students carried out in each component were new, and it was easy for them to get caught up with them and miss the relationships of the activities to the other components of the task. Failure to view the task as a combination of the components contributed to the weakness of the links between the performances of the students.

9.4.3 The influence of task affordance

Task affordance in this study refers to the properties of a technological task that determine its capacity to facilitate or hinder learning (Norman, 1988; Roth, Woszczyna & Smith, 1996). Carr (1997) identified three categories of affordance in literature: transparency, which refers to clarity of meaning or intention; challenge, which refers to difficulty, uncertainty and flexibility; and accessibility, which refers to the form of participation afforded by a task.

Transparency and accessibility of the technological tasks in this study did not have significant effect on the performances of the students. However, challenge has been observed to cause differences in the performances of the groups. It has been

observed in this study that the tasks that afforded a low degree of challenge to the students hindered the ability of students to connect the parts of the task together. When the challenge of a task was low, the students tended to skip some components of the task and concentrated mainly on building the products. For example, the group of girls who made brooms found this task to have a low challenge. Many of these girls were familiar with the problems of brooms, materials required and the method of putting a broom together. Sweeping in Tonga is a task for females and this group of girls saw not much reason in searching for a solution to identified needs and opportunities and for doing proper planning for the production. They went straight to the production of the solution. On the other hand, the group of boys who made brooms found a different level of challenge afforded by this task. Unlike the girls, Tongan boys do not (and are not expected to) do sweeping and are ashamed to do so. They do not know how to make brooms. Therefore they had to do proper planning in order to be able to make a broom. The resulting correlation coefficients between the performances of this group of boys on the components of the task were much higher than those for the group of girls. The correlation coefficient between the performances of boys in identifying needs and opportunities and planning for production was high. This indicates that the boys, after identifying needs and opportunities, spent time doing proper planning of production before they proceeded to produce their products.

The most difficult task, the task that afforded the highest challenge in this study, was the one that required students to build a kava drinking seat. A kava drinking seat is not only a new artefact in Tonga but also a Tongan invention. It is a seat with a back but without legs. It was designed to allow sitting cross-legged on the floor around a kava bowl for many hours. Kava drinking is a Tongan traditional form of social function, in which men sit cross-legged on mats around a bowl of kava and drink, tell stories and sing songs at night time. A kava drinking seat was invented in around the 1980's to enable kava drinkers to be more comfortable at kava parties.

This task provided good incentive, because kava drinking is a popular social function in Tonga. Most boys have elder brothers or fathers that drink kava, and would like to produce them a kava drinking seat. At the same time, building a kava drinking seat is not an easy task for students. Good preparation is required in order for one to be able to build a kava drinking seat. It has been shown in this study that

the boys in this group followed the components of this task more closely than any of the other groups. This group had to: identify needs and opportunities in a kava drinking seat, search for best solutions and do proper planning before they were able to build the seat. The challenge afforded by the kava drinking seat was adequately high for this group that they had to work closely to the instructions given in order to be able to produce the seat. The challenge also assisted the students of this group to view the task in a more holistic way than the rest of the students. This is a very significant result because it suggests that technological tasks must be challenging enough for students in order to assist them to view and perform a technological task holistically.

9.5 THE RELATIONSHIPS BETWEEN THE PERFORMANCES OF STUDENTS AND THE QUALITY OF THEIR FINAL PRODUCTS

This section discusses the relationships between the performances of students in the six components of technological capability assessed and the quality of their final products. Factors that contribute to the production of a good quality product are considered important in technology education. In this study, a good quality product is one that not only has characteristics that are appropriate to specified criteria but also is aesthetic. Important results from the exploration of the relationships between students' performances and the quality of their final products are discussed below.

9.5.1 Production of a solution was the main contributor to quality

Examination of the marks that the students obtained in each of the components of the task against their marks obtained for the quality of products was carried out to determine the relationships between the components of the task and the quality of the final products. This analysis was assisted by the correlation coefficients between the marks that students obtained and their marks for the quality of product. It was found that the component that related strongly to the quality of the final products was, as expected, production of a solution. The students who performed well in the production tended to produce products that not only had characteristics that were appropriate to the identified criteria but also aesthetic. The students who performed well in the other components but not in the production of the solution did not

produce good quality products. This result reflects the nature of practical work in technical subjects. The students who know how to use tools and machines to prepare parts of the products and who are good with their hands produce good quality products.

The contributions that the other components could make towards the quality of the product were not observed in the performances of the students in this study. It shows that there is much work to be done in order to enable the students to perform in the rest of the components of the task in such a way as to produce better quality products. It has been shown that the students who performed relatively well throughout the components of the task produced better quality products.

9.5.2 Students' performance in two types of criteria

The criteria developed for this study are of two main types. One is the *continuous* criteria, which assess the ability of students to continue from the results of the previous component. The other is the *discrete* criteria, which assess the skills local to each component. The students who performed well only in the continuous criteria produced products that were appropriate to the identified criteria but not aesthetic, resulting in low scores for Quality of Product. On the other hand, the students who only performed well in discrete criteria produced relatively more aesthetic products but not appropriate to the identified criteria, making the Quality of Product scores again low. A few students performed well at both continuous and discrete criteria. They produced products that were both relatively better aesthetically and more appropriate to specified criteria, achieving better scores for Quality of Products. It appears that better quality products would be produced if students performed well in both continuous and discrete criteria.

9.5.3 Correlation Coefficients and Students' Holistic View of Task

The students who produced better quality products were students who performed consistently better throughout the components. This connection was identified by examining the correlation coefficients between the consecutive components in each task. The tasks with consecutive correlation coefficients that are all positive and relatively high have some students performing consistently better than the rest of the students in the group in all of the components. It means that these particular students

understand the links and the whole task better than the rest of the group. Their performances on the parts add up better to the whole than the rest of the group. The consistent strength of the correlation coefficients between consecutive components in a task can be a simple indicator that may be used to determine students' ability to view the parts of a task in a holistic manner.

9.5.4 Evaluation, Total Scores and Quality of the Products

Students who did relatively better at the evaluation appear to understand the whole task better. Most of these same students achieved better overall scores. It was observed that the students who were good at evaluation obtained relatively better overall scores and eventually produced better quality products. If the students understand the links between the components of the task, they will be able to evaluate design, progress and outcome better and produce better quality products.

9.6 THE RELATIONSHIP BETWEEN STUDENTS' PERCEPTIONS OF TECHNOLOGY AND THEIR EXISTING TECHNOLOGICAL CAPABILITY

Three correlation tests were carried out to determine the relationship between students' perceptions of technology and existing technological capability: (i) students' total score on technological task against the number of pictures selected to be related to technology; (ii) students' total score on technological task against the number of ideas mentioned in the writing/drawing activity; (iii) students' total score on technological task against the type of ideas mentioned in the writing/drawing activity and the picture quiz. None of these tests showed a significant relationship between students' perceptions of technology and their existing technological capability. This result is contrary to the results reported by Jones and Carr (1993a) and Jones and Mather (1995), who found that there are strong links between students' concepts of technology and their technological practice. There are a few factors that can account for this discrepancy.

First, during the interview, the students were asked whether they found anything technological in the task they were doing. All of the students involved in this study

found it difficult to identify anything in the task they were doing to be related to technology. Since most of them viewed technology to be about changes and development, it is no surprise that they found no relationship between the task they were doing and change and development.

The second factor that influences the relationship between Tongan students' perceptions of technology and their existing technological capability is the absence of technology education in Tonga. It is understandable that the relationship did not exist because at the time of the study, the students had limited perceptions of technology and also had inadequate existing technological capability.

9.7 CONCLUSIONS

This section presents the conclusions established from the results of this study. The conclusions drawn from the results of the assessment of students' perceptions of technology will be presented first. These will be followed by the conclusions from the results of the exploration of the students' existing technological capability.

9.7.1 Students' Perceptions of Technology

The Tongan secondary school students have an enormous variety of ideas about technology. However, for simplicity, these ideas were classified into four main categories in this study. The first category is 'technology as a process'. This category comprises four of the ideas provided by the students. They are: technology as change and development, which is the most popular idea mentioned by the students; technology as new discoveries, new ideas and new ways of doing things; technology as an effort to make work easier, which was mentioned by more of the mature students; and technology as involving design and problem solving.

The second category is 'technology as artefacts'. The ideas that students mentioned that fall into this category are: technology as modern, better and newer tools; technology as machines and engineering; technology as goods imported from overseas; technology as vehicles and boats; technology as electrical appliances; and technology as human made; technology as useful things (safe and not dangerous).

The third category referred to technology as related to computers. The answers the students provided in the three instruments were different. This suggests that the students were not sure of the relationship between technology and computers. It indicates that the students were not sure of the meaning of technology. This is a sign that Tongan secondary students have a limited perception of technology. The fourth category referred to technology as science. This was mentioned by a very small proportion of the students involved in this part of the study.

Interest in technology was high among the students of this study. However, many were not sure and had limited ideas about the effect of technology on society.

In comparing the results for Form 1 and Form 6 students, Form 1 students had a larger variation of ideas about technology, while Form 6 students knew more about the meaning of technology. Form 6 students agreed more with the involvement of design in technology, more interested in technology and knew more about the effect of technology on society.

In comparing the results of male and female students, more boys viewed technology as change and development while a higher proportion of the girls viewed technology as new things in the island. Further, the boys showed more interest in technology than girls.

9.7.2 Students Existing Technological Capability

The overall performance of the students in the task was limited. They performed worst in searching for the best solution for the identified needs and opportunities and performed best in the production of the solution.

Most of the students lacked the appropriate knowledge, skills and experience in identifying needs and opportunities, in searching and developing best possible solution, in designing and planning for the production of the solution, in the presentation and in the evaluation. The students concentrated mainly on building the product. Classroom and Tongan cultures both showed influence on the way in which the students performed the activities involved in the task. The students were not sure of the important purposes of the task and lacked inventiveness in their work. They

also showed inappropriate attitudes towards using research results for the development of the solution. Accuracy and precision in measurements of lengths and parts of the products were not considered by the students to be important. The students did not put much thought into the designs and plans of their products, and most of them changed their designs or were not able to follow their plans while building their products. Most of the students were not serious in keeping the safety rules of the technical workshop and lacked skills in managing the workspace.

9.7.3 Relationships between the performances of students in various components of the task

The problem solving pathway that most students took was from identifying needs and opportunities to the searching for and developing of the best solution and to the production of the solution. The planning component did not link well to the searching for and developing the best solution and also to the production of the solution. This is a reflection of the nature of the practical work that they had been doing in Industrial Arts and Home Economics classes.

The main causes of the weaknesses of the links between the performances of the students in the various components of the task include: the needs and opportunities were simple and superficial; the students lacked the appropriate knowledge and skills for the task; the students were too familiar with the products they were building; the disparity between the students' minds and hands, that is the difference between what they were capable of planning and what they were capable of building; and the failure of most students to view the task holistically.

One of the major factors that influenced the ability of the students to link the components of the task together is task affordance. Task affordance category challenge has influenced the problem solving pathway that the students followed in the task. The tasks that afforded a low degree of challenge to the students hindered the students' ability to view the task holistically. The tasks that provided a higher challenge to the students enabled them to follow a more complete pathway in building the products.

The component of the task that contributed most to the quality of the students' final products was the production of the solution. The students who were able to use appropriate instruments to accurately measure required quantities, use appropriate tools to effectively perform work required, wear necessary safety gear and use tools safely while working, work in a careful manner and keep workspace tidy and well organized during and after work, fully implement the plan of action, produced good quality products. The contributions that the other components could make towards the quality of the final products were not observed in the performances of the students in this study.

9.7.4 Relationship between students' perceptions of technology and their existing technological capability

No relationship was found in this study between the performances of the students in the three instruments that assessed their perceptions of technology and their performances in the technological capability task. The students reported in the interview that they saw nothing in the task that was related to technology.

9.8 IMPLICATIONS

This section presents the important issues that have been implied by the results of this study. The implications for teaching and learning in technology education will be presented first and the implications for further research will follow.

9.8.1 Implications for Curriculum Development

The results of this study indicate that there is a need for Tonga to develop a technology education curriculum and to be implemented as one of the core subjects in Tongan primary and secondary education. Tongan students have been found to have inadequate perceptions of technology. This has been a common finding in previous studies on students' perceptions of technology (Raat, de Klerk Wolters & de Vries, 1987; Rennie, 1987; Rennie and Jarvis, 1995; Jarvis and Rennie, 1998; Burns, 1992). Also, the results of the performances of the students in this present study in the technological task indicated that they had unsatisfactory levels of existing technological capability. This result is similar to the findings of a similar study in New Zealand by Jones (1997b). These results indicate that the present

technical curriculum in Tongan secondary education is not effective in teaching the important ideas and skills in technology. The worldwide trend in the task of preparing students to understand and be able to cope with the advance of modern technology has been the development of the new subject in primary and secondary education called Technology Education (or Design and Technology in the UK). This study has shown that Tongan secondary school students, like the students in countries where previous studies similar to the present study were taken, have problems regarding the important issues and skills in technology. Tonga should follow the worldwide trend and recognise technology education as a distinct area of education and as an important subject to be included as a core subject in the school curriculum.

Tonga is at present not sure of which direction to follow in its effort to develop its secondary education technical curriculum (refer to Chapter 2). One development indicated a move into a more traditional technical program, while a later development indicated an interest in the more general approach adopted in technology education. It is timely for Tonga to seriously reconsider the path it wants to take regarding the proper type of technical education program to adopt. The results of this present study suggest that Tonga should develop a new technology curriculum and establish a new subject for all students and call it Technology Education. It should be broad-based and the objective should be technological literacy.

The effects of classroom culture on the views that students held about technology, on their performances in the technological task and on their learning process suggest that it would be most suitable for students to study the ideas and skills in technology in a technology education classroom and taught by technology education teachers. This study believes that technology education should not to be integrated to be part of the existing subjects. The effect of Tongan culture on students' learning in technology should be a major concern for developers of a technology education for Tonga in the future.

Tongan students' interest in technology was found to be high. However, most of them were not aware of the effects of imported technology on society and

environment. There is a need to teach students to be technologically literate and be able to make informed decisions regarding the development of technology in Tonga. They should be empowered to be able to make the right decisions about what technology to be imported and what to be avoided. This is a problem that needs as urgent action. Especially when the influx of modern technology into Tonga is at a dangerously high rate due to the gifts send from the great proportion of Tongan population living overseas to their relatives at home (refer to Chapter 2). The gap between Tongans' technological literacy and the modern technology arriving daily from their relatives overseas is increasing at an alarming rate. Tonga needs to develop a curriculum for technology in order to narrow this gap.

9.8.2 Implications for Teaching and Learning in Technology Education

The results of the exploration of students' perceptions of technology suggests that Tongan students need to be taught about the important concepts of (and in) technology. This means that a technology education curriculum for Tonga should include components that teach concepts of technology and the effects of technology on society and environment.

The results of the performances of the students in the components of the technological task indicate that the practical work in secondary school technical subjects in Tonga have not been able to teach students to be inventive while building products and put adequate thought into the design and plan of products. Most of the practical projects that the students carry out in technical subjects in Tongan secondary schools are of recipe type, in which students are required to follow instructions to build a product. The students only work with their hands. There is a need to enable the students to contribute more ideas towards the design and plan of the products. This study believes that the approach developed in technology education towards teaching technological capability is more appropriate towards enabling students to develop plan, design and produce better quality products.

The nature of technological task has a major influence on students' learning in technology education. There is a need to develop tasks with appropriate affordance in order to enhance teaching and learning the important skills in technology. It has

also been shown that the level of difficulty afforded by a particular technological task depends on the experiences of the students.

9.8.3 Implications for Further Research

The present study has not been able to establish the relationship between students' perceptions of technology and their existing technological capability. This has been due mainly to the absence of technology education in Tonga. There is a need for further research in this area in Tonga after technology education has been established in Tonga.

The method employed in this study to assess students' existing technological capability has been successful in revealing much of what the students were capable of technologically. However, there is much opportunity for improvement in this method and requires further research to enhance the method.

The relationship between task affordance and the ability of the students to follow the technological capability path provided in the students' worksheets was evident in this study. However, this study has highlighted only the effect of the task affordance category challenge on the ability of students to view the task holistically. Further research should be made regarding the relationship between transparency and assessibility and the performances of the students in the various components of a technological task.

A similar study should be carried out after five years from implementation of a technology education curriculum in Tongan schools in order to monitor the development of the curriculum.

APPENDICES

Appendix A. Research Instruments for Studying Students' Perceptions of Technology

Appendix A(1) Writing/Drawing Activity (English Version)
Appendix A(2) Writing/Drawing Activity (Tongan Version)
Appendix A(3) Technology Questionnaire (English Version)
Appendix A(4) Technology Questionnaire (Tongan Version)
Appendix A(5) Picture Quiz (English Version)
Appendix A(6) Picture Quiz (Tongan Version)

Appendix B. Research Documents for Studying Students' Existing Technological Capability

Appendix B(1) Assessment Criteria
Appendix B(2) Performance Descriptors
Appendix B(3) Students Worksheet (English Version)
Appendix B(4) Students Worksheet (Tongan Version)

Appendix C. Communication to Conduct Field Research in Tonga

Appendix C(1) Letter to Tonga Government
Appendix C(2) Letter of Approval from Tonga

APPENDIX A. RESEARCH INSTRUMENTS FOR STUDYING STUDENTS' PERCEPTIONS OF TECHNOLOGY

Appendix A(1) Writing/Drawing Activity (English Version)

TECHNOLOGY WRITING/DRAWING ACTIVITY

Name_____School_____ Class_____

Boy/Girl_____ Age _____ Village:_____

Mother's Job :_____

Father's Job :_____

Technology can mean different things to different people. When you read the word 'technology' what comes into your mind? Please tell us what technology means to you by writing about it, or by drawing a picture. You might like to do both.

DRAWING

Appendix A(2) Writing/Drawing Activity (Tongan Version)

FAKAMATALA'I PE TA FAKATATA'I 'O E TEKINOLOSIA

Hingoa _____ 'Apiako _____ Kalasi_____ Ta'u_____

Ta'ahine pe tamasi'i _____ Kolo: _____

Ngaue 'a e fa'e :_____

Ngaue 'a e tamai :_____

Ko e fo'i lea ko e tekinolosia (technology),'oku 'uhinga kehekehe ia ki he kakai kehekehe. 'I he taimi 'oku ke sio ai ki he fo'i lea ko e tekinolosia, ko e ha 'a e ngaahi me'a 'oku ha'u ki ho'o fakakaukau? Hanga 'o talamai pe ko e ha hono 'uhinga kiate koe 'a e fo'i lea ko e tekinolosia 'aki ha'o fakamatala'i 'i he ngaahi laine 'i lalo, pe ko ha'o ta mai ha fakatata 'a 'e ne mahino kiate koe 'a e tekinolosia. 'E lelei pe kapau te ke fakamatala pea ke toe ta mai mo ha fakatata.

_____

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FAKATATA:

Appendix A(3) Technology Questionnaire (English Version)

TECHNOLOGY QUESTIONNAIRE

Name _____ School _____ Class_____

Age_____ Boy/Girl (circle one) Village:_____

Mother's Job :_____

Father's Job :_____

For each of the statements under the questions below, put an 'X' in the appropriate box which indicates your view about the statement.

Part A: What is Technology?

	Strongly agree	Agree	Can't decide	Disagree	Strongly disagree
1. Technology mainly concerns computers and similar equipment.					
2. Making models and testing them is part of technology.					
3. Technological appliances can only be used by qualified people.					
4. Working with materials is an important part of technology.					
5. Without electricity, there would be no technology.					
6. Technology involves designing solutions to problems.					
7. Most people have little to do with technology in their everyday lives.					
8. In technology there are opportunities to design new products.					
9. Two hundred years ago there was no technology.					
10. Technology means inventing new ways of doing things.					

Part B. What do you think about Technology?

	Strongly agree	Agree	Can't decide	Disagree	Strongly disagree
1. I am interested in technology.					
2. Technology makes the world a better place to live in.					
3. I would like to learn more about technology.					
4. Technology has brought more good things than bad things.					
5. I would like a career in technology later on.					
6. It is worth spending money on technology.					
7. I would like to read books and magazines about technology.					
8. Inventions in technology are doing more good than harm.					
9. I would like to join a hobby club about technology.					
10. Technology is needed by everybody.					

Appendix A(4) Technology Questionnaire (Tongan Version)

KO E TALIFEHU'I FELAVE'I MO E TEKINOLOSIA

Hingoa _____ 'Apiako _____ Kalasi_____ Ta'u_____

Ta'ahine pe tamasi'i _____ Kolo: _____

Ngaue 'a e fa'e :_____

Ngaue 'a e tamai :_____

'I he ongo fo'i fehu'i 'i lalo, tohi'i 'a e 'X' 'i he ki'i puha 'oku fe'unga mo ho'o fakakaukau 'o fakatatau mo e fo'i setesi takitaha.

Konga A: Ko e ha 'a e tekinolosia (Technology) ?

	Mo'oni 'aupito	Mo'oni	'Ikai teu fakapapau'i	'Ikai mo'oni	Hala 'aupito
1. Ko e tekinolosia 'oku meimei felave'i pe mo e komipiuta mo e 'u kalasi misini pehe					
2. Ko e tekinolosia 'oku kau ai hono fa'u ha motolo 'o ha me'a pea tesi'i pe 'oku ngaue					
3. Ko e ngaahi me'angaue faka tekinolosia 'oku lava pe 'o ngaue'aki 'e he kakai 'osi ako kiai					
4. Ko e konga mahu'inga 'o e tekinolosia ko hono ngaahi 'o e ngaahi me'a kehekehe					
5. Kapau 'e 'ikai ke 'i ai ha 'uhila pea 'e 'ikai ke 'i ai ha tekinolosia ia					
6. Ko e tekinolosia 'oku kau ai mo hono tisaini pe fokotu'utu'u hano solova ha palopalema					
7. Ko e kakai tokolahi 'oku 'ikai ke nau faka'aonga'i 'a e tekinolosia 'i he 'enau mo'ui faka'aho					
8. 'I he tekinolosia 'oku 'i ai 'a e faingamalie ke tisaini ha fa'ahinga me'a fo'ou					
9. Na'e 'ikai ke 'i ai ha tekinolosia 'i he ta'u 'e 200 kuo 'osi					
10. Ko e tekinolosia ko e fekumi ke fa'u ha fa'ahinga founga fo'ou 'o e fai ha ngaue					

Konga E: Ko e ha ho'o fakakaukau ki he tekinolosia (technology) ?

	Mo'oni 'aupito	Mo'oni	'Ikai fakapapau'i	'Ikai mo'oni	Hala 'aupito
1. 'Oku ou manako 'i he tekinolosia.					
2. 'Oku hanga 'e he tekinolosia 'o ngaohi 'a e mamani ke lelei ange ki he mo'ui					
3. 'Oku ou fie ako ki he tekinolosia.					
4. 'Oku lahi ange 'a e ngaahi lelei 'oku 'omi 'e he tekinolosia 'i he ngaahi me'a fakatu'utamaki.					
5. Teu fie ngaue 'i he mala'e 'o e tekinolosia 'i he kaha'u					
6. 'Oku mahu'inga ke fakamoleki ha pa'anga lahi 'i he tekinolosia.					
7. 'Oku ou faka'amu keu lau ha ngaahi tohi mo ha makasini felave'i mo e tekinolosia.					
8. Ko e ngaahi 'ilo fo'ou faka tekinolosia 'oku lahi ange 'e nau 'aonga 'i he 'enau maumau.					
9. 'Oku ou fie kau 'i ha kalapu pe feohi'anga faka tekinolosia.					
10. 'Oku fiema'u 'e he tokotaha kotoa pe 'a e tekinolosia.					

Appendix A(5): Picture Quiz (English Version)

PICTURE QUIZ

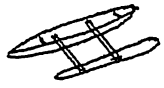
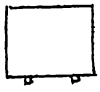
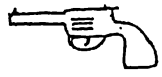
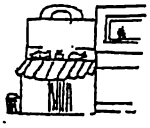
Name_____School_____ Class_____

Boy/Girl_____ Age _____ Village:_____

Mother's Job :_____

Father's Job :_____

For each of the diagrams below, put a tick (/) if you think the diagram has something to do with technology or put a cross ('X') if you think it does not. Please write down the reason for your decision in the spaces provided.

Jeans Reason_____	Canoe  Reason_____	Book Reason_____	'Ovava Tree Reason_____
Refrigerator  Reason_____	Computer Reason_____	Gun  Reason_____	Telephone Reason_____
Quarry Reason_____	Clock Reason_____	Cup Reason_____	Bridge Reason_____
Factory Reason_____	Volcano Reason_____	Hand Axe Reason_____	Mat Reason_____
Shop  Reason_____	Knife Reason_____	Chair Reason_____	Aeroplane Reason_____

Appendix A(6): Picture Quiz (Tongan Version)

FILI'I 'O E NGAAHI FAKATATA 'O E TEKINOLOSIA

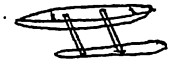
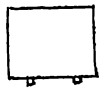
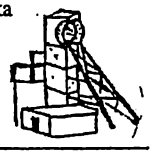
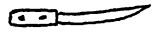
Hingoa _____ 'Apiako _____ Kalasi_____ Ta'u_____

Ta'ahine pe tamasi'i _____ Kolo: _____

Ngaue 'a e fa'e :_____

Ngaue 'a e tamai :_____

'I he ngaahi fakatata 'i lalo, hanga 'o fakatonuki 'a e fakatata 'oku ke pehe 'oku 'i ai ha'ane felave'i mo e tekinolosia, pea ke fakahalaki 'a e fakatata 'oku ke pehe 'oku 'ikai felave'i mo e tekinolosia, pea ke fakamatala'i mai ho'o 'uhinga 'i lalo 'i he fakatata takitaha.

Talauseselóloa 'Uhinga_____	Popao  'Uhinga_____	Tohi 'Uhinga_____	Fu'ú 'ovava 'Uhinga_____
Misini fo  'Uhinga_____	Komipiuta 'Uhinga_____	Me'afana 'Uhinga_____	Telefoni 'Uhinga_____
Keli'anga maka  'Uhinga_____	Uasi 'Uhinga_____	Ipu 'Uhinga_____	Hala Fakakavakava 'Uhinga_____
Falengaue 'Uhinga_____	Mo'ungaafi 'Uhinga_____	Tokimaka 'Uhinga_____	Falapaongo 'Uhinga_____
Falekoloa 'Uhinga_____	Hele  'Uhinga_____	Sea 'Uhinga_____	Vakapuna 'Uhinga_____

APPENDIX B. RESEARCH DOCUMENTS FOR STUDYING STUDENTS' EXISTING TECHNOLOGICAL CAPABILITY

Appendix B(1): Assessment Criteria

ASSESSMENT CRITERIA IN EACH TECHNOLOGICAL CAPABILITY

Capability A. Identifying Needs and Opportunities

A1. Can the student ask important and relevant technological questions about a given situation?
A2. Can the student identify the factors that are relevant to and influence the given situation?
A3. Can the student describe a plan of an investigation for gathering data on needs and opportunities?
A4. Does the student consult important and appropriate sources of information on needs and opportunities?
A5. Does the student collect relevant and sufficient data on needs and opportunities?
A6. How well does the student analyse data collected to identify needs and opportunities that existed?
A7. Can the student identify needs and opportunities intrinsic in the situation?

Capability B. Exploring and Developing Best Possible Solution and Strategies

B1. Can the student state (a) who will use the product, (b) where, (c) why, (d) when and (e) how the product will be used?
B2. Can the student clearly describe the types of information needed to obtain in order to solve identified needs and opportunities?
B3. How well does the student describe a plan of an investigation to collect information on solutions to the identified needs and opportunities?
B4. Does the student consult important and appropriate sources of information on solutions and strategies for the identified needs and opportunities?
B5. Does the student collect relevant and sufficient information on solutions and strategies for the identified needs and opportunities?
B6. Can the student identify solutions and strategies relevant to the needs and opportunities identified?
B7. Can the student identify the factors that influence the making of the solution to the identified needs and opportunities?
B8. Can the student identify knowledge and skills required for making the solution (product)?

Capability C. Planning the Production of the Solution (Product)

C1. Are the characteristics of the product planned by the student appropriate to the needs and opportunities identified?
C2. Can the student draw or describe an appropriate plan or recipe of the product with proper labels and scales?
C3. Can the student ascertain materials (with quantities required) and tools needed for the task?
C4. Can the student identify the measurements that needed to be made in making the product?
C5. Can the student determine the expenses involved in making the product?
C6. Can the student explain the appropriate steps involved in carrying out the task?
C7. Can the student identify the dangers involved in carrying out the task?
C8. Can the student identify the assistance needed from an expert or from an older person for carrying out the task?

Capability D. Production of Solution

D1. Can the student use the appropriate instruments to accurately measure the required quantities?
D2. Can the student use the appropriate tools to effectively perform the work required?
D3. Does the student wear necessary safety gear and use tools safely while working?
D4. Does the student work in a careful manner and keep the workspace tidy and well organized during and after work?
D5. Can the student fully implement the plan of action?
D6. Is the work produced by the student appropriate to its specified criteria?
D7. Is the work produced by the student aesthetic?

Capability E. Presentation of Ideas behind Design, Plan and Outcome

E1. Can the student prepare a good report of the technological activity?
E2. How well does the student explain design, plan and outcome of the project to a selected group of people?

E3. Does the student use appropriate specific technological terminology in writing the report of the project?
E4. Can the student describe the appropriate methods of promoting the technological ideas and product produced?

Capability F. Evaluation of Progress, Process and Product

F1. Can the student assess methods used to identify strengths and weaknesses throughout the whole process?
F2. Does the student carry out tests in the development of the product made and other same products?
F3. Can the student compare the desired results in the plan against the product made to identify differences?
F4. Can the student evaluate the quality of the work produced to identify improvements needed to be made?
F5. Can the student identify skills and knowledge gained from this project?
F6. Can the student make recommendations and give advice regarding the best way of doing this project?

Appendix B(2): Performance Descriptors

PERFORMANCE DESCRIPTORS USED TO DESCRIBE STUDENTS' PEFORMANCE IN EACH CRITERIA

A.1 The Ability of Students to ask Important and Relevant Technological Questions to Identify Needs and Opportunities

	Performance Descriptors
4	Student asks a wide range of relevant and important questions on users, makers, product, time and context.
3	Asks a very good range of relevant and important questions on most of the above.
2	A fair range of relevant and important questions on some of the above.
1	A limited range of relevant and important questions on one or two of the above.
0	Questions are irrelevant and not important.

A.2 The Ability of Students to Identify Important and Relevant Factors that Influence the Situation

Performance Descriptors	
4	The student gives a wide range of social, cultural, environmental, legal, time, human, resources, financial and technical factors related to the situation.
3	The student gives a very good range of relevant and important factors related to the situation.
2	A fair range of relevant and important factors related to the situation.
1	A limited range of relevant and important factors related to the situation.
0	The student cannot identify the relevant and important factors related to the situation.

A.3 The Ability of Students to Describe a Plan of an Investigation for Gathering Data on Needs and Opportunities

Performance Descriptors	
4	The plan described contains the aim of the investigation, materials and equipment needed, method of data collection, source of data and data management method.
3	Plan contains much of the information described above.
2	Plan described contains a fair amount of the information described above.
1	Plan described contains one or two of the areas described above.
0	The answer is not a plan of an investigation.

A.4 The Ability of Students to Identify and consult Important and Appropriate Sources of Information on Needs and Opportunities

	Performance Descriptors
4	The student consults consumer demands, users, makers and experts and searches library and books, existing technology and scientific discoveries.
3	The student consults a very good range of the sources above.
2	The student consults a fair range of the sources above.
1	The student consults a limited range of the sources above.
0	The student does not consult any of the resources above.

A.5 The Ability of Students to Collect Relevant and Sufficient Data on Needs and Opportunities

	Performance Descriptors
4	Student collects sufficient appropriate data from users, makers and experts, information on the product, costs, time and context.
3	Student collects a very good amount of appropriate data on the above.
2	Student collects a fair amount of appropriate data on the above.
1	Student collects a limited amount of appropriate data on the above.
0	Collects either no data or inappropriate and irrelevant data.

A.6 The Ability of Students to Analyse Data Collected to Identify Needs and Opportunities that Existed

	Performance Descriptors
4	Student identifies important needs and opportunities existing in data collected.
3	Identifies most of important needs and opportunities in data collected.
2	Identifies a fair number of important needs and opportunities in data collected.
1	Identifies a limited number of important needs and opportunities in data collected.
0	Cannot identify needs and opportunities existing in data collected.

A.7 The Ability of Students to Identify Intrinsic Needs and Opportunities

	Performance Descriptors
4	Student identifies the important range of intrinsic needs and opportunities in the situation regarding the properties of the products in relation to who, when, where, how and when.
3	Identifies most of intrinsic needs and opportunities mentioned above.
2	Identifies a limited number of intrinsic needs and opportunities mentioned above.
1	Identifies a fair number of needs and opportunities but only in one area.
0	Identifies a limited number of needs and opportunities.

B.1 The Ability of Students to Describe (a) Who will use the Product, (b) Where, (c) Why, (d) When, and (e) How the Product will be Used

	Performance Descriptors
4	The student specifically states who, where, why, how and when the product will be used.
3	Student specifically states almost all of the above.
2	Student specifically states half of the above.
1	Student specifically states 1 or 2 of the above.
0	The student cannot specifically state any of the above.

B.2 The Ability of Students to Describe the Characteristics of Products that could Solve Needs and Opportunities Identified

	Performance Descriptors
4	The student describes clearly the characteristics the product should have in order to solve identified needs and opportunities.
3	The student's description of the product to be made relates well to the needs and opportunities identified earlier.
2	The student's description of the product to be made relates fairly to the needs and opportunities identified earlier.
1	The student's description of the product to be made relates minimally to the needs and opportunities identified earlier.
0	The student's description of the product to be made does not relate to the needs and opportunities identified earlier.

B.3 The Ability of Students to Describe a Plan of Investigation to Collect Information on Solutions to Identified Needs and Opportunities

	Performance Descriptors
4	The student describes a plan that contains the aim, materials and equipment needed, method of data collection, sources of data and data management method.
3	Plan described contains much of the information listed above.
2	Plan described contains a fair amount of the information described above.
1	Plan described contains one or two of the areas described above.
0	The answer is not about an investigation to be carried out.

B.4 The Ability of Students to Consult Appropriate Sources of Information on Solutions and Strategies for Identified Needs and Opportunities

	Performance Descriptors
4	Student consults experts, users, makers, resource materials, existing technology and scientific discoveries.
3	Student consults a very good range of the sources above.
2	Student consults a fair range of the sources above.
1	Student consults a limited range of the sources above.
0	Student consults no real sources.

B.5 The Ability of Students to Collect Relevant and Sufficient Data on Solutions and Strategies for Needs and Opportunities Identified

	Performance Descriptors
4	Student collects a sufficient amount of appropriate data on solutions to the needs identified.
3	Student collects a very good amount of appropriate data on solutions to the needs identified.
2	Student collects a fair amount of appropriate data on solutions to the needs identified.
1	Student collects a limited amount of appropriate data on solutions to the needs identified.
0	Collects either no data or inappropriate and irrelevant data.

B.6 The Ability of Students to Analyse Data Collected to Identify Solutions to Needs and Opportunities Identified

	Performance Descriptors
4	Student identifies all the important information on solutions that exist in the data collected.
3	Student identifies most of the important information on solutions that exist in the data collected.
2	Student identifies a fair amount of important information on solutions that exist in the data collected.
1	Student identifies a limited amount of the important information on solutions that exist in the data collected.
0	Student cannot identify any of the important information on solutions that exist in the data collected.

B.7 The Ability of Students to Identify Factors that could Influence the Making of the Proposed Product to Satisfy Needs and Opportunities Identified

Performance Descriptors	
4	The student considers a wide range of social, cultural, environmental, legal, time, human, resources, financial and technical factors related to the solutions and strategies.
3	Considers a good range of relevant and important factors on most of the above.
2	Considers a fair range of relevant and important factors on some of the above.
1	Considers a limited range of relevant and important factors on a few of the above.
0	Does not consider any factor.

B.8 The Ability of Students to Identify Knowledge and Skills Required for Making the Product

Performance Descriptors	
4	Student identifies sufficient skills and knowledge required for the task.
3	Student identifies a good number of skills and knowledge required for the task.
2	Student identifies a fair number of skills and knowledge required for the task.
1	Student identifies a limited number of skills and knowledge required for the task.
0	Student cannot identify any of the skills and knowledge required for the task.

C.1 The Appropriateness of the Characteristics of the Product Planned by the Students to the Needs and Opportunities Identified

Performance Descriptors	
4	Characteristics described are appropriate to all needs and opportunities identified.
3	Characteristics described are appropriate to almost all identified needs and opportunities.
2	Characteristics described are appropriate to a fair number of needs and opportunities identified.
1	Characteristics described are appropriate to a limited number of needs and opportunities identified.
0	Characteristics described are not appropriate to the needs and opportunities identified.

C.2 The Ability of Students to use Drawing or Explanation to Produce an Appropriate Plan of the Product with Proper Labels and Scales

Performance Descriptors	
4	Student uses drawing (or explanation for students who made food) to produce a good plan (or recipe) of the product, with suitable scales and labels (or ingredients and amounts).
3	Student produces a good plan (or recipe) with suitable labels (or names of ingredients).
2	Student produces a poor plan (or recipe) with suitable labels (or names of ingredients).
1	Student produces a poor plan (or recipe) with no labels (or names of ingredients).
0	Student produces an extremely rough plan (or recipe) with no labels (or names of ingredients).

C.3 The Ability of Students to Ascertain Materials and Tools Needed for the Task

Performance Descriptors	
4	Student lists all tools and materials together with quantities required for the task.
3	Student lists all tools and materials but not with appropriate quantities.
2	Student lists most of tools and materials but not with appropriate quantities.
1	Student lists half of the materials or half of the tools but not with appropriate quantities.
0	Student does not know the right tools and materials needed for the task.

C.4 The Ability of Students to Identify the Measurements Needed

Performance Descriptors	
4	Student identifies all the things that needed to be measured.
3	Student identifies almost all the things that needed to be measured.
2	Student identifies half of the things that needed to be measured.
1	Student identifies one or two of the things that needed to be measured.
0	Student identifies non of the things that needed to be measured.

C.5 The Ability of Students to Determine the Expenses Involved in Making the Products

Performance Descriptors	
4	Student describes all costs of the materials and expenses involved.
3	Student describes most of the materials to be bought together with their prices.
2	Student describes most of the materials to be bought but without their prices.
1	Student describes one or two of the materials to be bought but without their prices.
0	Student cannot describe costs and expenses involved.

C.6 The Ability of Students to Describe the Appropriate Steps Involved

Performance Descriptors	
4	Student fully describes in order the steps in carrying out the task.
3	Student describes in order most of the steps involved in carrying out the task.
2	Student describes half of the steps involved in carrying out the task.
1	Student gives one or two of the steps involved in carrying the task.
0	Student cannot describe the steps in carrying out the task.

C.7 The Ability of Students to Identify the Dangers Involved in Carrying out the Tasks

Performance Descriptors	
4	The student can identify all of the possible dangers involved in carrying out the task.
3	The student can identify almost all of the possible dangers involved in carrying out the task.
2	The student can identify half of the possible dangers involved in carrying out the task.
1	The student identifies a limited number of the possible dangers involved in carrying out the task.
0	The student cannot identify any of the possible dangers involved in carrying out the task.

C.8 The Ability of Students to Identify the Assistance Needed from an Expert

Performance Descriptors	
4	The student identifies all the tasks that could best be carried out by an expert.
3	Student explains some of the tasks to be carried out by an expert.
2	Student expects the expert to show or teach them how to make the product.
1	Student is not clear of the tasks to be carried out by an expert.
0	Student cannot see the need for obtaining assistance of experts.

D.1 Using Appropriate Instruments to do Measurement

Performance Descriptors	
4	The student uses appropriate instruments to accurately measure all required quantities.
3	The student uses appropriate instruments to accurately measure some of the required quantities.
2	The student can use only some of instruments to measure some of the required quantities.
1	The student has problems with measuring quantities required.
0	The student does not measure required quantities.

D.2 Using Appropriate Tools to Build Product

Performance Descriptors	
4	The student is competent in using all the appropriate tools to carry out the work required.
3	The student can use almost all of the appropriate tools to carry out the work required.
2	The student is skillful in using only some of the appropriate tools to carry out the work required.
1	The student has problems in using the appropriate tools to carry out the work required.
0	The student cannot use the appropriate tools to carry out the work required.

D.3 Taking Care of Safety Issues

Performance Descriptors	
4	The student wears all the necessary safety gear and handles tools safely while working.
3	The student wears almost all of the necessary safety gear and handles most tools safely while working.
2	The student wears part of the necessary safety gear and handles some of the tools unsafely while working.
1	The student wears very little of the safety gear and is sometimes careless with tools while working.
0	The student does not wear any of the safety gear and at times is dangerous with tools while working.

D.4 Organisation of Workspace

Performance Descriptors	
4	The student is always careful and always keeps the workspace tidy and well organized.
3	The student is careful and keeps the workspace tidy and well organized most of the time.
2	The student is careful and keeps the workspace tidy and well-organized half of the time.
1	The student is careless and the workspace is not well-organized most of the time.
0	The student is always careless and does not work in an organized manner.

D.5 Implementation of Plan of Action

Performance Descriptors	
4	The student is able to fully implement the whole plan of action.
3	The student is able to follow the main steps of the original plan of action.
2	The student makes minor changes to the original plan of action in order to improve the product.
1	The student has difficulty in following the plan of action.
0	The student does not follow the plan of action.

D.6 Appropriateness of Solution to Criteria

Performance Descriptors	
4	The work produced by the student is appropriate to its specified criteria.
3	The work produced by the student is appropriate to most of the specified criteria.
2	The work produced by the student meets half of its specified criteria.
1	The work produced by the student meets a limited number of its specified criteria.
0	The work produced by the student is not appropriate to its specified criteria.

D.7 Aesthetic of Solution

Performance Descriptors	
4	The work produced by the student is highly aesthetic.
3	The work produced by the student is very aesthetic.
2	The work produced by the student is moderately aesthetic.
1	The work produced by the student is hardly aesthetic.
0	The work produced by the student is not aesthetic.

E.1 Preparation of Report of Technological Activity

Performance Descriptors	
4	Report covers all aspects, good order and well organized.
3	Report covers almost all aspects, good order and well organized.
2	Report covers a fair aspects of the project, not in good order and not very well organized.
1	Report omits some important aspects, poor order and also poorly organized.
0	Very poor and unorganized and omits most of the aspects of the project.

E.2 Explanation of Design, Plan and Outcome of the Project

Performance Descriptors	
4	Student clearly covers all ideas underlying the design, plan and outcome.
3	Clearly covers almost all ideas underlying the design, plan and outcome.
2	Covers the main ideas underlying the design, plan and outcome.
1	Covers a small proportion of ideas underlying the design, plan and outcome.
0	Has difficulty explaining the main ideas underlying the design, plan and outcome.

E.3 Use of Correct Specific Technological Terminology in Report

Performance Descriptors	
4	Student uses a very wide range (>12) of appropriate specific technological terminology.
3	Student uses a good number (10-12) of correct specific technological terminology.
2	Student uses a fair number (7-9) of specific technological terminology.
1	Student uses a limited number (4-6) of appropriate technological terminology.
0	Student does not use (<4) specific technological terminology

E.4 Describing Methods to Promote Selling of Ideas and Product

Performance Descriptors	
4	Student explains purposes of product, ideas behind design, needs of users, nature of product, advertising, marketing, pricing, packaging and writing instructions for use.
3	Good range of methods above.
2	Fair range of methods above.
1	Student explains a limited range of methods above.
0	Student explains only one of the above.

F.1 The Ability of Students to Assess Methods to Identify Improvements Required

Performance Descriptors	
4	The student identifies at least four of the weaknesses of the methods used throughout the whole process.
3	The student identifies three of the weaknesses.
2	The student identifies two of the weaknesses.
1	The student identifies one of the weaknesses.
0	The student cannot identify any of the weaknesses.

F.2 The Ability of Students to do Tests in the Development of the Product

Performance Descriptors	
4	The student carried out at least four tests to evaluate the properties of the product made and other same products.
3	The student carried out three tests.
2	The student carried out two tests.
1	The student carried out one test.
0	The student carried out no test.

F.3 The Ability of Students to Compare the Plan against the Product to Identify Differences

Performance Descriptors	
4	The student compared the results against the plan and identified at least four of the differences.
3	The student compared the results against the plan and identified three of the differences.
2	The student compared the results against the plan and identified two of the differences.
1	The student compared the results against the plan and identified one of the differences.
0	The student was not able to identify any of the differences between the plan and the product made.

F.4 The Ability of Students to Evaluate the Quality of Products to Identify Improvements Required

Performance Descriptors	
4	The students identified at least four improvements needed to be made on the product.
3	The students identified three improvements needed to be made on the product.
2	The students identified two improvements needed to be made on the product.
1	The students identified one improvement needed to be made on the product.
0	The students was not able to identify any of the improvements needed to be made on the product.

F.5 The Ability of Students to Identify Skills and Knowledge Gained from the Project

Performance Descriptors	
4	Identified skills in planning, making, presenting and evaluating.
3	Identified skills in three of the above.
2	Identified skills in two of the above.
1	Mentioned common skills.
0	Very general or no answer.

F.6 The Ability of Students to Make Recommendations and Give Advice Regarding the Best Way of Doing This Project

Performance Descriptors	
4	Specific advice regarding planning, building, presenting and evaluating the product.
3	Specific advice regarding three of the above.
2	Specific advice regarding two of the above.
1	General description on how to build the product.
0	Very general or no answer.

Appendix B(3): Students Worksheet (English Version)

TECHNOLOGICAL CAPABILITY WORKSHEET

ACTIVITY A. IDENTIFYING TECHNOLOGICAL PROBLEMS / NEEDS AND OPPORTUNITIES

Name: _____ Subject:_____ Date:_____

Village _____ Gender: male/female _____ Age:____

Your task in this exercise is to identify technological problems, needs and opportunities in the situation you are working in.

Please answer the following questions in the spaces provided.

1. What are the important questions that must be asked in order to find out problems, needs and opportunities with regards to the artifact you are going to build?

_____

_____

_____

_____

_____

_____

_____

2. What are the factors that influence making and using of the artifact you are going to build?

_____

_____

_____

_____

_____

_____

3. Describe an activity to collect information relating to the problems, needs and opportunities relating to the making and using of the artifact you are going to build?

_____

_____

_____

_____

_____

_____

_____

4. Carry out the activity you described above. Record the METHOD you used, where you collected your information from (SOURCE) and the INFORMATION you collected in the space below.

Source	Method	Information collected

5. Describe the needs and opportunities exist in the information you collected.

6. Which of the identified needs/ problems/ opportunities identified above would you like to solve ?

7. What is your reason for your selection ?

8. How can you improve the method you used in order to get better results ?

TECHNOLOGICAL CAPABILITY WORKSHEET

ACTIVITY B. EXPLORING POSSIBLE SOLUTIONS AND STRATEGIES

Name: _____

Your task in this exercise is to seek for best possible solutions and strategies for the problems identified in the last exercise.

Please answer the following questions in the spaces provided:

1. Describe a survey that you can do to collect adequate information on possible solutions and strategies for the identified needs and opportunities you selected in the Activity A.

2. Carry out the survey. Fully describe all the places you obtain your information from (SOURCES), the METHODS you used to collect the information and the INFORMATION you collected in the table below.

Source	Method	Information collected

3. Base on the information you collected, what will be the best solutions / strategies to the identified needs and opportunities you selected ? Write down the main steps of the activity below.

4. What are the factors that may influence the strategies / solutions described above ?

5. What are the skills and knowledge required to carry out the tasks suggested above?

6. Are you satisfied with the method you used to carry out your survey ? Can you suggest a better way of doing the survey ?

TECHNOLOGICAL CAPABILITY WORKSHEET

ACTIVITY C. PLANNING OF PRODUCTION

Name: _____

Your task in this exercise is to plan the activity that you suggested that could solve the problem identified.

Please answer the following questions in the spaces provided:

1(a) What is the task that you have chosen to do?

_____

_____

1(b) Who will use the product you plan to make?

_____

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1(c) Where will it be used?

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1.(d)Why is it needed?

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1(e) When will it be needed?

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1(f) How will it be used?

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2. In the space below draw a design or plan of the product you are going to make.

3. Make a list of the materials you need together with the quantity of each in the space below.

4. What are the expenses and how are they going to be paid?

5. When and how are measurements going to be made?

6. Are there any dangers involved in carrying out this task?

7. How can you make sure that the final product will be attractive to people?

8. What method can you use promote selling this product?

9. Write down the steps you are going to follow in producing the product you plan to make

10. What learning outcomes you expect to gain from the activity?

11. What assistance would you need from experts to carry out this task?

TECHNOLOGICAL CAPABILITY WORKSHEET

ACTIVITY D. PRODUCING SELECTED SOLUTION OR PRODUCT

Name: _____

Your task in this exercise is to produce the solution or product for the identified need.

Please carry out the following:

1. Carry out the task described in the planning activity. Record the steps you take in the space below

2. Record any measurements you made in the space below.

3. Record in the space below any problems that you come across during the process of producing the required product.

4. Write down the methods you used to solve the problems described above.

5. Describe all the things that you are not satisfied with the product you have made. How can you improve the product ?

6. Describe ways you think you can use to improve the product.

TECHNOLOGICAL CAPABILITY WORKSHEET

ACTIVITY E. PRESENTATION OF DESIGN, PLAN AND OUTCOME

Name: _____

Your task in this exercise is to prepare a report of the tasks that you carried out, present the product you made to the class and demonstrate how you can promote the product you made and the technological ideas underlying it.

Please carry out the following:

1. Describe ways you can use to help selling the product you made.

2. Present the product to the class and clearly explain the technological ideas underlying the product and try to make the class buy your product.

3. Prepare a report of the tasks that you carried out.

TECHNOLOGICAL CAPABILITY WORKSHEET

ACTIVITY F. EVALUATING DECISIONS, PROGRESS AND PRODUCT

Name: _____

Your task in this exercise is to revise and assess your product and strategies.

Please carry out the following:

1. Record in the space below any decisions you made that you think were not satisfactory.

2. What would you do differently if you were to repeat the task that you carried out?

3. Are there any differences between the plan you made and the product you came up with? What are they ?

4. What skills and knowledge have you gained from this project?

5. What recommendations would you make in order to improve the strategies you used and the product you made?

Appendix B(4): Students Worksheet (Tongan Version)

PEPA NGAUE FAKA-TEKINOLOSIA

NGAUE 1. FEKUMI KI HE NGAAHI PALOPALEMA MO E NGAAHI FIEMA'U

Hingoa: _____ Lesoni:_____ 'Aho:_____

Kolo _____ Tamasi'i/ta'ahine_____ Ta'u motu'a:_____

Ko ho'o ngaue 'i he konga ko 'eni ko ho'o fekumi ke 'ilo ha ngaahi palopalema pe ko ha ngaahi me'a 'oku fiema'u ke fakalelei'i 'i he me'a 'oku ke teu ke ngaahi.

Kataki 'o tali 'a e ngaahi fehu'i ko 'eni 'i he ngaahi laine 'oku 'oatu.

(i) Ko e ha 'a e ngaahi fehu'i mahu'inga kuo pau ke 'eke, ke 'ilo'i ai 'a e ngaahi palopalema pea mo e ngaahi me'a ke fakalelei'i 'i he me'a 'oku ke teu ke ngaahi ?

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(ii) Ko e ha 'a e ngaahi tefito'i me'a mahu'inga 'oku ne uesia 'a hono ngaahi (fa'u) mo ngaue'aki 'a e me'a 'oku ke teu ke ngaahi ?

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(iii) Fakamatala'i mai pe 'e fefe ha'o ma'u ha ngaahi fakamatala ke ke ala 'ilo mei ai 'a e ngaahi palopalema mo e ngaahi me'a ke fakalelei'i felave'i mo hono ngaahi (fa'u) mo hono ngaue'aki 'a e me'a 'oku ke teu ke ngaahi.

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(iv) ‘Alu ‘o fekumi mo tanaki ha ngaahi fakamatala felave’i mo e ngaahi palopalema mo e ngaahi me’a ke fakalelei’i ‘i he me’a ‘oku ke teu ke ngaahi. Hiki mai ‘a e ngaahi feitu’u na’a ke ma’u mei ai ‘a e ngaahi fakamatala, ngaahi founga na’e tanaki ‘aki, pea mo e ngaahi fakamatala na’ake tanaki, ‘i he tepile ‘i lalo.

Ma’u mei fe (pe mei a hai)	Founga na’e tanaki ‘aki ‘a e fakamatala	Fakamatala na’e ma’u

(v) Ko e ha ‘a e ngaahi palopalema mo e ngaahi me’a ke fakalelei’i ‘i he me’a ‘oku ke teu ke ngaahi na’ake ma’u mei he ngaahi fakamatala na’ake tanaki ?

(vi) Ko e ha ‘a e ngaahi palopalema pe ko e ngaahi me’a ke fakalelei’i ‘a ia na’ake ma’u, ‘oku ke fili ke ke hanga ‘o solova ?

(vii) Ko e ha ho’o ‘uhinga ki ho’o fili ?

(viii) Ko e ha ha fakalelei teke fai ki he founga na’ake ngaue’aki ki hono kumi ho’o fakamatala felave’i mo e palopalema mo e ngaahi fakalelei ki he me’a ‘oku ke teu ke ngaahi ?

PEPA NGAUE FAKA TEKINOLOSIA

NGAUE 2. FEKUMI KI HA NGAAHI FOUNGA KE SOLOVA 'AKI 'A E PALOPALEMA

Hingoa: _____

Ko ho'o ngaue 'i he konga ko 'eni ko ho'o fekumi ki ha ngaahi founga ke solova 'aki 'a e ngaahi palopalema pe ko e ngaahi fakalelei 'a ia na'ake ma'u pea ke fili ke ke fai 'i he ngaue 'uluaki.

Kataki 'o tali mai 'a e ngaahi fehu'i ko 'eni 'i he ngaahi laine 'oku 'oatu.

(i) Hanga 'o fakamatala'i mai ha savea pe fakatotolo teke ala fai, ke tanaki 'aki ha ngaahi fakamatala 'o e ngaahi founga 'e ala solova 'aki 'a e ngaahi palopalema na'ake fili ke ke solova.

(ii) Hanga ‘o fai ho’o savea (fakatotolo) na’ake fakamatala’i. Hanga ‘o hiki mai ‘a e ngaahi feitu’u na’ake ma’u mei ai ‘a e ngaahi fakamatala, ngaahi founga na’ake ngaue’aki, pea mo e ngaahi fakamatala na’ake ma’u, ‘i he tepile ‘i lalo.

Ma’u’anga ‘o e fakamatala	Founga na’e ngaue’aki	Fakamatala na’e ma’u

(iii) Vakai ki he ngaahi fakamatala na'ake ma'u, ko e ha ha founga lelei taha ki hono solova 'o e palopalema ?

(iv) Ko e ha 'a e ngaahi me'a mahu'inga tene uesia 'a e founga solova 'o e palopalema na'ake fakamatala'i 'i 'olunga ?

(v) Ko e ha 'a e ngaahi poto'i ngaue mo e ngaahi 'ilo 'oku fiema'u ki hono fai 'o e fo'i ngaue na'ake fakamatala'i 'i 'olunga ?

(vi) 'Oku ke fiemalie ki he founga savea (fakatotolo) na'ake fai ? Ko e ha ha'o fakalelei ki ai teke ala fai ?

TOHI NGAUE FAKA-TEKINOLOSIA

NGAUE 3. KO HONO PALANI 'O E NGAUE

Hingoa: _____

Ko ho'o ngaue 'i he konga ko 'eni, ko ho'o hanga 'o palani ho'o ngaue ko ia ke solova 'a e palopalema na'ake fakamatala ki ai 'i mu'a..

Kataki 'o tali 'a e ngaahi fehu'i ko 'eni 'i he ngaahi laine 'oku 'oatu.

(i) Ko e ha 'a e ngaue kuo ke fili ke ke fai ?

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(ii) Ko hai te ne faka'aonga'i ho'o me'a 'oku ke teu ke ngaahi ?

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(iii) 'E faka'aonga'i 'i fe ?

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(iv) Ko e ha hono 'uhinga 'oku fiema'u ai ho'o me'a 'oku ke teu ke ngaahi ?

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(v) 'E fiema'u fakaku ?

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(vi) 'E faka'aonga'i fefe ?

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(vii) 'I he peesi ko 'eni, hanga 'o ta mai ha palani pe ko ha tisaini pe '*recipe*' 'o e me'a 'oku ke teu ke ngaahi.

(viii) Ko e ha ‘a e ngaahi naunau teke fiema’u ke fai ‘aki ho’o ngaue ?

(ix) Ko e ha ‘a e ngaahi fakamole fakapa’anga ?

(x) ‘Oku ‘i ai ha ngaahi me’a ke fua (measure) ?

(xi) Ko e ha ha ngaahi me’a ‘e ala fakatu’utamaki ‘i ho’o ngaue ?

(xii) Ko e ha hono ‘uhinga ‘e manakoa ange ai ho’o me’a ‘oku ke teu ke ngaahi ‘i he ‘u me’a tatau kehe?

(xiii) Ko e ha ha founga teke ala fai ke faingofua ange ai mo vave hono fakataua ho’o me’a ‘oku ke teu ke ngaahi ?

(xiv) Hiki mai e hokohoko ho’o ngaue ‘e fai ki hono ngaahi ho’o me’a ‘oku ke teu ke ngaahi.

(xv) Ko e ha ha ngaahi me'a mahu'inga teke ako mei he fo'i ngaue ko 'eni 'oku ke fai ?

(xvi) Ko e ha nai ha ngaahi tokoni mei ha taha 'oku poto ange, 'oku ke fiema'u ki hono ngaahi ho'o me'a 'oku ke teu ke ngaahi ?

TOHI NGAUE FAKA-TEKINOLOSIA

NGAUE 4. NGAOHI 'O E ME'A 'OKU KE TEU KE NGAAHI

Hingoa: _____

Ko ho'o ngaue 'i he konga ko 'eni ko ho'o ngaahi 'a e me'a 'oku ke teu ke ngaahi 'a ia na'ake palani ke ngaahi 'i mu'a.

Kataki 'o fai 'a e ngaahi me'a ko 'eni.

(i) Fai 'a e ngaahi ngaue kotoa ko ia na'ake palani 'i mu'a. Hanga 'o hiki kotoa mai 'a e ngaahi me'a 'oku ke fai 'i he ngaahi laine 'i lalo.

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(ii) Hiki mai mo ha ngaahi me'a na'ake fua (measurement).

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(iii) Ko e ha nai ha ngaahi palopalema na'ake faingata'a'ia ai 'i ho'o ngaue ?

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(iv) Na'e fefe ho'o fakalelei'i e ngaahi faingata'a na'ake fetaulaki mo ia 'i ho'o ngaue ?

(v) Ko e ha ha ngaahi me'a lolotonga ho'o ngaahi ho'o me'a na'ake ngaahi na'e 'ikai teke fiemalie ki ai ?

(vi) 'E fefe ha'o fakalelei'i ho'o founga ngaue ke toe lelei ange ho'o me'a na'ake ngaahi ?

TOHI NGAUE FAKA-TEKINOLOSIA

NGAUE 5. KOE LEKOOTI MO HONO FAKAMATALA'I 'O E PALANI MO E ME'A NA'AKE NGAAHI

Hingoa: _____

Ko ho'o ngaue 'i heni, te ke hanga 'o fa'u ha lipooti ho'o ngaue na'e fai, pea teke hanga 'o fakamatala mahino ki he kalasi 'a e ngaahi tefito'i fakakaukau na'ake fa'u 'aki 'a e me'a na'ake ngaahi, pea pehe foki ki ho'o fakamatala'i 'a e ngaahi founga teke ngaue'aki ke feinga ke fakataua ho'o me'a na'ake ngaahi.

Kataki 'o fai 'a e ngaahi me'a ko 'eni.

(i) Fakamatala'i mai e ngaahi founga teke ala ngaue'aki ke tokoni ki hono fakataua ho'o me'a na'ake ngaahi.

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(ii) Teuteu ke ke fakamatala'i ho'o me'a na'ake ngaahi ki he kalasi. Fakamatala'i mahino 'aupito e ngaahi tefito'i fakakaukau na'ake ngaohi 'aki, mo hono ngaahi mahu'inga.

(iii) Fa'u ha lipooti ke fakaha kakato ai 'a e ngaue na'ake fai.

TOHI NGAUE FAKA-TEKINOLOSIA

ANGAUE 6. KO HONO SIVI'I 'O E NGAUE NA'E FAI MO E ME'A NA'AKE NGAOHI

Hingoa: _____

Ko ho'o ngaue ko hono sivi'i mo toe vakai'i e founga mo e ngaue na'ake fai, pea pehe foki ki ho'o me'a na'ake ngaohi.

Kataki 'o fai 'a e ngaahi me'a ko 'eni.

(i) Hiki mai 'a e ngaahi me'a na'ake fai 'oku ke pehe na'e 'ikai totonu ke fai.

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(ii) Kapau 'e talaatu keke toe fai 'a e fo'i ngaue tatau, ko e ha ha ngaahi me'a teke fie hanga 'o liliu ke faingofua ange ho'o ngaue mo lelei ange ai ho'o me'a na'ake ngaahi?

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(iii) Ko e ha ha kehekehe 'i he me'a na'ake palani mo e me'a na'ake ngaohi ?

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(iv) Ko e ha ha fa'ahinga 'ilo pea mo e poto'i ngaue kuo ke ma'u mei he poloseki ko 'eni ?

(v) Ko e ha ha ngaahi fale'i 'oku ke fie fai ke fakalelei'i 'aki hono ngaahi 'o e me'a na'ake ngaohi ?

APPENDIX C. COMMUNICATION TO CONDUCT FIELD RESEARCH IN TONGA

Appendix C(1): Letter to Tonga Government

Centre for Science,
Mathematics and Technology
Education Research

The University of Waikato
Private Bag 3105
Hamilton, New Zealand

Ph: 64-7-838 4035 (Centre direct line)
Fax: 64-7-838 4272

The University of Waikato
Te Whare Wānanga o Waikato

5th July, 1999.

Chief Secretary & Secretary to Cabinet
Prime Minister's Office
Nuku'alofa
Tonga.

Re: Requesting Government Permission to do Educational Research in Tonga.

Dear sir,

I am presently studying for a PhD degree at the University of Waikato, at the Centre for Science, Mathematics and Technology Education Research (CSMTER). My supervisors are Dr Alister Jones and Dr Mike Forret.

My research study is on the field of Technology Education. I am proposing to look at the perceptions that Tongan secondary school students have on technology and also at their existing technological capability. The purposes of my research are to investigate the Tongan secondary school students' perceptions of technology, to examine the students' existing technological capability, and to develop ways of enhancing teaching and learning of technological concepts and processes in Tonga.

This project can contribute much to the development of technological literacy in Tonga. First it will stimulate an increased awareness of the importance of teaching the concepts and processes of technology in secondary schools in Tonga. Second, it will not only identify the conceptions that Tongan secondary school students have regarding technology, but it will also establish the range of existing technological capability that Tongan secondary school students possess. This information will be important towards the enhancement of teaching and learning of concepts in technology and development of problem solving approaches for the enhancement of technological capability. This study will be the first of its kind to be conducted in Tonga. The results will not only be important to the development of technology education in Tonga, but will also form a base for further research in this area.

The purpose of this letter is to request official permission from the Government of Tonga to do my research in Tongan secondary schools. Data collecting methods will be through questionnaire and interview. I am hoping to collect these data in September and October of this year, 1999, and in May and June of next year, 2000. All findings will be reported in general terms and any teacher's or student's work used as examples will be completely anonymous. I hope you can see the value of the findings of this research for Tonga in planning future curriculum of Technology and Technology Education and also in ways of enhancing the teaching and learning process.

Yours faithfully,

F Mone

Fisi'ihoi Mone

Appendix C(2): Letter of Approval from Tonga

TONGA GOVERNMENT

MINISTRY OF EDUCATION
(Please address all replies to the Director of Education)

Ref: 43/2/1

29 September 1999

Mr. Fisi'ihoi Mone
Fangaloto
Nuku'alofa

Dear Fisi'ihoi

Educational Research in the Ministry of Education

Reference is made to your letter dated 26 September 1999 to the Hon. Minister of Education regarding the above matter.

Please be informed that your request to conduct your research in the Ministry of Education has been approved by the Hon. Minister of Education. You are therefore requested to see the Deputy Director of Education (Primary & Secondary), Mr. Viliami Takau at your earliest convenience inoder to further discuss your programme.

May I also take this opportunity to wish you all best with your studies and the research that you are currently undertaking. Good luck and God bless.

Yours faithfully

Kalolaine T. Moeaki
for **Director of Education**

Ref: ORG 1/8 V7

20th September, 1999

PRIME MINISTER'S OFFICE
NUKU'ALOFA, TONGA.

Mr. Fisi'ihoi Mone
C/- The University of Waikato
Centre for Science, Mathematics and
Technology Education
Private Bag 3105
Hamilton, NZ

Dear Fisi'ihoi Mone

Re: Request for Permission to conduct research in the Kingdom

I am pleased to inform you that His Majesty's Cabinet on the 9th September, 1999, approved your application for permission to conduct research in 'Tonga on Education Technology'. Your request for the research fee to be waived was also approved.

Please be reminded that at the end of your research as stipulated by His Majesty's Cabinet on the 9th Sept., 1999, "that two completed copies of your research findings be submitted to the Prime Minister's Office free of charge".

Wishing you all the best with endevouring to improve and bring forth developments of new technologies to the schooling system in the Kingdom.

Should you require further assistance, please do not hesitate to contact me

With kind regards

Yours faithfully

GOVERNMENT OF TONGA
NUKU'ALOFA

'Aleiteisi L. Tangi
for Chief Secretary & Secretary to Cabinet.

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