

Unlocking Curious Minds Evaluation report: City of the Future makerspace programme

**Project title: Developing a STEM mobile
makerspace and maker educator learning
resources**

Dr Elaine Khoo & Prof Bronwen Cowie
University of Waikato
Hamilton, New Zealand

2021

This project is a collaboration between the University of Waikato and
Hamilton City Libraries

Table of contents

Executive summary	3
Introduction and background	4
The project team	6
Research and development design	6
Data collection	6
Makerspace programme participants	7
Development of a makerspace curriculum and maker educator professional learning resource	8
Developing shared principles for the culture of the makerspace programme	8
Establishing a theme	9
Focusing in on activities for the City of the Future curriculum	10
A maker educator curriculum development and learning programme	11
Implementation of the makerspace programme	13
Advertising and recruitment	13
Cycle 1 in action	14
Highlights from Cycle 1	14
Cycle 2 in action	19
Evaluation and impact of the programme	26
Maker Educator views	26
Parent/caregiver and children perspectives	28
Finding out about the makerspace programme	28
Reasons for enrolling in the programme	28
Length and location of the programme	28
General benefits of the programme	28
The STEM learning benefits of the programme	32
Value of the take-home resource during lockdown	33
Summary of parent and child views	34
Suggestions to enhance the programme	35
Ideas from the maker educators	35
Ideas from Parents and Children	35
Dissemination	36
Acknowledgements	36
References	36
Appendices	38
Appendix 1: Focused discussion questions for Maker Educators	38
Appendix 2: Parent/caregiver Evaluation of the Programme (Survey)	39
Appendix 3: Interview questions with parents and children	41
Appendix 4: Workshop 1 for Maker educators	42
Appendix 4a: Workshop Makerspace Research on Children’s Learning	43
Appendix 4b: Workshop Question bank for Maker Educators	47
Appendix 4c: Workshop Working with children & parents	48
Appendix 4d: Workshop Next steps	51
Appendix 5: Cycle 1 Overview makerspace curriculum (Term 3)	53

Appendix 6: Maker Educator Professional Development Principles.....	55
Appendix 7: Website advertisement and registration	60
Appendix 8: Cycle 1 activities and maker educators’ reflections.....	63
Appendix 9: Maker Educator Workshop 2 agenda.....	65
Appendix 10: Cycle 2 Overview of refined makerspace curriculum (Term 4)	66
Appendix 11: Cycle 2 Activities and maker educators’ reflections.....	68
Appendix 12: Makerspace curriculum sample lesson plans Introduction	72
Appendix 12a: Lesson Plan — Ideas for Living Building the infrastructure Session 1	77
Appendix 12b: Lesson Plan — Ideas for Living Building the infrastructure Session 2	81
Appendix 12c: Lesson Plan — Ideas for Playing Session 1	83
Appendix 12d: Lesson Plan — Ideas for Playing Session 2.....	88
Appendix 12e: Lesson Plan — Ideas for Living Session 1 Solar Energy.....	90
Appendix 12f: Lesson Plan — Ideas for Living Session 2 Solar Energy	96
Appendix 12g: Lesson Plan — Ideas for Living Session 3 Wind Turbine.....	99
Appendix 12h: Lesson Plan — Ideas for Moving	105
Appendix 12i: Lesson Plan — Ideas for Learning.....	109
Appendix 13: Story for Unlocking Curious Minds website	113

Executive summary

This report details our research project funded under the Unlocking Curious Minds initiative 2020. It was conducted in parallel with the makerspace programme: *Building a city of the Future 2040*. This report describes the project aims, rationale, the City of the Future themed intervention, and findings of the developmental initiative.

Introduction and background

A makerspace is a space where people gather to learn how to use, and to use a range of materials and technologies to create or make things/products that are of interest to them. Makerspaces are based on the fundamental value of learner-centred hands-on learning through discovery, exploration, play, tinkering, making, following one's intuition, troubleshooting and trial and error (Martinez & Stager, 2019). These are skills that go across many disciplines and provide a useful basis for supporting and pursuing Science, Technology, Engineering and Mathematics (STEM) interests. Promoted as part of the maker movement, makerspaces encapsulate the learning ideas promoted by educational experts such as Seymour Papert (constructionism) and Jean Piaget (constructivism). *Learning through making* in STEM-rich makerspace environments aim to engage children in the use of scientific and technical tools and processes, fostering the practice of exploration, questioning, problem-solving, critical thinking and self-directed learning through open-ended tasks (Vongkulluksn et al., 2018). There is evidence that after-school makerspace programmes assist children to develop STEM identities and skills (Bender & Pepler, 2019; Sahin et al., 2014) including their self-efficacy, interest and motivation to participate in future STEM activities and careers (Vongkulluksn et al., 2018).

Makerspaces have been set up in a range of places, including schools, libraries and museums. Public libraries as spaces for the community to access learning resources are increasingly establishing makerspaces as an extension of their work. Their goals typically include broadening community participation, providing access to equitable learning opportunities, and promoting adaptive lifelong and life-wide learning. In this way, library makerspaces aim to facilitate informal and creative learning opportunities and connections between home, school and community contexts.

The Unlocking Curious Minds (UCM) funded project: *Developing a mobile makerspace and maker educator resources*—aimed to enhance primary-aged children's (9–12 years) access to and engagement with STEM ideas and skills through an after-school public library mobile makerspace programme. Hamilton City Libraries (Libraries) established its mobile makerspace programme in 2017. The library makerspace programme is free and offered to members of the public during the school term. The programme is intended to enhance children's engagement with coding, robotics and science ideas so that they develop the skills to solve problems, think creatively, and develop innovative ideas.

A 2018 study (Khoo & Cowie, 2018) of the Libraries' mobile makerspace programme identified community support for the programme and its value in supporting children's out-of-school STEM learning including learning of digital skills. Parents reported the programme was easy to access and was free. Many cited the opportunity to use expensive equipment which they could not utilise/afford at home as a key advantage. The programme's activities fostered and extended their child's learning interest and were practical and engaging. Children could be introduced to science concepts which they can follow up by taking the materials home to complete or pursue investigations without needing parental supervision. Parents liked the fact their children could try different activities in the programme, meet other children and adults (social skills), and learn to complete a task systematically from beginning to end (problem solving skills). All parents unanimously agreed that their children were learning future-oriented skills which included life and digital skills; offered their children resources and activities which they could not afford otherwise. All parents were supportive of the programme and keen to see it grow and strengthened to provide their children with future-focused skills to be productive contributors to society.

In November 2019, Hamilton City Libraries extended the makerspace programme to a permanent modern space, known as Auaha. Auaha is strategically located at the entrance to the Library, has glass doors and is highly visible to those walking past or going into the Library. It is open for free access by the public and focuses on STEM learning and creativity.

The UCM project was specifically designed to strengthen the existing mobile makerspace programme and to develop library staff capacity to facilitate STEM-oriented maker programmes as maker educators. As such it had a development and research focus, which was encompassed in the following three aims:

1. Design, develop and implement a makerspace curriculum and learning resources in support of primary-aged children's learning through making within the Hamilton City Library mobile makerspace programme to widen children's access to and participation in STEM through semi-formal, experiential, exploratory and collaborative activities.
2. Design, develop and implement a maker educator professional learning programme to enhance library staff and volunteer teaching capability (maker pedagogies) and STEM content knowledge.
3. Develop a digital resource containing a makerspace curriculum and teaching-learning resource for other New Zealand maker educators who might wish to work in similar settings.

The project team anticipated that a focus on these aims would contribute to understanding how to support library staff as maker educators responsible for the design and enactment of makerspace curricula. The goal was to produce maker educator professional development resource materials and makerspace curriculum activities that promoted science, coding, and robotics skills and were offered in engaging, and open-ended ways.

The project research dimension was included to enable the team to report robust findings. The research questions following from the aims were:

1. How can curriculum resources be designed to facilitate maker educator understanding of STEM-based learning through making and associated pedagogical actions?
2. What are maker educators' perceptions regarding their experiences and the development of their roles and practices over the course of their professional learning as part of the UCM project?
3. How do children and caregivers perceive and experience the maker programme in terms of its impact in fostering children's STEM understandings and practices?

Due to the COVID-19 lockdown and government mandated physical and social distancing measures over 2020, the original mobile makerspace programme intention to conduct the programme across six community libraries, and three community spaces had to be reconsidered. The final decision was to run a fixed makerspace programme in the Auaha space. This imposed a limit of 10–12 children to accommodate social distancing and manage contact tracing. The UCM makerspace programme ran over 10 sessions (10 weeks) of the school Terms 3 and 4 for one and a half hours each session. It was not viable to run the programme in Terms 1 or 2 due to COVID restrictions.

The project team

Project Leader: Dr Elaine Khoo (University of Waikato)

Research team:

- Professor Bronwen Cowie (University of Waikato).
- Aaron Martin (Whakaahu/Innovation Librarian, Hamilton City Libraries).
- Professor Martin Ebner (Adjunct Professor of Media Informatics & Head of Educational Technology Department, Graz University of Technology, Austria).
- Dr Sandra Schön (Graz University of Technology, Austria).
- Maria Grandl (Graz University of Technology, Austria).

Maker educators at Hamilton City Libraries:

- Aaron Martin.
- Lauren Rowe.
- Su Bradburn.
- Gameedah Jones.

Research and development design

This collaborative project between science educator, digital and computer-science experts, and library maker educators adopted a two-cycle design-based intervention research approach (DBIR). DBIR promotes communication between practitioners and researchers through “agile interventions” as education designs play out in practice (Kirshner & Polman, 2013). The two-cycle design (Cycles 1 and 2) was a reduction from the original intent to conduct a three-cycle intervention due to COVID-19 lockdown measures over the first half of the year.

Each cycle involved a planning and professional learning workshop for maker educators to explore possibilities and plan for topics and activities, to refine their teaching capability and to discuss the implementation of the makerspace programme over the ten weeks of a school term. Cycles 1 and 2 were respectively conducted during Terms 3 and 4 in 2020.

The research gathered participants’ feedback on their experiences and the impact of the programme for promoting interest and engagement in, and building knowledge about science, coding, and wider applications of technology. End-of-session feedback informed successive sessions and the end of cycle debrief of Cycle 1 informed planning for Cycle 2.

Data collection

Data were collected from different participant groups who voluntarily participated in the research:

- Documentation from the professional learning workshop activities with library maker educators including planning materials and resources that the research team generated.
- Observations (field notes and photos taken) of maker educators: a) participating in the professional learning workshops, and, b) facilitating the makerspace programme.
- Observations (field notes and photos taken) of and conversations with children and/or their parents/caregivers participating in the organised makerspace activities.

- Focus group interview with maker educators at the end of the project (see Appendix 1).
- Weekly informal reflections from maker educators focused on key teaching-learning interactions during the preceding session.
- Survey of parents to obtain their perception and experience of the programme in terms of the value of the programme and its impact on their child's STEM understandings (see Appendix 2).
- Individual interviews with a small number of volunteer parents and their children (see Appendix 3).

All interviews were transcribed and participants given the option of reviewing them. Each dataset was thematically analysed (Braun & Clarke, 2006) to identify key ideas emerging from the study within each participant group (maker educators and children/their parents).

Cross-analysis of the different datasets was conducted to identify general patterns related to the teaching-learning experiences in the programme.

The study obtained ethical approval from the Division of Education's Human Ethics Committee, University of Waikato (no. FEDU009/20, approved on 21 February 2020). All participants took part on a voluntary basis.

Makerspace programme participants

The following number of participants participated in the programme:

- Library Maker educators: Four participants.
- Cycle 1 (Term 3 2020): 10 children enrolled in the programme—six girls and four boys. They were between 9- to 12-years of age with the exception of a younger participant who was six years of age. The ethnicity of the children was—six children were New Zealand European, three were Chinese and one was of mixed parentage (New Zealand-Chinese). At the end of the term, 10 parent surveys were received and six parent-child interviews were conducted.
- Cycle 2 (Term 4 2020): 14 children enrolled in the programme—four girls and 10 boys, seven completed the programme. Two of the children had attended the programme in Term 3 and had interest in extending what they had learnt in Term 4. They were between 9- to 12-years of age. In terms of ethnicity, six children were Middle Eastern, three were New Zealand European, two were of mixed parentage (New Zealand-Chinese), one was Indian, one was Chinese and one was Japanese. At the end of the term, three parent surveys were received and two parent-child interviews were conducted.

Development of a makerspace curriculum and maker educator professional learning resource

Prior to the commencing of Cycle 1, the team had met and consulted with the experts in the project to canvass ideas, possibilities (strategies for outreach and themed activities) for the design of the makerspace programme. The team deliberated over the possible formats for conducting the programme to cater for the eventuality of different levels of COVID-19 lockdown restrictions. Much thought and considerable planning time was spent on designing fully online, blended as well as a scaled back face-to-face maker curriculum programme format and activities that children could engage in at home and or at the library.

Developing shared principles for the culture of the makerspace programme

The first maker educator workshop began with a brief overview of research on makerspaces. This was used to ground a discussion about what principles would underpin the culture the educators were aiming for in their makerspace programme—in its design, development and implementation. The paper by Hatch (2013) offered a useful set of nine principles that was used to start the discussion and then the group brainstormed ideas and publicly crafted these into a taken-as-shared list of principles. Similar principles were affirmed by Schön, Ebner, and Grandl's (2020) research. For the UCM study, these principles focused on supporting children to explore and pursue ideas, working together and enjoying the experience. The principles as agreed were:

The MAKER Principles:

1. We are here to have fun.
2. Let's own our space.
3. It's great to be curious.
4. Explore!
5. It's ok to fail.
6. It's cool to ask for help.
7. Let's use what we have.
8. Don't give up. Keep going.
9. It's great to share.
10. Let's get creative.

The team gave careful attention to wording the principles so that they would be understandable and engaging for children aged 9- to 12-years as the target participants for the maker programme. These principles were introduced to the children at the beginning of a programme (see Figure 1 for the poster of the principles that was displayed in the makerspace).



Figure 1: Maker principles designed by the team

Maker educators later noted that the principles acted as a useful reference point for children when they were becoming frustrated as they made clear, for example, that it was more than acceptable to ask for help. This first workshop also covered maker educator facilitation strategies such as asking questions and not telling which were consistent with these principles. The workshop also considered how educators might interact with parents/caregivers, something previous programmes had identified as important in ensuring their support for developing their child’s problem-solving skills and agency (see Appendix 4–4d).

Establishing a theme

Based on success our experts from Austria have had with a similar theme (Grandl, et al., 2019; Schön et al., 2020), strategic alignment with Hamilton City Council’s Smart City initiative (see <https://www.hamilton.govt.nz/our-partner-projects/smarthamilton/Pages/default.aspx>) as well as the positioning of the Auahua space within the Library adjacent to a venue that promoted Hamilton’s smart city initiatives to the public, the team decided to adopt an overarching theme as the basis for the makerspace curriculum and programme: *Building a city of the Future 2040*.

This theme was strategic for the local context and is recognised internationally as having the potential to widen public participation in the smart city development agenda at the same time as generating children’s deeper inquiry into STEM. For example, the concept of a smart city has been used to leverage the potential of makerspaces (Almurbati, 2019; Niaros et al., 2017), including their potential to foster a more inclusive, participatory vision of a city. In addition, Ylipulli and Luusua’s (2019) study found support for public libraries to act as democratic spaces in promoting citizen’s understanding and control over new technologies. This was fundamental to developing a more participatory, inclusive and bottom-up approach to enable more informed civic engagement with the smart city development agenda. As can be seen later in reports of parent and child comments, participants considered they gained a broader appreciation of the various elements of city and its functioning.

This theme anchored the inquiry activities that were designed and implemented in the programme across the two 10-week cycles. Within this theme, the following four areas were the foci:

- Living in the future—the focus here was on buildings with this leading to consideration of the kinds of houses and facilities (hospitals, libraries, schools and so on) would be needed and desirable in the future.
- Playing in the future—the intention here was to prompt children to think about the kinds of activities they would like to engage in for enjoyment and leisure.
- Moving in the future—this addressed matters to do with transportation around the city and beyond.

- Learning in the future—here the focus was on how and where children and adults might be involved in learning.

The year 2040 was selected as being distant but conceivable for children aged 9- to 12-years.

The UCM University researchers conducted internet searches and identified that a range of ideas and approaches were being explored and implemented in cities around the world. This information provided a useful backdrop to the activities the children would be engaging in. The team decided on the following overarching structure for the ten-week programme although as detailed in the section below (see the Section: Implementation of the makerspace programme) this was reviewed and revised in response to both the children’s interests and their making. For more details, see Appendix 5 for the overview of the makerspace curriculum.

Week 1: Introduction to City of Future theme.

Introduce children to the overarching theme of planning for Hamilton as the city of the future based on four aspects—playing, living, moving and learning. Support them to brainstorm and visualise what their future city might look like.

Weeks 2–3: Living in the Future.

Children will explore what ‘living’ in the futuristic city could look like, for example home/building designs and then design and make some buildings.

Week 4–9: Playing/Moving/Learning in the Future.

Depending on children’s interests explore each of these aspects in turn.

Week 10: Show and tell/Exhibition.

A celebration of children’s achievements where children presented and described/ explained their model of the city of the future to family and friends.

Examples of lesson plans and activities that make up the makerspace curriculum can be seen in Appendix 12–12i.

Focusing in on activities for the City of the Future curriculum

The team sourced, trialled and then used a range of activities linked to the theme of *City of the Future* and to the four aspects of Living, Moving, Learning and Playing. The Library maker educators, led by Aaron, reviewed the activities they had used in previous years to identify those that might be relevant to the theme. The University Researchers sourced activities and ideas from research and a range of websites.

The team as a whole worked through a number of activities at each workshop, attempting to take a child’s perspective as a way of gaining insight into possible issues and challenges and hence the questions the educators might pose to a child and ideas and or resources they might suggest. During the end-of-programme interview they were emphatic that it was important to work through all the activities they asked children to complete as part of their preparation to interact with children in a way that maintained the child’s interest and ownership of ideas and products (see Section: Evaluation and impact of the programme).

A key finding from each of the two cycles was however that it was difficult to anticipate the challenges children might face and the timeframe they might need for particular constructions. The team conducted a debrief at the end of each weekly session to identify what had been achieved; what had worked well; what had proved challenging, including unexpected challenges, and what might be next steps. In between sessions team members sourced and developed new ideas and activities meaning that the curriculum evolved in response to the focus and skills of the child participants. We consider this will

likely be the case for any themed programme when what the children are expected and are expecting to achieve is partially open (they can design and make what their imaginations and skills allow) and partially closed (what they make needs to be relevant to the theme and to be deemed relevant by all/most participants).

A maker educator curriculum development and learning programme

The maker educator programme for the UCM project comprised of, a) two-half day workshops prior to the commencement of the makerspace programme in school Term 3, b) a half day workshop prior to the commencement of the programme in school Term 4, and, c) a half day end-of-programme debrief/reflection. The programme considered input from parent/caregiver and child interviews and parent/caregiver surveys. Key activities and accompanying recommendations to inform the design and implementation of an effective maker educator programme are set out in Appendix 6. Here, we list key principles:

- Develop a set of principles for the functioning and goals of your maker space.
- Consider identifying a theme for the programme—this needs to be locally relevant and to capture the imagination of children and parents/caregivers.
- Plan the first session carefully in order to establish an expectation of collaboration, creativity and making.
- Consider a combination of individual and group activities, which involve thinking, doing and movement around the space so that children ‘get to know and own the space’.
- Where possible work through activities before using them with children to identify possible issues and responses.
- Consider the space relative to group size along with the possibility of keeping children’s work on display in one place.
- Consider a balance of new and recycled resources; consider limitations on these (link to sustainability).
- Consider ensuring that the public can view the development of the city when they come to the library as part of outreach and information sharing.
- Discuss staffing—we recommend at least two people with different roles and expertise.
- Identify and explore strategies for getting to know and working with children, encouraging children but not telling them what to do.
- Discuss strategies for establishing expectations and interacting productively with parents/caregivers.
- Consider if time can be made for post session reflections and follow up.



Figure 2: A resource for maker educators developed to prompt children’s ideas

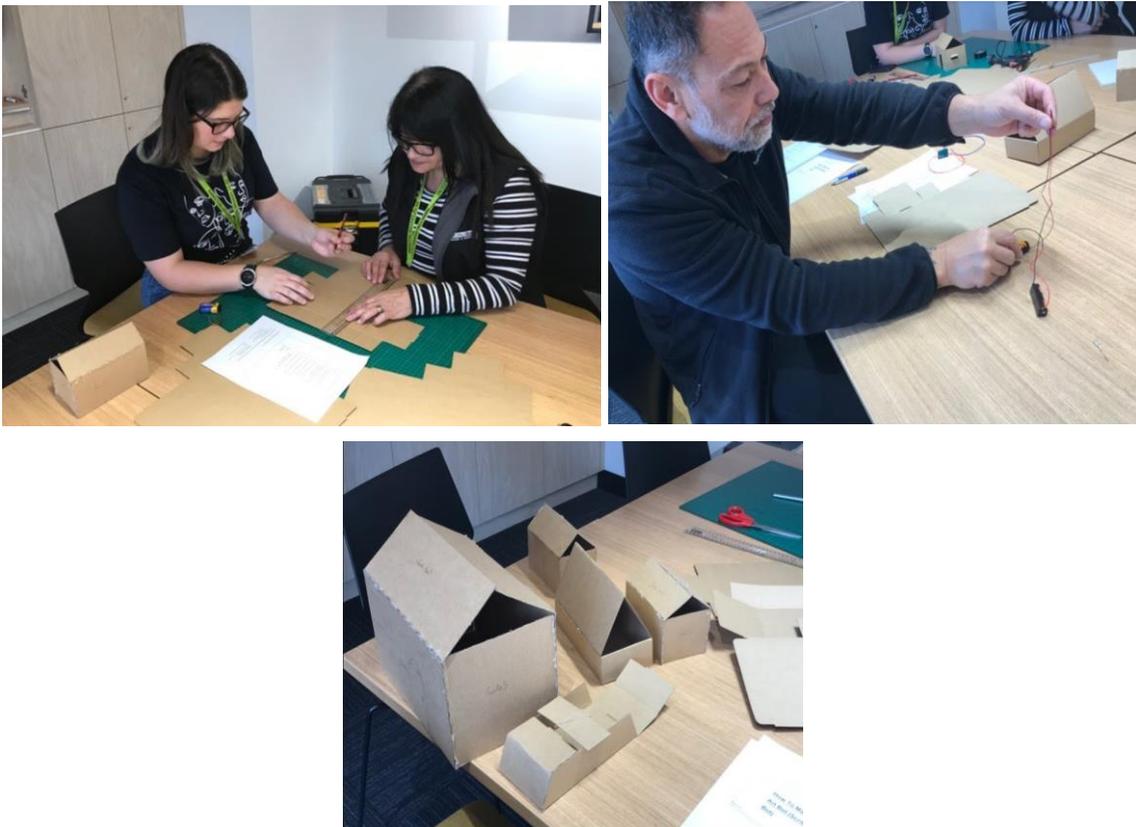


Figure 3: Maker educators in the workshop trialling planned activities prior to the programme

Implementation of the makerspace programme

Cycle 1 was conducted when COVID-19 lockdown restrictions were lifted in time for Term 3 of the school term. We implemented a scaled back face-to-face format for the programme in both terms.

Advertising and recruitment

The makerspace programme was advertised to the community via the Library website and Facebook site (see Figure 4).

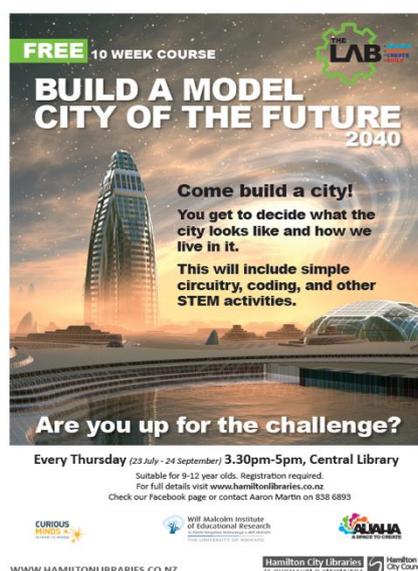


Figure 4: Advertising the programme to the public

The library website promoting the themed makerspace programme: Build a model city of the future 2040 was accessible via: <https://hamiltonlibraries.co.nz/whats-on/childrens-events/build-a-model-city-of-the-future-2040/>

The advertising material stated: “You are a city planner and your job is to design and build a future city for people to live in that is safe, sustainable and fun! You will design how people will live, move, play and learn. This will include simpler circuitry, coding, and other STEM activities. Are you up for the challenge?” It stated that the programme would be of interest to children aged 9–12 and that there was a limit of 10 children. The website and Facebook also stated that as part of the programme parents/caregivers and children could choose to take part in research study to find out how to strengthen the programme for others, making clear participation in the research was voluntary. The fact that the makerspace programme was a collaboration between Hamilton City Libraries, the University of Waikato and Unlocking Curious Minds was included. Caregivers registered children’s details on the website and were then informed via email by the Library if their enrolment was successful (see Appendix 7). In each case enrolments exceeded the limit of ten. Aaron fielded a number of queries about the programme, some of these from parents/caregivers whose children were involved in other Library programmes. As can be seen in the Section: Evaluation and Impact of the Programme, parents/caregivers reported that the theme had captured their imagination, prompting enquiries and enrolments.

Cycle 1 in action

We conducted the 10-week programme from 23 July 2020 to 24 September 2020. The planned activities had to be remodified half way through due to disruption from the second wave of COVID-19 lockdown restrictions mandated by the government. The programme was able to be resumed towards the final few weeks of the term.

Participants: 10 children (6 girls, 4 boys).

As noted above the programme evolved from week to week. Appendix 8 sets out the activities that the children worked through and the maker educators' reflections on these.

Highlights from Cycle 1

This section provides further information on some of the activities the educators highlighted as particularly productive.

The first session

Here the photographs tell the story of the sequence of activities for the first session.



Figure 5: Icebreaker



Figure 6: Introducing the maker principles

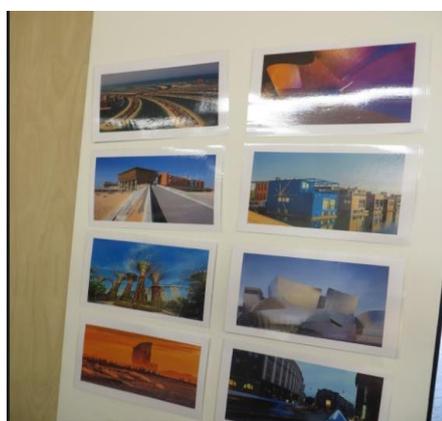


Figure 7: Getting ideas

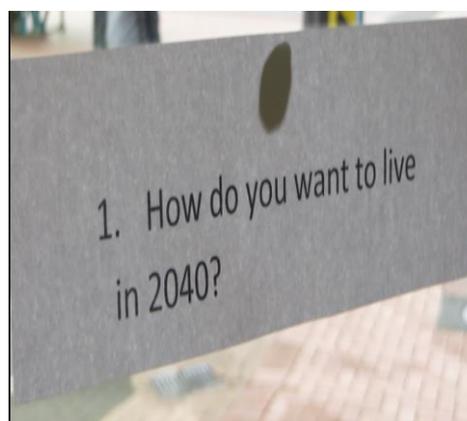


Figure 8: Brainstorming ideas for the 4 aspects of the theme



Figure 9: Examples of the brainstormed ideas



Figure 10: Voting on which ideas the group would pursue



Figure 11: Allocating areas for housing, parks, utilities

Developing collaboration - help seeking and help giving



Figure 12: Help seeking and help giving

Further developing ideas for buildings and spaces



Figure 13: Ideas for buildings and spaces

Evidence of imagination in action

As part of this cycle, one child, whose focus was on developing her design for a sustainable home took into account the roofline, the need for triple-glazed windows, the inclusion of a solar panel, a skylight for extra natural light, a composting toilet and a tank for water collection. She explained:

I wanted to do the roof-line differently to everyone else's too. So that's why I raised it up on one side. It was supposed to have windows going right, right around the whole—between the house and the roof, triple-glazed ones. And a skylight. I also wanted the house to be off the grid a little. So, solar panels reduce power and that skylight was for extra light. And also, it was just meant to look pretty and to be a window. And the toilet was a composting toilet. And I have an underground tank to get the water for the sink.

Another child, designed and made a house that rotated so the solar panel kept facing the sun and so did the windows. He placed a motor under his house to do this but the rotation was too fast. He then tried resistors but these didn't work. Next, he investigated and tried out a gearbox but the motor could not

drive the house. He then experimented with another motor and gears and trialled using fidget spinners until he got his model to work. He expanded on this:

It was a two-story house. It rotated for some of the solar panels to face the sun. And the wind ... also faced the sun the whole time so that you could get the sun in the house. I thought it would be simple, and I could just put a motor under the house and that would rotate it. And then I discovered that the motor was too fast and so I thought the resistors would fix the problem. But then after several tries with resistors, it didn't work. So, I got advice that gears would be the best solution. And so, we tried a gearbox and it had cogs, so each cog would divide the rotations by four but when you add friction onto the motor, the motor would stop. And so, then we turned it sideways and we got another motor with a different configuration. That makes it rotate on the side. That ended up working, but we needed bearings so that there wasn't any friction going onto the cog. And so, we tried several different designs. It was using a fidget spinner for the bearings. Then in the middle of all experimenting I thought if we had the room exposed so everybody could see how it looks, how it worked inside. And so, we went with the design that looked cool as well as worked.



Figure 14: Examples of innovative themed houses

Working with motors and a wind turbine

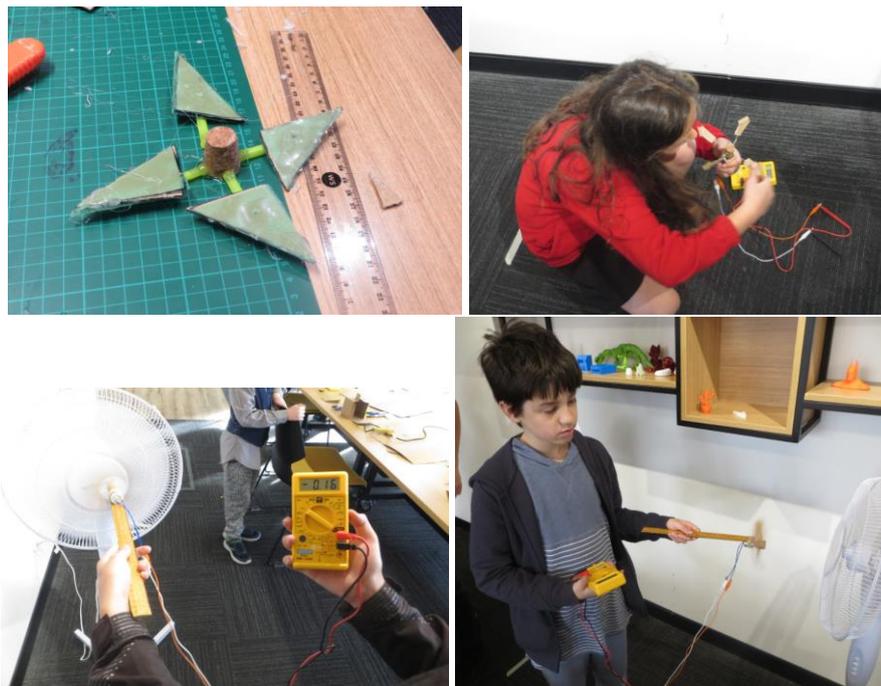


Figure 15: Making a wind turbine to generate electricity

Learning about solar panels and circuits



Figure 16: Using solar panels to generate electricity

The take-home resource



Figure 17: Take-home resource

Making with origami



Figure 18: Making origami for play spaces

Cycle 2 in action

Following Cycle 1, the team met for a second maker educator workshop to reflect and plan for the second cycle (see Appendix 9). The refined programme (see Appendix 10) commenced in Term 4. Term 4 was a busy time of the year and not all children who had enrolled in the programme were able to complete it. In this cycle, the decision was made to place the children's weekly work-in-progress on display in a prominent corner of the library for the public to view. This proved useful to draw public attention to the programme with curious members of the public calling in to visit during sessions.



Figure 19: The public display notice about children's work in progress

Appendix 11 sets out the Cycle 2 activities that the children worked through and the maker educators' reflections on these. Refer to Appendix 12–12i for the sample lesson plans for the weekly activities.

Generating ideas from different sources



Figure 20: Getting ideas from library books and spaces



Figure 21: Invited architect speaker—Mr Brian Squair from Chow:Hill Architects to inform building design thinking



Figure 22: Collated group ideas

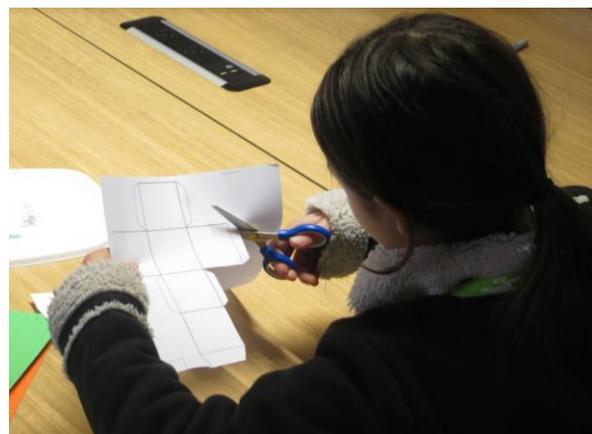


Figure 23: Using design nets

Emphasising design

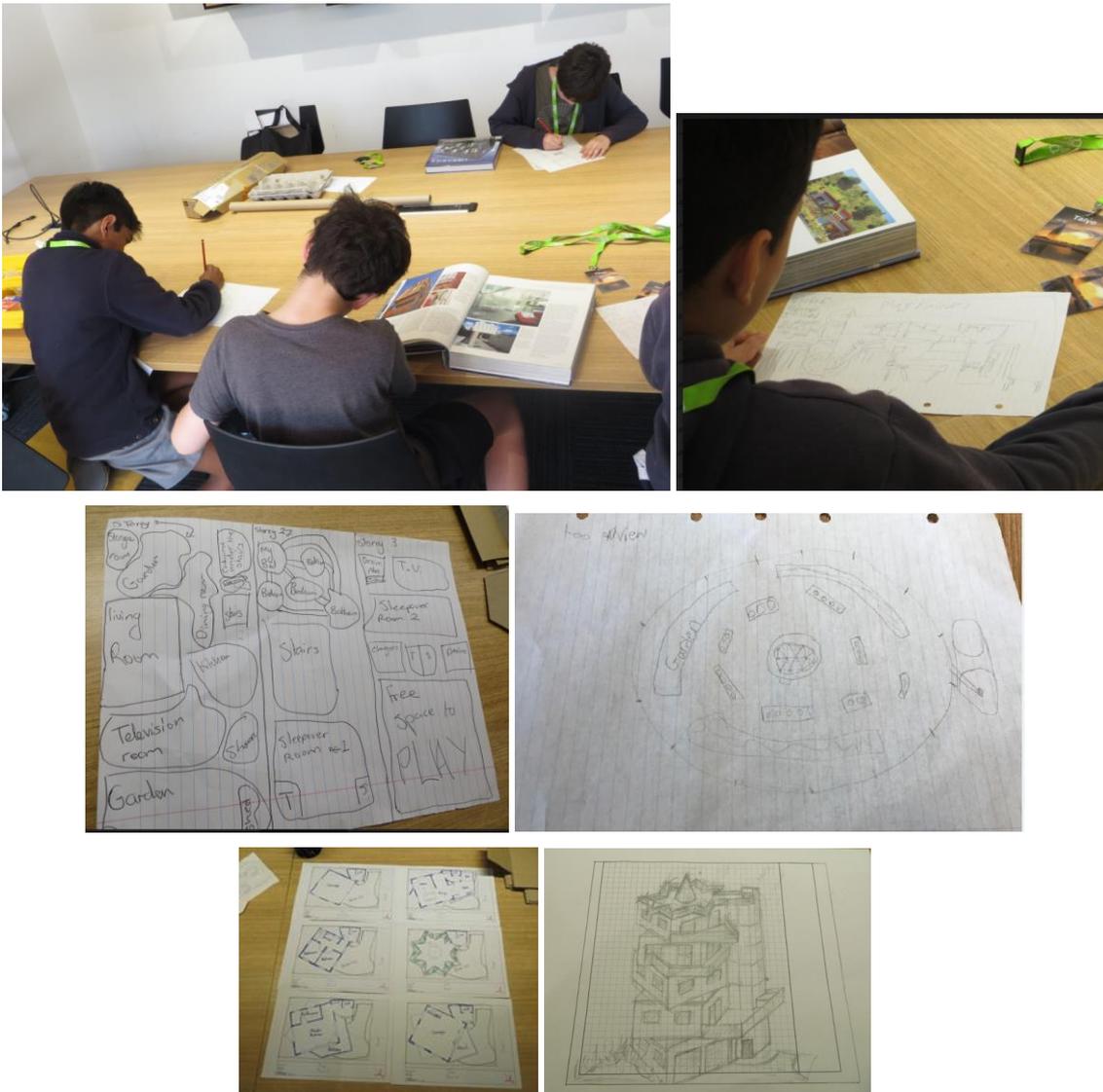


Figure 24: Emphasising design

Learning to design in 3D by coding in TinkerCad

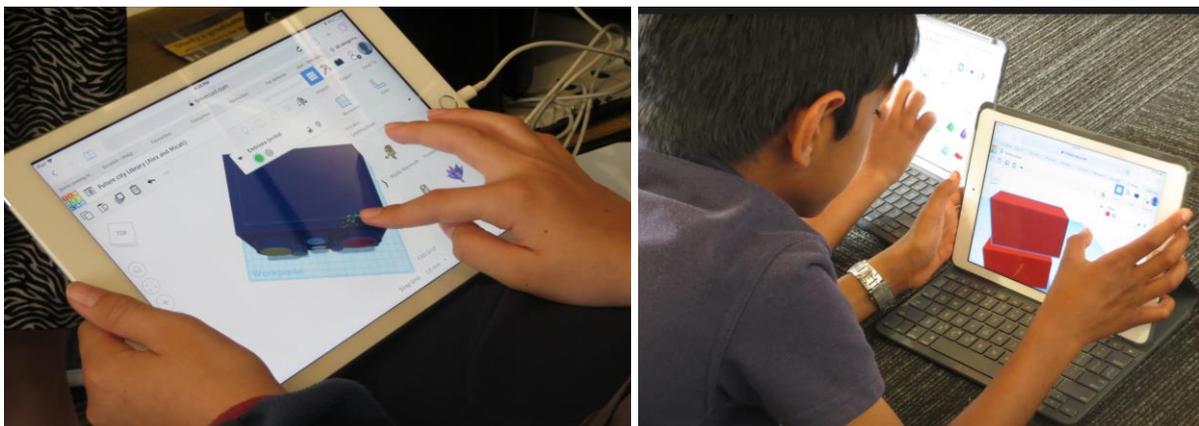


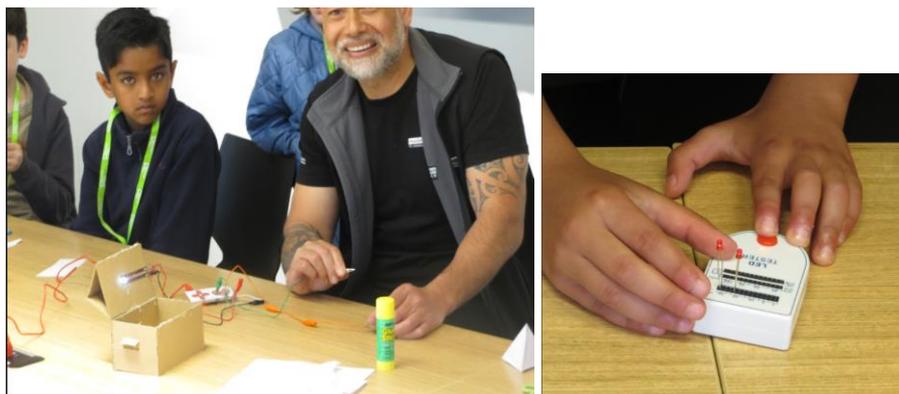


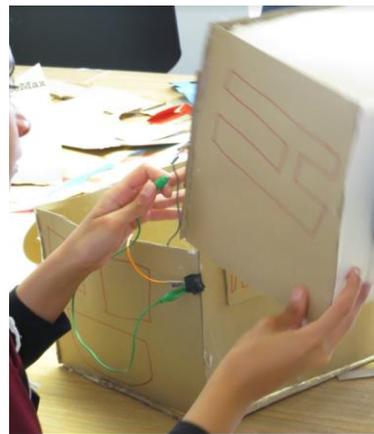
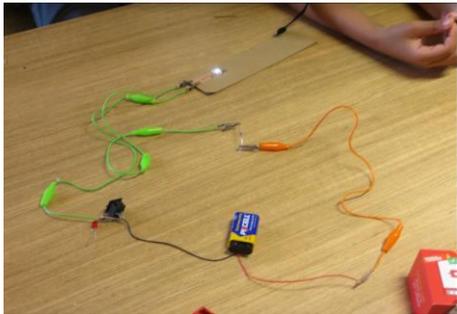
Figure 25: Using TinkerCad to visualise 3D designs



Figure 26: Tinkering, trouble-shooting, trial-and-error

Working with circuits, copper tape, chibitronics and makey makey





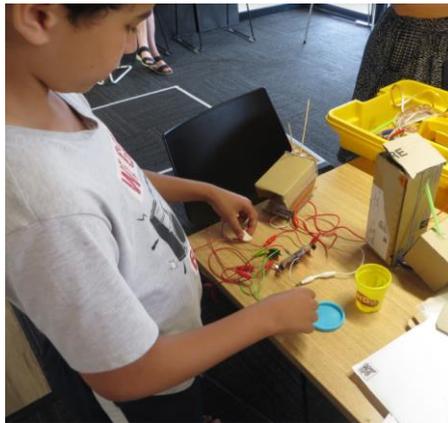
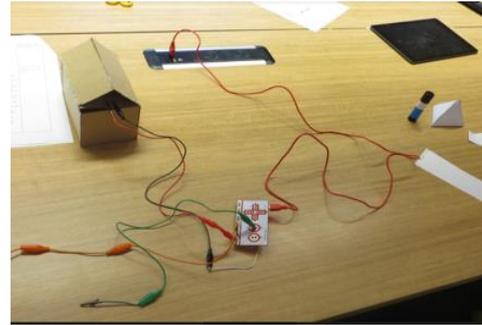
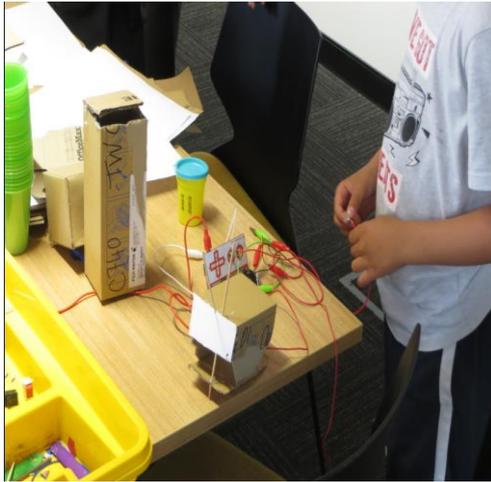


Figure 27: Making a switch for the circuit

Evidence of learning





Figure 28: Evidence of learning



Figure 29: Certificate given at the end of the programme

Evaluation and impact of the programme

Maker Educator views

Overall, the two main maker educators, Aaron and Lauren, considered the maker programme had been a success. The theme had worked to anchor student attendance, interest and making over the 10 sessions. Highlights for them included:

- The first session—as described above, which established a positive culture for exploration, collaboration, persistence and the exercise of imagination.
 - The breadth of ideas developed as part of a brainstorm of ideas for living, learning, moving and playing.
 - Scaffolding for children’s ‘what if thinking’ about what a city of the future needed to include: what if there was a fire, they got hurt and so on.
 - Voting for ideas to be focused on using dots so that children had input and ownership of what was to be made.
 - Discussions on making a sensible range of buildings.
- Children coming to appreciate the range of activities, buildings and services that are central to the effective functioning of a city.
- Children beginning to appreciate the meaning of sustainability in relation to resource use and limitations.
- The sequence introducing circuits in Cycle 2—examining and discussing the function of the different components (LED, switch, battery, alligator clips and what is needed for a connection); practicing using the copper tape (this was sticky on one side and was challenging to unfold and stick down as a unbroken strip); building and testing a circuit to light a LED. The educators concluded there was value in doing this before the children wanted and needed to include a working light in their ‘house’.
- Explanation of the function and how to incorporate a solar panel into constructions.
- Children pushing themselves beyond the ideas introduced in the sessions, especially in the first cycle.
 - One child explored the use of a motor to rotate his building which inspired others and added to the dynamics of the group. Other children took their projects home and brought them back with new elements and materials.
 - Another child was interested in windmills and used a hot glue to shape and weigh the blades with a focus on generating speed.
- “Everybody had a voice; all the children had an opportunity to offer ideas”—the educators were pleased that they had developed an inclusive and democratic environment. Children were able to explore their ideas no matter if they might be outrageous and also to scaffold the children towards a balance between their ideas and the reality of construction
- Ongoing monitoring of individual, group and whole group involvement and progress.
 - Team tagging—educators circulated around the group, asking how each child was are going, were they happy with their progress, and posing questions and offering suggestions (ideas and resources).
 - Educators found it easy slot in with what the children were doing, they had worked through the activities and had the background they needed to help.

- Development of children’s technical skills— measuring, safely using craft knives for cutting and the hot glue gun.
 - Cutting and gluing stations were established at different ends of the table.
 - One educator was always on hand to monitor the use of the cutting and gluing.
 - Some children were initially afraid to use a glue gun but the educators reported that they were careful not to do this kind of task for the children but rather to assist in ways that ensured that they stayed in charge of ideas and products.

The educators identified a number of challenges or surprises to do with what the children did and did not do/could and could not do over the course of both programmes. These could be categorised as i) conceptual understanding, ii) technical skills, and iii) social dynamics.

(i) Conceptual understanding involved in drawing and making from 2D plans

The debrief of Cycle 1 identified the need to spend more time focused on planning as part of a design cycle of design/plan and make. An architect attended the second session in Cycle 2 and outlined the points that he/architects considered when designing and planning a building/space. The children also visited the Reference book section of the library and borrowed books on architectural design and drawing. Nonetheless they struggled with drawing a plan of the house/buildings they imagined and wanted to construct. They struggled to draw front and side views even when prompted to walk around objects/buildings to experience what they could see from different vantage points and to think about taking photographs from different points and how buildings looked different from different viewpoints.

An important finding was that children of all ages could explain what their drawing illustrated even when this was not apparent to an educator, alerting them to the need to talk with children and not rely on observation of products alone. Educators were of the view they needed to ask each child: What they were aiming for? What was their intended purpose of an action or function of a construction? Why had they done this? What did the drawing represent to them?

(ii) Technical skills

The educators introduced TinkerCad, a free software tool that allows users to create/code 3D designs to facilitate the children’s learning about the design-drawing process and to help them translate 2D ideas to 3D spaces. As noted in the Section: Evaluation and Impact of the programme below, some children found this useful. While with others it was a different experience for them to determine the value of the tool. Overall, the link between the children’s planning/ drawing and their model was not always apparent. Others have found children may not see the link between planning and making (Cowie et al., 2013) but differences between children's drawings and what they had in mind could also explain the differences as could their need to adjust their plans to accommodate the limitations of the materials they had access to. In addition, correctly gauging the scale of their building posed a challenge for the children as the buildings needed to fit on the area set out in the city plan that they had developed in the first session.

Collating resources for individual sessions—as the focus and activities changed from week to week time needed to be allocated to searching out ideas and preparing resources. The educators aimed for a mix of new and recycled materials in line with a focus on sustainable living.

(iii) Social skills

Dynamics of some of the interactions between the children in relation to monitoring and managing thoughtless remarks children sometimes made about each other’s creations needed consideration. The educators noted there was a need to make clear that children were expected to respect other people’s ideas and work—older children respecting younger children’s ideas, appreciating what younger children could do, guiding and not telling them what to do.

Parent/caregiver and children perspectives

Finding out about the makerspace programme

Of the 13 survey respondents, seven parents had heard about the programme from the Library's website, two had seen the Library's Facebook website, and the others found out about the programme when they had visited the Library and seen the promotional posters and/or received emails about the promotion (as subscribers to the Facebook website).

Reasons for enrolling in the programme

Reasons parents offered for enrolling their child in the makerspace programme were to:

- encourage their child's learning about STEM skills (12 responses);
- give their child experience of hands-on learning (8 responses);
- extend their child (6 responses);
- the fact the programme was free (6 responses);
- they were curious (5 responses);
- it was an opportunity for their child to socialise with like-minded others (4 responses);
- keep their child occupied (one response);
- their child was keen (1 response).

These reasons aligned with the interview responses when parents described what they and their child valued.

Length and location of the programme

Overall, nine parent survey respondents thought the length of the 10-week programme was "just right" while four thought it was "too short". In the interviews, parents thought the 10 sessions were a good length. They also liked the fact the programme's location at Auahua was accessible and that the after-school timing worked for them as their families are busy on weekends.

General benefits of the programme

Overall parents' survey responses about the value of the programme were very positive. They detailed the following:

Table 1: Benefits of the programme

Programme benefit	Number of responses (N=13)	Example comments from parents and children
Opportunities to think of an idea and then make it	11	<p>Learning how the parts of a city are related and contribute to the quality of life. How to assess and design something to improve outcomes. (Parent)</p> <p>There was something he could enjoy, and something that he could use his imagination. He could basically dream. But at the same time there were practical things he could explore, and even research, and try and create very practical as well as very imaginative design type elements. (Parent)</p> <p>[The programme] help to expand her knowledge more about how a city life actually works, and how you need each other to live and to survive. (Parent)</p>
Learning to work with others	10	<p>Navigating his work alongside other children. Helping others. (Parent)</p> <p>Learning to speak in a group. (Parent)</p> <p>There was some good problem-solving working with different children, because that always happens which is a cool thing that comes out of those things as well. You get lots of different personalities. (Parent)</p> <p>I also want her to learn about how she can cooperate with other kids, and also learn something about science and mathematics. (Parent)</p> <p>I think in the future—not even when she goes to secondary school, but also when she goes to the workforce. Teamwork is very important, you need to cooperate with other staff members in order to work better with the whole project, for your specific task. It's very, very important to have good communications ... good people skills ... (Parent)</p> <p>[I enjoyed] the learning with all of the people and sharing ideas with them. I really enjoyed that, learning from all these critical people who also like building. (Child)</p>
Experience of contributing to a team project	9	<p>Because you've got the smaller numbers and then you can really learn with them, and do the things that they want to do, and talk to them. And that's where all the learning happens. (Parent)</p> <p>It's probably collaboration as well. Like he worked with other children and different things. It was a good skill to have. (Parent)</p> <p>She has lots of ideas, and not all of them would work in every circumstance, but she really gets a lot out of having those ideas type discussions. (Parent)</p>
Experience of problem solving	9	<p>I'm a big supporter of STEM initiatives [like this programme]. I also think that the art aspect is really important. And I think that it creates children that are more resilient and better problem-solvers and that they are able to move forward in the world that we live in. So, I think</p>

		<p>that that is essential really, that we have problem-solvers and big thinkers. (Parent)</p> <p>He had this ambitious idea to have (his house) rotating (so it would face the sun in any direction to maximise the use of solar panels). And that was quite a complicated element because it went through several steps of, ‘Let’s try this. Oh, that’s not going to work. How about this step?’ And then—he learnt a lot, even just about electronics through that. (Parent)</p>
Experiences of working on a long-term project	9	<p>[Over the 10 weeks, my child learnt about] solar panels, hot glue guns, learning to create with fiddly bits in the house, *Interact* with other kids, and to be patient. How to be patient—sometimes you feel frustrated, but I just tell her, ‘It’s okay, you can learn from experience. (Parent)</p> <p>I also liked the idea of them building a whole city. Because it was 10 weeks, I expected it to be very structured, and it has been a lot. They have lots of instructions. I liked the age range. (Parent)</p>
Designing, making and re-designing something	8	<p>He had an ambitious idea of making the top floor spin around and came up to many obstacles which resulted in a lot of perseverance, problem solving and resilience skills to solve. (Parent)</p> <p>I really liked making ... The materials that I had allowed me to make some really interesting things like buildings completely made out of straws. Some of those—I really liked doing that. (Child)</p>
Learning about circuits, solar panels	8	<p>Learning about circuits, building and using circuits. (Parent)</p> <p>Working out the circuit for the solar panel. (Parent)</p> <p>I know she really enjoyed learning about how the solar panel worked, and the electricity and circuits. And trying to work it out whether it was in parallel, or series or... (Parent)</p> <p>Solar power, this is the new knowledge for the children. and for in the future because power is important, very important for the future. (Parent)</p> <p>I didn’t know that they [solar panels] could be like that tiny. And I didn’t know that they could pick up power so fast. You pretty much have to put it in the sun for one second and the light is already going. (Child)</p>
Using their imagination	7	<p>She really enjoyed being able to imagine her house and to craft it and design it. She does tend to think outside the box a little bit. She always had in mind that this was for the future, this was a future-styled house that she was going for. (Parent)</p>
Learning to work more independently on their own projects	5	<p>Learning to safely use a craft knife.</p> <p>My son now enjoys making things by hand. He made a beautiful house and furniture out of cardboard. Now every day he searches the internet for some handmade videos to watch and make. (Parent)</p> <p>We put it together, together. And I said, “Go test whether it will work”, and she took it outside on her own and came back in and said it works. (Parent)</p>

Value of the themed programme

In the interviews, parents highlighted the value of the opportunities for learning and imagination afforded by the Future City theme. Parents made the following comments in relation to this:

- They [children] learnt about what constitutes a city, that a city is built around parks, and know what to expect as part of city life - businesses, shopping malls, universities.
- It gave them exposure to the city/what a city should be so children know what to expect. It is different from village and rural life.
- They got to think about how to improve the city, build buildings for a futuristic city, build a better and cleaner city.
- The theme helped children appreciate that a city is made up of interconnected systems of people, energy, resources etc
- Plants a seed in their young minds ... helps them to choose university subjects and careers such as electronics, doctor, engineer, librarians. Children gain knowledge about future life, not just now.
- This programme expands children's minds so that they become open minded and children are aware of what they can do in the future, what lives they want, what job they want for the future so they can start to think about it now.
- You don't tend to think like the bigger picture about what's happening around you in regards to what's happening in the city. I just think it gives you a bigger picture of what life is like, or about. Like how the city is running, or how— what you need ... 'Cause what you need is always there, but you don't really think about it. But I think it gives you an opportunity to really think outside your own world.
- So, having a purposeful project meant we could try out a soldering iron and try creating different circuits and working out what the different things were. A bit of trial-and-error there. He's probably gone from a very little knowledge of or basic knowledge of electronics to a much more... We're still learning, a lot more to learn, but even though the programme learnt a lot. About circuitry and he learned all about gears and that sort of thing as well. And solar panels.

We can see from these quotes that parents thought the theme not only prompted children to think deeply about how a city functions but also the future focus opened them up to thinking about their own futures and careers.

Having a theme allowed for cumulative learning, which the parents appreciated in that:

- children could expand on learning from one session to the next,
- the theme stimulated creativity and opened up space for imagination. Children could then design and make something,
- the overarching theme required children to think about the whole big picture at the beginning. For example, the placing of doors and windows to accommodate circuitry.

Parents thought the future and technology forward focus was beneficial, offering ample opportunities for the exercise of imagination and problem solving. They were learning to be big thinkers through 'playful learning' so they were not stressed.

Outreach to girls in STEM

Half of the parents interviewed thought the programme was useful in reaching out to girls to give them opportunities to participate in STEM activities they would otherwise not have. The following two quotes from parents and their children affirmed the programme's value for encouraging girls in STEM activities and careers:

Parent 1: She said that she's kind of fascinated with the whole engineering thing.

Child: I do kind of want to be an engineer when I grow up or like technology.

Parent 2: The complexity of what she's building just for fun has gone up. So, it's nothing like the house, but It's encouraged that complexity in her building. We brought a cheap solar panel model that we're going to put together.

Child: We're trying to build a solar car ... also a solar windmill ... it's solar powered, but it's a windmill.

Developing social and personal skills

In the interviews all parents noted that the level of interaction and cooperation amongst the children developed over the course of the sessions. They saw benefit in their child having the opportunity to work with/alongside children of different ages and from different schools/contexts—children building relationships and learning to work as a team and 'Bouncing ideas with another child'. The research team noted examples of pairs of children of different ages and skills actively helping each other. In one instance, a parent noted that her child had shared ideas on circuits with siblings at home. Parents also commented favourably on their child's opportunities to interact with other adults (maker educators and researchers) outside of school. One parent reported, "He found it (the makerspace programme) empowering; his voice being heard and respected". For some the value of this interaction included the chance to talk with other adults, using English. Parents saw collaboration and communication as 'soft skills' that would be important for future careers.

Parents commented favourably on evidence that their children had demonstrated patience and persistence or resilience. One example, was that their child had spent half a day at home making their house using materials they sourced and YouTube for guidance on various aspects of construction.

I mean all problem-solving is about challenges and there is a challenge, but it's something that is a positive thing, because you create, 'Well what am I trying to achieve?' And then you achieve it. So, I think throughout the programme there were a lot of challenges like that. ... the beauty of the programme was that there were people to ask, and, and help. (Parent)

As in this example, some parents commented directly on the initiative and independence their child had shown and or developed—sourcing own materials, seeking out advice on making, using a range of resources to access ideas, and sharing ideas with others.

The STEM learning benefits of the programme

In the survey, four parents reported that the programme was "very helpful", another seven thought it was "helpful" while another two thought it was "somewhat helpful" in encouraging their child's learning about STEM. The reasons given for this focused-on children's appreciation of the complexity of a city and the role STEM plays in city life: "He understands the importance of knowledge. To build a city, you need all kinds of talents, and learning about STEM well is especially important". Parents also reported that their children had gained an understanding of construction and circuitry. These two aspects tended to be linked in parent commentary as illustrated in the following examples:

- Children learnt about constructing a house, adding lights and circuits, very do-it-yourself (DIY) focused, how to use TinkerCad.
- He learned about how to work motors and electronic circuits.

- He knew the function of solar powered panels. This experience improved his interest and exploring abilities about technology and science.
- Learning about circuits, fascinating how it makes light conversion from battery to LED lights.
- She learnt that solar panels face North. She also learnt to think differently about buildings in terms of sustainable designs and living.
- Building knowledge & circuitry. She is interested in learning more about engineering.
- This programme encouraged him to look for more information about circuits and ask more questions about designing and building. He always shares his new learning with his parents, we are both engineers, and show interest to learn more and ask deeper questions.
- Learning about circuits, fascinating how it makes light conversion from battery to LED lights.
- Making houses, police stations and connecting LED wires to solar panels.

Across Cycles 1 and 2, the children who were interviewed stated that they enjoyed most the ‘new’ materials (resistors, LEDs, batteries, solar panels) and using TinkerCad to add blocks and shapes, manipulate sizes, design houses and buildings. Children were introduced to ideas to do with series and parallel circuits, resistors, batteries and positive and negative ends and then experience of actually making a working circuit.

In Cycle 2 in particular there was a strong focus on design thinking, stimulated by the invited talk by an architect (Mr Brian Squair of Chow:Hill Architects) of how he went about a design commission and followed up by Aaron and Lauren through their feedback to the children on their drawings/plans and making. This focus was noted by parents as illustrated in the following comments:

- She now knows she can build ideas from scratch.
- She knows how to execute an idea by first gathering information, designing then planning.

In Cycle 2, one of the interviewed children commented that she had enjoyed “imagining what a house could look like”, then “putting my ideas on paper”. Another commented on the nature of the design activities as playful.

Value of the take-home resource during lockdown

Seven parents reported their child collected and used the take-home resource provided by the Library during Cycle 1. The resource contained equipment such as simple circuitry and solar panel (battery, wires, LED), instruction sheets, basic materials for building (e.g., cardboard, glue, scissors, etc.) for children to trial, use and problem solve with. Parents thought the resource was useful and enabled their child to continue working on their building over the COVID-19 lockdown period. This process continued even after lockdown had been lifted. In the open-ended survey response and interviews, parents and children described the benefits of having this “homework” project as the following:

- He got to spend more time working through the issues he came up against and problem solving. It also allowed him to add more details he might not have had a chance to in class.
- She had the ability to build some skills more slowly at home and had time to think things through a lot more.
- My child enjoyed working with her dad in completing the project together. Also being able to use resources at home to expand on her build.
- It was good because it gave her something to do, something to achieve. And everything she needed was in the box and she had to problem-solve over what she had and what she could do with it. And especially because of lockdown for the two weeks.

- Some kids are automatically ready to just fit [things] together... But this project was different, you knew you were chopping things up and you were moving things—different materials—around. We just really appreciated the [take-home] kits.

Summary of parent and child views

When asked about the best part of the programme, parents thought it was the opportunity for their child to participate in the overarching theme of building a futuristic city: “Being part of a bigger concept. Looking to the future”. They also valued their child learning about specific aspects to do with designing and constructing a futuristic building and learning about and adding lights and solar panels. These aspects can be linked to STEM ideas to do with design-make cycle, with construction, and with ideas to do with circuits. They also valued their child’s “Access to alternative learning opportunities and expanding awareness of community”. Within this, opportunities to work as a team and develop relationship building skills were also seen as important. Both parents and children liked the ‘new’ materials such as circuits and solar panels.

In the interviews, children affirmed these aspects. They thought their STEM understanding had been extended, they had enjoyed the experience of developing their own ideas and problem solving, of working with others and seeing the outcomes of their own and other childrens’ building projects. Examples of children’s quotes are:

- I learnt all about wiring and construction because I don’t usually do construction. So, I learnt a lot about construction, and wiring and electronics, simple electronics.
- I learned how to build, how to put on a solar panel, and building (building a house) and teamwork.
- I like working by myself away from big rooms. So, it—this programme kind of forced me to work as a team which I actually enjoyed in the end.
- Making and connecting. I learnt how to connect wires and about soldering and how it works. And how to improve the city, like a cleaner city.
- [I learnt] How to put my ideas onto paper [part of design process]. How to draw, I didn’t think about that kind of thing before.
- I learnt how to make a house like a model of the future. And a fire station for the future city. And I learnt how to use TinkerCad to build a basic house.

Overall experience in the programme

Challenging aspects of the programme for some of the children were their “feeling like an outsider” initially in the new environment of being in the programme, aspects of learning to work with others and some frustration with accessing online resources such as TinkerCad.

Children’s advice to other children who will be participating in the programme included ideas such as “ask for help/get someone to show you”; “dream big but be realistic”, “make better use of your resources”.

In the interviews, parents liked the fact the programme was freely accessible which meant everyone can be involved; posing no economic burden to them. They and their child thought being given a certificate of completion at the end of the programme was a useful and nice gesture. Children were able to use them at show-and-tell at school; supporting the sharing of their learning with others outside the programme.

Suggestions to enhance the programme

Ideas from the maker educators

- Retain the structure of the first session; include making something.
- Estimating the time needed for different activities is challenging as is deciding and how to manage moving on—consider providing a resource box for children to take home to finish models in their own time.
- Clearer structure in terms of design and build, moving from drawing to TinkerCad to building.
- Spend more time developing ideas to do with 2D–3D perspective.
- Bring forward the wiring activity—children can learn about this outside of wiring their houses.
- Consider if and how parents might be part of the programme with their child—would need brief them and balance this with need to foster children's independence.

Ideas from Parents and Children

In the open-ended survey responses as well as interviews, parents offered suggestions to enhance the programme:

- More specific STEM content and facilitation of this.
- More in-depth exploration of various aspects of a city, e.g., sewer system.
- Continued and stronger emphasis on sustainability so children are reminded that resources are limited.
- More encouragement for children to think about plan and design before making, extend beyond building houses:
 - Some direct instruction on translating 2-D to 3-D.
 - Use lego blocks instead of TinkerCad to support initial manipulation of 3D design thinking.
- Earlier use of tools such as TinkerCad; use of LEGO Mindstorms.
- Additional resources—for making and for reference (e.g., list of books).
- Stronger support for children to ask questions.
- More opportunities for managed paired or small group work:
 - Monitor pairings that are emerging and how they are working together; consider whether to support or to suggest wider group interaction.
- More opportunities to extend children.
- Keep the take-home projects and provide time for children to share their ideas.
- Increase the number of weeks and length of session; run programme over the weekend as it was very challenging to attend during the week immediately after school.
- A follow-on programme to build on the skills and knowledge learned to date.
- Allow younger siblings to join the programme so siblings can share ideas and work together.
- Consider more involvement of parents, experts and other resource people.
- Establish a network for parents so that, if they choose, their children can continue working together.

Overall, all parents agreed the programme was valuable, and would like to see it continue to be offered to children in the community. One parent considered the programme to be part of education in the community and a tool to make people in the community think; “create opportunities to develop New Zealand and do things differently”. Another parent aptly encapsulates the programme as being fundamental for nurturing young minds and that libraries are well placed to offer opportunities for children to develop knowledge and new skills:

I think that they [programmes like this one] are vital because they nurture curious minds and extend children who aren't getting enough of it at school. It's the world I want to live in where the libraries produce opportunities for kids to develop a deeper interest in and extend their knowledge and work together, team building and new friends, new ideas.

Dissemination

A website about this project has been developed, see:

Developing a STEM mobile makerspace and maker educator learning resource: <https://www.waikato.ac.nz/wmier/projects/developing-a-stem-mobile-makerspace-and-maker-educator-learning-resource>

Other online links mentioning this project include:

1. See link: [Learning through making as an education game changer](#) by The University of Waikato (Published March 9, 2020).
2. See link: [New research says makerspaces help develop students' STEM interest and skills](#) by [EducationHQ News Team](#) (Published February 17, 2020).
3. See link: [Full STEAM ahead Embracing hands-on learning](#) By Education Gazette editors, Issue: Volume 99, Number 7 (Published 18 May 2020)

A story for dissemination/publication on the Curious Minds website has also been developed (see Appendix 13).

We intend to disseminate our findings and recommendations for other library maker educators via the Library and Information Association of New Zealand Aotearoa's (LIANZA) professional development website for librarians, see: <https://lianza.org.nz/professional-development/>

Acknowledgements

We are grateful for the funding support from Unlocking Curious Minds to extend the STEM focus in the makerspace programme and to conduct the research. We are indebted to the participants in the research project—maker educators, parents and children—for their time, support and participation in contributing their insights for the project.

References

- Almurbati, N. A. (2019, March). The role of Makerspaces and smart citizens in shaping Bahrain as a smart city. In *2nd Smart Cities Symposium (SCS 2019)*. Bahrain. <https://doi.org/10.1049/cp.2019.0199>
- Bender, S., & Pepler, K. (2019). Connected learning ecologies as an emerging opportunity through Cosplay. *Comunicar*, 58, 31–40. <https://doi.org/10.3916/C58-2019-03>

- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Cowie, B., Moreland, J., & Otrell-Cass, K. (2013). *Expanding notions of assessment for learning*. Sense.
- Grandl, M., Ebner, M., & Strasser, A. (2019, April). Setup of a temporary Makerspace for children at university: MAKER DAYS for kids 2018. In *International Conference on Robotics and Education RiE 2017* (pp. 406–418). Springer.
- Hatch, M. (2013). *The maker movement manifesto: Rules for innovation in the new world of crafters, hackers, and tinkerers*. McGraw Hill Professional.
- Khoo, E., & Cowie, B. (2018). *Mobile makerspaces as a catalyst for fostering STEAM activities in the community*. WMIER, University of Waikato. https://www.waikato.ac.nz/_data/assets/pdf_file/0016/434131/Makerspace-report-WMIER-Library-research-project-7Sept2018.pdf
- Kirshner, B., & Polman, J. L. (2013). Adaptation by design: A context-sensitive, dialogic approach to interventions. *National Society for the Study of Education Yearbook*, 112(2), 215–236.
- Niaros, V., Kostakis, V., & Drechsler, W. (2017). Making (in) the smart city: The emergence of makerspaces. *Telematics and Informatics*, 34(7), 1143–1152. <https://doi.org/10.1016/j.tele.2017.05.004>
- Martinez, S. L., & Stager, G. (2019). *Invent to learn: Making, tinkering, and engineering in the classroom*. Constructing Modern Knowledge Press.
- Sahin, A., Ayar, M. C., & Adiguzel, T. (2014). STEM related after-school program activities and associated outcomes on student learning. *Educational Sciences*, 14(1), 309–322. <https://files.eric.ed.gov/fulltext/EJ1038710.pdf>
- Schön S., Ebner M., Grandl M. (2020). Designing a Makerspace for Children – Let’s Do It. In Moro M., Alimisis D., Iocchi L. (Eds.), *Educational Robotics in the Context of the Maker Movement. Edurobotics 2018. Advances in Intelligent Systems and Computing* (vol 946) (pp. 3-15). https://doi.org/10.1007/978-3-030-18141-3_1
- Vongkulluksn, V. W., Matewos, A. M., Sinatra, G. M., & Marsh, J. A. (2018). Motivational factors in makerspaces. *International journal of STEM education*, 5(1), 43–62. <https://doi.org/10.1186/s40594-018-0129-0>
- Ylipulli, J., & Luusua, A. (2019, June). Without libraries what have we? Public libraries as nodes for technological empowerment in the era of smart cities, AI and big data. In *Proceedings of the 9th International Conference on Communities & Technologies-Transforming Communities* (pp. 92–101). Association for Computing Machinery. <https://doi.org/10.1145/3328320.3328387>

Appendices

Appendix 1: Focused discussion questions for Maker Educators

1. Did anything surprise you about what the children did and did not do/could and could not do/interacted over the 10 sessions?
2. What do you think were the main things they learned? How do these fit with what you envisioned as the main purpose/s for the programme?
3. What did you do in the programme to promote these skills/key areas of learning? [check role undertaken, types of activities, resources used, support from other staff etc.]

Challenges and rewards of the programme

4. Did you have any concerns/face any challenges with the running of the programme?
5. How would you change things? [types of activities, planning, resources, timing, etc.]
6. Can you suggest ways the programme might be extended to cater to participants'/other community users' learning needs?

Maker educator PD programme

7. What were the key ideas/skills/learning you think you had gained from being part of the maker educator workshop? [Probe: learning to engage children's learning, learning technical skills to facilitate makerspace activities].
8. Did you notice any benefits to your professional learning as a result of the workshop?
9. How useful were the following to your learning to be a maker educator:
 - a. Attending the professional learning workshop.
 - b. Participating in the regular/weekly reflections.
 - c. Making use of the web resources shared.
10. After going through the professional learning workshop:
 - a. what did you like MOST about the workshop?
 - b. what did you like LEAST about the workshop?
11. How can the workshop be improved to better support your learning?
12. What other topics would you like to see covered to better support your professional learning?
13. Is there a dissemination network amongst local and regional public libraries?
 - a. What would you add to it e.g., 10 tips for developing your library makerspace programme—produce a sheet on this for dissemination.
14. Is there anything else you'd like to share about the programme or about your professional learning as part of the programme?

Appendix 2: Parent/caregiver Evaluation of the Programme (Survey)

Build a model city of the future 2040

End of the programme survey

Dear parents/caregivers

We invite your voluntary participation in this short anonymous survey. The study is a collaboration between Hamilton City Libraries and the University of Waikato and is funded by the Unlocking Curious Minds (UCM) initiative by the Ministry of Business, Innovation and Employment (MBIE) as a research project. It has received ethical approval from the University of Waikato Ethics Committee (no. FEDU009/20).

The survey will take 15 minutes to complete. The information you provide will be used for the purposes of the research and to improve the programme. By completing the survey, you give your consent to participate in this study. If you have any questions or issues you wish to raise concerning the study, please contact Aaron (aaron.martin@hcc.govt.nz) or Elaine (elaine.khoo@waikato.ac.nz).

1. How did you hear about the ‘Build a model city of the future 2040’ programme? Please tick ONE option?

- Website
- Word of mouth
- Facebook
- Other:

2. Please tell us why you enrolled your child in the programme? Please tick all that apply.

- I was curious about the programme.
- To encourage my child’s learning about STEM (Science, Technology, Engineering, & Maths).
- To give my child experience of hands-on learning.
- It is free.
- To keep my child occupied.
- To extend my child.
- An opportunity for him/her to get to know like-minded others.
- Other:

3. How would you rate the length of the 10-week programme

- Too short
- Too long
- Just right

THINKING ABOUT YOUR CHILD’S LEARNING

4. We are interested to know what sort of skills you think your child has developed as a result of participating in the programme. Please tick all that apply:

- Learning to work more independently on his/her own projects.
- Experience of problem solving.
- Learning to work with others.
- Experience of contributing to a team project.
- Experiences of working on a long-term project.

- Thinking of an idea and then making it.
- Designing, making and re-designing something.
- Using their imagination.
- Finding out more about STEM ideas such as solar panel.
- Learning about circuits.
- Other:

4a. Please describe an example of your child’s learning that stood out for you?

5a. How helpful was the programme to encouraging your child’s learning about STEM (Science, Technology, Engineering, & Maths)?

- Not at all helpful.
- Somewhat helpful.
- Helpful.
- Very helpful.
- Other:

5b. Please tell us why?

THINKING ABOUT DOING THINGS AT HOME

6a. Did your child make use of the take-home resource pack (cardboard box resources)?

- Yes
- No

6b. What did your child find interesting and useful about the take-home resources?

6c. Do you have any suggestions to improve the resource?

7a. Did your child bring any of the activities home to work on?

- Yes
- No

7b. Which ones?

7c. What do you think he/she learn/gain from this experience?

THINKING ABOUT THE PROGRAMME AS A WHOLE

8. What was the best part about the programme?

9. What would you like to see more of in the programme?

10. Anything we could do to improve the programme?

Thank you for indicating you are happy to be interviewed with your child about the programme (about 15 mins). Are you still prepared to do this?

Yes / No

If Yes, we will be in touch through your given contact details within the week to arrange a time for a face-to-face meeting or an online zoom meeting.

Thank you for your time and help

Appendix 3: Interview questions with parents and children

For parents:

1. What expectations/hopes did you have for your child when you signed up to the ‘Build a model city of the future 2040’ programme?
2. What do you think your child gained/ learned from being part of the programme?
3. What did the programme encourage your child to do/not do in terms of learning about STEM (Science, Technology, Engineering, & Maths)?
4. What do you think your child found challenging about the programme?
5. Do you have any suggestions for the next version of the programme?
6. What role do you think initiatives like the programme have in our community?
7. Is there anything else you’d like to share with us?

For children:

1. Can you tell us about what you did and made over the 10 weeks?
2. What are you most proud of? What did you enjoy most? Was there something you didn’t enjoy?
3. What did you think you learned from being part of the programme?
4. Would you like to do more activities like this in your future sessions? (e.g., learn more about STEM (Science, Technology, Engineering, & Maths? Why/why not?)
5. What advice would you give to other children who joined a programme like this?
6. Have you shared what you have learnt in the programme with anyone else?
7. What advice would you give to improve the programme?
8. Is there anything else you’d like to share with us?

Appendix 4: Workshop 1 for Maker educators

Workshop for Maker Educator Library Staff

13th July 2020

Hamilton Central Library — LVL1 — Auaha Meeting Room

- 8.30–8.45 Introductions and agenda for the day (Elaine and Aaron)
- 8.45–9.00 Research on children’s learning in makerspaces (Elaine)
- 9.00– 9.15 The LAB makerspace programme: The vision for the City of the Future (Aaron)
- Explaining why the focus of the LAB is on the City of the Future
 - Why we think this will be relevant and motivating for children
 - A very broad brush of programme structure.
- 9.15–9.45 What would it mean to be a child in this programme? (Aaron)

Activity 1: Participants will work through an activity that has been selected by Aaron as one that is challenging for children and offers rich learning and experiences to them. Participants to note:

- What questions did they ask about the situation?
- What things did they try?
- Where did they get stuck?
- What did they do and think to ‘unstuck’ themselves?
- What helped them keep going?

- 9.45–10.00 Feedback to group—pool issues and ideas (Elaine)
Aaron comments on what he has seen children do within this activity

- 10.00–10.15 Asking not telling—ideas for productive questioning (Elaine)

10.15–10.45 Morning tea

- 10.45–11.05 Activity 2: Working through and discussing another activity (Aaron)

- 11.05–11.45 Working with children and parents: Thinking about principles (All)
- Scaffolding- What is it? Why is it a useful idea? (Bronwen & Elaine)
 - Technical matters—e.g., small fingers, using scissors
 - Behavioural issues
 - Managing diverse abilities and skills
 - Managing diverse interests
 - Strategies to support persistence
 - Engaging with parents - expectations and assistance

- 11.45–12.00 Overview of the 10 weeks—next steps (Aaron)

Appendix 4a: Workshop Makerspace Research on Children's Learning

Makerspace Research on Children's Learning

In makerspaces children learn through...

Making, tinkering, trial-and-error, exploration, experiment with innovation, develop an open mind, be creative, compute, and problem-solve, direct their learning interest while considering the impact of their creations on society, ecology, and the environment

Learning through making (doing) can

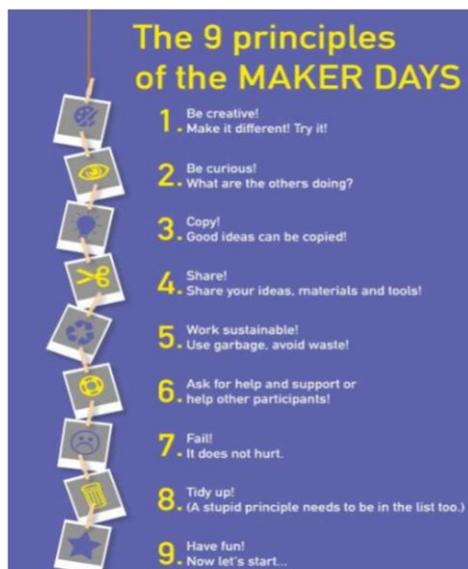
- Promote equity and empowerment
- Engage children in the use of scientific and technical tools and process,
- Support children to explore, question, problem-solve, think critically thinking
- Develop children's self-confidence, interest and motivation to participate in future STEM activities and careers

Makerspaces facilitate informal and creative learning opportunities and connections between home, school and community contexts

Thinking about principles for 2020 LAB programme?

Any thoughts?

Some makerspace principles from our research partner



Hatch, M. (2013). *The Maker Movement Manifesto: Rules for Innovation in the New World of Crafters, Hackers, and Tinkerers*. McGraw-Hill.

Thinking about principles for 2020 LAB programme?

Any new thoughts?

Principles from earlier discussions for the LAB

- Be Creative - tinker
- Communicate your ideas
- Collaborate
- Be Brave - have confidence
- Take Risks
- Brainstorm ideas
- Evaluate and refine ideas



C
R
I
B

What parents told us they liked about the LAB in 2017....

- Introduced children to science concepts which they can follow up by taking the materials home to complete tasks or investigations without needing parental supervision
- Children learn about computational thinking and coding through the Lego Mindstorms activity
- Children learn to work through a task systematically
- Children learn problem-solving skills and the value of persistence
- Children could try different LAB activities
- Had hands-on and easy activities that can be followed up at home using common materials

What parents told us they liked about the LAB in 2017....

- Children learn to pause and consider their own behaviour before acting and to think about different ways of problem solving.
- Children could meet other children and adults
- Children learn skills helpful in their future - future-oriented skills, life skills and digital skills
- Children could access resources and activities which parents could not afford otherwise
- All parents were supportive of the programme and keen to see it grow and strengthened

Appendix 4b: Workshop Question bank for Maker Educators

Why are we focusing on questioning?

Our aim is to ensure children have an opportunity to share and discuss their ideas for how to solve the problem we have posed. We want to support children to think more deeply about ideas and make connections with the big picture.

A well-timed question can spark new thoughts for children to develop perseverance through a difficult task.

General advice

- As a first response ask a question rather than telling the idea BUT it is OK to introduce new ideas/show children what to do when you see they are stuck.
- Try to ask open questions where there is more than one answer or more than yes/no.
- Try not to ask more than one question at a time.
- Give children time to think—count to 20!
- Add ‘how’ or ‘why’ to a child’s response to help them think more deeply.
- Set up an expectation that *all* ideas will be respected by modelling this.
- You can ask other children to answer a child’s question.
- Consider rephrasing a question—just as you might not understand an answer the child may not understand the question.

Generic questions to guide children through the process of designing and making

<p>Understanding the task</p> <ul style="list-style-type: none"> ● What is the challenge for today? ● What things do we need to consider? ● What materials do you have? ● What information do you need? ● What are some ideas for what you could do? ● Can you think of any other ideas? 	<p>Clarifying and planning</p> <p>Tell me more about xxxx.</p> <p>What things do you need to think about? Why?</p> <p>What do you think about xxxx?</p> <p>What do you mean by xxxxx?</p> <p>How is x, y, z important?</p> <p>How could you use the material that you have to create your idea?</p> <p>How could we combine different ideas?</p> <p>Which idea will you make and why?</p> <p>Do you think it will fit in the space we have?</p> <p>How does this link to the big idea of the City of the Future?</p>
<p>Making</p> <p>What tasks need to be done?</p> <p>Who will do them?</p> <p>What skills do you need?</p> <p>Who can help you with it?</p>	<p>Evaluating</p> <p>What is it about your design that are you most proud? Why?</p> <p>Does your design work as you intended?</p> <p>What parts need improvement?</p> <p>What would you do differently next time?</p>

We are thinking that for each session maker educators will need to have thought through the kinds of things children might do, the ideas they will need as a basis for the design and making thinking, and also some skills that they might need so that the educators are best set up to scaffold children’s learning and making.

Appendix 4c: Workshop Working with children & parents

Working with children and parents

What are our expectations of how children will behave – work together

What issues do we anticipate?
- what ideas do we have?

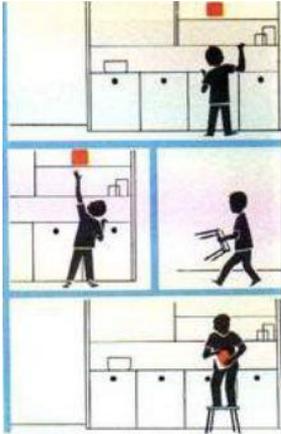
What are our expectations of how children will behave – work together

- What do we expect of the children in terms of their behavior?
 - Respect, sharing, collaboration, cooperation
 - Roles if working as a small group/pair
- What actions will we challenge?
 - Rudeness
 - Not sharing
- How will we do this?
 - Can a child be asked to leave?
 - Involve parents early
 - Do not threaten!!!!
 - Feedback on productive and positive actions
 - Consider rewards such as stickers for best thinker, planner etc.
 - Expectation chart

Co-teaching

- There is value in one person having the overview and keeping their focus on the group
- There is value in the second person troubleshooting issues more one-to-one

How can we get parents to help with children's learning?



Scaffolding involves providing support....

that is gradually withdrawn as the learner gains competence and confidence

How can we manage diverse abilities & interests?

Check the accessibility of our activities

- what do children need to be able to do to enjoy them?
- what if a child has already done it?
- what if a child finishes before everyone else?
- what if a child can't start/get stuck/get so far behind?

Appendix 4d: Workshop Next steps

Next steps

Establishing the purpose for each session

- See our plan
- Engage with science, technology, engineering and mathematics (STEM) ideas and skills
- Appreciate using sustainable resources
- Develop an appreciation of scale when planning and creating artifacts
- Consider the limitations and constraints involved in planning and implementing ideas
- Participate in *learning through making using a Plan-Design-Make-Evaluate cycle*

What do we expect children to do and learn each session/ in each activity?

- See the plan
- We need to have worked through the activities
- Do we have ways to simplify and extend an activity?

Appendix 5: Cycle 1 Overview makerspace curriculum (Term 3)

Cycle 1 (Term 3) City of the Future Curriculum Overview of Weeks 1-10

Theme: City of the Future- Hamilton in 2040

Overall content objective: To support participating children to:

- Engage with science, technology, engineering and mathematics (STEM) ideas and skills.
- Appreciate using sustainable resources.
- Develop an appreciation of scale when planning and creating artifacts.
- Consider the limitations and constraints involved in planning and implementing ideas.
- Participate in learning through making via the Plan-Design-Make-Evaluate cycle.

Overall skill development: To support participating children to develop the following qualities:

C R I B	<ul style="list-style-type: none"> - Create/ tinker - Communicate - Collaborate - Creativity - Confidence - Risk taking/managing uncertainty - Brainstorm ideas - Evaluate and refine ideas
------------------	---

Session Format:

Each session format will incorporate aspects of the Plan-Design-Make-Evaluate cycle to:

- capture children's attention: Introduction to a scenario,
- promote active generation and processing of ideas: Brainstorm ideas, Communicate ideas and seek Feedback,
- facilitate their practice of making/creating and reflection: Plan-Design-Make-Evaluate cycle,
- photos will be taken (at least 2 photos per child/pair) of children at work each week.

Scenario:

Hamilton City is wanting to develop a 20-year plan. They have asked us to find out your ideas so that we are building a city of the future for and with you: *A city friendly to children is a city friendly to all.*

The city needs to include the activities you love to do and the kind of places you'd like to go.

Your views are important as you will be part of this city.

So how do you want to live in the year 2040?

If you have the ability to design and build a city for the year 2040, how would you start?

- How would you like to live?
- What would it look like?
- Who would you build it for?
- What would you put in it?

Session Content:

The theme will be explored through five main sections across 10 weeks:

Week 1: Introduction to City of Future

Introduce children to the overarching theme of planning for Hamilton as the city of the future based on four areas- playing, living, moving and learning. Support them to design, plan and visualise what their future city might look like

Week 2-3: Playing in the Future

Children will explore ideas on how 'playing' in the futuristic city might look like (e.g., playground designs and equipment/toys) and get to design and create their own playground artifact.

Week 4-5: Living in the Future

Children will explore how 'living' in the futuristic city could look like (e.g., home/building designs, forms of sustainable energy) and get to design and create their own building and sustainable energy resource.

Week 6-7: Moving in the Future

Children will visit how might 'moving' in the futuristic city might look like (e.g., transportation (air, road, sea), roading system) and create a roading system and an example of a futuristic form of transport.

Week 8-9: Learning in the Future

Children will consider how 'learning' in the future could look like (e.g., learning through digital games, virtual field trips). Children will have the opportunity to design and create an example of a game for learning in the future.

Week 10: Show and tell/ Exhibition

A celebration of children's achievements. Children to present their model of the City of the future- Hamilton in 2040.

Appendix 6: Maker Educator Professional Development Principles

Design, development and implementation of a Maker educator professional learning programme

The maker educator programme comprised a one-day workshop prior to the commencement of the makerspace programme in school terms three and four and end of session debrief/ reflections. The workshop for Term 4 was adjusted based on participants' feedback on the first workshop and their implementation of the *Build a model city of the future* over Term 3. Maker educators took time to review and reflect on student responses and their own experiences at the end of each session. What follows is a synthesis of the two workshops and maker educator analysis of and reflection on their experiences on individual sessions over the two 10-week programmes. Key activities are described followed by recommendations for activities that would support maker educators to design and implement an effective maker programme.

Setting the scene: Building on research and developing shared principles for the functioning and goals of maker space

It is worthwhile beginning the first workshop with a brief overview of current research on makerspaces. This can be used to highlight the affordances of maker spaces as including:

These affordances can then be used to ground a discussion about the principles that will underpin the—its design, development and implementation. The paper by Hatch (2013) offers a useful set of nine principles that can be used to start this discussion but it is worthwhile taking time to brainstorm the ideas with the group and to publicly craft ideas into a taken-as-shared list of principles. For the UCM study these principles were agreed as:

The team gave careful attention to wording the principles so that they would be understandable and engaging for children aged 7 to 12 years as these were the target participants for their maker programme. These principles were introduced to the children at the beginning of a programme. Maker educators noted that they acted as a useful reference point for children when they were becoming frustrated as they made clear that it was more than acceptable to ask for help.

Recommendations:

- Take the time to develop a set of principles that will ground the development and implementation of the local maker curriculum.
- Considering developing programme principles with maker programme participants rather than simply sharing them, if challenges of timing and the time involved could be circumvented.

Topic selection

The UCM project drew on research and the expertise of the project consultants to assist in identifying the topic for the maker programme: *Build a model city of the future*. Also relevant, the Central Library was host for a 'Smart Space' as part of the Smart Hamilton, more specifically Smart Society, initiative by the Hamilton City Council. The website states:

Smart Hamilton is about encouraging this mindset and supporting innovation that improves the wellbeing of the community, enables better decision-making and responds effectively to our greatest challenges.

<https://www.hamilton.govt.nz/our-partner-projects/smarthamilton/Pages/default.aspx>

This meant that the future city as a maker curriculum topic had strong local relevance and currency. The co-location of the Smart Space and the Maker programme reinforced this relevance, providing clear evidence that there was a purpose for the topic.

The topic advertising brief for the maker programme was negotiated as:

You are a city planner and your job is to design and build a future city for people to live in that is safe, sustainable and fun! You will design how people will live, move, play and learn. This will include simpler circuitry, coding, and other STEM activities. Are you up for the challenge? In this way the brief clearly signalled that participants would be expected and need to exercise their imagination, something that was commented on favourably by parents who enrolled their children and by children and their parents during the end-of-programme interviews. The topic also had the advantage that it could draw on the children's everyday experiences of living in a city.

Building on Grandl, Ebner and Strasser (2019) and Schön, Ebner, Grandl (2020) the overall plan for the series of sessions was structured by the following foci:

- How do you want live?
- How do want to play?
- How do you want to move?
- How do you want to learn?

These questions target key aspects of city life. As Grandl and Schön and colleagues' research had indicated these foci also proved accessible to the children in the UCM programme. The four categories provided some structure and focus to the 10 weeks, so that the children encountered different ideas and challenges.

Recommendations:

- Consider selecting a theme that will hold together and provide coherence across a range of making activities, knowledges and skills.
- Consider selecting a topic of local relevance and for which there is a clear and obvious purpose.
- Consider selecting a topic that includes space for children to exercise their imagination and draw on their experience.
- Consider 3-4 foci within the overall topic theme to provide variety

Plan the first session carefully

The first session is important for establishing expectations for what the children will do over the course of the programme—the kinds and level of contributions they will be able and encouraged to make, and the kinds of activities they will engage in and the kinds of interactions and support that will be available. The following sequence was effective in setting up expectation in line with the principle's discussion above through a combination of individual, small group and whole group activities, input from the educators and the children, and a combination of thinking and doing.

Icebreaker: A group activity that requires collective physical interaction and is fun—form a circle of linked hands and follow a series of instructions that become more complex

Introduce the makerspace the principles: Introduce the principles as a first step to establish the culture of how children and adults will work together.

Introduce the theme for the programme using a variety of media and resources—videos and photographs of actual and imagined cities, buildings, transport systems.

Brainstorming ideas to be included in the city: Children as individuals brainstorm ideas for each of the four different focus area questions. Their ideas are written on posits and then posted on sheets around the room, a process that involved movement and further interaction amongst the children. Children were then given three sticky spots and asked to vote for three ideas. The ideas and votes were collated by an

educator on a central board. Ideas were read out so the children did not need to voice their idea if they were not confident to do so, although some chose to elaborate on what was meant.

Considering the layout of the city: Ask the children as a group to consider the layout of their city in terms of areas for housing, recreation by placing different coloured squares of paper on the table where their city would be built. The table was of a size the children could all stand around – having squares of paper for different items allowed for easy movement which fostered negotiation about where and why

Recommendations:

- Use an icebreaker to assist children to get to know each other.
- Consider a combination of individual and group activities, which include thinking and doing.
- Include activities that allow interaction and movement amongst the children in different groupings and that also help them get to know each other and to know and own the space.
- Provide lanyards with children's names to ease conversation.

Space and resources

The space and resources available to maker educators for their programme need to be considered as part of the professional learning and programme development process. In the case of the UCM project the available space dictated a limit of 10-12 children if each child was to have their own working space and children were to be able to easily observe each other to get idea and to ask for help. The children worked on one large table which added to the ease with which they could interact and help each other.

Consider what resources will be provided with a balance of new and recycled materials and some electronics component and so that children gain a range of experiences.

Resources including cardboard, straws, corks, various electrical components and other materials as well as hot glue guns and scalpel's for cutting were always available.

During the first session the maker educator team introduced the children to the table where they would be placing what they constructed. The size of this was an important consideration in terms of room capacity and its implications for the scale of the constructions the children would need to make. The space used in the City study was a 2x2m board

In both Cycles the table and the children's constructions were clearly visible to visitors to the library and attracted a lot of interest. It provided a good forum for conversation as the public could see the constructions slowly evolving. It prompted queries from families about how to get their child involved. It also helped library staff to promote the Library's work and make connections with other organisations. In Term 3, this table was in the space where the children worked. In Term 4 it was in the library.

Recommendations:

- Consider the space relative to group size along with the possibility of keeping children's work on display in one place.
- Consider a balance of new and recycled resources; consider limitations on these (link to sustainability).
- Consider ensuring that the public can view the development of the city when they come to the library as part of outreach and information sharing.

Staffing

Make at least two people available to support the children at all times. One of these people needs to be designated to monitor health and safety issues.

It can be useful to bring in more people for some sessions and also to invite people with special interests and expertise to add variety.

Recommendations:

- Discuss staffing—we recommend at least two people with different roles and expertise and one person designated to monitor health and safety.

Working through activities to prepare to work with children

The effective facilitation of a maker space programme in an informal/semi-formal space which is typically not familiar to the children participation who are very unlikely to know each other relies a facilitator who is able to employ strategies to get to know and scaffold children who likely have very different background knowledges, interests and practice expertise. The maker workshops included the activity “What would it mean to be a child in this programme?” For this the maker educators worked through an activity selected as being challenging and which offered rich learning experiences. For this, educators worked in pairs and attempted to think as a child about: What kinds of questions might they ask? What things might they try? Where might they get stuck? What could they do and or think to get unstuck? What would help them to persist? This activity was useful in prompting sharing and discussion of likely issues and productive educator responses. Discussion about activities encompassed the need to reiterate dangers of use in some equipment as “Kids don’t know how hot a hot-gun is until they touch it”.

The final maker focus group confirmed that working through activities was essential preparation for interacting effectively with children. This process enabled educators to gain an appreciation of the technical aspects of an activity, including what to expect, the use of tools and resources, and how and why things might or might not work. This experience meant that the educators could act as trouble-shooters and problem solvers who were able to identify potential pitfalls and be confident with the kinds of advice that might be useful.

Working through activities proved to be a useful scaffold to a focus on questioning. The maker educator professional learning programme include a specific focus on questioning. An initial set of questions was developed see Appendix 4b. The final focus group identified a set of ‘check-in’ questions as useful for scaffolding their interactions with children and worthy of sharing. These questions were useful for monitoring children’s progress/ achievements, and identifying children’s goals and challenges as a basis for helping them progress their ideas. Educators were of the view it was not sufficient to rely on their own observation of children’s constructions or actions they needed to ask each child: What they were aiming for? What was their intended purpose of an action or function of a construction? What is the idea you are going for? How can I help?

Other advice from the educators and ideas for inclusion in a professional learning programme included the need to monitor who is and who is not being focused on/ receiving attention and feedback. They noted that, ‘just because a child is capable does not mean that they do not need or appreciate some positive feedback—the appreciate affirmation even if they do not need much support’. In the final interview they reiterate the value of written instructions so that children could work independently and not need to wait for adult to suggest and extension or, on some occasions, help them problem solve. Writing instructions for TinkerCad and Youtube videos were useful for scaffolding origami.

Recommendations:

- Where possible work through activities before using them with children, considering what a child might need to know and be able to do to prepare to identify issue and possible responses.
- Discuss a set of questions that can be used to scaffold and not ‘tell’ children what to do.
- Think about offering guidance and extension in a variety of ways.

A focus on informing and working with parents

The professional learning programme included a session on working with —how to communicate the focus of the maker space curriculum and the programme aims and expectations. For themed programme, such as the Build a model city of the future programme, expectations include matters such as their child attending all sessions (that is meeting their commitments), being on time, cooperating with other children, exercising choice, working on tasks. The educators considered it was important that parents felt welcome and comfortable to leave their child to work within the programme and also the nature of the assistance parents could usefully offer. In some instances, this meant negotiating for a parent to stay for part of a session.

Decide and communicate who parents need to contact so that they can let the team know if their child will be late or not able to attend a particular session.

Recommendations:

- Ensure the programme focus and expectations are clearly communicated to parents.
- Ensure that all maker educators have thought through how to interact with parents who take over tasks from their child.
- Establish a contact person.

Regular post session reflection

Build regular post session reflections into the maker programme. These only need to be around five minutes and can be done while packing up. They are important in identifying how a session went and how to build on this for next time.

Recommendations:

- Include regular post session reflections with the whole team

Appendix 7: Website advertisement and registration

Hamilton City Libraries
TE OHOMAURI O KIRIKIROA

My account

[Home](#) / [What's on](#) / [Children's events](#) / [Build a model city of the future 2040](#)

Build a model city of the future 2040

The LAB

You are a city planner and your job is to design and build a future city for people to live in that is safe, sustainable and fun! You will design how people will live, move, play and learn. This will include simpler circuitry, coding, and other STEM activities. Are you up for the challenge?

This is a free 10 week programme, for children aged 9-12 years. Term 3 ends 24 September, with registrations full.

Term 4 (15 October - 17 December) registrations are now open- please fill in form below.

As part of the programme, you can choose to take part in a small research study to find out how to strengthen the LAB programme. For the research study, we will be asking for your consent for researchers to be part of the LAB sessions, talking to children and taking photos. Participation in the research is voluntary. Further details about the study can be found linked below.

This is a collaboration between Hamilton City Libraries, University of Waikato and Unlocking Curious Minds.



CURIOUS MINDS
HE HIRI I TE MAHARA



Wilf Malcolm Institute of Educational Research
Te Pūtahi Rangahau Mātauranga o Wilf Malcolm
THE UNIVERSITY OF WAIKATO

Contact information

Phone: 07 838 6893

Email: aaron.martin@hcc.govt.nz

Term 4 registration form

Parent/caregiver name

Contact email

Contact phone

Child's name

Gender

Age

School

Ethnicity

Submit

Upcoming event sessions

Thursday 17 September

Central Library

3:30pm - 5:00pm

Thursday 24 September

Central Library

3:30pm - 5:00pm

Thursday 15 October[Central Library](#)

3:30pm - 5:00pm

Thursday 22 October[Central Library](#)

3:30pm - 5:00pm

Thursday 29 October[Central Library](#)

3:30pm - 5:00pm

Thursday 5 November[Central Library](#)

3:30pm - 5:00pm

Thursday 12 November[Central Library](#)

3:30pm - 5:00pm

Thursday 19 November[Central Library](#)

3:30pm - 5:00pm

Thursday 26 November[Central Library](#)

3:30pm - 5:00pm

Thursday 3 December[Central Library](#)

3:30pm - 5:00pm

Thursday 10 December[Central Library](#)

3:30pm - 5:00pm

Thursday 17 December[Central Library](#)

3:30pm - 5:00pm

Links[**Letter of information and consent for parents**](#)

© 2020 Hamilton City Libraries Privacy Policy

Appendix 8: Cycle 1 activities and maker educators' reflections

Week	Activity	Maker Educator Reflections
1	<p>Introduction to the theme City of the Future</p> <ul style="list-style-type: none"> • Discuss ways for how we want to work in our makerspace • Icebreaker activity • Prompts with futuristic images to generate ideas • Brainstorming how we want to live, play, learn, move in 2040 on yellow stickers • Children vote for the ideas they'd like to include in their city using red dots and ranking system • Planning the layout of the city 	<ul style="list-style-type: none"> • Icebreaker worked really well • Keep reminding children about ways we work throughout sessions • Have lanyards and vests on all the sessions • Children's brainstorming ideas were good, suggest finding ways to capture this electronically, e.g. on a word cloud • Different coloured papers for the layout was useful to denote different utilities and earmarked spaces • Size of the base board to build the city was good • Too much talking for this first session?
2	<p>Living in the Future Checking/confirming city layout with children</p> <ul style="list-style-type: none"> • Children allocated into pairs, each pair given 3 pieces of cardboard to create their houses • Planning their designs on paper (2D)-> 3D • Initial building • Health & Safety (H&S) briefing on using hot glue gun, craft knives, etc. 	<ul style="list-style-type: none"> • Keep the icebreaker activity which was useful to socialise the group • Cardboard allocated was too stiff, hard to cut through, children took easy way out- folding instead a simplistic box-like design • Children had difficulty translating design on 2D to 3D • Suggest use of design nets next time to support and facilitate the physical house structure building • Issue with children following instructions regarding requirements for their house & building to scale • One maker educator could only watch 3 children cutting with knives at a time
3	<p>Living in the future</p> <ul style="list-style-type: none"> • Children work in pairs, continue with building • H&S on using hot glue gun • Reminder of requirements for their house buildings & scale • Reminder to children to bear in mind directions - N, S, E, W - as they will be adding solar panel to the buildings 	<ul style="list-style-type: none"> • Better prompts on how solar panel works and link with compass directions • Make sure children know what is in the resource box & plan what to use wisely (sustainably) • What didn't work well: dimensions didn't work out well due to last week (use of thick cardboard). Next time use cardboard NOT foldable boxes. • What worked well: Pair dynamics worked well - older and younger pairing -> tuakana-teina
4	NO SESSION – national Level 2 alert (COVID-19)	

5	<p>NO SESSION – National Level 2 alert (COVID-19)</p> <ul style="list-style-type: none"> • Take-home kit/resource for parents & children to pick up • Resource had cardboards, craft, circuit with instructions - LED, instruction regarding dimensions to go with their house. Instructions regarding solar panels placement and considering position of sun 	
6	<p>Living in the future</p> <ul style="list-style-type: none"> • Completing the houses • Attach circuits & solar panels hooked up and working • Attach houses and circuits to board 	<ul style="list-style-type: none"> • Agree that even in COVID-19 lockdown situation, we can make opportunities available to children through sent home kits. • Agree that it would be useful to see the extent children create their houses on their own without their pair using the kit materials (can compare the sophistication of what they have done with their pair work) • Agree to start the session by children sharing what they have done and take photos to document what each child had done with their kit over the week • Homework was useful <p>Key ideas to revisit next week and in analysis:</p> <ul style="list-style-type: none"> • Resources (limited resources) even in COVID lockdown, we can make opportunities available to children • Pairings • Sustainability issues
7	<p>Playing in the future</p> <ul style="list-style-type: none"> • Children design green spaces around their buildings • Option of working in pairs or different • Select green spaces on board to work on 	<ul style="list-style-type: none"> • Building takes longer than expected. More structure needed next time to facilitate this process • Show examples next time, some children need visual cue
8	<p>Playing in the future</p> <ul style="list-style-type: none"> • Children to focus on completing 1 equipment on the playground • Offer children origami option 	<ul style="list-style-type: none"> • More structure needed to support the building
9	<p>Playing and Living in the future</p> <ul style="list-style-type: none"> • Children to complete their designed green space • Start on wind turbine making activity (half of the group) 	<ul style="list-style-type: none"> • Relook into wind turbine material (electronics to increase voltage)
10	<p>Children complete their projects & end of programme celebrations</p>	

Appendix 9: Maker Educator Workshop 2 agenda

5 October 2020

9.00-9.30am	Discuss findings from parent interview and survey as a group
9.30-10.30am	Follow up on the findings in terms of (i) buildings (ii) how to include more STEM e.g. coding, robotics, 3D printer.
10.30-11.00am	Morning tea
11.00-12.00	Hands-on activities with Aaron (makey makey, and microbits, 3Doodler pen)

Appendix 10: Cycle 2 Overview of refined makerspace curriculum (Term 4)

Cycle 2 (Term 4) City of the Future Curriculum Overview of Weeks 1-10

Session Content

Week 1: Introduction to City of Future

Introduce children to the overarching theme of planning for Hamilton as the city of the future based on four areas- playing, living, moving and learning. Support children to plan, visualise and design what their future city might look like:

- follow Term 3 plan for Week 1—images of future, post it notes, dot stickers,
- introduce Nets (pre-cut template & materials) for children to consider and work through what shape the nets might look like,
- books for children to borrow/take home about future buildings/cities,
- some ideas:
 - [6 Sustainable Design Principles to Consider When Building Your Own Green Home](#),
- World's 33 MOST Unusual Buildings: https://www.youtube.com/watch?v=w44zd9Eu_I0 (13mins).

Week 2-3: Living the Future

1. Children will explore how 'living' in the futuristic city could look like (e.g., home/building designs, forms of sustainable energy) and get to design and create their own building and sustainable energy resource.
2. Introduction to design nets
 - Invite an architect in to talk to children about designing buildings.
 - Children design their own buildings on 2D then build (Drawn-design-build).
 - Use manila cardboards, different kinds of paper e.g. translucent paper.
 - Provide a variety of net templates for children to design and build. See two websites that touch on designing house nets:
 - <https://www.stem.org.uk/elibrary/resource/25323> see their package at https://www.stem.org.uk/system/files/elibrary-resources/2016/01/Package%20download_2.pdf also
 - <https://www.math-salamanders.com/paper-models-for-download.html> and scroll down to the different nets (tetrahedron, cube, truncated 3D shapes, the house example from the above website, square based pyramid, hexagonal pyramid).
 - Prepare box of resources for children—show children so they know how much material is available to use for the term.
 - Prepare personal box for children to keep houses in or to take home to work on
 - Books for children to borrow.

Week 3: Living in the Future

Children to complete their:

1. Construction.
2. Chibitronics circuit—discussion on circuits (parallel vs serial), testing it out to see if it works
 - Chibitronics & makey-makey—see video at: <https://www.instructables.com/Makey-Makey-Chibitronics-Light-up-Houses/>.
 - See step-by-step instructions at <https://content.instructables.com/pdfs/E8A/3TBJ/K02P4IRW/Makey-Makey-Chibitronics-Light-up-Houses.pdf>

- Video explanation of serial vs parallel circuits:
<https://www.youtube.com/watch?v=js7Q-r7G9ug>
- <https://www.youtube.com/watch?v=HOFp8bHTN30>

Week 4: Living & Moving in the Future

1. Children to have completed their construction. Lights via Chibitronics circuit to be working by this lesson.
2. Children will visit how might 'moving' in the futuristic city might look like (e.g., transportation (air, road, sea), roading system) and create a roading system and an example of a futuristic form of transport.
3. Brainstorm 'moving' in the future— how to get around, plan layout on the city

Week 5: Moving in the Future

Children divided into two groups:

1. Road system – build towards the inclusion of traffic lights and coding with Scratch
2. Car design – circuitry for moving cars

Week 6: Living in the Future

Building other supporting buildings in the city – emergency services, food supply etc

- Children design their own buildings on 2D then build (Drawn-design-build)
- Use manila cardboards, different kinds of paper e.g. translucent paper
- Provide a variety of net templates for children to design and build

Week 7: Living in the future

1. Children to complete their buildings
2. A focus on sustainable energy resource - introduction to solar panels, what they are, how they work
 - Video on how solar panels work, where they are best placed, consider orientation of buildings e.g. Science Learning Hub solar power explanation:
<https://www.sciencelearn.org.nz/resources/1582-solar-power>

Week 8: Living in the future

Connecting the buildings up to light up using:

- Circuits & Makey-makey kits.

Week 9: Playing in the Future

Children will explore ideas on how 'playing' in the futuristic city might look like (e.g., playground designs and equipment/toys) and get to design and create their own playground artifact. Children to design and create one example of a playground equipment for learning in the future.

- Go through Drawn-design-build process

Week 10: Completing projects & Exhibition

1. Children to complete their playground equipment & any other things to be completed.
2. Offer children origami session to create things that will complement the city.
3. A celebration of children's achievements. Children to present their model of the City of the future- Hamilton in 2040.

Appendix 11: Cycle 2 Activities and maker educators' reflections

Week	Activity	Weekly Maker educator reflection
1	<p>Introduction to the City of the Future</p> <ul style="list-style-type: none"> • Welcome & Icebreaker & introducing ways of working in our makerspace • Prompts with futuristic images and introduction to the 4 areas of living, moving, learning and playing in 2040 • Brainstorming ideas in groups how we want to live, play, learn, move on yellow stickers • Voting for ideas with red dots, ideas with the most red dots gets included • Instructions for what we will be working on over the next few weeks <ul style="list-style-type: none"> – children to design, create individual futuristic house within parameters given and add in electric circuits – Aaron shows a model house that has been built with retractable roof and chibitronics lighting system as a guide • Planning the layout of the city as a group using multi-coloured cards. Discussions about logistics of placement of utilities around the city. Brainstorming other facilities possible for the future city • Using design nets to introduce children to 3D shapes 	<ul style="list-style-type: none"> • Icebreaker worked well and to keep it • Keep reminding children about ways we work throughout session • Introducing the design nets this first week was good to get children to start to make/create • Next week to print nets onto cards so children can easily cut out • Guide children to narrow down their brainstormed ideas to the top 5 buildings to create for the city • This term the emphasis is on the Design- draw-make cycle • Inviting an Architect for next week's session to give an overview of designing buildings
2	<p>Living in the Future</p> <ul style="list-style-type: none"> • Invited speaker—Mr Brian Squair from ChowHill Architects—provided an overview of ideas for designing buildings. • Bringing children to the reference section books on architecture to go through and get more ideas for their houses that they will be creating. • Children sketch their initial designs of their futuristic house they will be creating—offering shape of house, front view, side view, top down view. • Discussions with maker educators regarding their design ideas from Brian and books. Children borrowed some books to take home to continue working on their design. 	<ul style="list-style-type: none"> • Invited speaker was excellent and gave children lots of different ideas and scope to work with. • Good idea for children to canvass ideas from architecture books. • Some children struggled with getting ideas on paper even though conceptually they can visualise their potential house designs (disconnect between ideas in mind with on paper). • Next week: Suggest to bring out the house model to prompt children on drawing the front, side and top down (bird's eye view). <ul style="list-style-type: none"> – Emphasis on design is crucial to ensure robust creations. Start with simple activities to guide children to translate what their design could look like then only build.

		<ul style="list-style-type: none"> • Next week: To prepare box kits for children to keep working on their projects at home.
3	<p>Living in the future</p> <ul style="list-style-type: none"> • Maker educators go through children’s designs and discussions with children about their house design. Offered guidance where needed. Emphasis on front view of building designs and less on the interior for now. • Children reminded about the parameters of their building & issues about the scale of their building. • Children introduced to box of resources (design nets, straws, boards, different coloured materials, etc) they can draw from when they are ready to build their designs. • Health & safety briefing on using tool (hot glue guns, craft knives), designated areas to work safely. • Children whose designs have been signed off commence building using resources. 	<ul style="list-style-type: none"> • Emphasis is still on design thinking today. • need to watch out for children who may find the task challenging and to offer more support. • Next week: To focus the first half of the session on building and then second half on creating green spaces for playing/recreation. • Children can bring their house home to complete.
4	<p>Living in the future</p> <ul style="list-style-type: none"> • Some children finalised their designs this week. • All children start working on their buildings using different resources. • Some had parents come in to assist. • Maker educators facilitate and assist where needed. 	<ul style="list-style-type: none"> • Some children struggled with the concept of leaving the roof open so that they could add in circuits later. Suggest more guidance for this aspect in the future. • Some children found it a challenge translating what they had planned into what they were making and so focus shifted to an evaluation of their creation rather than accuracy of translation from 2D to 3D. • The buildings for this cycle embodied a number of different approaches to the design and creation - children had taken on board what the architect said as this was reflected in their buildings.
5	<p>Living in the future</p> <ul style="list-style-type: none"> • Focus on circuits this week. • Children introduced to circuits, wiring, LED light, resistors, copper tape and chibitronics. • Children shown model house with completed circuits to prompt thinking. • Discussions on how to complete circuits, role & use of resistors, testing of LED, role switches, use of copper tape & chibitronics. • Children guided in stages to complete their circuits. Reminded to include their circuits in their houses. 	<ul style="list-style-type: none"> • Hands-on session went well. • Good idea to progressively guide children through circuitry. • Good mix of DIY activities followed by some design drawing. • Children working in pairs—some good collaborative interactions. • Next time: to introduce children to makey makey. • Next week: Children to finalise their utility design and builds.

	<ul style="list-style-type: none"> • Second half of session, children brainstorm other facilities/utilities for their city, vote on which ones to work on. They work in pairs to design their facility together. 	
6	<p>Living in the future</p> <p>Children continue working on their designs and making their buildings.</p>	<p>Not many children could attend the session.</p> <p>Suggest to reconsider timing of the programme in Term 4 as it is a busy time for parents, schools and children.</p>
7	<p>Living in the future</p> <ul style="list-style-type: none"> • Children introduced to TinkerCad, online modelling programme, to support their thinking in 3D terms. • Children guided to work through the resource: <ul style="list-style-type: none"> - Build a TinkerCad House - https://www.instructables.com/Create-the-Walls-of-the-House-1/ • Children work on individual iPads and worked through the resource sheet with guidance where needed. • Once they completed the exercises they were encouraged to develop their own 3D drawings for their buildings. 	<ul style="list-style-type: none"> • Working with TinkerCad was a useful experience for children. • This can be built early into the introductory sessions to support the 2D-3D translation of design ideas. • Children who finished early started modelling their buildings. It was really good to see their drawing take shape using Tinkercad. • Future thoughts: Since TinkerCad was a successful session, could look into some unplugged activities prior to the children using it so they get into the frame of thinking faster and might be helpful for those unfamiliar with it.
8	<p>Living in the future</p> <ul style="list-style-type: none"> • Children continue to make their buildings based on planning from last week's TinkerCad modelling. • Children reminded about parameters for their building and to allow space inside their buildings to add chibitronics circuit. 	<ul style="list-style-type: none"> • Children are more focused on their buildings and ready to go after having had rounds of designing and trialling. • Those who had clearer designs, builds were clearer. • Use of TinkerCad was valuable. • To watch out for dynamics in some children pairings. • Next week: focus on electronics for the buildings, use makey makey kits. • Future: Suggest from Week 1 to introduce 2D then 3D on 3D model to help children visualise designs.
9	<p>Living in the future</p> <ul style="list-style-type: none"> • Children continue with building their public buildings today and finish them up. • Addition of circuitry to their buildings. • Children who have completed their buildings experimented with single and parallel circuits, adding in copper tape to build circuits, attach to makey makey and created switches to control their circuits. 	<ul style="list-style-type: none"> • Hands-on building and circuitry development work went well. Good to see children experimenting and problem solving with different circuits and kinds of circuitry to suit their building design. • Use of makey makey was new but good problem solving experience for children.

	<p>Some children were working with multiple circuits for their building design.</p> <ul style="list-style-type: none"> • Maker educator provided support where and as needed. Continued having valuable conversations with children about strengthening their designed buildings to prompt thinking. 	<ul style="list-style-type: none"> • Discussions with children around strengthening their building design was valuable as some children came up with very innovative ideas. • Observations of children growing in confidence over the past few weeks in thinking, working through and voicing their ideas and their making their creations in a variety of innovative ways. We saw examples of learning actions – measuring and cutting to scale, working with materiality of cardboard and different resources for building, working out hinges and angles to place hinges to connect parts of a building together, etc.
10	<p>Display and End of the project celebration</p> <p>Children add finishing touches to their creations. Final display of our City.</p> <p>Celebrations & Certificate giving</p> <ul style="list-style-type: none"> • Children who wanted to continue developing their buildings could take home extra resources (resistors, wires etc.). • Children could leave their building in the library for the next week for public display before collecting them to take home. 	

Appendix 12: Makerspace curriculum sample lesson plans Introduction

Introducing City of the Future (Session 1)

Lesson Plan:	City of the Future - Hamilton in 2040
--------------	---------------------------------------

Week:	Week 1 of 10
Subject:	Introducing the theme City of the Future
Topic:	Explore ideas on futuristic cities & designing the layout of a potential city
Session Duration:	1 ½ hours

Objective: For children to learn about:
<ol style="list-style-type: none"> 1. Introduce children to the scenario /big picture overview of what the next 10 weeks will involve. 2. To think about the location of buildings and green space in a way that is beneficial to ppl and the environment. 3. Give children opportunity to input and communicate ideas. 4. Give children opportunity to spatially visualise their city, design and build it 5. 3D spatial visualisation—consider space and elements within the space (geometry and geography). 6. To plan how ppl will move between these spaces (spatial awareness). 7. Critical thinking about the practicality of where elements of the city are placed - health and safety. 8. Understanding of sustainability/ limitations in resources (STEM).

Materials/Equipment
<ul style="list-style-type: none"> ● Board to build the city on (2x2m). ● Paper, pencils and markers—for designing, sketching drawing plans ● Coloured paper—e.g., blue for river, or white for Main Street or green for green spaces, grey for bridges. ● Scissors, colour pencils. ● Yellow post-it stickie notes. ● Red sticker dots for voting.

Session outline:		
Tasks	Activity Description	Maker educators to consider
Background	Have pictures/images of future cities & buildings playing in the background as children enter the room.	Maker educators to prepare materials ready Have welcoming packs ready for children—name lanyard, vests.

<p>Introducing the theme (10 minutes)</p>	<p>Introduce ourselves—Aaron and Lauren (Aaron).</p> <p>Safety brief and principles (Lauren).</p> <p>Kids will introduce themselves.</p> <p>Ice-breaker activity with children.</p> <p>Overview for 10 weeks (Aaron).</p> <p>Introduce children to the scenario. Scenario: Hamilton City is wanting to develop a 20-year plan. They have asked us to find out your ideas so that we are building a city of the future for and with you: <i>A city friendly to children is a city friendly to all.</i></p> <p>The city needs to include the activities you love to do and the kind of places you'd like to go.</p> <p>Your views are important as you will be part of this city.</p> <p>So how do you want to live in the year 2040?</p> <p>If you have the ability to design and build a city for the year 2040, how would you start?</p> <ul style="list-style-type: none"> - How would you like to live? - What would it look like? - Who would you build it for? - What would you put in it? <p>Take children on a virtual field trip to visit some of the futuristic cities in the world: The world's 9 most futuristic cities article: https://www.orbitz.com/blog/2015/05/worlds-futuristic-cities/</p> <p>This building on wheels could be the future of architecture: https://edition.cnn.com/videos/tv/2020/11/06/charles-renfro-spc-intl.cnn/video/playlists/saved-by-the-future/ (2min 36sec)</p> <p>Ted Talk - 7 principles for building better cities https://www.youtube.com/watch?v=IFjD3NMv6Kw (start from 7mins-12mins)</p>	<p>Maker educators to check childrens' understand of the meaning of terms.</p> <p>What do you notice on these pictures and what makes it futuristic?</p> <p>Ask children: What does sustainable mean? Where have you heard it before?</p> <p>Have links to images/videos ready.</p>
<p>Brainstorming ideas (5 minutes)</p>	<p>Brainstorm the above questions with children. Break into small groups and brainstorm onto post-it-notes.</p> <p>Place Questions (on walls around the room)</p> <ol style="list-style-type: none"> 1. How do you want to live in 2040? 	<p>Maker educators to hand out post-it notes and pens to children.</p> <p>Maker educators to: - encourage children to share ideas e.g.,</p>

	<p>What is an example of a space you want to live in?</p> <ol style="list-style-type: none"> 2. How do you want to play in 2040? 3. How do we want to learn in 2040? 4. How do you want to move around in 2040? <p>Come back together as a group and discuss ideas on the board.</p>	<p>discuss how neighbourhoods and communities around them look like, function and/or differ, based on where they are located, why they are important, what makes them unique, what features would they keep or change if they were designing the city for the future.</p>
Discussing ideas	<p>Brainstorming must-haves</p> <p>What things do you like about our city i.e., park, pools, library, etc?</p> <p>What are some things you don't like? Do you wish you could walk or bike to school instead of taking the bus?</p> <p>Write down ideas/solutions onto post-it notes.</p> <p>What will we have in our city?</p> <ul style="list-style-type: none"> - Homes (neighbourhood). - Shops. - School. - Park. - Power station. <p>How will we divide our city up i.e., homes, green space, school, power station, etc.</p> <p>How will people get around?</p> <ul style="list-style-type: none"> - Car/bus—roads. - Bike—bike paths. - Walk—footpaths. <p>Ideas go onto board.</p> <p>The group decides what are the must haves...</p> <p>These are the must haves in our current city. Are these what you want in 2040?</p> <p>The group can refine their ideas on the wall.</p>	<p>Maker educator to encourage them to come up with creative new ideas, or improvements on traditional playground equipment. The idea is encouraging children to generate creative ideas</p> <p>20-minute cities Must haves:</p> <ul style="list-style-type: none"> • Transport Centre • Emergency Services: <ul style="list-style-type: none"> - Hospital/Dr. - Fire Service. - Police. • School. • Housing. • Supermarket. • Power source. <p>Plus 2 others (children to choose).</p>
Voting	<p>Children get two dots to vote from the list of ideas brainstormed. They can get 2 more for extra fun must haves...</p>	<p>Note: Remind children not all ideas were accepted- democracy.</p>

<p>Planning the layout</p>	<p>Draw children’s attention to the board/space they will use to create elements of their future city.</p> <p>Children will work together to map out the physical shape of their city based on` the top voted design.</p> <p>Use city planning cards and position possible layout of i.e., buildings, power station, green space, etc.</p> <p>Cards:</p> <ul style="list-style-type: none"> • Green for playground. • Red for power station. • White for houses. • Grey for buildings. <p>Once the layout plan has been decided. The group will look how roads, footpaths, cycleways will connect with each space. Also look at pedestrian crossings, round-about, trees, flowers, etc.</p> <p>Where will our roads, footpaths and cycle ways go?</p> <p>Position the roads, footpaths, cycleways between the cards.</p> <ul style="list-style-type: none"> - Power lines and water works i.e. household water and wastewater. 	<p>Think about how the spaces will interact and connect with each other</p> <p>Think about location of spaces i.e., power station next to houses</p> <p>Mark with pencil What if your cycleway crosses a road?</p>
<p>Mapping the layout physically to scale (15 minutes)</p>	<p>Use coloured and white cards to place location of different city elements.</p> <p>(Note: these cards are the foundation for the city but can be rearranged later as children develop each area of the city.)</p>	<p>Maker educators to moderate organisation of children.</p> <p>Maker educators prepare assorted colour and white cards (to scale) for children to place where their city elements will be located. Have extra empty cards ready in case children come up with new ideas of where they would like to place things</p> <p>Take a photo in case cards get lost/blown away.</p> <p>Save this as a record for next 9 weeks as things may get rearranged over time as the city gets built up.</p>

<p>Making—Design Nets</p>	<p>Children will be introduced to sample design nets to cut out and start to visualise shapes for possible buildings.</p> <p>Two websites that touch on designing house nets: https://www.stem.org.uk/elibrary/resource/25323</p> <p>See their package at https://www.stem.org.uk/system/files/elibrary-resources/2016/01/Package%20download_2.pdf https://www.math-salamanders.com/paper-models-for-download.html</p> <p>And scroll down to the different nets.</p>	
<p>Extension Activity</p>	<p>Introduce children to the City Creator software where they will get to build their own city: http://www.citycreator.com/</p> <p>Short training session to explain to children how the software works.</p> <p>Allow children time to create their city.</p> <p>LEGO Challenge #2: Build that Bridge! http://www.clubscikidzmd.com/march-break-resources-activities/wednesday-5-6-build-that-bridge/</p>	<p>Maker educators to have preloaded iPads with the link to the city.</p> <p>Maker educators to help with technical difficulties.</p>

Resources:

Ideas for introducing city of the future:

<https://www.education.com/download-pdf/activity/174841/>

<https://www.sciencelearn.org.nz/resources/2439-futures-thinking-toolkit>

<https://www.sciencelearn.org.nz/resources/2438-teaching-futures-thinking>

<https://www.sciencelearn.org.nz/resources/459-mapping-the-future>

Appendix 12a: Lesson Plan — Ideas for Living Building the infrastructure Session 1

Lesson Plan:	City of the Future - Hamilton in 2040
Subject:	Infrastructure (Session 1)
Topic:	Building our house - Explore ideas on futuristic buildings
Session Duration:	1 ½ hours

Objective: For children to learn about:

1. To think about the location of buildings and green space in a way that is beneficial to people and the environment.
2. Give children opportunity to input and communicate ideas.
3. Give children opportunity to spatially visualise their city, design and build it.
4. 3D spatial visualisation—consider space and elements within the space (**geometry and geography**).
5. To plan how ppl will move between these spaces (spatial awareness).
6. Critical thinking about the practicality of where elements of the city are placed—health and safety.
7. Understanding of sustainability/ limitations in resources (**STEM**).

Materials/Equipment

- Paper, pencils and markers—for designing, sketching drawing plans.
- Scissors, colour pencils, arts and craft material.
- Box of recycled materials for children to use and build their buildings.

Session outline:

Tasks	Activity Description	Maker educators to consider
Introduction to buildings of the future (5 minutes)	<p>Discuss with children what futuristic buildings might look like. Show one of the following examples:</p> <p>What a Living Building is made of (5mins) https://www.youtube.com/watch?v=3ryQmLa06yA</p> <p>The Living Building Challenge: New Zealand's First Living Building (2mins 41sec) https://www.youtube.com/watch?v=jxFCglWNB R8</p> <p>6 Sustainable Design Principles to Consider When Building Your Own Green Home</p> <p>World's 33 MOST Unusual Buildings: https://www.youtube.com/watch?v=w44zd9Eu_I Q (13mins)</p>	Maker educators to have links ready, be aware of big terms to explain to children.

	<p>Why great architecture should tell a story (Ted talk) (16mins). https://www.ted.com/talks/ole_scheeren_why_great_architecture_should_tell_a_story?language=en#t-428596</p> <p>Mystery Science—building a house out of sustainable resources: Could you build a house out of paper?</p>	
<p>Generating ideas (5 minutes)</p>	<p>Brainstorm some ideas on the kinds of homes, offices, buildings might look like on a post-it notes. (Note: 5-10 ideas.)</p>	<p>Maker educators to hand out post-it notes and pens to children.</p> <p>Encourage children to brainstorm.</p>
<p>Designing our building & getting feedback (15 minutes)</p>	<p>Draft and design on paper their building (home, office, library, supermarket).</p> <ul style="list-style-type: none"> - Reiterate instruction: How would you like to live in the future? What might your home, building, office etc., look like if you were to create one? - Explain to children—they will be designing and building a sample building for living in 2040. Everyone will be responsible for designing and making a 3D model of building. They will be working in pairs. These will be <u>arranged together around the playground</u> safely, independently to make up the city. Their buildings will be powered by at least one source of sustainable energy. - Children will draft, sketch and design their buildings of the future. - Instructions for children: <ul style="list-style-type: none"> • If they are building a public/community building, their building needs to be accessible to everybody (all age groups, people with disabilities etc.). • In your design you can consider height, wide, shape, etc. (maximum 5 features). <p>Instructions: <i>House must have:</i></p> <ul style="list-style-type: none"> - Entrance (doorway). - Windows x 3. <p><i>House scale dimensions</i></p> <ul style="list-style-type: none"> - Height 8cm - Length 15cm - Sides 10cm <p>LED light and mini solar panel attached.</p>	<p>Maker educator to encourage them to come up with creative new ideas, or improvements on current building designs. The idea is to encourage children to generate creative ideas.</p> <p>Maker educators to bear questions below in mind and ask children to help them consider and evaluate their design.</p> <p>Maker educators to take note of what building each pair is designing to ensure there is a variety of type of building.</p> <p>Maker educators to prepare cards with building types ready for children to place where their buildings will be located. Have extra empty cards ready in case children come up with new ideas of where they would like to place things.</p>

	<p>Feel free to add you own artistic design and look.</p> <p>Ask children to share their ideas -why or why not? Get some feedback from peers, staff to improve their design.</p>	
<p>Mapping the layout of their building (5 minutes)</p>	<p>Children will then discuss as a big group to work out where they would place their buildings in the city.</p> <ul style="list-style-type: none"> - Use cards to indicate where things are placed. 	<p>Maker educators to moderate organisation of children.</p>
<p>Making/Creating phase (20 minutes)</p>	<p>Children will start making their buildings.</p> <ul style="list-style-type: none"> - Keep for next week if they have not finished. 	<p>Maker educators to have arts and craft resources available.</p> <p>Maker educators to assist children with cutting, folding, gluing etc.</p> <p>Maker educators to bear questions below in mind and ask children to help them consider and evaluate their design and artifacts as they make them.</p> <p>Note: Please take at least 2 photos of each child at work so we can compile a picture book of their learning journey.</p>
<p>Extension activities</p>	<p>Activities</p> <p>Using TinkerCad to help children design their ideas in 3D:</p> <ul style="list-style-type: none"> - Build a TinkerCad House: https://www.instructables.com/Create-the-Walls-of-the-House-1/ - Tangrams for different geometrical shapes: https://www.tangram-channel.com/tangram-puzzles/geometrical-shapes-easy/ <p>Have paper templates for potential buildings ready in case children run out of ideas/need help to design 3D buildings:</p> <ul style="list-style-type: none"> - https://www.education.com/worksheets/?q=%22build+a+city%22 (paper templates for 3D houses, buildings, houses, police station). 	<p>Maker educators to have iPads/Chromebooks available. Need to be familiar with the video links</p>

	<ul style="list-style-type: none">- 3D House template: https://www.pinterest.nz/pin/52002570667761783/- 3D Paper House Children's Craft: https://www.youtube.com/watch?v=MBnRhcpya2U- Designing an energy efficient house (look for levels 3-4): https://www.schoolgen.co.nz/teachers/resources/	
--	--	--

Appendix 12b: Lesson Plan — Ideas for Living Building the infrastructure Session 2

Lesson Plan:	City of the Future – Hamilton in 2040
--------------	---------------------------------------

Subject:	Infrastructure—Session 2
Topic:	Building our house
Lesson Duration:	1 ½ hours

Objective: For children to understand:
<ul style="list-style-type: none"> • How will people will get to difference spaces i.e., bus, walk, bike and build suitable roads, footpaths, and cycle ways. • Design and build roads, paths, cycles, and other city utility elements.

Materials/Equipment
<ul style="list-style-type: none"> • Board to build city on 2x2m. • Paper, pencils, and markers—other arts and crafts. • Card. • Glue. • Planning cards. • Box of recycled materials for children to use.

Lesson outline:		
Tasks	Activity Description	Maker educators to consider
Introduction	Re-cap on last week.	Prepare arts and crafts materials for this week’s activity.
	<p>Brainstorm: Where will our roads, footpaths, cycle ways go?</p> <p>Once the layout plan has been decided the group will look how roads, footpaths, cycleways will connect with each space. Also look at pedestrian crossings, round-about, trees, flowers, etc.</p> <p>Position the roads, footpaths, cycleways between the scale cards.</p>	
Making session	<p>Pairs will build roads, footpaths, cycle lanes, pedestrian crossing, round-about.</p> <p>Build terrain element i.e., small hill, round-about, etc. Also, trees, flower, etc.</p>	<p>What do roads, footpaths, cycle lanes look like?</p> <p>The space will be flat.</p>

	<p>Roads, footpaths, cycle ways will need to be built to scale.</p>	<p>paint, brushes, drop cloth, etc.</p> <p>What colour is road and markings, footpath (how do we identify the difference between each of these.</p> <p>Papier mache for terrain.</p>
--	---	--

Appendix 12c: Lesson Plan — Ideas for Playing Session 1

Playing in the Future

Lesson Plan:	City of the Future—Hamilton in 2040
Subject:	Play: Designing Hamilton’s best playground in 2040 (Session 1 of 2)
Topic:	Thinking and creating our playground layout
Session Duration:	1 ½ hours

Objective: For children to learn about:

1. 3D spatial visualisation—consider space and elements within the space (**maths—geometry and geography**).
2. Critical thinking about the practicality of where things are placed—health and safety.
3. Understanding of sustainability/ limitations in resources (**STEM**).
4. Building models to scale using a range of materials available from the household, from arts and crafts materials to digital resources (**maths & measurement, arts**).
5. Communicating their ideas, and selecting the best design/plan (e.g., in a democracy).
6. Building 3D models using recyclable and arts and crafts material (**maths and art**).
7. How to drag and drop digital images into the relevant place to develop spatial awareness using a freely available online programme [extension activity] (**digital technology**).

Materials/Equipment:

- To scale cards of the elements that they might like to use—hill, pond, swing, slide, roundabout, merry-go-around, tree, board games, water feature, bushes, pathway.
- Paper, pencils and markers—for designing, sketching drawing plans.
- Post-it notes—for jotting initial ideas.
- Sticker dots—at least 5 for each child.
- Arts and craft materials—coloured cardboard & paper, scissors, glue, tape-double sided & sellotape, straw, string, crayon and felt pens, material, sponges, paint, brushes, newspaper, hot glue guns, foams/sponges, egg cartons, paper cups/interesting shaped containers that can be used to form contours of a playground (plates, bowls, plasticine, modelling clay, buttons, blue tack etc.).
- iPads (to be tested) x 10 for those who would like to take part in the extension activity.

Session outline:

Tasks	Activity Description	Maker educators to consider
Introduction (5 minutes)	<p>What does play look like in 2040? Setting the scenario [show images and examples]</p> <p>Narrative Prompt: A safe space of children to play is very important. What are the kinds of play areas that you can think of that you really like? How would you like to play in the future?</p> <p>Today, our challenge is to create a plan for a futuristic playground. We want you to design Hamilton’s best playground in 2040.</p>	Maker educators to have links ready.

	<ul style="list-style-type: none"> - What do you think your playground could look like if you were to create one? - What will you include/won't include? Why? - What will your playground look like? Do? <p>Here are some ideas from others: Futuristic playground designs</p> <p>https://www.pinterest.nz/pin/313703930273542177/?e_t=84a56c7308ab4e78a548f6da9cf326dd&utm_source=31&utm_medium=2004&utm_campaign=rtpinrecs&utm_content=31370393027354217&utm_term=8</p> <p>https://theimaginationtree.com/inspiring-outdoor-play-spaces-kids/</p>	<p>Maker educators have prepared images on walls/shared with children.</p>
<p>Generating ideas (5 minutes)</p>	<p>Look at some of the playgrounds in Hamilton—Destination playgrounds.</p> <p>This is the green space that we have to build our playground (dimensions).</p> <p>The features and elements our playground must have:</p> <ul style="list-style-type: none"> - hill (how can we use the hill as part of the playground design i.e., tunnel, slide, etc. - trees, - pathways, - water feature (pond), - bridge. <p>Brainstorm some ideas on what your playground might look like on a post-it notes:</p> <ul style="list-style-type: none"> - Group brainstorming of ideas for playground (Note: 5-10 ideas). - Emphasise that there needs to be equipment that everybody can use (all age groups, people with disabilities etc. In your design you can include bridges, water features, trees/bushes, pathways, animals, etc. but it <u>must include</u> at least a hill, some form of water, pathways, some greenery (maximum 5 features). - Include up to 5 pieces of play equipment in your design (e.g. swings, ladders and slides, seesaws, sandpits, mazes, chess/draught/snakes and ladders board game, flying fox). 	<p>Maker educators to hand out post-it notes and pens to children.</p> <p>Encourage children to brainstorm—5 pieces of play equipment our playground must have.</p> <p>Prepare Instructions for children.</p>

<p>Giving and receiving feedback (10 minutes)</p>	<p>Ask children to share their ideas—why or why not? Get some feedback from peers, staff.</p> <p>Children need to get feedback from 3 different people in the group and to use the feedback to evaluate and improve their ideas.</p>	<p>Maker educators to draw from questions bank to prompt children.</p>
<p>Designing the layout and equipment (10 minutes)</p>	<p>Draft and design on paper the layout and equipment.</p> <p>It must include the elements and play equipment</p> <ul style="list-style-type: none"> - What do you think your playground could look like if you were to create one? - Explain to children—you will be designing a model of the best playground for 2040. Everyone will be responsible for designing and making a 3D model of at least one piece of equipment for the playground. These will be arranged together to make one big playground model. 	<p>Maker educator to encourage children to come up with creative new ideas, or improvements on traditional playground equipment. The idea is encouraging children to generate creative ideas.</p>
<p>Choosing the design for our city (5 minutes)</p>	<p>Take all the elements of what they like and vote.</p> <p>Use to scale cards element cards hill, pond, swing, slide, roundabout, merry -go-around, tree, board games, to test playground designs on board.</p> <p>Compile everyone’s ideas on the wall. Vote on top 3 designs (layout and equipment). Then choose 1 top design that the group would like to make.</p> <p>Also allocate the different features (water, bridge, animals, greenery, pathway, etc.) to be made to different children.</p> <p>Each child can choose 1 piece of equipment they would like to create (for next week when they work in pairs).</p>	<p>Maker educators: You can also give each child 3 sticky dots to vote for their top 3 designs/ideas on the list. This will produce the shortlist of ideas to be included in the playground model. Children can nominate the piece of equipment they will design.</p> <p>Maker educators to take note of what each child has chosen to create and see who they can potentially pair up for next week’s activity if they are making similar equipment.</p> <p>Maker educators to prepare cards for children to place where their playground elements will be located, have extra empty cards ready in case children come up with new ideas of where they would like to place things.</p>

Organisation (5 minutes)	Instruction: Pairs of children will choose 1 piece of equipment from the chosen design to make. Pairs will be given a limited amount of materials to use.	Maker educators to allocate children to pairs and pieces of equipment to be made.
Training session (10 minutes)	Activities: - Papier Mache to form the layout for playground. - introduction to tangrams. - Templates for potential equipment.	Maker educators to have arts and craft resources available.
Making/Creating the model	<p>The group will start to make the elements of the playgroup i.e., hill, trees, water feature, bridge, pathway, using craft materials and papier mache.</p> <p>Note: papier mache will need time to dry. Note: Materials for elements will be limited.</p> <ul style="list-style-type: none"> • Pairs will start building their playgroup equipment using craft materials (each pair will have limited materials to build with). • Use arts and craft material to form features of the playground. <p>Note: Playground features will need to be built to scale.</p>	<p>Maker educators to assist children with cutting, folding, gluing etc.</p> <p>Maker educators to bear questions below in mind and ask children to help them consider and evaluate their design and artifacts as they make them.</p> <p>Note: Please take at least 2 photos of each child at work so we can compile a picture book of their learning journey.</p>
Extension activities	<p>Activities:</p> <ul style="list-style-type: none"> - Introduction to tangrams, origami to fold and create the elements for their playground. - Have paper templates for potential equipment. - Consider how do you make the trees stand up or animals to prop up. <p>Origami video tutorials https://www.youtube.com/watch?v=cZdO2e8K29o—butterfly, flowers (need test note squares)</p> <p>How to make 3D tangram video tutorials https://www.tangram-channel.com/crafts-activities/3d-tangrams/3d-tangrams-templates/</p> <p>How to create animals etc with tangrams: https://www.tangram-channel.com/tangram-solutions/</p> <p>3D Paper templates of different shapes https://www.math-salamanders.com/paper-models-for-download.html</p> <p>Homemade Marble Runs</p>	Maker educators to have iPads/Chromebooks available. Need to be familiar with the video links and how to make the shapes beforehand.

	<p>https://buggyandbuddy.com/10-awesome-homemade-marble-runs/</p> <p>3D tree Template https://www.pinterest.nz/pin/378795018643309654/</p> <p>Use Drop and Drag Playground Designer to build a 3D model of your playground: https://playgroundideas.org/introducing-the-drag-drop-playground-designer/#</p> <p>Designing your own playground: https://playgroundideas.org/three-ways-to-create-your-own-playground-design-plans/</p>	
--	---	--

Appendix 12d: Lesson Plan — Ideas for Playing Session 2

Playing in the Future

Lesson Plan:	City of the Future—Hamilton in 2040
Subject:	Play: Designing Hamilton’s best playground in 2040 (Session 2 of 2)
Topic:	Thinking and creating our playground equipment
Lesson Duration:	1 ½ hours

Objective: For children to learn about:

1. 3D spatial visualisation—consider space and elements within the space (**geometry and geography**).
2. Critical thinking about the practicality of where things are placed—health and safety.
3. Understanding of sustainability/ limitations in resources (**STEM**).
4. Building models to scale using a range of materials available from the household, from arts and crafts materials to digital resources (**maths & measurement, arts**).
5. Communicating their ideas, and selecting the best design/plan (e.g., in a democracy).
6. Building 3D models using tangrams, origami to build models (**maths**).
7. How to drag and drop digital images into the relevant place to develop spatial awareness using a freely available online programme [extension activity] (**digital technology**).

Materials/Equipment:

- Paint and brushes.
- Arts and craft materials—coloured cardboard & paper, scissors, glue, tape-double sided & sellotape, straw, string, crayon and felt pens, material, sponges, paint, brushes, newspaper, hot glue guns, foams/sponges, egg cartons, paper cups/interesting shaped containers that can be used to form contours of a playground, marbles/ball bearings.
- Coloured paper for tangrams and origami.
- iPads & Chromebooks for those who would like to view the tutorial on how to make tangram shapes and origami.
- iPads (to be tested) x 10 for those who would like to take part in the extension activity.

Session outline:

Tasks	Activity Description	Maker educators to consider
Recap (5 minutes)	Recap from last week’s session—focus on designing the best futuristic playground for Hamilton in 2040.	Maker educators be aware that some children might have missed last week’s session and might need to go through the session.
Making session (remaining time)	<ul style="list-style-type: none"> - The group will continue to make elements if needed. The group will paint and add final detail to elements <ul style="list-style-type: none"> - Pairs will continue to build their playgroup equipment using craft 	Maker educators to have paint and brushes ready. Need to keep time so children don’t go overboard.

	<p>materials (each pair will have limited materials to build with).</p> <p>Note: Can use straws as braces for swings, trees, bridges, slides, swings, roundabouts, big board games, mazes, puppet theatre.</p> <p>Note: Playground equipment will need to be built to scale</p>	<p>Maker educators to have arts and craft resources available.</p> <p>Maker educators to assist children where needed.</p>
<p>Extension activity</p>	<p>Potential activities:</p> <ul style="list-style-type: none"> - Introduction to tangrams, origami to fold and create the elements for their playground. - Have paper templates for potential equipment. - Consider how do you make the trees stand up or animals to prop up. <p>Origami video tutorials https://www.youtube.com/watch?v=cZdO2e8K29o—butterfly, flowers (need test note squares)</p> <p>How to make 3D tangram video tutorials https://www.tangram-channel.com/crafts-activities/3d-tangrams/3d-tangrams-templates/</p> <p>How to create animals etc with tangrams: https://www.tangram-channel.com/tangram-solutions/</p> <p>Building your own 3D mazes https://dash.makersempire.com/lesson_plans/show_modal/458?modal=true</p> <p>Homemade Marble Runs https://buggyandbuddy.com/10-awesome-homemade-marble-runs/</p> <p>Use Drop and Drag Playground Designer to build a 3D model of your playground: https://playgroundideas.org/introducing-the-drag-drop-playground-designer/#</p> <p>Designing your own playground: https://playgroundideas.org/three-ways-to-create-your-own-playground-design-plans/</p>	<p>Maker educators to have iPads/Chromebooks with online software available. Need to be familiar with the software beforehand.</p>

Appendix 12e: Lesson Plan — Ideas for Living Session 1 Solar Energy

Ideas for Living: Sustainable energy resources (Solar power)

Subject:	Living: Designing future buildings for Hamilton in 2040
Topic:	Exploring a sustainable energy—solar power
Session Duration:	1 ½ hours

Objective: For children to learn about:
<ol style="list-style-type: none"> 1. Building 3D models to scale using recyclable and arts and crafts material (maths-measurement, geometry, area, perimeter & arts). 2. Exploring different forms of sustainable energy—solar and wind energy (science). 3. Making a solar house & electrical circuit (science, technology, engineering). 4. Understanding of sustainability/ limitations in resources (STEM).

Materials/Equipment
<ul style="list-style-type: none"> ● Sheets of Cardboard. ● A hot glue gun. ● Hot glue sticks. ● Some choice acrylic paints. ● Xacto Knife. ● Scissors. ● Paint brushes. ● Pencils. ● Cutting board.

Session outline:		
Tasks	Activity Description	Maker educators to consider
Part 1: introduction to sustainable energy		
Recap from last week's session	<p>Are we happy with the layout of our city? Refine and make changes (if needed).</p> <p>Key questions to consider:</p> <ul style="list-style-type: none"> – Consideration of where building are? Are they too close to the power station? Is it easy to get to essential services i.e., hospital, supermarket, etc? – How will the spider move from place to place? – Roof top garden. How will that work? Solar panels and where will those fit? The support structure of the roof (double cardboard) Access to the roof and watering. Think about location and relation to pollution. – Consideration of directions North, south, east, west—where best to place your house. 	

	<ul style="list-style-type: none"> - Can they build a solar panel to capture the sun (rotating machine)? - What is the name of the city? 	
<p>Introduction to this week's theme (5 minutes)</p>	<p>Introduction to the theme of living in 2040. Introduce the idea of sustainable energy to power their homes, buildings.</p> <p>Solar Power</p> <ol style="list-style-type: none"> 1. Exploring what kinds of sustainable energy might be used to power their homes. 2. Introduction to solar energy and how to build a circuit based on solar power, pairs build house, build circuit for solar panel (to get idea on how to convert sun to electricity). 3. Create buildings in pairs then circuits. <p>Activity: Show examples of solar houses, discuss what they are, pick 1-2 examples of solar house photos</p> <p>Explain how to make a solar house: https://www.instructables.com/id/Solar-House/</p> <p>Resources for kids and maker educators: Solar Energy for life Sun Poster (levels 3-4) - Level 5 explanation also available if we have older kids.</p>	<p>Maker educators to have ready URL links. Need to be familiar with the video links.</p> <p>Maker educators to be aware of big terms such as 'energy', 'sustainable', 'forms of energy', 'pollution', etc. to check children understand what they mean.</p> <p>Maker educators to provide introduction to solar energy.</p> <ul style="list-style-type: none"> - Introduce the word 'photovoltaic'. Write it up and ask students if they recognise a word within the word. Most students will respond with 'photo'. A discussion on photos and cameras will reveal that light is involved. Write up 'light'. Often someone will also recognise the word 'volt', which is then associated with electricity. Write up 'electricity'. Help students realise photovoltaics is about making electricity using light. - Discuss the concept of producing electricity using a semiconductor and photons. Photovoltaic panels are made up of many solar (photovoltaic) cells. The more cells you have, the more electricity you will produce. - Where have you seen photovoltaic panels?

		<p>(Students may suggest the bus stop or roofing panels, or they may be aware of solar panels on space satellites or lighthouse beacons.)</p> <ul style="list-style-type: none"> - Have iPads ready if children would like to follow links to the different sites?
Organisation (5 minutes)	Instruction: Pairs will work together to build solar house.	
Training session (10 minutes)	<p>Activities:</p> <ul style="list-style-type: none"> - Cutting cardboard. - Using hot glue gun. 	Maker educators to have ready materials for solar house making.
Making a solar house (40 minutes)	<p>Video of solar house.</p> <p>House must have:</p> <ul style="list-style-type: none"> - Entrance (doorway). - Windows x 3. - Ceiling to hang LED light. - Floor. - Scale dimensions (single level dwelling and multi-level). - Height 8cm. - Length 15cm. - Sides 10cm. <p>Hand out paper so pairs can design their house.</p> <p>Think about the shape of your house and where you want the electronic and solar panels to be. Make marks on the cardboard where you want to cut, then cut it out to fit your plan.</p> <p>Each pair get 3 pieces of cardboard (building with limited resources).</p> <p>House</p> <ul style="list-style-type: none"> - Start by cutting the cardboard into several pieces: <ul style="list-style-type: none"> • Draw the pieces on the cardboard with a pencil before you start cutting. • The Front wall: 15 x 8cm. • The Back wall: 15 x 8cm. • The Front roof piece: 15 x 6cm. • The Back roof piece: 15 x 6cm. • Both sides: 9.5 x 8cm. • Design and paint i.e., exterior, doors, windows, etc. 	

	<ul style="list-style-type: none"> • Glue. • Assemble. • Once finished, test to see if it works using a powerful lamp. 	
Extension activity	<p>Activities:</p> <p>Making a paper circuit house: https://www.schoolgen.co.nz/teachers/maker-projects/make-a-paper-circuit-house/</p> <p>Making party lights to understand electrical circuits and switches: https://www.microsoft.com/en-us/education/education-workshop/party-lights.aspx</p> <p>Making a solar oven out of a pizza box: https://www.schoolgen.co.nz/teachers/maker-projects/make-a-solar-oven/</p> <p>Genesis school-gen: maker projects for sustainable energy - Make a sun inclinometer https://www.schoolgen.co.nz/teachers/maker-projects/</p> <p>Paper Turbine https://www.schoolgen.co.nz/wp-content/uploads/2020/05/School-gen-Paper-Turbine.pdf</p> <p>Balloon on a string rocket https://www.schoolgen.co.nz/wp-content/uploads/2020/05/School-gen-Balloon-on-a-String-Rocket.pdf</p>	

Resources:

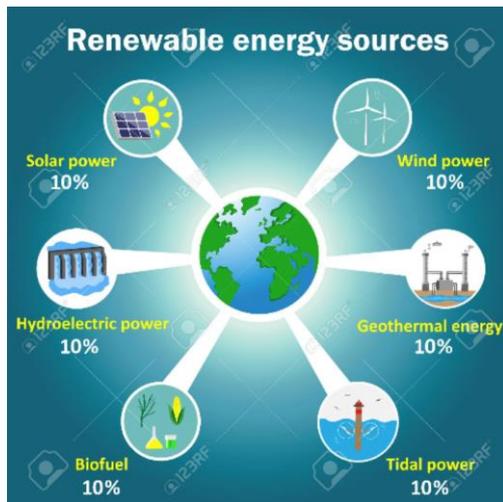
How would you like to live in 2040? Setting the scenario [show images and examples]

- Show examples of a polluted world.
- Discuss the difference between renewable and non-renewable energy sources. e.g., <https://www.schoolgen.co.nz/teachers/resources/> (see levels 3-4).

New Zealand's energy demands:

<https://www.sciencelearn.org.nz/videos/875-new-zealand-s-energy-demand> (1 min)

- Discuss the importance of renewable energy.



Renewable energy:

See Renewable Energy Sources from National Geographic (3 mins):

<https://www.youtube.com/watch?v=1kUE0BZtTRc>

Renewable Energy Explained in 2.5 minutes

<http://www.clubscikidzmd.com/march-break-resources-activities/thursday-5-7-lego-challenge-3-build-a-wind-car/>

Genesis Energy explanation on Introducing Electrical energy:

<https://www.schoolgen.co.nz/teachers/resources/>

Science Learning Hub explanation:

<https://www.sciencelearn.org.nz/resources/1571-renewable-energy-sources>

Genesis school gen: e-Books - Learn about energy and sustainability as you read e-Books in English or te reo Māori.

<https://www.schoolgen.co.nz/teachers/e-books/>

<https://www.schoolgen.co.nz/teachers/resources/>

Solar energy:

Science Learning Hub solar power explanation:

<https://www.sciencelearn.org.nz/resources/1582-solar-power>

Focus on solar energy scroll down to bottom of page:

[Solar Energy for life Sun Poster \(levels 3-4\)](#)

& levels 1-2 (depending on children's age)

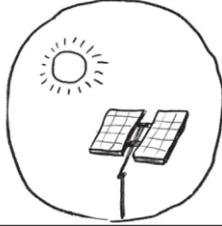
Renewable electricity from solar PV cells:

<https://www.schoolgen.co.nz/teachers/resources/> (see levels 5-6)

Children can check if their school is a solar school on the Genesis Energy website:

<https://www.schoolgen.co.nz/solar/>

Sun Energy



<https://www.sciencelearn.org.nz/resources/1571-renewable-energy-sources>

<https://www.sciencelearn.org.nz/resources/1579-inglewood-high-school-enviropower-project>

<https://www.sciencelearn.org.nz/resources/2491-future-fuels-question-bank>

<https://www.sciencelearn.org.nz/resources/1565-wind-power>

<https://www.sciencelearn.org.nz/resources/1566-future-fuels-introduction>

<https://www.sciencelearn.org.nz/resources/1636-energy-sources-through-time-timeline>

<https://www.sciencelearn.org.nz/resources/2439-futures-thinking-toolkit>

<https://www.sciencelearn.org.nz/resources/2438-teaching-futures-thinking>

<https://www.sciencelearn.org.nz/resources/459-mapping-the-future>

Appendix 12f: Lesson Plan — Ideas for Living Session 2 Solar Energy

Ideas for Living: Sustainable energy resources (Solar power)

Lesson Plan:	Hamilton City of the Future 2040
Subject:	Living: Solar House Week 2
Topic:	Exploring a sustainable energy—solar power
Lesson Duration:	1 ½ hours

Objective: For children to learn about:

- Build a parallel circuit for solar panel (**science, technology, engineering**).
- Understanding of sustainability/ limitations in resources (**STEM**).

Materials/Equipment

- Solar panel.
- 2 Double (AA) batteries and battery holder.
- Switch (optional, since we are going to make our own switch).
- LED bulbs.
- Incandescent bulbs (holiday lights).
- Buzzer.
- Motor.
- Uncoated wire.
- Clamp wires.
- Aluminium tape.

Lesson outline:

Tasks	Activity Description	Maker educators to consider
Introduction (5 minutes)	<p>Solar Power:</p> <ol style="list-style-type: none"> 1. Exploring what kinds of sustainable energy might be used to power their homes. 2. Introduction to solar energy and how to build a circuit based on solar power, pairs build house, build circuit for solar panel (to get idea on how to convert sun to electricity) 3. Create buildings in pairs then circuits. <p>Activity: Show examples of solar houses, discuss what they are, pick 1-2 examples of solar house photos</p> <p>Explain how to make a solar house: https://www.instructables.com/id/Solar-House/ Resources for kids and maker educators: Solar Energy for life Sun Poster (levels 3-4) - Level 5 explanation also available if we have older kids</p>	Maker educators to have ready URL links. Need to be familiar with the video links.

Organisation (5 minutes)	- Instruction: Pairs will work together to build circuit and add onto house.	
Training session (10 minutes)	Activities: - What the components are how do they work? - Build a parallel circuit.	Maker educators to have arts and craft resources available.
Making session	Pairs will test their electronics to make sure they are working. Build a parallel circuit and add a switch. Add electronic parts onto house. Wire the part together and test. Change the power source to solar panel.	Maker educators to have ready materials for circuits. Maker educators to have prepared knowledge about solar energy and electric circuits.

Resources:

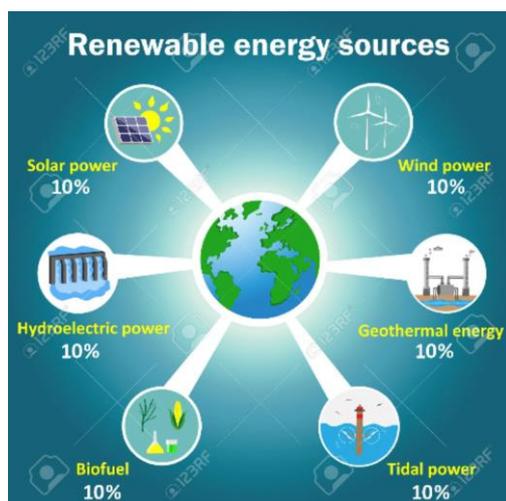
How would you like to live in 2040? Setting the scenario [show images and examples]

- Show examples of a polluted world.
- Discuss the difference between renewable and non-renewable energy sources.
e.g.: <https://www.schoolgen.co.nz/teachers/resources/> (see levels 3-4).

New Zealand's energy demands:

<https://www.sciencelearn.org.nz/videos/875-new-zealand-s-energy-demand> (1 min).

- Discuss the importance of renewable energy.



Renewable energy:

See Renewable Energy Sources from National Geographic (3 mins):

<https://www.youtube.com/watch?v=1kUE0BZtTRc>

Renewable Energy Explained in 2.5 minutes:

<http://www.clubscikidzmd.com/march-break-resources-activities/Thursday-5-7-lego-challenge-3-build-a-wind-car/>

Genesis Energy explanation on Introducing Electrical energy:

<https://www.schoolgen.co.nz/teachers/resources/>

Science Learning Hub explanation:

<https://www.sciencelearn.org.nz/resources/1571-renewable-energy-sources>

Genesis school gen: e-Books—Learn about energy and sustainability as you read e-Books in English or te reo Māori:

<https://www.schoolgen.co.nz/teachers/e-books/>

<https://www.schoolgen.co.nz/teachers/resources/>

Solar energy:

Science Learning Hub solar power explanation:

<https://www.sciencelearn.org.nz/resources/1582-solar-power>

Focus on solar energy scroll down to bottom of page:

[Solar Energy for life Sun Poster \(levels 3-4\)](#)

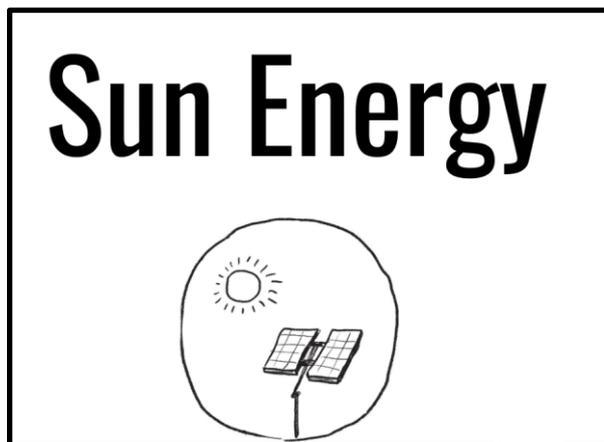
& levels 1-2 (depending on children's age).

Renewable electricity from solar PV cells:

<https://www.schoolgen.co.nz/teachers/resources/> (see levels 5-6).

Children can check if their school is a solar school on the Genesis Energy website:

<https://www.schoolgen.co.nz/solar/>



<https://www.sciencelearn.org.nz/resources/1571-renewable-energy-sources>

<https://www.sciencelearn.org.nz/resources/1579-inglewood-high-school-enviropower-project>

<https://www.sciencelearn.org.nz/resources/2491-future-fuels-question-bank>

<https://www.sciencelearn.org.nz/resources/1565-wind-power>

<https://www.sciencelearn.org.nz/resources/1566-future-fuels-introduction>

<https://www.sciencelearn.org.nz/resources/1636-energy-sources-through-time-timeline>

<https://www.sciencelearn.org.nz/resources/2439-futures-thinking-toolkit>

<https://www.sciencelearn.org.nz/resources/2438-teaching-futures-thinking>

<https://www.sciencelearn.org.nz/resources/459-mapping-the-future>

Appendix 12g: Lesson Plan — Ideas for Living Session 3 Wind Turbine

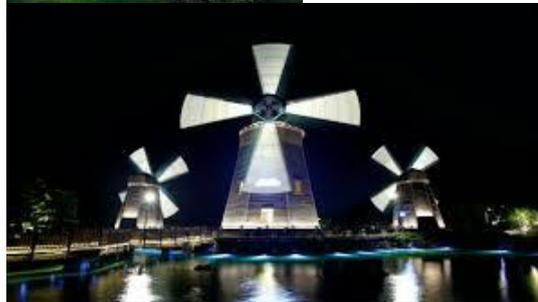
Living in the Future

Lesson Plan:	Hamilton City of the Future 2040
Subject:	Living: Wind Power Week 3
Topic:	Exploring a sustainable energy—wind power
Lesson Duration:	1 ½ hours

Objective: For children to learn about:
<ul style="list-style-type: none"> • Build a model wind turbine that produces an electrical current to power a LED light (science, technology, engineering). • Connect to model house. • Understanding of sustainability/ limitations in resources (STEM).

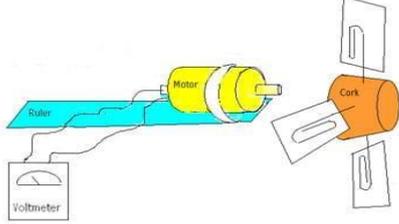
Materials/Equipment
<p>Wind turbine:</p> <ul style="list-style-type: none"> • DC motor. • electrical wire. • 1 x rubber band. • 1 x ruler. • 1 x cork. • 4 x paper clips. • Sellotape. • Scissors. • Cardboard. <p>Other:</p> <ul style="list-style-type: none"> • Fans. • DC voltmeter.

Lesson outline:		
Tasks	Activity Description	Maker educators to consider
<p>Introduction (5 minutes)</p>	<p>Introduction to Wind Power</p> <ul style="list-style-type: none"> - Our city needs power. https://docs.google.com/presentation/d/1epwO8f0KZapSLoivQQl6qYS8ZPzp_XSuetXoB_Ot3QE/edit#slide=id.g552d44ea45_0_0 <p>Renewable energy. Sources of energy that can replenished themselves like wind, solar, and hydroelectric power.</p> <p>How can wind power be convert into electrical energy?</p> <p>Show examples of wind-powered housing/buildings.</p>	<p>Maker educators to have ready URL link. Need to be familiar with the activity.</p> <p>Have ready materials for wind turbines & circuits to power buildings.</p>



Demonstration (a practical demonstration)

Explain what we are doing today and the activity:
Today we are going to create a small-scale wind turbine that convert wind energy connected to a motor into electrical energy (voltage). Then, we will measure how the wind speed affects our wind turbines. We will also design own sets of blades, varying the size, shape, material and number. We will attach these new blades to the motor and adjust them at various angles to produce the greatest voltage.

Organisation (1 minutes)	Instruction: Pairs will work together to build a wind turbine that produce enough voltage to power a LED light.	
Training session (15 minutes)	Activities: <ul style="list-style-type: none"> - How to use a Multimeter to measure electrical current. - Blade size and shape for wind turbine. 	Info-graphic sheet explaining basic circuit. Maker educators to have arts and craft resources available. Blade patterns x 2—big and small blade design. Test both.
Making session (remaining time)	<p>In pairs design and build a free-standing wind turbine that can catch the wind to generate an enough voltage to power a LED light.</p> <ol style="list-style-type: none"> 1. Attach turbine to house to power LED light inside. 2. Build wind turbine and test voltage. <p>Instructions: See Hands-on Activity: Wind Power! Designing a Wind Turbine activity below. Detailed instructions at https://www.teachengineering.org/activities/view/cub_energy2_lesson07_activity2</p> <ol style="list-style-type: none"> 3. Kids work in pairs. Provide each pair with materials and a work space. 4. Have students use a rubber band to attach the electric motor to the ruler with the motor shaft positioned at the end of the ruler. (See Figure 1). The ruler serves as a platform for the wind turbine.  <p>Figure 1. The activity setup: A wind turbine prototype hooked to a voltmeter.</p> <ol style="list-style-type: none"> 5. Straighten out the lower part of each of four paperclips. (See Figure 1). The ruler serves as a platform for the wind turbine. 6. Cut out four 3 x 5 cm pieces of cardboard. Use tape to firmly attach a piece of cardboard to each paperclip. 	While design their wind turbine kids will need to consider the size and its location to their house. Maker educators to assist children and be familiar with activity.

7. Stick the straightened part of each paperclip into the curved sides of a cork to create four turbine blades. Be sure to space the blades equally around the cork.
8. Push the cork into the motor shaft. Make sure the shaft goes into the exact centre of the cork.
9. Rotate the blade in the cork so that it is at a 45° angle to the flat plane of the edge of the ruler. You have completed your wind turbine!

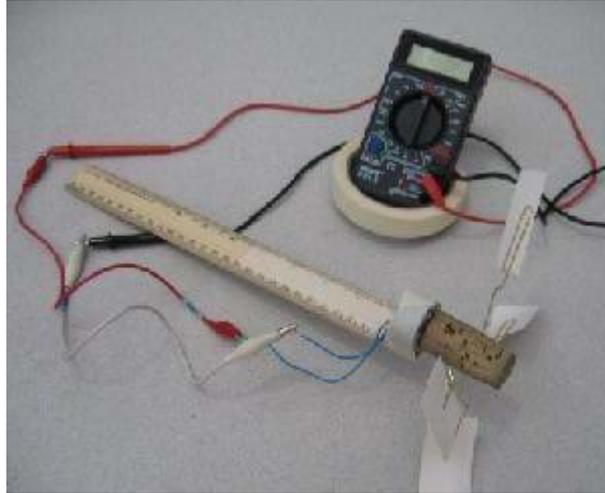


Figure 2. The activity setup.

10. In teams, have students bring their wind turbines to the testing station.
11. For one team at a time, use alligator clips to attach the free ends of the wires to a DC voltmeter. While waiting, have other teams work on the worksheet.
12. Start by placing the wind turbine about 30 cm away from the wind source (fan or hair dryer). Adjust the distance, depending on the strength of the wind source.
13. Turn on the wind source and measure the voltage produced. Record on paper
14. Repeat with the wind turbine at different distances from the wind source.

Questions for maker educators:

Did the turbine design of any team produce more voltage at the same distance, compared to the rest? Did anyone adjust the angle of the blades? What did that do? What happened as you moved your wind turbine closer or farther away from the wind source? How might you alter your turbine design or position to better capture the wind and produce more voltage? What factors might engineers consider when deciding where to put a wind turbine generator or a wind farm?

<p>Extension activities</p>	<p>LEGO mindstorm activity on City Safety https://education.lego.com/en-us/lessons/wedo-2-computational-thinking/city-safety</p> <p>Lego Design & Build a Wind Car http://www.clubscikidzmd.com/march-break-resources-activities/thursday-5-7-lego-challenge-3-build-a-wind-car/</p> <p>Lego Build a balloon car: http://www.clubscikidzmd.com/march-break-resources-activities/wednesday-5-5-lego-stem-challenge-1-balloon-car/</p> <p>What coding or apps can be developed to reduce energy use?</p> <p>Garbage bin that says thank you using Makey Makey/ microbits, e.g., https://dochub.com/elainekhoo/6mO8oy7Kp7MXELPRqg5p9J/doi-project-toolbox-pdf?pg=54 see p. 54</p>	<p>Maker educators to have iPads/Chromebooks available. Need to be familiar with the video links.</p>
-----------------------------	---	---

Resources:

Introduce the idea of wind energy as another form of sustainable energy



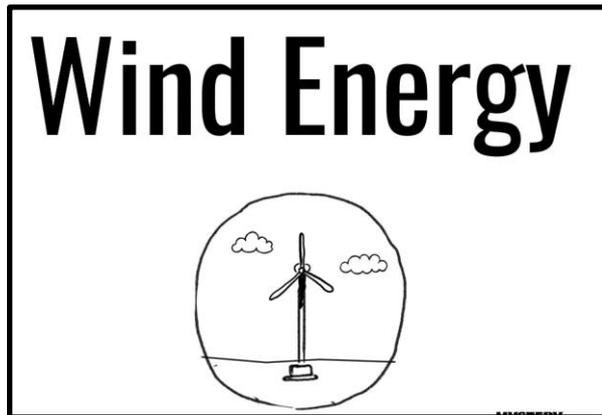
History of wind energy (short video clips 1 min long, choose 1-2 to show):
<https://globalwindday.org/about-wind-energy/>

See Genesis energy explanation on Introducing Wind energy and turbines
<https://www.schoolgen.co.nz/teachers/resources/>

Science Learning Hub wind energy explanation:
<https://www.sciencelearn.org.nz/resources/1571-renewable-energy-sources>
<https://www.sciencelearn.org.nz/resources/1565-wind-power>
<https://www.sciencelearn.org.nz/resources/1566-future-fuels-introduction>

See example of a high school that used both solar and wind energy:

<https://www.sciencelearn.org.nz/resources/1579-inglewood-high-school-enviropower-project>



Genesis energy maker project how to make a wind turbine:

<https://www.schoolgen.co.nz/teachers/maker-projects/>

Another example:

<https://www.microsoft.com/en-us/education/education-workshop/activity-library.aspx>

Appendix 12h: Lesson Plan — Ideas for Moving

Ideas for moving in the Future (2 weeks)

Lesson Plan:	City of the Future—Hamilton in 2040
Subject:	Moving: Designing what future roading system might look like for Hamilton in 2040 & considering forms of sustainable transportation (air/road)
Topic:	Exploring what future transportation systems might look like & designing a form of future transport
Session Duration:	1 ½ hours

Objective: For children to learn about:

1. 3D visualisation of space and location of things in space (**maths - geometry & geography**).
2. Explore current and future modes of transport (e.g., electricity, wind) and transportation system (e.g., smart roads, air) (**science, engineering and technology**).
3. Design a potential roading system to scale using recyclable and arts and crafts material (**science, technology, engineering & arts**).
4. Design a potential form of sustainable transport (**technology, engineering**).
5. Coding a potential sustainable transportation to overcome a problem (**digital technology**).
6. Understanding of sustainability/ limitations in resources (**STEM**).
7. Critical thinking about the practicality of where things are placed—health and safety.
8. Encourage children to express and communicate their views.

Materials/Equipment

- Paper, pencils and markers—for designing, sketching drawing plans.
- White and coloured for children to map out where their roads will be located, scissors, blue tack.
- Rulers.
- Arts and craft materials—coloured cardboard & paper, glue, tape-double sided & sellotape, straw, string, crayon and felt pens, material, sponges, paint, brushes, newspaper, hot glue guns, foams/sponges, egg cartons, paper cups/interesting shaped containers that can be used to form contours of a city—traffic lights, roundabouts, signage.

Session outline:

Tasks	Activity Description	Maker educators to consider
Part 1: Designing our transportation system (road/air)		
Introduction (5 minutes)	<p>Visit the idea of Moving in the Future. Ask children to consider: How would like to move from place to place in the year 2040?</p> <p>Setting the scenario [show images and examples] - How are people moving in physical spaces? https://mysteryscience.com/energy/mystery-7/heat-energy-energy-</p>	<p>Maker educators to set up websites for introduction.</p> <p>Maker educators to have gone through the websites themselves and are familiar with ideas of safe road systems etc.</p>

	<p>transfer/268?r=3729497#slide-id-4927 (1min 12secs)</p> <p>Examples of vehicles of the future - Future transportation system 2050: https://www.youtube.com/watch?v=CUS2w4y2Qj4 (12 min 29sec)</p> <p>Futuristic gyroscopic transportation system: https://www.youtube.com/watch?v=bJj1oc8RzGA (6 mins long)</p> <p>Select 1–2 videos as intro to the topic: See NZ government’s NZTA website on Virtual trips of Smart Motorways: https://education.nzta.govt.nz/virtual-trips/</p> <p>Smart Motorways virtual field trip: https://education.nzta.govt.nz/virtual-trips/smart-motorways/</p> <p>NZTA Share the road—design thinking and a safer transport system for everyone: https://education.nzta.govt.nz/virtual-trips/share-the-road/</p> <ul style="list-style-type: none"> - Designing Roads for Everyone. - Keeping Safe on the Waikato Expressway. <p>The Safe System approach: https://www.saferjourneys.govt.nz/about-safer-journeys/the-safe-system-approach</p>	
<p>Brainstorming</p>	<p>Children to brainstorm how their transportation (roading/airways etc) system might look like.</p> <ul style="list-style-type: none"> - Consider where the location of their designed buildings and playground are and how to wrap around their roads to connect buildings and places easily. - Can refer to their initial Week 1 city design sketch/ city creator printout. - Maximum of 3 ideas each and their layout—traffic control—lights, roundabout, signs (stop, slow down, junctions, barrier arms, train railways, walking pathways, etc.). <p>(Children to sketch their designs?).</p>	<p>Maker educators encourage children to brainstorm. Ask questions to get children to consider health & safety.</p>
<p>Deciding on our ideas</p>	<p>Children as a group come to a consensus based on brainstormed ideas—vote for top 3 ideas then top idea.</p>	<p>Maker educators to manage voting.</p>
<p>Building/ creating</p>	<p>Children to map out and build their road system using arts and craft material</p> <ul style="list-style-type: none"> - Re-arrange the cards of various streets etc., from Week 1. 	<p>Maker educators to moderate children.</p>

		<p>Note: Please take at least 2 photos of each child at work so we can compile a picture book of their learning journey.</p>
<p>Part 2: Designing a sustainable form of transportation</p>		
	<p>To decide:</p> <p>simple electric mini-car, simple electric propellor car</p> <p>Build a Junkbot - robots from recycled material https://www.sciencebuddies.org/teacher-resources/lesson-plans/junkbots#summary</p> <p>Examples of LEGO https://education.lego.com/en-us/lessonsfilter?Subjects=Coding</p> <ul style="list-style-type: none"> - Sort to Recycle - Spy Robot using sensors - Moving material - Cleaning the ocean - Wildlife crossing the road safely - Object Detection - Autonomous Intersection - Roaming vehicles <p>Use Lego Mindstorms EV3 Tricycle in less than 3 minutes - for beginners https://www.youtube.com/watch?v=J6dZhE3p_C M</p> <p>EV3 Cartwheel Robot https://teachkidsengineering.com/our-favorite-lego-mindstorms-ev3-projects/</p> <p>Lego mindstorm project—Car with sensors <i>Make a little smart car that can automatically stop when it encounters an obstacle.</i></p> <p>Coding the LEGO Mindstorms to detect obstacles, sense traffic light changes.</p> <p>Monorail system that runs through the city—LEGO Technics (mechanical parts of LEGO).</p> <p>Concept of superconductivity—trains (see resource link below).</p>	<p>Note: Please take at least 2 photos of each child at work so we can compile a picture book of their learning journey.</p>

Extension activity	<p>Activities of transportations: hovercrafts, airplanes, 2 paper flyers,</p> <p>Wobble Bots—robot pets https://www.instructables.com/id/Wobble-Bot/</p> <p>Build a balloon rocket: https://kidspot.co.nz/activities/build-a-balloon-rocket/</p> <p>Balloon rocket experiment: https://kidspot.co.nz/activities/balloon-rocket-experiment/</p> <p>Paper templates for cars, buses, taxi, police car: https://www.education.com/worksheets/?q=%22build+a+city%22</p> <p>Film Canister Rocket https://www.schoolgen.co.nz/wp-content/uploads/2020/05/Film-Canister-Rocket.pdf</p> <p>Build A Catapult Plane https://nanogirlslab.com/programs/free-experiment-catapult-plane?categoryId=45468</p> <p>Lego Build a Car that Can be Powered by a Balloon</p>	
--------------------	--	--

Resources from Science Learning Hub:

<https://www.sciencelearn.org.nz/resources/2184-rev-it-up-electric-cars>—maybe not so much

<https://www.sciencelearn.org.nz/resources/1467-radical-bike-redesign>

<https://www.sciencelearn.org.nz/resources/2834-driving-us-into-the-future>

<https://www.sciencelearn.org.nz/resources/2833-the-environmental-footprint-of-electric-versus-fossil-cars>

<https://www.sciencelearn.org.nz/embeds/61-electric-car-history>

<https://www.sciencelearn.org.nz/resources/1777-superconductivity>—this activity is useful

Appendix 12i: Lesson Plan — Ideas for Learning

Lesson Plan:	City of the Future—Hamilton in 2040
Subject:	Learning: Consider how learning in the future might look like & design a form of learning that will appeal to children in 2040.
Topic:	Exploring what future learning systems and tools might look like & designing a form learning appropriate for children.
Session Duration:	1 ½ hours

Objective: For children to learn about:

1. Encourage children to explore ideas on learning in the future.
2. Support children to design a learning game that will appeal for a younger child (**computational thinking**).
3. Introduce children to coding - basic programming with scratch (using Scratch Jr) (**digital technology**).
4. Encourage children to express and communicate their views.

Materials/Equipment

- Paper, pencils and markers - for designing, sketching drawing plans.
- White and coloured cards printed with basic algorithm terms to introduce children to basic coding.
- iPads/Chromebooks enough for 1-1 or 2 to 1 device.

Lego Mindstorms? Brushbots? Or Scratch? Creating your own virtual tour/field trip.

Session outline:

Tasks	Activity Description	Maker educators to consider
Introduction	<p>Introduce children to the theme—how would you like to learn in the future?</p> <p>Brainstorm what would learning in the future be like:</p> <ul style="list-style-type: none"> • What kinds of skills might be important in the future—maybe skills like reading, writing, maths, problem solving, keeping time etc? <p>Show examples of games that can be programmed.</p>	
Brainstorm	<p>Thinking about games for learning.</p> <p>Ask children: if we can create a game to help younger children learn these skills, what might you do?</p> <p>Contextualise the game to include.</p> <p>[Note: Record ideas, discuss as a group top 3 ideas that you would like to teach a younger child to learn.]</p>	[Note: Everyone jots down ideas]

	<p>Parameters: within your game environment, please be respectful. Your game can:</p> <ul style="list-style-type: none"> - have at least 2 levels of game playing (easy to harder levels), - at least 3 characters/sprites, - include at least a sound, - background, - movement, - questions/instructions to guide your user. 	
<p>Refining ideas</p>	<p>Obtain feedback and revise your ideas.</p>	
<p>Introduction to programming/ Training without using the computer</p>	<p>Starter Activity: Introduction to Scratch Jr using printable blocks.</p> <p>Programming with ScratchJr takes place on-screen, but that doesn't mean you can't incorporate screen-free activities to enhance learning! For example, brainstorming techniques like storyboarding and collaborative planning can be done with paper and pencil before beginning to create programs in ScratchJr. Our large printable blocks can also be used to learn how to put together programs before trying them on the app!</p> <p>See: http://scratchjr.org/pdfs/blocks.pdf</p>  <p><i>Try this: Using the large printable ScratchJr blocks, play a game of "Simon Says" by putting together syntactically correct and incorrect program sequences and having your kids act them out! This is a great screen-free activity to get them moving and learning how to put together working programs at the same time!</i></p>	<p>Maker educators to prepare materials and go through with children Need to organise children.</p>

	<p>Other examples to teach children about computational thinking paper-based: https://www.pinterest.nz/search/pins/?q=Lego%20coding&rs=srs&b_id=BMoJoUcvbuR1AAAAA AAAAADv2Cyv2fO0ps52pj_K1D4zTEpV3g7HeiIJKKZkQCf35aVHPmorG0gy&source_id=Sg47iCHc</p> <p>Learn programming from home with fun online tutorials, aimed at 5–13-year-olds: https://code.org/</p> <p>If you have never used a certain block before, or if you aren't sure about a block's function, the best thing to do is try it in a program! Use the block descriptions page on the ScratchJr website to help guide your understanding about each unique block. See: http://scratchjr.org/learn/blocks</p>	
Training using the computer	<p>Have a go at using the ScratchJr software to create a simple prototype—see http://scratchjr.org/teach/curricula/playground/full and pick 1-2 activities for children to get started with.</p> <p>Use examples from Starter Project as introduction then plan their own game.</p>	
	<p>Children design their game (continue next week). They might like to remix from others' projects. See examples from https://scratch.mit.edu/studios/4156532/ https://scratch.mit.edu/explore/projects/games/</p>	
Extension Activity	<p>Lego Mindstorms EV3 Dancing Robot: https://teachkidsengineering.com/lego-mindstorms-dancing-robot/</p> <p>Other ideas for Lego Mindstorms https://teachkidsengineering.com/category/projects/ https://teachkidsengineering.com/our-favorite-lego-mindstorms-ev3-projects/</p> <p>Create a FREE virtual tour: https://www.youtube.com/watch?v=wSTy_MNXIn8</p> <p>Create your own 360 virtual tours https://arvr.google.com/tourcreator/</p> <p>Creating Virtual Fieldtrips with Google Earth https://www.youtube.com/watch?v=RafGzl3xgM0</p>	

	<p>https://www.educatorstechnology.com/2014/02/a-step-by-step-guide-to-creating.html</p> <p>How To Make An Art Bot (Scribble Bot)</p> <p>https://www.makerspaces.com/how-to-make-an-art-bot/</p>	
--	--	--

Resources:

<http://scratchjr.org/teach/curricula>

Appendix 13: Story for Unlocking Curious Minds website

Title: Making and Tinkering Away at the City of the Future

Primary-aged children in Hamilton have had the opportunity to participate in Hamilton City Libraries' *Build a city of the Future 2040* makerspace programme initiated under the Unlocking Curious Minds' 2020 funding initiative. The programme is a collaborative project between the University of Waikato and Hamilton City Libraries aimed at evaluating the learning impact of makerspaces for STEM (science, technology, engineering and mathematics) learning and sought to develop a maker educator curriculum to support library staff facilitating the makerspace programme.

The project, led by Dr Elaine Khoo from the University of Waikato, had input from experts in science education—Professor Bronwen Cowie from the University of Waikato and in makerspace and maker educator development - Professor Martin Ebner from Graz University of Technology, Austria together with his team, Dr Sandra Schön and Maria Grandl. The library maker educators in the project were led by Aaron Martin with Lauren Rowe, Su Bradburn and Gameedah Jones.

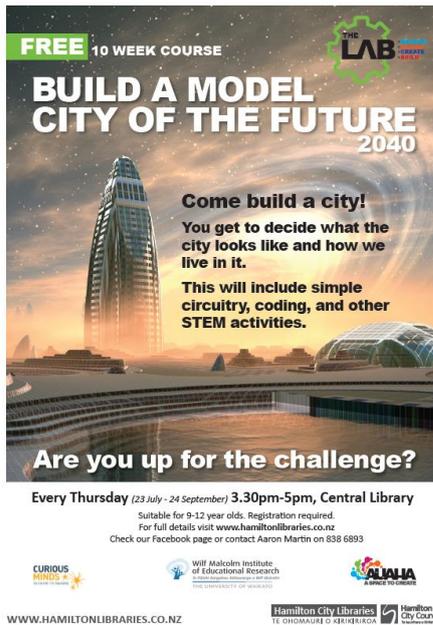
Elaine explains, “A makerspace is a space where people gather to learn how to use, and to use a range of materials and technologies to create or make things that are of interest to them. Makerspaces engage children creatively. There’s evidence that children who participate in after-school makerspace programmes can develop STEM interests and skills through experiential, exploratory and collaborative learning experiences”.

Hamilton City Libraries (Libraries) established its mobile makerspace programme in 2017.

In November 2019, Libraries extended the makerspace programme to a permanent modern space, known as Auaha. Auaha is strategically located at the entrance to the Library, has glass doors and is highly visible to those walking past or going into the Library. It is open for free access by the public and focuses on STEM learning and creativity.

Learning STEM through Building the City of the Future

The theme *Building a city of the Future 2040* was decided on as an overarching theme to guide the inquiry-based activities in the makerspace. This theme was based on success the Austrian experts have had with a similar theme for their summer makerspace outreach programme to youth. It also had strategic alignment with Hamilton City Council's current Smart City initiative. This was the first time the Libraries' makerspace programme had adopted an overarching theme over the 10-week school term. The year 2040 was selected as being distant but still conceivable for primary-aged children to stimulate their creativity, imagination and develop futuristic ideas.



The advertisement for the makerspace programme

Library Maker Educators Preparing to Work with Children

Prior to the programme commencing, a workshop was held with maker educators to plan and go through ideas in STEM themed activities, and to consider strategies for interacting productively with children and parents/ caregivers.



Maker educators in the workshop trialling planned activities prior to the programme

The Makerspace Programme in Action

During the programme, maker educators worked with children to introduce a range of STEM-based activities such as designing sustainable homes, sustainable energy sources (solar panels, wind turbines, electrical circuitry using makey makey and chibitronics), and design thinking in 2-dimensions and 3-dimensions using software such as TinkerCad. Children worked in pairs, as a whole group as well as individually on their chosen projects.

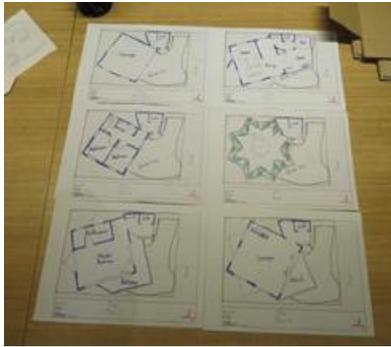


Children brainstorming ideas for the theme

The programme was also stimulated by an invited talk by an architect—Mr Brian Squair of Chow:Hill Architects, Hamilton—on designing buildings.

Developing ideas for buildings and spaces

Children learned about the design process as they developed their own designs for their futuristic building and city.



Emphasising design thinking on paper and through coding with TinkerCad to visualise 3D designs

Children enjoyed being introduced to this process. Two children in particular commented:

“[I learnt] How to put my ideas onto paper [part of design process]. How to draw, I didn’t think about that kind of thing before.”

“I learnt how to make a house like a model of the future. And a fire station for the future city. And I learnt how to use TinkerCad to build a basic house.”

Learning STEM through Making

Throughout the 10-week programme, children made use of recycled materials to bring their designs to life. They explored sustainable energy forms- solar panels and wind turbines, worked with electric circuitry, origami, considered directions for the solar buildings to best face the sun, and worked with motors.

Maker educators cited examples such as one child being interested in windmills and used a hot glue to shape and weigh the blades with a focus on generating speed.

Children also grew in terms of their technical skills - measuring to scale, visualising and designing in 3-dimensional aspects, safely using craft knives for cutting and the hot glue gun and so forth.



Children working on various aspects of their chosen project such as wiring and solar panels



Creating wind turbines

Children enjoyed working with ‘new’ materials (resistors, LEDs, batteries, solar panels) and using TinkerCad to add blocks and shapes, manipulate sizes, design houses and buildings. They liked being introduced to ideas to do with series and parallel circuits, resistors and batteries and then the experience of actually making a working circuit.

“I learned how to build, how to put on a solar panel, and building (building a house) and teamwork”.

“I learnt all about wiring and construction because I don’t usually do construction. So I learnt a lot about construction, and wiring and electronics, simple electronics”

“Making and connecting. I learnt how to connect wires and about soldering and how it works. And how to improve the city, like a cleaner city”.

Developing collaboration — help seeking and help giving

In addition to STEM ideas and skills, children learnt important life skills such as collaboration, problem-solving, developing resilience and independent learning from the programme.

Parents recognised this breath of learning.

“I mean all problem-solving is about challenges and there is a challenge, but it’s something that is a positive thing, because you create, ‘Well what am I trying to achieve?’ And then you achieve it. So, I think throughout the programme there were a lot of challenges like that. ... the beauty of the programme was that there were people to ask, and, and help.”

“[Over the 10 weeks, my child learnt about] solar panels, hot glue guns, learning to create with fiddly bits in the house, *Interact* with other kids, and to be patient. How to be patient—sometimes you feel frustrated, but I just tell her, ‘It’s okay, you can learn from experience.’”



Fostering creativity and imagination

Children highlighted that the open-ended future focused theme allowed them to imagine, to learn STEM ideas and skills and to work with others at the same time. They offered comments such as being able to enjoy “imagining what a house could look like”, then “putting my ideas on paper”.

One of the children explained how he created a rotating house so the solar panel kept facing the sun as did the windows. He placed a motor under his house to do this but the rotation was too fast. He then tried resistors but these didn’t work. Next, he investigated and tried out a gearbox but the motor could not drive the house. He then experimented with other motors and gears and trialed using fidget spinners until he got his model to work.



An innovative rotating themed house

Feedback about the project

Maker educators were pleased to see children’s depth and breadth of exploration of STEM ideas including ideas about sustainability. They noted children’s developing confidence in terms of expressing their ideas, pushing themselves beyond the ideas introduced in the programme but also in their confidence and working with other children to develop communication and teamwork skills.

“Everybody had a voice, all the children had an opportunity to offer ideas”, says Aaron.

Parents affirmed the programme was valuable to supporting their children’s STEM thinking and technical skills, developing social and personal skills and allowed them to imagine and create their own projects.

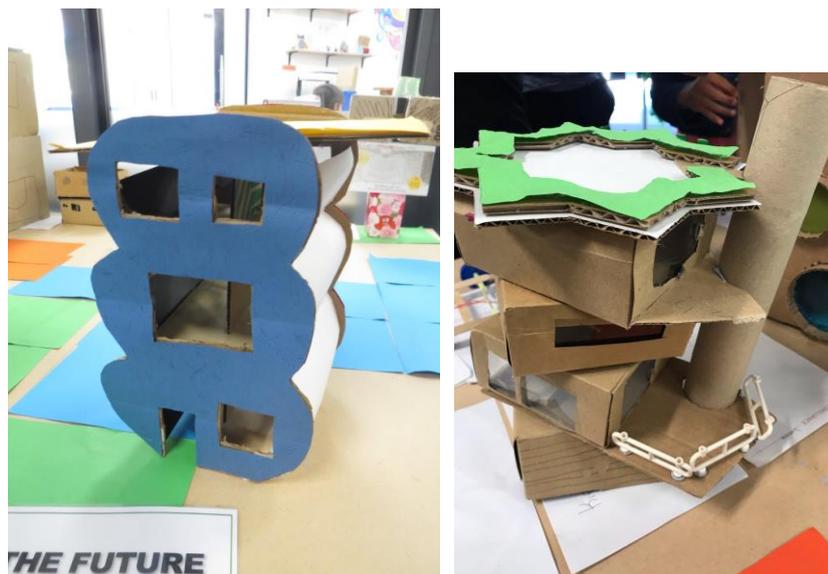
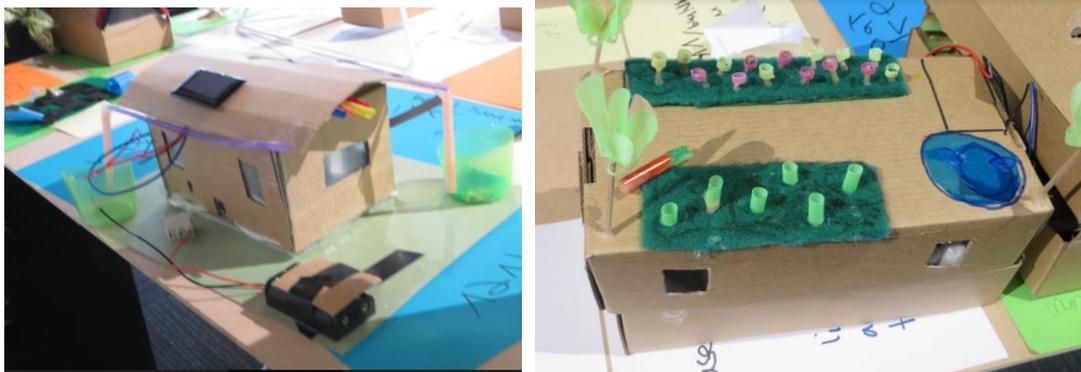
“I know she really enjoyed learning about how the solar panel worked, and the electricity and circuits. And trying to work it out whether it was in parallel, or series.”

“There was something he could enjoy, and something that he could use his imagination. He could basically dream. But at the same time there were practical things he could explore, and even research, and try and create very practical as well as very imaginative design type elements.”

“The theme helped children appreciate that a city is made up of interconnected systems of people, energy, resources.”

“Plants a seed in their young minds ... helps them to choose university subjects and careers such as electronics, doctor, engineer, librarians. Children gain knowledge about future life, not just now.”

“This programme expands children's minds so that they become open minded and children are aware of what they can do in the future, what lives they want, what job they want for the future so they can start to think about it now.”



Examples of children's future styled buildings

Children affirmed they enjoyed the programme.

I didn't know that they [solar panels] could be like that tiny. And I didn't know that they could pick up power so fast. You pretty much have to put it in the sun for one second and the light is already going

[I enjoyed] the learning with all of the people and sharing ideas with them. I really enjoyed that ... learning from all these critical people who also like building.

I really liked making ... The materials that I had allowed me to make some really interesting things like buildings completely made out of straws. Some of those—I really liked doing that.



Children's work on display at the end of the two programme in Terms 3 and 4 2020 with the name given to their city - Auaha City

“For me, this project is about broadening community participation in STEM, providing kids from diverse communities with access to equitable STEM learning opportunities and encouraging them to develop lifelong learning skills”, says Dr Khoo.

More information about the project

A website about this project has been developed at:

Developing a STEM mobile makerspace and maker educator learning resource:
<https://www.waikato.ac.nz/wmier/projects/developing-a-stem-mobile-makerspace-and-maker-educator-learning-resource>