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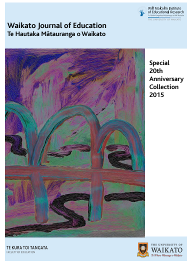

The Science-for-Life Partnerships: Does size *really* matter, and can ICT help?

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Abstract

This study introduces findings of an initial pilot from a New Zealand government-funded initiative known as Science-for-Life, which aims to enhance the quality of science teaching through the formation of face-to-face and virtual learning partnerships involving crown research institutes (CRIs) and primary and secondary schools. Using a case study methodology, it describes and analyses a trial partnership between the CRI, Scion Research, and teachers of Seadown Primary School in Hamilton. The study uses Grobe's (1990) typology of industry-education partnerships as an analytical "lens" through which to evaluate the characteristics of the partnership, and explores the role that ICT played in establishing and sustaining it, well beyond its anticipated conclusion. Findings indicate that while in terms of Grobe's framework a genuine partnership label may not have been appropriate in this case, the interaction nonetheless proved to be extremely valuable in supporting learning goals, and that while ICT played a significant role in this, it was not fundamental to the partnership's success.

Keywords

ICT, information, technology, science, inquiry, partnership, research, industry, collaboration, interaction

Introduction and background

This study documents and describes an initial partnership pilot involving the Rotorua-based crown research institute (CRI) Scion[i], and the staff and students of Seadown[ii] Primary School near Hamilton, New Zealand. The partnership was part of a wider New Zealand Ministry of Research in Science and Technology (MoRST) funded science education initiative known as Science-for-Life, which had as its primary goals

- to create positive experiences for students in science;
- to engage students in authentic and contextual research projects; and

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[i] Further information on the work of Scion Research can be found at: http://www.scionresearch.com/
[ii] A pseudonym

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- to energise science teaching and develop best practice models. (Scion, 2008)

The Science-for-Life partnerships developed in 2007 as an initiative by the then Minister of Research in Science and Technology, the Hon. Peter Hodgson, to help address the relatively static progress and long "achievement tail" of New Zealand students in science, as indicated by data from the Programme for International Student Achievement (PISA; OECD, 2007) and the Trends in International Mathematics and Science Study (TIMMS; National Center for Education Statistics, 2007). While the studies indicated our top-performing students rated favourably with the best in the world, some concern was noted relating to students' lack of general understanding of basic science concepts and the nature of science and its relationship with society, and declining student interest in advanced science studies and science-related careers (OECD, 2007). Overseas experience had shown that the establishment of school-scientist partnerships or SSPs could be an effective way of helping to address some of these issues (Donahue, Lewis, Price, & Schmidt, 1998; Spencer, Huczek, & Muir, 1998), and the Minister, in association with his Ministry, identified the state-funded crown research institutes as being in an ideal position to support such partnerships in New Zealand.

Industry-education partnerships

According to Zacchei (1986), arriving at a single definition of an industry-education partnership that covers all possible permutations is problematic. However, he suggests that partnerships have common attributes "characterised by an exchange of ideas, knowledge, and resources. Partners form a mutually rewarding relationship with the purpose of improving some aspect of education" (Zacchei, 1986, p. 5). However, despite a long history of industry-education partnerships dating back to the late 1800s, there have been relatively few completed studies which analyse in any depth the nature of these partnerships, or the impact they have at school level or beyond (Lankard, 1995; Zacchei, 1986).

Grobe (1990), in a paper prepared for the American Office of Educational Improvement and Development, developed a series of three typologies analysing industry-education partnerships. Although a little dated now, her ideas serve as a useful analytical lens for identifying more specific characteristics and attributes of industry-education partnerships. Her typologies, which help identify those which could be termed *true* partnerships as opposed to more *one-off* interactions, are levels of involvement, the partnership structure, and the level of impact of the partnership on the education system.

The first of these, *levels of involvement*, contain three distinct phases—support, cooperation and collaboration. Within this typology, as the partnership evolves, the relationship changes from one generally focused on one-way provision of resource (usually from industry to school), through to a model in which both parties "enjoy a relationship among equals" (Grobe, 1990, p. 9), and where the initiative becomes part of the "natural ways of working" of both organisations, often with its own staffing. In the second typology, *partnership structure*, the development of the relationship can be mapped through a series of stages from simple, moderately complex, to complex. At the most basic level, the partnership is managed and run by one partner, with the other being generally concerned with "providing support services or resources" (Grobe, 1990, p. 9). As the partnership evolves, both partners become more involved in decision-making with each party having their own substantive programme responsibility, with schools no longer the mere "recipient of service" (Grobe, 1990, p. 10). In its most complex form, the partnership structure may assume a "life of its own", involving multiple schools, multiple partners, or even establishing its own organisational entity.

The final typology is the *level of impact* the partnership has upon the education system. This typology is perhaps the most useful, as it is concerned not so much with the nature of the partnership itself but with its outcomes. This typology looks at the *breadth and depth* of the impact of the partnership in affecting positive change—and whether this affects anything from a single school or a cluster of schools or a district, through to a state-wide or national system. While Grobe (1990) acknowledges that such an assessment does not by itself constitute an accurate measure of the value or worth of any partnership, it does help to identify those that may, by their level of penetration of the education system, have the potential to yield more widespread and significant change.

For the purposes of this study, Grobe's (1990) third typology served as a valuable analytical tool through which to evaluate the nature and performance of the partnership. Despite its somewhat historical nature, a comprehensive literature search revealed it as one of the few useful published frameworks available in this area.

Research significance

The study described in this paper helps address the dearth of research in industry-education partnerships in science by providing insights into how the partnership was established, negotiated, implemented and sustained. It identifies important aspects of the partnership's focus, structure, content and delivery that influenced its effectiveness. It also raises implications for other partnerships in this programme in particular, and industry-education interactions more generally. It also highlights the contribution information and communications technologies (ICT) made to the partnership, and its role in enhancing student engagement in, and the quality of, their science inquiries.

Methodology and data collection

A case study methodology was adopted for this research as, according to Burns (1997), case studies can serve a number of purposes or functions within educational research. Due to their intense and subjective nature, Burns (1997) suggests that case studies are particularly suited to acting as preliminaries to major investigations by providing a "source of hypothesis for future research" (p. 365), or by assisting in developing deeper understandings "of the class of events from which the case has been drawn" (p. 366).

This study is the first in a series of Science-for-Life case studies exploring the efficacy of SSPs in the New Zealand context. When combined with data from subsequent studies, it is expected that greater understanding will be gained about how successful partnerships can be formed, and the benefits from these for students, teachers, and participating scientists. Undertaking a range of case studies exploring different types of partnerships in different contexts is appropriate, as they will reveal different experiences that can be collectively analysed to identify common principles and activities.

Consistent with qualitative studies of this nature, data were collected using multiple methods and tools comprising document analysis (teacher reflective log and planning documents, Scion planning and contractual information, an online class wikispace, emails); programme observation (field notes, photographic and video data); and semi-structured interviews with the participant teacher, scientists, and the Scion facilitator—before and after the partnership. In all data presented in this paper, names have been changed to preserve participant confidentiality, and the study complied with Scion ethical guidelines for educational research (2008).

The research context

The research was conducted in a small, 128-student, semi-rural primary school on the outskirts of Hamilton, New Zealand, over a 10-week period, during the third term of the 2009 school year. The school is surrounded by small-block farms and lifestyle properties, and is bordered by a gully and stream on one side, and farmland on the other. The class selected for the study was a Year 5/6 composite class (9 and 10-year-olds) comprising 13 boys and 15 girls, whose female teacher had 18 years' teaching experience. The negotiated unit of learning the partnership was based on was an exploration of the plant and animal life in the gully adjacent to the school, aiming to identify possible threats and issues associated with the gully's care and overall health. Approximately three hours' dedicated topic time was allocated to the unit per week for the 10-week period, with additional hours being integrated with scheduled literacy and language activities when appropriate.

Research focus and questions

As the study was broadly focused, this paper will examine the findings and provide discussion of two of the four research questions. The first of these focuses on evaluating the nature of this partnership, in particular the processes involved in its negotiation and initial development, using Grobe's (1990) typology as the analytical lens. The second focus relates to assessing the role that ICT played in helping to support the partnership, and facilitate it from a distance. This was an important objective, given broader imperatives around Science-for-Life to use technologies productively to both enhance the student learning experience and link CRIs and schools separated geographically.

The following research questions under consideration in this paper are:

- What was the process by which this partnership was established and implemented, what were its key outcomes, and how did it "measure up" against Grobe's (1990) typology?
- What role did ICT play in establishing, implementing and sustaining the partnership?

Data coding

Data from this study were coded using deductive Thematic Analysis (Braun & Clarke, 2006). Thematic Analysis is described as "a method for identifying, analysing and reporting patterns [themes] within [qualitative] data. … A theme captures something important about the data in relation to the research question, and represents some level of *patterned* response or meaning within the data set" (Braun & Clarke, 2006, p. 80). By using Thematic Analysis as the framework for data analysis across the case studies, it is expected that common elements will more readily be able to be identified, thus supporting the validity of conclusions reached in the identification of effective partnership models.

The following three broad themes emerged from the analysis of data, and were subsequently used as the basis for coding and reporting the findings:

- Partnership negotiation and implementation;
- Pedagogical alignment and support for knowledge development; and
- The availability and use of ICT.

These findings will now be presented and discussed.

Findings

Partnership negotiation and implementation

From the beginning, the success of this partnership was likely to be contingent upon two things: firstly, the degree of *alignment of expectation* that could be achieved between the participating teacher (Helen) and Scion, particularly Simon, one of the scientists; and secondly, the extent to which partners adhered to the agreed plan and scope. To help facilitate this, initial negotiations around the topic and the input of stakeholders was collaboratively carried out via a series of face-to-face meetings. Helen also visited Scion to gain a better understanding of the scientists' work. During these initial meetings, Helen presented a draft outline of her intended unit and talked about her wish to focus on the use of ICT, the development of questioning and higher order thinking skills, and an exploration of the Nature of Science/Living World/Planet Earth objectives from the *New Zealand Curriculum Framework* (Ministry of Education, 2007). She also mentioned her intention to focus on the key competencies of thinking, and participating and contributing (Ministry of Education, 2007, p. 12), through her goal of involving students in a *real* scientific investigation with an environmental and social focus (Helen, planning meeting, August, 2009).

A valuable outcome of the face-to-face meetings was the level of understanding each partner developed about the other's "ways of working", their likely constraints, and what they were able to bring to the partnership. This process proved valuable for developing a realistic level of expectation, and avoided planning for activities or support that could not be achieved. The meetings also dealt with logistical elements of the partnership, such as how and when the specific interactions were going to take place, and what form these might take. These decisions took into account factors such as the geographic distance of the school from Scion. As it was located over 100km away, it effectively limited the number of face-to-face options available, which prompted the exploration of ICT tools to support interactions at a distance. These options ranged from linking through audio and video conferencing, to the use of Skype™ and collaborative Web 2.0 tools such as wikis and blogs. However, while the contribution of ICT was deemed to be valuable, both Helen and Simon agreed on the need to involve scientists working directly with the students:

> … it would be good … [if] someone [a scientist] … could come into the gully … 'cause there has been some native planting, but there is a lot of ... what's that weed … convolvulus … and it strangles the trees … it would be really useful if we had someone go through the gully with the kids … you know, these are natives, these are not natives, and what damage has been caused—'cause the gully hasn't been managed properly … that would be really worthwhile … and even talking to the kids about basic things like "how trees work" … you know, taking in CO^2 … I did some of that before, but I didn't know it all. (Helen, interview transcript, August 2009)

From the Scion perspective, the negotiation of the partnership represented an important learning opportunity. While Scion staff had previously been involved in smaller scale activities with schools, their knowledge of curriculum, school planning and assessment processes, and the constraints under which teachers operate, was not strong. Simon emphasised the reciprocal nature of the partnership in this respect, in that one of his goals was to learn more about planning requirements and school processes to better inform subsequent partnerships. He commented on the proposed role of ICT in this process by saying that

> … one of the things … I would love you to put your Word stuff up and I will get you a place to put it up [in an online collaborative space] … as you update your plan … as for me, that will be one of my learnings … the reciprocal nature of this … I am totally unaware of how planning happens in a school. One of the things I want to do from this is to develop these ideas a bit further, and put it all up in an LMS [online Learning Management System] so others can use it … we have a digital unit ready to go…. (Simon, interview transcript, August 2009)

While the above provides only a short summary of some aspects of the partnership negotiation process, it was an important phase that assisted in locating the project within the normal activities of the classroom. It also helped ensure that realistic expectations were established, mapped out how specific interactions were to take place, and identified the mechanisms through which these were to be achieved.

The next section reviews another important component that was pivotal to the success of the partnership, namely pedagogical alignment.

Pedagogical alignment and support for knowledge development

An important component of the implementation phase was ensuring alignment of the pedagogical approach used in the partnership. From the Scion perspective, the preference was to use an open-ended, student-led inquiry model, which had been identified in earlier project research as an effective way of developing both science conceptual knowledge, and investigative skills (Falloon, 2009). For Helen, the use of inquiry presented some challenges, and represented a significant departure from her traditional approach to teaching, which tended to follow a more predetermined (and teacher-directed) sequence. By her own admission, the inquiry approach prompted her into rethinking her pedagogy to take the best advantage of learning opportunities *as and when they arose*, even if this meant "missing out" on pre-planned activities in other curriculum areas in order to capitalise upon the interests and questions of the students. Understandably she was initially a little uncomfortable with this; however, because of a range of factors she displayed confidence in pursuing various lines of inquiry as they arose. This was bolstered by high and enduring student enthusiasm and interest, and ongoing support from Scion, who provided encouragement, new ideas, knowledge and resources. Helen observed that

> … normally I'm much more structured … I'm going to do this … then that… a lot more things planned ahead. I suppose I've relaxed a bit and let things flow a bit more. It's worked particularly well because of all the contacts we've had [Scion], and the gully, which is local. (Helen, interview transcript 2, November, 2009)

Helen described her adoption of inquiry as "a big learning curve" (Helen, interview transcript 2, November, 2009), but one which she saw as being extremely valuable in maximising the benefits of the partnership, by allowing her students greater levels of ownership and direction of their learning. The move effectively meant that much of her planning was occurring either concurrently with the activities or in retrospect, because it was not possible to accurately predict and plan in advance a single learning pathway:

> … I have allowed a lot of the learning to be directed by the kids and what they are interested in, and then what's been available—so I've constantly had to add to my planning, and it has changed and evolved. Things I planned to do weeks ago just haven't happened, because we have done all this other stuff instead. (Helen, interview transcript 2, November 2009)

When examining the role of Scion in this partnership, it is apparent that without the support of scientists and other partnership resources "on tap", Helen would have been in a far weaker position to implement the unit using an inquiry model. Falloon (2009) argues in a Science-for-Life literature review that one of the most significant barriers facing primary teachers' planning of science topics is a lack of conceptual and procedural knowledge. In commenting on this point, Helen indicated that the partnership had increased both her science pedagogical content knowledge and her understanding of correct scientific procedures, "but in a way that had stuck" (Helen, interview transcript 2, November, 2009). She attributed this largely to applying her knowledge directly to a meaningful context, rather than learning it more theoretically via the Internet or a book. Supporting this point, she commented on the relationship she had formed with the Scion staff, and the fact that she was "able to listen and learn with the kids" (Helen, interview transcript 2, November, 2009), as well as approach scientists when she was unsure of something:

> … my own knowledge base isn't huge in any of this … you can go to the Internet, but there's so much information … it's hard to know what to take and what to leave. I just have to email [Scion] and ask if they have any information about this … it's having the contacts … I just emailed and asked him [Dave, a scientist] if he had any information on deforestation … and he sent me though a whole slideshow. (Helen, interview transcript 2, November 2009)

The Scion link appeared to act as something of a safety net for Helen, allowing her to capitalise on the enthusiasm of her students and take the inquiry in new and unplanned directions:

> … the motivation, excitement … the questions were great. Deciding on the next step, who we can find out from, who we can write to, working it all out. It's the whole inquiry model … but you need to be flexible and prepared to go in multiple directions, and as a teacher, be willing to drop what I'm doing and be prepared to do something else, and take risks … huge risk taking for me personally as a teacher … but having them [Scion] there was fantastic … there was always someone to ask. (Helen, interview transcript 2, November 2009)

The alignment of pedagogical approaches was an important element in developing this partnership. It provided a commonly understood framework against which both Scion and Helen could make decisions related to what was to be taught and how, and what resources and support could be provided by the CRI to help achieve this. It also enhanced motivation and engagement by affording students greater responsibility for decisions about learning direction and priorities, while at the same time provided opportunities for extending teacher knowledge in new areas of science, and in new approaches to teaching it.

The final section summarises findings about the contribution of ICT to the partnership—a contribution that proved to be one of the most important in supporting and sustaining the partnership's inquiry learning model.

The availability and use of ICT

An integral component of this partnership was Helen's use of ICT in almost every aspect of the unit. By using a range of different technologies from whole class audioconferencing, Skype™, blogs and wikis, to laptops, digital microscopes and infrared cameras provided by Scion, Helen was able to gather data and bring to the classroom expert knowledge from the Scion staff, which was used extensively within student-led inquiries, and for furthering her own pedagogical content knowledge. ICT was also used for communicating outcomes to, and receiving feedback from parents and other stakeholders, as the unit developed.

There were three key areas in which ICT made a valuable contribution to this partnership. Firstly, Scion provided a resource kit comprising four laptop computers, four digital microscopes, an infrared night vision camera, and three digital cameras, for the duration of the partnership. Access to these additional computers to complement the two older classroom computers meant that Helen was able to involve her whole class in groups as they went about their inquiries. They used the Internet, and analysed soil samples or other specimens found in the gully using the digital microscopes (Figure 1).

Having sufficient technology available for the whole class proved critical to the success of this unit. The Internet opened up a wider range of information sources than the students normally had access to. These resources were built into the inquiry framework in a structured way, or used in response to student-initiated questions. Where there was a need for all students to develop specific science content or investigative-skill knowledge, Helen sourced suitable websites and linked them to the class wiki, along with focus questions to direct student note-making. When student questions prompted lines of inquiry not originally planned for, Helen encouraged them to identify keywords that could be used as search terms. She then modelled a range of search strategies using Google (and other search engines) using the class data projector, before allowing the groups to undertake independent investigation.

Figure 1. Students using the digital microscopes and laptops Scion provided

Helen said that

> … having access to the laptops was brilliant. I could have all the children in groups on a computer, answering specific questions, which these websites were linked to [the wiki] … so it was quite directive in some places … but they were still making their own notes. It was great … there was no point in going down to the gully and putting food in the traps when we didn't know what the predators liked to eat! I couldn't have done it without the technology, a lot of it, and having the night camera and being able to get real footage … that was huge. (Helen, interview transcript 2, November 2009)

Audioconferencing was used by the whole class to interact directly with scientists at Scion, particularly when students needed specific information to help with their field investigations, or, as in one case, they wanted to find out more general information about the work of scientists. According to Helen, the synchronous audioconferencing interaction was extremely valuable, in that "actually hearing someone talk about it made it seem more real to the kids" (Helen, interview transcript 2, November, 2009). It also supported her objectives from the Nature of Science strand of the curriculum by helping to dispel the myth of science being all about "the mad scientists with crazy hair" (Helen, interview transcript 2, November, 2009), and provided students with a greater understanding of the purpose of scientists' work. She stated that an audioconference with the Scion entomologist Kerry was particularly useful in this respect, as she linked her comments directly to the students' gully investigation, adding authenticity to their work:

> … the whole process of planning an experiment, thinking up questions and working out how you are going to answer them with an experiment … finding the answer. You have to want to know what's going on around you … how things work … and be interested in finding out more. You need to think clearly and plot solutions … just like you guys are doing in your gully. (Kerry, audioconference transcript, September 2009)

The second significant contribution ICT tools made was twofold: it was the means by which partners could communicate and share project outcomes with diverse audiences, and it had learning benefits for students—especially in terms of their sustained engagement in literacy-related activities such as procedural writing and reading. For the duration of the unit, Helen established a class wiki on Wikispaces (Figure 2), which was used to report project findings and invite contributions and comments from others, particularly parents and those in the wider community involved in similar activities. She also used the wiki as a means of communicating with the Scion team—particularly the scientists who came to the school for the gully investigation—to gain feedback and guidance on the practical investigations the class was involved in.

The wiki was the principal communication tool used for this project, and it served its purpose effectively by engaging the parents of students in the class, and the wider school community, in this unit. Helen commented that

> … having the wiki space … it's a vehicle for sharing information and what we are doing … the feedback from parents was great … they were really excited about how enthused the kids were, they were all coming home from school talking about it. One mum who has three children at school said they were all talking about the same thing … asking each other questions, getting on the wiki … with the wiki they [parents] can see what we're learning … they can get on at home. (Helen, interview transcript 2, November 2009)

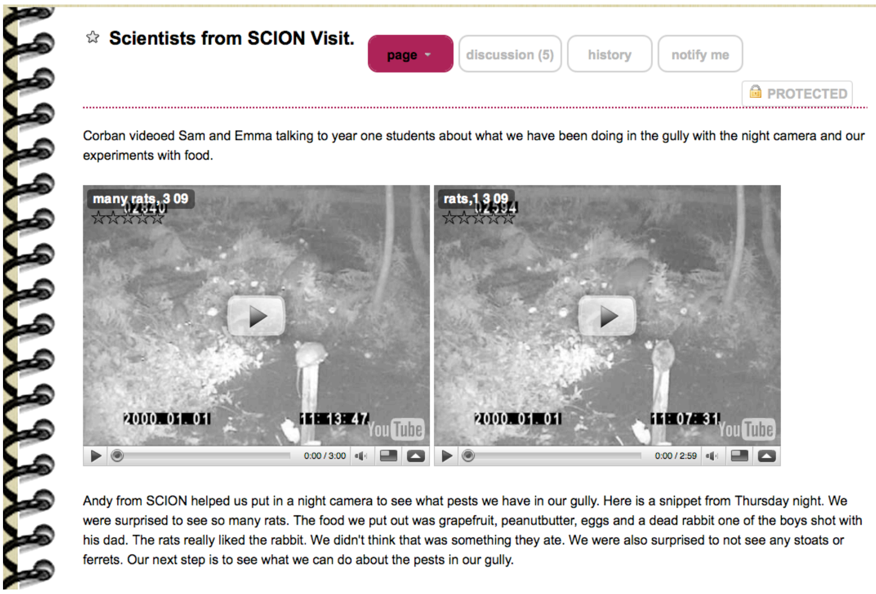

Figure 2. The project wiki on Wikispaces showing footage gathered by the night vision camera

The wiki also appeared influential in encouraging students who were usually reluctant writers to engage with the unit. Helen observed that there were at least two motivating aspects to this: the authenticity of the project, and the fact that students were communicating, via the wiki, with a "real" audience. According to her, both the volume and quality of students' written language improved significantly during the study, largely because using the wiki:

> … gives them more of a sense of purpose, they've got a real audience… it's not just us [the class] seeing it. Often you do work, and you know it's great learning and stuff, but it stays in the classroom, no one else gets to see it. For some kids, like one of my girls, not the best writer … but you should see her wiki … she was downloading the photos and writing about them. It was huge motivation. It helped her literacy skills without a doubt. They don't realise they're reading or writing when they're on the computer. (Helen, interview transcript 2, November, 2009)

This finding is consistent with other studies that identified significant motivational and engagement benefits from using digital technologies for authentic writing tasks in literacy programmes, particularly with students who had a history of non-engagement or under-achievement in this area (McDowell, 2010).

Developing skills to make best use of the wiki was an ongoing process, with Helen often introducing them to the students as she learned them herself. She also taught them by demonstration, and supported students to teach each other. She particularly commented on the merit of this approach for one boy who had social issues, but had very good computer skills. He valued the opportunity to teach skills to others, and in the process "gained a bit of status" (Helen, interview transcript 2, November, 2009).

Thirdly, the opportunity to access whole-of-class technology was highly significant to Helen professionally. She viewed the chance to learn about and use a range of new technologies such as the infrared night vision camera and the digital microscopes as unique, and developed significant technical and problem-solving skills as a result. Because help from Scion was over 100km away, she generally had to solve any issues herself:

> … it's a huge learning curve for me … with the technical things like the night camera … we had to take it down over the weekend … I had to reset it. It forced me to learn, I had to learn all sorts of things, like the wiki and the video footage from the camera. I had to learn how to convert it into something we can see … it's really great when the scientists [from Scion] give us feedback on our wiki, which they have done a few times. (Helen, interview transcript 2, November, 2009)

Additionally, because Scion personnel could not be on-call to assist with issues, Helen's students also assumed responsibility for developing their own solutions to problems, and sourcing answers to questions. While the scientists were always in the background to provide support if needed, they were viewed as only *one source* of help, amongst others. This was both significant and important, as sustaining partnerships such as this requires the establishment of a *non-parasitic* relationship. That is, the relationship needs to be one where support is provided initially and where needed, but has the longer term goal of sustaining higher quality science teaching largely from within the school.

In summary, the ICT Scion provided for this partnership was important to its overall success. During different phases of the unit, various ICT tools were essential to support independent, student-led investigations, enable the collection and use of data which would have otherwise been inaccessible, and serve as a highly effective medium for communicating project outcomes and gaining feedback and engagement from parents and the community. Another key aspect was that the amount of ICT hardware was sufficient for the whole class, which meant that access management difficulties were lessened. It was possible, therefore, to seamlessly integrate its use into the day-to-day classroom programme.

Discussion

When reflecting on the brief summary of Grobe's (1990) typology presented in the literature review, it is debatable whether or not this interaction could indeed be termed a genuine partnership, or at very best, it would exist at the most basic level of partnership arrangements. As previously discussed, a genuine partnership should be a mutually satisfying relationship, which typically involves the free sharing and exchange of knowledge and ideas to the benefit of both parties. However, while knowledge and ideas certainly flowed freely in this example, it was predominantly one way. In stating this, however, there is no doubt that Helen, the students and to a lesser extent the whole school, benefited significantly from this series of interactions. While the partnership may have been extremely simple according to Grobe's (1990) framework, it was nonetheless very effective, with benefits going well beyond the undoubted enhancement of ICT provisioning alone.

The reasons for concluding this largely relate to the role Scion personnel played in building Helen's confidence to be able to actually teach science with interest and accuracy, by using an approach that was effective and engaging for students. By her own admission, Helen had traditionally experienced difficulties with teaching science because of a lack of confidence in her accuracy and interpretation of science concepts, and structuring and undertaking student-led inquiries to support the development of such concepts. This previously resulted in science being taught in a diluted way through integrating it with other curriculum areas, sometimes to the extent that the actual science learning was unrecognisable. While this partnership directly bridged some gaps in Helen's conceptual knowledge, indirectly the impact was far greater. Helen's participation in the project revealed to her *that she really could do this*, and gave her the confidence that departing from her tried and true, strongly teacher-directed approach could yield better outcomes for her students and improve her own knowledge and skills in the process. While the partnership was more of a direct intervention by Scion in the class's unit, it was negotiated and implemented in such a way that it served to *scaffold* (Vygotsky, 1978) learning for Helen and her class, in that it *modelled* the sort of approaches needed to undertake successful inquiry-based science.

From initial meetings when goals and objectives were collaboratively negotiated, through to the structuring and timing of on-site visits by scientists and the audioconference and wiki-based interactions, this partnership adopted a *needs-driven* approach. This effectively ensured that high levels of project ownership, identification, and direction were vested in Helen and her class. While it was apparent that Helen may have initially lacked the confidence to undertake student-led science inquiries on her own, she did not lack the attitude to *give it a go*. Professionally she viewed this opportunity as unique, and a chance to branch out and try a new approach in an area she was not confident in, because she could draw on expert guidance and support. It was a combination of these things that appeared very successful in motivating and engaging Helen and her students, and undoubtedly contributed to her enhanced sense of self-efficacy in being able to independently design similar approaches in the future.

While data indicated that the partnership was highly significant from Helen's perspective, in terms of the kind of reciprocal relationship Grobe (1990) suggests, the outcomes and benefits for Scion appeared less obvious. While Simon stated a desire to learn more about the planning and organisational aspects of science teaching in schools through the development of a collaborative online workspace, it never happened. Instead, decision-making about Scion's input was ultimately up to Helen, and this reflected accordingly in her planning. There appeared to be little evidence of discussion about how Scion's input was to be tied to curriculum goals and student learning outcomes. While anecdotal feedback from Simon suggested he had gained some knowledge of this, there was no data to validate this claim, nor to specifically identify what this knowledge may have been. This issue was accentuated by the absence of any evaluation process or procedure through which either the developing outcomes and general impact of the partnership could be assessed, or feedback provided where needed. Had such procedures been developed during the initial planning meetings, there would possibly have been greater opportunities for formative interactions between Simon and Helen to assist in meeting such goals.

The role that ICT played in delivering and sustaining this partnership was significant, particularly given the geographical separation of the participants. Apart from learning advantages for students through their access to information via the Internet, audioconferencing, and Skype™—and the enhanced motivational factor often aligned with technology use (Wright, 2010), ICT was an important tool for sustaining this relationship over its 10-week duration. Particularly important was how the class wiki was used, in that it provided something of a *public front* for the partnership, and served as an effective medium for gathering feedback from scientists, parents, family, and others with an interest in environmental ecology. As the project developed, each student group had responsibility for some aspect of the wiki's development, and used it to display data such as information about their investigations, live video from the infrared night camera, letters to the city council about caring for the gully, and outcomes from interviews with scientists.

While the wiki did not generate a large volume of responses, its impact was still significant. In some cases, feedback provided students with new ideas for gully investigations, or information helpful for solving research problems. The ongoing and supportive feedback students received via the wiki enhanced their motivation and reinforced the authenticity of their investigations, through affirmation by an audience beyond the school. The fact that the wiki delivered this feedback almost continuously was fundamental to sustaining student interest in the unit, long after its anticipated conclusion date. This sustained engagement was further enhanced by access to the web-enabled laptops, digital microscopes, night vision cameras, audioconferencing equipment and other digital devices, which were used independently by students to search for information and solve problems. Helen could therefore broaden the unit in different directions simultaneously, in response to specific student interest and motivation.

From Scion's perspective, ICT tools were also essential to the production of a viable and sustainable partnership model. It was critical that the costs involved in establishing and operating the partnership were minimised, and ICT was viewed as a principal way of achieving this. While data indicated how valuable face-to-face interactions were between scientists and students, longer term and on a wider scale such a model would be unsustainable, given the financial constraints and fiscal return-on-investment environment in which CRIs currently operate. Although no exact figure was provided by Scion on the cost of engaging three expert scientists in field work for this partnership (approximately two days), in addition to time for audioconferences and responding to wiki postings, there can be little doubt that it was considerable, both in terms of the paying-project opportunity cost, and the direct financial cost of transporting them for each of the visits.

In developing partnership models therefore, careful consideration needs to be given to overall cost and efficiency, balanced against the most effective way of achieving the partnership's goals. While the comprehensive use of ICT undoubtedly enhanced this partnership, it complemented, rather than substituted for, the *human element*. ICT could not replace the process of science inquiry the scientists demonstrated—it could only provide information and communicate links about it.

This study strongly suggests that at a primary school level, where teacher knowledge and confidence may be lacking, face-to-face support is highly valuable. It is clear, however, that challenges exist in arriving at viable cost-benefit partnership models at this level.

Acknowledging that this partnership was one of the first in the Science-for-Life programme, analysing its form and nature using Grobe's (1990) typology enables us to learn more about how such interactions could develop into longer term, mutually satisfying relationships of increasing complexity and impact. While it would be unrealistic to have expected this partnership to have met Grobe's criteria for broad-ranging, complex partnerships of widespread impact, the typology does provide useful "markers" that can be used to guide the evolution of partnerships from simple interactions such as this, to ones of greater efficiency and impact. From this partnership, analysis indicates that deficits in areas such as evaluation and feedback, communication system development, collaborative goal setting and planning, partnership sustainability (through exploring more cost-effective support mechanisms) and improving the reciprocity of the relationship need addressing for future partnerships to evolve. However, in stating this, it needs to be remembered that Grobe's framework was never intended to be used as a yardstick for assessing the *actual value* of partnerships, but rather as a conceptual tool useful for guiding their development. As illustrated by this case study, although the partnership was very simple and may not have met many elements of Grobe's (1990) framework, it was nonetheless a highly worthwhile and successful endeavour.

Conclusion

Whilst recognising this was a single case study, it nevertheless provides some tentative insights into the potential value of SSPs such as Science-for-Life, and illustrates the difficult balancing act between cost-effective ICT-facilitated partnerships, and partnerships based on highly effective but expensive face-to-face interactions. It also highlights that for partnerships to be of value, they do not *necessarily* need to be complex, expansive, or have high degrees of penetration at different levels of the school system. To that end, Grobe's typology was both a useful analytical lens through which to review this initiative, and at the same time help identify areas for possible future development. Further research needs to be undertaken into different models for industry-education partnerships in science, to enable the knowledge and capability potential inherent in organisations such as CRIs to be utilised effectively for furthering science literacy goals through the use of relevant ICT tools.

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