Knowledge building with senior secondary sciences students: The OUASSA project

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Introduction

The Otago University Advanced School Sciences Academy (OUASSA) project was a two-year (2011–2012) project funded by the New Zealand Ministry of Education and the University of Otago to support potentially high achieving Year 13 students from rural/provincial or low-decile schools to cultivate their interest in science and enhance their ability to excel in the NCEA (National Certificate of Education Achievement) examinations. In each year of this project, a cohort of more than 50 students from across New Zealand was selected to participate in two five-day residential schools at the University of Otago. The residential schools aimed at enriching the participants’ understanding of how real scientists work as well as enhancing their knowledge of science subjects. In the first residential school in late January students were accommodated in a hall of residence at the University of Otago campus. During the July school term break, a second residential school was held, and students were accommodated at a boarding residence of a Dunedin high school. In collaboration with a number of academic departments at the University of Otago, lectures, lab sessions, field trips, individual and collaborative projects were organised during each residential school. Throughout the year a virtual school was set up using the knowledge-building approach and the networking software Knowledge Forum to support the participants to develop their capability in creating and building knowledge in science in an online...
community of inquiry. It is recognised that New Zealand, as a knowledge society, needs to develop its young people's competency to work creatively and innovatively with knowledge to acquire the competency of becoming “competent thinkers and problem solvers, [who] actively seek, use, and create knowledge” (Ministry of Education, 2007, p. 12). The purpose of the virtual school was not so much in enhancing the participants’ subject knowledge expertise, but rather to facilitate the development of their skills and confidence in becoming knowledge creators in science.

In this paper the knowledge-building community approach will be discussed and some findings from the first cohort (52 students) of the OUASSA project will be reported.

The knowledge-building community approach

With the advent of digital technologies, increasingly teachers are using technology-supported learning environments to facilitate students to develop metacognitive, problem solving, collaborative, and learning-how-to-learn skills that are required to work with and create knowledge in the knowledge society (Lin & Sullivan, 2008). We have seen a myriad of technology-enhanced learning environments that have been designed and researched internationally in the last two decades. These include projects such as problem and project-based learning (Krajcik & Blumenfeld, 2006), discovery learning (de Jong, 2006), anchored instruction (CTGV, 1994), cognitive apprenticeships (Collins, 2006), and knowledge-building communities (Scardamalia & Bereiter, 2006). We now understand that to have a sustained impact on teaching and learning, technology-supported learning environments need to be well designed, based on learning and pedagogical principles, and integrated into the school curriculum (Lai, 2008). One of the very few of these technology-supported learning environments that is based on a well-designed pedagogical model is knowledge-building communities, developed by Scardamalia and Bereiter (2006). This model has been developed from over two decades of cognitive research on intentional learning, and it views learning as a constructive process of knowledge building (Scardamalia & Bereiter, 2010). The goal of knowledge building is “the production and continual improvement of ideas of value to a community” (Scardamalia & Bereiter, 2003, p. 1370) and the role of the teacher is
to guide learners to “engage in extended questioning and explanation-driven inquiry” (So, Seah, & Toh-Heng, 2010, p. 480). In the knowledge-building model, there are 12 pedagogical principles (Scardamalia & Bereiter, 2006). These principles (refer Table 1) are student-centred principles based on the premise that all learners can create authentic knowledge and advance communal knowledge in their classes, similar to what research and science communities do (Lee, Chan, & van Aalst, 2006). Knowledge-building research has shown that by being immersed in knowledge-building communities, students can create and develop domain knowledge, and the competencies and cultural practices which are needed in the knowledge society (e.g. Bielaczyc & Ow, 2010; Fong, 2010; Oshima, et al., 2006; Zhang, Scardamalia, Lamo, Messina, & Reeve, 2007).

Table1: Twelve pedagogical principles of knowledge building

<table>
<thead>
<tr>
<th>Real ideas, authentic problems</th>
<th>Symmetric knowledge advancement</th>
</tr>
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<tbody>
<tr>
<td>Improvable ideas</td>
<td>Pervasive knowledge building</td>
</tr>
<tr>
<td>Idea diversity</td>
<td>Constructive uses of authoritative sources</td>
</tr>
<tr>
<td>Epistemic agency</td>
<td>Knowledge building discourse</td>
</tr>
<tr>
<td>Community knowledge, collective responsibility</td>
<td>Embedded, concurrent, and transformative assessment</td>
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<tr>
<td>Democratising knowledge</td>
<td>Rise above</td>
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</table>

In knowledge-building communities, a web-based networking software, Knowledge Forum, is used to support online knowledge-building discourses and to engage participants to develop, reformulate, critique, and build on ideas on authentic questions to advance personal understanding and communal knowledge. Views (similar to discussion forums) can be set up in Knowledge Forum for participants to contribute ideas by posting notes and annotation notes to the views. Notes can be built onto each other and links between notes are displayed on the view. To kick off a knowledge building discussion, the teacher typically would post an opening note to ask a broad question, or post a problem to be solved by the class. Students are also encouraged to
post questions that are relevant to the topic under investigation. Throughout the knowledge-building discourse, students contribute ideas and build on each other’s ideas to develop theories and solutions. To provide evidence to support their theories, students would read articles, search for information, or conduct experiments, undertaken either individually or in groups. Scaffolding tools in the form of writing prompts (e.g., My theory, A better theory, I need to understand, etc.) are available in Knowledge Forum to support students to build theories and ask questions.

The study

While knowledge-building research has been conducted in a number of countries in the last two decades, the majority of this research was at the primary level. It is not clear how the knowledge-building approach and Knowledge Forum can be effectively integrated into the senior secondary school curriculum where there is far less flexibility in its implementation. Also, no research has been conducted to investigate how the knowledge-building pedagogy can be used to support distance learning. In this study, several research questions have been investigated, but for the purpose of this paper, findings on how the project has affected the participants’ interests in science, as well as its effects on the development of ideas during the knowledge building discourses, will be reported. Data was collected from several sources, including pre- and post-questionnaire surveys, student interviews, and the knowledge-building notes.

In Cohort 1, there were 52 students (42% male, 58% female), with the majority of them being New Zealand Europeans (87%), and only 2% were either Māori or Pacific Islanders. Over three-quarters of the students (78%) came from lower decile schools (Decile 5 or below). Fifty-two and 28 students responded to the pre- and post-questionnaires, respectively. Thirteen students (six male and seven female) were interviewed in July.
How did the project affect participants’ interest in science?

New Zealand is a sparsely populated country and many schools in rural areas have very small classes, particularly in senior secondary classes. Due to small school size and the lack of specialist teachers, many rural secondary schools are formed into clusters to deliver a wide range of subjects to their students using videoconferencing as the primary delivery tool. There are now over 200 schools, formed into 15 Virtual Learning Network clusters (http://www.virtuallearning.school.nz), with the Virtual Learning Network Community being its national organisation. Students undertaking videoconferencing classes seldom have the opportunity to meet their classmates face-to-face and very often they are isolated both socially and academically. It has been clearly shown in the literature that social interaction is essential in supporting distance students to learn and construct knowledge (e.g., refer Kreijns, Kirschner, & Jochems, 2003), and the lack of social contact in videoconferencing classes has to be addressed.

The OUASSA project provided participants the opportunity to meet with like-minded people and work together in a community of inquiry. This opportunity was highly valued by the participants, and the social contact had a positive impact on their attitudes towards learning. As reported by a student from a small and low decile school, the OUASSA project has brought:

Around a whole group of like minded students [which] is fantastic, it’s just something you don’t get so much, especially at my own school … 50 people who all have the same level of thinking … helps challenge you … pushing you to think harder, think further than what school requires you to … who I can discuss ideas with … other students who are as passionate about science as I am … [I have learned] a lot about the nature of science and how scientists need to focus on the reliability of topics and how to express science to others in a scientific or non-scientific field. (S01)
Student S02 was the only student in his year who did physics through videoconferencing, and in his biology class there were only two students. He commented on the benefits of the OUASSA project:

While we’re different, we’re kind of like-minded, we’re all looking at science in the future and that’s something you don’t get in the smaller school. (S02)

Another student agreed:

I enjoyed the hands on approach … they are not babying us … My school is quite small … like 300 from Year 7 to 13, and there’s only like 12 of us in Year 13 … there’s lots more people I can connect with here … with similar interests. (S08)

Even though students might have friends in school, they needed the academic challenges, as pointed out by one student:

[What] I’ve enjoyed most is all the people I’ve met because just like coming from a small rural school and being fairly intelligent … I have lots of friends but not that I can talk … kind of sophisticated things. (S10)

Being able to communicate and work with like-minded people widened the perspectives of the participants and allowed them to see the bigger picture. As commented by the following two students:

You meet a lot of people that have similar interests to you, you know you make different conclusions. You think about things you never really thought about in that topic … it’s a lot bigger in the real world … the bigger picture. (S05)
It’s great. I really enjoy seeing other people’s ideas being expressed …[as well as seeing] my preconceptions change and … other peoples [changing] so that we end up with a consensus that slowly becomes far more valid and far more reliable. (S01)

Gaining confidence

The OUASSA project has also increased the confidence of the participants to share ideas and talk about science as an epistemic agent. The following comments from the participants showed the increase of confidence of learning on their own:

I’ve gained lots of friends, a bit more confidence in terms of my schooling and knowing I can learn things. (S06)

Confidence to not just look at what we’re doing in terms of how I can write an answer to this but look at it in terms of how can I comprehend that for myself … I can figure it out for myself rather than having to be show … how to think about science … being able to apply what you know to those new situations. (S01)

Definitely my confidence … I could ask … even if they don’t know, I’ll just go and I’ll look it up online … the January one, it wasn’t so much about knowledge … we learned some interesting things in the broad idea of science. (S12)

For many participants, it was also a valuable social experience:

I’ve gained friends I’ll probably have for life … it is a social experience too … I’ve sort of become more confident … as well as learning stuff … I’ve learnt a bit about myself … and got better into situations around new people. (S11)
Future career

The interview data showed that the OUASSA project had impacted on the students’ choice of science as their future career. In particular, the residential schools were invaluable in widening students’ perspectives about their future careers, as the following students commented:

It’s too short a time to learn anything specific … but it did give me certainly more a feel for what scientists do … more an intimate knowledge of science as a career. (S10)

It opened up my view on it [science] … I actually see what science extends to and where its applications are. (S11)

For several students in Cohort 1, being able to experience university life has changed their ideas of what they saw as their future career:

Definitely my career … something I’d like to do at Uni next year … it’s been a life changing experience really. I mean I wasn’t even considering coming to Uni before I came here. (S05)

It’s made me a lot more passionate about the different aspects of it now that things are starting to make more sense … how the different things relate to what you could possibly be doing in the future. (S03)

Development of ideas

During the January residential school, the knowledge-building approach was introduced to the students, and a workshop was run to provide students with hands-on experience using Knowledge Forum. In the July residential school, the knowledge-building model was again discussed. The topics of discussion were primarily related to different aspects of climate change. A number of views (discussion forums) were created from March to
September for the first cohort of students. There were five main views which were the more active in this cohort. The first view, titled \textit{Climate Change}, was active during March and April. Thirty-five students contributed 122 notes and annotation notes to this view, plus 12 students who did not contribute but read the notes (refer Figure 1 for a screenshot of this view). A follow-up view was set up in May, titled \textit{Is anthropogenic climate change real?}, and had 15 contributors (plus 21 readers) contributing 47 notes. In these two views the whole cohort participated as a group in the discussion. From May onward, three parallel views were set up and the participants could choose to participate in any of the three views. The number of contributors for each view was therefore quite low, with only four to five contributors in each view, although the number of readers was much higher (13–18), and these views were active for about a month. Since participation is voluntary in the virtual school and knowledge building discussion is considered an extra-curricular activity, this level of participation, while disappointing, was not unexpected. Possible reasons affecting the low level of participation include the group size, the discussion topics, the technical issues encountered, and the way that the knowledge-building forum were moderated. Some of these issues will be discussed later.

\begin{center}
\textbf{Figure 1: Screenshot of the Climate Change view}
\end{center}
To investigate how ideas were developed in these views, we chose the first view as an example. The Climate Change view was the first and primary discussion forum in this cohort. Over two-thirds of the students have contributed notes to this view. If reading (but not contributing) notes is also considered as a form of participation, 90% of the students have participated in this forum. In this view there were 109 notes, plus 13 annotation notes (a total of 124 notes). There were 12 clusters of notes (refer Table 2). In each of the clusters in this view, we have seen development of ideas, although the extent of development varies from cluster to cluster, as in some cases clusters might be quite small. We can see that many students have contributed ideas and theories during the discussion, and some have also provided resources to facilitate discussion. There were 77 notes (63%) in these clusters, which were build-on notes (notes developing ideas contributed in previous notes), and the rest (47) were either isolated notes, or notes asking questions or providing answers, but not engaged in idea developments. It is also noted that the number of participants who contributed more than one note in each cluster was quite small, showing that ideas were not frequently followed up or further developed by the original contributor.

Table 2: Contributions to the discussion forums, Cohort 1

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Notes and annotations</th>
<th>Contributors</th>
</tr>
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<tbody>
<tr>
<td>C1</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>C2</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>C3</td>
<td>3</td>
<td>3</td>
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<td>C4</td>
<td>8</td>
<td>7</td>
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<td>C5</td>
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<td>8</td>
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<td>C6</td>
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<td>C7</td>
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<td>C8</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>C9</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>
The following excerpt from the *Physics of Climate Change* view provides an example of idea development. In this view, students were asked to explore the physics behind the greenhouse effect and propose scientifically based solutions to reduce this effect. In one of the clusters of this view, seven participants contributed 16 notes and annotation notes. The following is an excerpt of the discussion.

Student H: [My solution is to] create more clouds to reflect the sun’s energy back out of the atmosphere.

Student G built on to this idea: Large bodies of forestry in a sense “create” clouds … it is better to plant trees than build mountains, apart from the costs of mountain production, lies in the forests ability to hold moisture. Forests … will very likely create clouds, which would serve the purpose of reflecting heat.

Student D: Clouds actually also contribute to global warming as well … While I’m not saying your idea is bad, in fact it’s most likely a viable idea as it also encourages CO2 reduction by means of photosynthesis … What I am saying is that clouds may not have as large of an impact as you thought.

Student G: I think you’re right. I'll build onto this in a couple of days.

[After a few days]

Students G: Ok … given Student D’s info, and this global dimming
phenomena, I now propose it would be irresponsible to stop global warming, in the physics aspect, by adding things to the air … [a better theory]. We need to focus on how to deal with the amount of man-made emissions getting into the atmosphere, and working on removing the excess.

In this example, Student G has built on the idea contributed by Student H and then developed his own theory of how to reduce the greenhouse effect. However, his theory was critiqued by Student D. After reflecting on Student D’s comments, Student G revised his theory. We can clearly see the development of ideas from this example.

*Effects of the knowledge-building process*

Other than creating and developing ideas, the knowledge building process has impacted the students in other ways. The following comment from a student suggested that the Knowledge Forum discussions have widened his perspectives on science.

I definitely gained a lot of knowledge through Knowledge Forum … Through Knowledge Forum there’s definitely that interplay of ideas and exchange of ideas trying to understand how other students think as well and trying to see their thought patterns and processes. (S01)

Some students suggested that the Knowledge Forum discussions have increased their critical thinking skills:

The Knowledge Forum especially just helps with your critical thinking and actually trying to understand an idea, ’cause quite often we just get told what it is that happens and we just assume that’s the way why it works without actually thinking about it, whereas in Knowledge Forum, we discuss with other people then our ideas start to change because we can see other people’s point of view and how that’s slightly different than what we had originally thought, so I find that really interesting. (S03)
Students also commented on the effects of the Knowledge Forum discussions on their communication skills.

I’ve gained how to put together a proposal or idea … at the beginning … I had trouble with writing out any ideas I had … and what I’ve gained, this focused in a paragraph in a post … like the one idea of physics and of biology. (S02)

The ability to communicate more … when I write something I try to make it as nice as possible … I like it when I read other people’s stuff and it makes me think. (S03)

The participants were asked in the post questionnaire survey as to what extent they felt like learning in the virtual schools by themselves and also as a group, and 67.3% were happy to learn as a group. The qualitative data showed that overall, students in this study were very happy to collaborate with other students online. For students from small rural schools, it is an opportunity for them to work with students in other schools and discuss topics that were of interest and relevant to them.

I quite like the idea … there’s not many people at my school that I can actually talk to about this sort of thing … so that discussion online was pretty good. (S06)

When asked how they felt about the knowledge-building process, in particular, whether or not the process had supported them to develop ideas, two-thirds of the 18 students who responded to this question were positive. The following are typical comments:

I feel that I better understand the process of discussion – that ideas can be built on by multiple people to form a coherent and clear idea. (S53)
When using the Knowledge Forum in the July science camp to construct theories and ideas to solve a problem, I think it helped me learn to discuss ideas with other people as a team which resulted in a better solution. (S17)

The discussions are great because they have helped me to develop more lateral thinking patterns which is useful when trying to understand a scientific idea, and for building an idea where I can easily pull in other relevant information to refine an idea. (S11)

**Issues with knowledge building**

*Technical issues*

Students in the 2011 cohort initially had experienced a lot of technical issues in using Knowledge Forum. They had to spend time to familiarise themselves with the software with the technical and security issues associated with the use of a Java-enhanced web browser to access the graphic mode of the software. As some students commented:

And the Knowledge Forum … you know they have complicated filtering systems … when I go to give them a logon for the Knowledge Forum, it does a sort of jittery thing and I just can’t get on it from the school, so I have to look at it at home. (S02)

My password wouldn’t work for ages … there was a setting … I tried it several times with the different things … but it didn’t work for ages, I think it took about three weeks to be able to get on there … I found it really hard to use. (S13)

Knowledge Forum could be used …[in] very good [ways], it’s just the way it’s currently being used [in such a serious manner], that’s not working out … (S05)
Topics of discussion and time commitment

Some Cohort 1 students also complained about the topics of discussion:

Knowledge Forum … the first topic was good but then people started to get over it and wanted a new topic so it sort of died down a bit. A better topic could’ve been chosen that would’ve kept our interests the whole way through it … if the topic had interested me, I would’ve put more time into it but it didn’t. (S06)

Participating in online knowledge building is time consuming, and since the topics of discussion were not directly related to their schoolwork, some students were reluctant to spend time on it:

They are really deep and complex questions that take a lot of time than thought, and that’s the time and thought you tend to want to be using on your study … it’s a bit much of a stretch when it’s not directly related to what we need to learn … they needed to be more related to our school studies and then it would have been a lot more beneficial. (S05)

I did learn a few things … but it was over a long stretch of time and not the best way to learn things … I could Google it and probably find out similar ideas which is what they were doing … I didn’t learn it efficiently. (S08)

Discussion and conclusion

Findings from the questionnaire surveys, interviews, and content analyses showed that the virtual school was effective in enhancing the participants’ interest and understanding of science, and the knowledge-building discussions had a positive effect on idea development. As most of the participants came from low-decile and small rural schools, the project provided them an opportunity to meet with real scientists and work with
them in advanced science labs, which has greatly increased their understanding and widened their perspectives of the nature of doing science. What the participants valued most was the opportunity to engage with like-minded people and the opportunity to discuss academic matters and challenge each other’s viewpoints, both face to face and online, which they seldom had the chance to discuss in their small rural schools.

There were some technical issues of using the Knowledge Forum software that needed to be addressed should this project be continued in the future. We understand the knowledge-building research community is currently redeveloping Knowledge Forum as an open-sourced, web-based networking software. The technical issues discussed in this report should be resolved once this new version of the software is available in 2013. The problems with the topics of discussions identified in the first year of the study have been addressed in the second year. The experience and knowledge that have been gained from using the knowledge-building approach and Knowledge Forum in supporting developing ideas by the OUASSA teachers also had a positive effect on how discussions were structured and supported in the second year of the project.

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References


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