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RESEARCH INITIATIVE
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# Designing knowledge building communities in secondary schools

Kwok-Wing Lai
With: Ann Trewern, Ken Pullar, Conor Bolton, Madeline Campbell, Tamara Yuill Proctor, Darren Sudlow, and Tony Zaolum

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# Introduction

With the emergence of globalisation and the knowledge economy, it has become a priority for economically advanced countries to increase and democratise the innovative capacity of their citizens. In New Zealand, there is an urgent need to develop young people's capacity to work creatively and innovatively with knowledge (Ministry of Education, 2007). This presents a huge challenge for teachers, who will be required to shift their pedagogical beliefs and practices from supporting students to reproduce knowledge, to "actively *interact with* it: to understand, critique, manipulate, create, and transform it" (Bolstad & Gilbert, 2008, p. 39, emphasis in original).

A knowledge building communities (KBC) model developed by Scardamalia and Bereiter (2003) has been used internationally to support students to become knowledge creators of the 21st century. Developed from over three decades of cognitive research on intentional learning, the goal of knowledge building is "the production and continual improvement of ideas of value to a community" (p. 1370), and this model has 12 principles (refer to Appendix 1). The KBC model is based on the premise that students can create authentic knowledge and advance communal knowledge, in a similar manner to research and science communities (Lee, Chan, & van Aalst, 2006). In this model, students primarily use Knowledge Forum, a Web-based networking software system to support knowledge building discourse. Knowledge Forum has a set of thinking prompts designed to engage users to develop, reformulate, critique, and build on ideas about authentic questions to advance personal understanding and communal knowledge.

It is important to distinguish between the KBC model and other inquiry-based learning approaches (Lai, 2014). On the surface, some of the features of the KBC model are similar to inquiry learning, which refers to an active learning approach designed to facilitate students learning content and thinking skills through investigating topics collaboratively, with learning activities organised around authentic problems or questions. Students develop understanding by sharing information and developing evidence-based explanations to answer an initial question (Hmelo-Silver, Duncan, & Chinn, 2007). While the inquiry process of these two approaches may look similar, e.g., learning activities are often undertaken collaboratively in both approaches, their goals are slightly different. The goal of knowledge building is to generate and improve ideas to create shared community knowledge, whereas the goal of inquiry learning is primarily to enhance individual understanding of content and skills to be resided in the student's mind, although shared knowledge may also be created during the inquiry process. In a knowledge building class, students will work in small groups or as a whole class (online and/or face-to-face), sharing information and personal understandings on an open-ended topic. They will ask questions, conduct research, produce ideas, explanations, and theories and develop these ideas and theories collectively as knowledge belonging to the community.

The majority of KBC research conducted in the last three decades has been at the primary school level. It is not clear how the KBC approach can be effectively used to teach the senior secondary school curriculum, which is perceived as far more compartmentalised and less flexible. Very little KBC research has been undertaken in New Zealand schools, although one national project was recently conducted by Lai (2012, 2013) with a group of Year 13 science students from rural and low-decile schools. Prior to the present study, no research had been conducted to investigate how knowledge building pedagogy can be used to support distance learning. In the New Zealand context, it is particularly important that this knowledge gap be filled.

In KBC research, Knowledge Forum is usually used to support online knowledge building discourse. In Knowledge Forum, the discussion space is called a *view* and discussion notes contributed by participants are posted to a view. Figure 1 is a screenshot of a view of the biology class in this project.

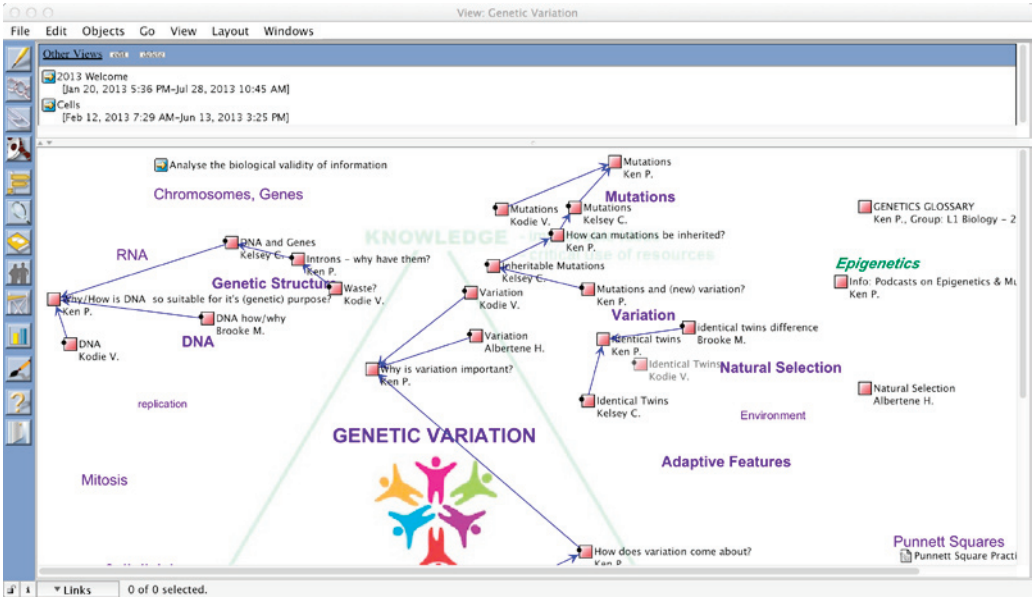



Figure 1: A Knowledge Forum view of the biology class

In the knowledge building process, students contribute ideas by posting "notes" or "annotations" to a view. Notes can be built onto each other and links between notes are displayed on the view. An annotation is similar to a Post-it note, and can be attached to a note. Figure 2 is an example of a note with an annotation attached to the bottom. Figure 3 is an example of an annotation. To start a discussion, a teacher or student would post a start-up note to provide the class with a broad question or problem. Students respond by contributing ideas, and building on each other's ideas, to develop theories and solutions, or ask further questions. To provide evidence to support their theories, students read literature, search the Internet for information, consult experts, and conduct field trips or experiments. Students may use the thinking prompts available in Knowledge Forum or design their own to support theory building or progressive problem solving.

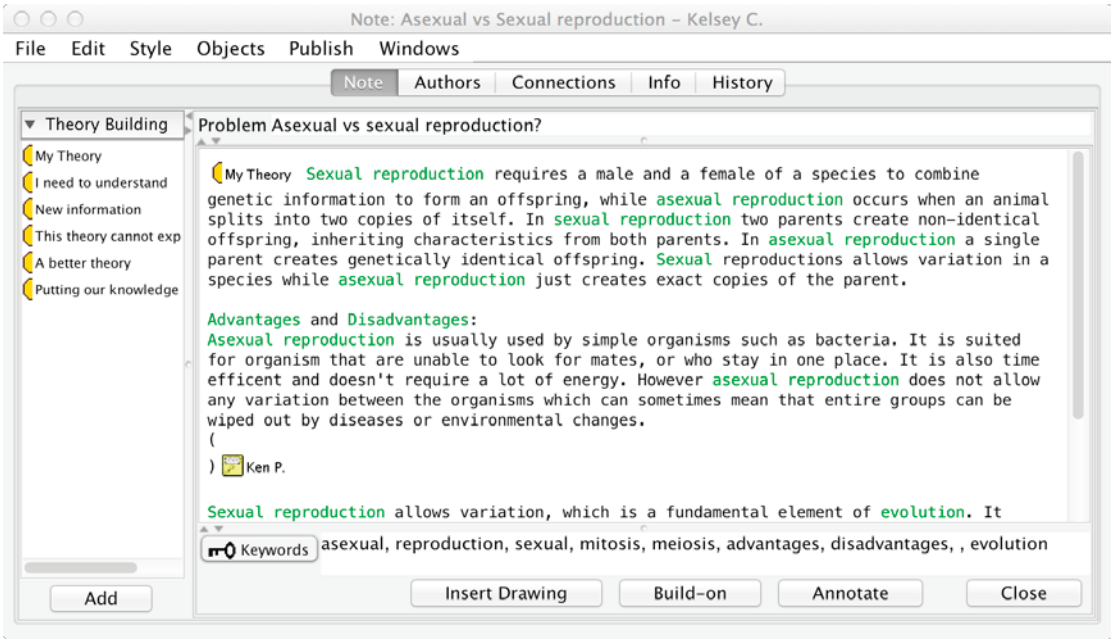



Figure 2: Example of a note

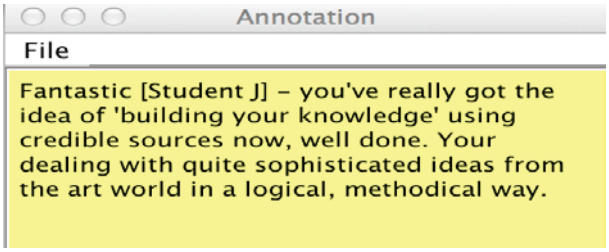



Figure 3: Example of an annotation

In the following section the methodology of the project is discussed. Findings of the case studies and cross-case comparisons will be presented, followed by a discussion of the implications for practice and a conclusion.

# Methodology

## Research questions

The following research questions guided the study:

1. How can a knowledge building community be designed and effectively integrated into the New Zealand senior secondary school classroom-based and distance learning contexts? What factors affect the roles of teachers and what teaching strategies and design principles do teachers use to support students' advancement of knowledge?
2. What are the effects of a knowledge building community mediated by Knowledge Forum on students' learning and knowledge building outcomes? Have students' domain knowledge, skills of learning how to learn, collaborative learning skills, and dispositions as an epistemic agent,[1] changed over time?

# Research design

A design-based research methodology was employed in this multi-site case study. As a 2-year project, this study had two design cycles. As the participating teachers had begun with little prior understanding of the knowledge building pedagogy, Year 1 focused on developing their understanding of the knowledge building principles and expertise in implementation strategies. During this year, teachers only used the knowledge building approach for one school term. In Year 2, most teachers used the knowledge building approach for the whole school year, and formal assessments were integrated in the knowledge building environment. While data were collected in the first year, because this was a design-based project these data were primarily used in the evaluation cycle to help teachers revise their design. Data collected in the second year were analysed in depth and are presented in this report.

## Data sources

- Questionnaire survey—a questionnaire was administered to all students at the beginning and end of each year. The SPOCK instrument developed by Shell et al. (2005) was incorporated into the questionnaire to measure respondents' changes of learning styles and preferences. Twenty-eight items from the SPOCK instrument were adapted to measure five factors: (a) collaborative learning, (b) knowledge building, (c) self-regulation, (d) high-level questioning, and (e) low-level questioning. These items were measured on a Likert-type scale, with 1 = almost never, and 5 = almost always. Additional items were included in the questionnaire to measure student attitudes on knowledge building and Knowledge Forum. Table 1 summarises the number of respondents taking part in the surveys.

1 Epistemic agency is one of the 12 principles of the KBC model: see Appendix 1 for a definition.

Table 1: Respondents to student surveys, 2013

| Class | Survey 1 respondents | Survey 2 respondents | Respondents to Survey 2 open-ended questions |
|---|---|---|---|
| Art history | 10 | 6 | 6 |
| Biology | 5 | 4 | 4 |
| Classical studies | 23 | 10 | 10 |
| Economics Year 11 | 13 | 15 | 12 |
| English | 18 | 19 | 16 |
| Physics | 12 | 11 | 10 |
| Total | 81 | 65 | 58 |

- Class observations—Each on-site class was observed once per year.
- Teacher interviews—All teachers were interviewed individually in January 2012 and in the third school term of 2012 and 2013. Group interviews were conducted in November 2012 and 2013.
- Student interviews—One semi-structured focus group interview of at least six students per class was conducted in the first year, and 23 students were interviewed individually in the second year. Interviews were conducted by videoconferencing or by phone (see Table 2).

Table 2: Student interviewees, 2013

| Class | Number of interviewees |
|---|---|
| Art history | 3 |
| Biology | 2 |
| Classical studies | 4 |
| Economics Year 11 | 5 |
| Economics Year 12 | 4 |
| English | 2 |
| Physics | 3 |
| Total | 23 |

- Content analysis—19 views were purposively selected for content analysis, based on the activity level of the view and when it was set up (at least one view was selected per school term, see Table 3). In total 968 notes were analysed (65 percent of all notes). A coding scheme adapted from Damsa, Kirschner, Andriessen, Erkens, and Sins (2010) was used to categorise epistemic actions (see Table 4), to understand the extent that ideas were being developed in the knowledge building classes. Each Knowledge Forum note was considered a unit of analysis and was coded once.

Table 3: Views included in the analysis

| Class | Number of views analysed (out of all views) | Number of notes contributed to all views | Number of notes analysed | % of notes analysed |
|---|---|---|---|---|
| Art history | 4 (10) | 313* | 165 | 53 |
| Biology | 4 (9) | 165 | 117 | 71 |
| Classical studies | 3 (7) | 206 | 159 | 77 |
| Economics Year 11 | 5 (15) | 558 | 330 | 59 |
| English | 4 (7) | 235 | 174 | 61 |
| Physics | 1 (1) | 23 | 23 | 100 |
| Total | 19 (49) | 1,500 | 968 | 65 |

* 189 notes contributed to 6 additional views were excluded from the analysis as they were not directly related to course content.

Table 4: Coding scheme for epistemic actions

| Epistemic action | Explanation |
|---|---|
| 1. Identifying problem/inquiry; defining/refining questions; identifying knowledge gaps—individual | Teacher or student provides a starter question; student asks clarifying question; student/teacher asks a new question (not related to the starter question). |
| 2a. Sharing of information—individual | Student provides information related to the topic of inquiry. Isolated notes or notes may be linked but contents not related. |
| 2b. Sharing of ideas—individual | Student contributes ideas based on personal experience/knowledge or information retrieved. Ideas are not built on by self or other students. No communal idea development. Isolated notes or notes may be linked but contents not related. |
| 3. Creating communal ideas | Students working on an idea/question/information contributed by a student in the community. They may add examples from external sources or from personal experience; they may critique, expand, revise the idea, or ask a clarifying question. Evidence of a new idea/solution being created or emerging after students have worked on an initial idea. Recognition as a new idea by the community (e.g., in the student portfolio or in a note). |

- Document analysis—Plans and materials developed for the teaching units were reviewed to evaluate strategies used in the knowledge building classes, and the extent these strategies were integrated in the school curriculum.
- Participation data—User data generated by Knowledge Forum at the system level, such as login and contribution frequencies, patterns of communication, etc. was collected to assess the development of the knowledge building classes.

# Findings

## Participants

In total 220 students from 16 senior secondary classes participated in this project. Table 5 provides information about the number of students in each class.

Table 5: Summary of classes and participants, 2012 and 2013

| Class | 2012 | Number of students | 2013 | Number of students |
|---|---|---|---|---|
| Accounting* | Y12 (V)** | 16 | | |
| Art history | Y13 (V) | 10 | Y13 (V) | 12 |
| Biology | Y11 (V) | 9 | Y11 (V) | 5 |
| Classics | Y13 (V) | 25 | Y13 (V) | 20 |
| Economics A* | Y12 (V) | 7 | | |
| Economics B | Y12 (C)** | 9 | Y12 (C) | 11 |
| Economics B | Y13 (C) | 13 | Y11 (C) | 17 |
| English | Y11 (C) | 23 | Y11 (C) | 20 |
| Physics | Y13 (C) | 13 | Y13 (C) | 11 |
| Total | | 124 | | 96 |

*The Accounting teacher did not continue with the project in Year 2. There were two Economics teachers. Economics teacher A did not continue with the project in Year 2.

**(V) stands for videoconferencing class and (C) stands for on-site class.

# Case studies

The six case studies below briefly outline teacher and student experiences with the KBC approach in different classes. The cross-case analysis discusses findings that emerged in relation to the research questions.

## Art history Year 13 class

There were 12 students in this distance class, one male and 11 female. Students came from schools on the West Coast and Auckland, and were mostly high-achieving students who could sit Scholarship examinations. This class had three 1-hour self-directed learning periods and one 1-hour video-conference period per week, and the knowledge building approach was used throughout the year.

In this class students chose to study either modern or Renaissance art. A total of 16 views were created. The teacher (Meredith)[2] designed an "orienteering map" to help students learn how to use Knowledge Forum. She also used an app called Padlet in her class. On the whole students were quite positive about using Knowledge Forum.

The art history class was exemplary in the way that the knowledge building principles had been implemented and also how Knowledge Forum was used to support discourse. There was a clear shift of the roles of the teacher and students, the teacher being the thinking coach, and the students "co-curators", responsible for generating content for the class collectively. There was clear evidence that new ideas useful to the class

2 All teacher names are pseudonyms.

community were created. The knowledge building discussions also helped develop personal understanding of content. Meredith "was constantly blown away at what, at how [students] could think [and] what they knew already." A strong sense of community was felt by most students in this distance class. New assessment methods were used, including students producing a thinking portfolio. Students liked this approach and reported that they benefited from it. Several students also reported that they had become more self-directed in their learning.

### Biology Year 11 class

This distance class had five students who were all female. Students came from two South Island schools, with four from one school. As a distance class, there was one video-conferencing period and three self-study periods per week. The teacher (Keith) was the only teacher in the project who had prior experience with the KBC model. Knowledge Forum was used throughout the year. Nine views were set up. All students except one participated actively in the discussions, with notes evenly contributed by them. Most students were positive about the knowledge building process.

Keith felt that a critical mass was needed to sustain knowledge building discourse, and he did not think a sound knowledge building community was formed in his small class, although epistemic actions in the form of sharing ideas and information were found. While Keith had encountered some connectivity issues, which created barriers for effective communication and community development, he was reasonably optimistic that the knowledge building approach was a promising future-focused pedagogy. Keith felt that the knowledge building process made assessment easy. He asked his students to submit a personal portfolio for assessment, which included individual ideas and ideas synthesised from online class discussions. As students could access what others were thinking and doing from the portfolio view they enjoyed the assessment process.

### Classical studies Year 13 class

This class had 20 students, eight male and 12 female, who came from several schools in the North and South Island. As a distance class, there was one video-conferencing period and three self-study periods per week. In 2013, knowledge building had become an integral part of the course.

The teacher (Bruce) used Google+ Communities to develop a class community, and it was successful. Despite having developed some online tutorials to support his students in learning how to use Knowledge Forum, some students had technical difficulties. Participation was uneven in this class, with six very active students, and the rest being less active. Most notes contributed by students were substantial and thoughtful. The majority of students felt that their personal understanding of the topics under study had been enhanced and the benefit of self-directed learning was also highlighted.

In terms of knowledge building implementation and benefits, this class was one of the most successful classes in the project. Bruce introduced self-assessed portfolios as a new form of assessment. In terms of developing and creating new ideas, he was "blown away by the level of thinking sophistication, the level of interaction going on with a group" and was "fairly impressed with a good number of students and actually what was achieved there".

### Economics Year 11 class

This class (17 students) was in a decile 5 state-integrated boys' school in the North Island, with a roll of about 400 students. While the teacher (Terry) used the knowledge building approach for the whole year, it was interspersed with traditional teaching and the use of workbooks for formative assessment. Terry also had a knowledge building Year 12 class (11 students) in the first term, but decided to drop it as he felt that students primarily used Knowledge Forum for social "chitchat".

Knowledge Forum discussions were primarily conducted during class time, and 16 views were set up. While Terry and his students contributed a large number of notes and annotations, most of them were very brief and students' contributions were highly uneven. The majority of students were positive about the knowledge building process and the use of Knowledge Forum.

Terry found it difficult to develop a collaborative learning culture in his class, however. He suspected that the low literacy levels of some of his students had contributed to the lack of participation in online discussions. Students had no problem commenting on others' ideas, but they often engaged in debating rather than improving each other's ideas. Students were asked to produce a personal e-portfolio for a NZQA internal standard, which was peer reviewed. Students reported that they thoroughly enjoyed the assessment process and believed that they had done better with this method.

### English Year 11 class

This class was in a decile 10, fully independent, co-educational school in the South Island, with a roll of about 1,400 students. There were 20 mixed-ability students, 12 males and eight females. The knowledge building approach was only used in one school term. Students had two periods a week using computers in the library. During these periods worksheets with some general information and learning activities and tasks were provided to students. In the other two in-class periods, students discussed what they had done online, clarified ideas and thinking, and developed learning techniques through watching movies and class-based activities. The two student interviewees both felt that their class had a strong sense of community.

Seven views were set up in this class. Notes contributed were very brief, and sometimes there were only a few words or a sentence or two in a note. Most students participated actively, primarily sharing ideas and information, rather than creating new knowledge. The lack of elaboration of ideas in the notes discouraged further idea development.

The teacher (Anna) considered the knowledge building process worked in her class. While there was little evidence that new communal ideas had been created, the sharing of individual ideas and information had facilitated students in developing a deeper understanding of content.

### Physics Year 13 class

This class was in a decile 8 state co-educational school of 2,000 students in the North Island. It was a small extension class with only two periods per week. There were 11 students in this class, three females and eight males. The knowledge building approach was used for 15 weeks.

Students had no difficulties in using Knowledge Forum in class, and the majority considered Knowledge Forum a good tool to use. Students participated actively to create knowledge for the class community. They tried to work out the solutions rather than continually search for information from the Internet. While only one view was set up and a small number of notes (23) created, notes were submitted after lengthy group or whole-class discussions, and they were very thoughtful and substantial. Also, all the notes (except three) were co-authored, with eight notes having four to five authors. Students enjoyed the knowledge building process, and there was a very strong sense of community. The benefits of self-directed learning were also highlighted. Students were asked to submit an individual portfolio for assessment and they reported that they liked the assessment approach.

This was clearly a successful class. While new ideas developed by students were by no means ground breaking, they were, nonetheless, new ideas to the class. As a community students had developed some ideas which were even new to the teacher.

## Cross-case comparisons

### Changing pedagogical beliefs

Teachers came with different pedagogical beliefs when they joined the research team in 2012. Initially all of them had difficulties in distinguishing the KBC approach from inquiry learning. Through readings, discussions, and practice in two consecutive years, teachers came to understand the differences and the strengths of the KBC model. For example, at the end of the second year Bruce commented:

> The first year I thought it was sort of really a community inquiry thing … it's about a research team working together, sharing ideas. This year I've realised that it's about improving ideas … that you're continually sort of digging and try and improve each others' and that it's an ongoing process … I think it really challenges you to think outside the box … I value an inquiry approach to learning … but [knowledge building] really takes it to another level.

Meredith reflected that the change in her pedagogical beliefs was deep and profound. Her vision of teaching had broadened:

> I've changed. I think about learning and knowledge differently now … my understanding of what I do is so much deeper and so much more intensive … it has phenomenally transformed me as a teacher … my whole practice is completely embedded in teaching and inquiry and practitioner research … I feel like a completely different person to what I was two years ago.

While teachers in this project had different levels of understanding of, and commitment to, the knowledge building approach, they firmly believed that this approach had great merits for future-oriented teachers and were committed to using it in their own teaching. All six teachers have continued using the KBC approach in 2014, and Meredith has started mentoring several art history teachers from other schools in its use.

## Implementing knowledge building

**Changing roles and responsibilities.** The teachers' roles had changed as a result of implementing the KBC approach. For example, Meredith considered herself a thinking coach, not a knowledge provider:

> My role was [as a] thinking coach and the students' role was, I labelled them co-curators, being art history, to try and shift our thinking about what we're actually doing and just break up that idea of the traditional teacher/student type roles.

Students were responsible for generating content for the class collectively and were asked to generate questions, conduct research, provide answers, and create new ideas. They were considered epistemic agents capable of taking control of their own learning. Meredith commented:

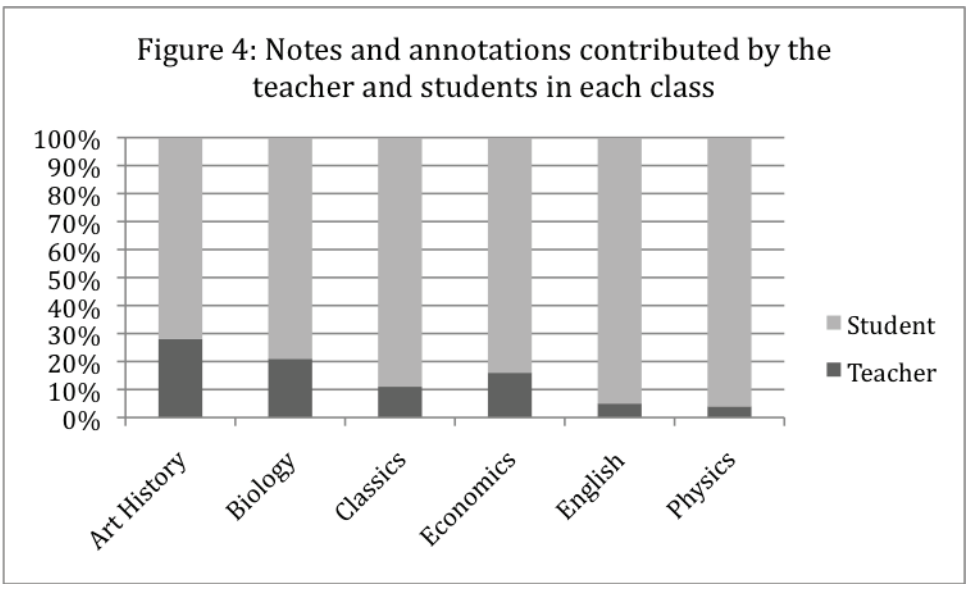
> But I don't think they ever felt unsupported or abandoned … Putting students in charge of content is not about abandoning them. It's about supporting them to engage and learn, just a different way … they engaged more quickly at a much deeper level with the content than when I deliver it …

The physics teacher Joe, also encouraged an open-ended inquiry approach in his class, and allowed students total control of content.

The extent of a teacher's presence can be gauged by the number of notes and annotations he or she contributed. Figure 4 shows that Meredith had a high teaching presence, but a closer examination reveals that the high percentage was mainly due to the large number of annotations she had contributed, which were used primarily to affirm and encourage students' participation. If Meredith's annotations and notes in the non-teaching-related views (views 11–16) were excluded, the percentage of her contribution would drop to 14 percent, which was similar to the classical studies teacher (11 percent).

The biology teacher had the highest percentage of contribution (21 percent), as can be seen from Figure 4. In fact, in one of the biology class views, Keith provided all the discussion questions. The economics teacher (Terry) also had a strong teaching presence, contributing 16 percent of the total number of notes and annotations in the online discussions. These notes included questions for discussion, resources on the topics of study, and comments on ideas and information provided by students. Terry considered himself a "knowledge transmitter" and quite "teacher centric" in the beginning of the project and this might have accounted for his high teaching presence.

In terms of idea development, art history, classical studies, and physics were the three most successful classes in this project, and all three teachers had asked students to take charge of content. This strategy seems to be important in supporting the development of students' epistemic agency, as we can see from the large proportion of high-level epistemic actions undertaken by students in these classes (see Figure 5, p. 21).




**Creating a sense of community.** Commitment to a collective responsibility for creating and improving new ideas was emphasised in all classes. For example, in the art history class, having a strong sense of trust was a key reason accounting for students' willingness to actively contribute. The importance of creating a collaborative learning culture should not be underestimated even in on-site classes. For example, students in the physics class valued the strong sense of community, while the failure to develop a collaborative culture was a factor for reverting to conventional teaching practices in the economics Year 12 class in 2013. Keith (biology) also found it difficult to develop a collaborative culture in his small class (five students, the smallest class in the project), which may account for the lack of idea development in this class.

**Dealing with technical issues.** The use of digital technologies was challenging for some teachers. In the first year there were huge connectivity issues for most classes but the situation improved in the second year. Accessing computers during class time was also an issue for the economics classes at times. Was it more difficult to implement the KBC approach in distance classes? It seems not, as two of most successful classes were distance classes (art history and classical studies). In fact, distance students in these two classes were more familiar with online text-based discussions than the on-site students. However, as distance students came from different schools, it is important that their home schools were aware that a new pedagogy was being used and that they could provide technical support. According to Bruce (classical studies), "that's something that an e-teacher has to take a lot of responsibility to try and set that up". For Keith (biology), distance teaching using the knowledge building approach was not a problem, however, but the lack of control of the technical environments of the home schools presented challenges for those students.

Another question investigated in this project was whether or not Knowledge Forum was an essential tool in the knowledge building process (Lai, 2014). While in theory it is possible to undertake knowledge building without having to use any networking technologies or Knowledge Forum, in practice it is difficult to scaffold knowledge building (e.g., facilitating distributed expertise and tracking idea developments) without using Knowledge Forum. We have used and reviewed several other software packages (e.g., Mural.ly, Padlet) and we found Knowledge Forum the most effective software to support knowledge building, probably because it was designed based on the 12 knowledge building principles (Scardamalia, 2002). For example, Anna felt that her English students could have done knowledge building on a piece of paper, but Knowledge Forum helped to support the knowledge building process.

> They can do it on paper … I've had the big A3 sheets of paper out and … keeping a record of it … but you don't have to have [Knowledge Forum] in order to have development of ideas. What you're doing is capturing it [but] when [Knowledge Forum] becomes easier to use, and more intuitive and there's more of a flow to it, then I think the development of the ideas will come faster and it will seamlessly integrate into the classroom.

Keith in his physics class used a sheet of butcher paper and Post-it notes in the first session to show how the knowledge building discourse worked, without having to use Knowledge Forum. However, he considered it essential to use Knowledge Forum in subsequent sessions as it was too difficult to record and develop complex ideas on papers.

**Evaluating progress.** Ongoing monitoring was needed to encourage student participation in the knowledge building community and to assess the extent to which new ideas had been developed in class. We found that annotations could be effectively used to affirm students' work and encourage further development of ideas. Meredith provided an excellent example in her art history class. In this class, several views were set up to help students to monitor their progress. For example, in the beginning of the year a view called "Sharing learning problems" was set up. A view was also set up during each assessment period for students to review each other's work. In addition, to help students better understand the knowledge building principles, a view was set up at the end of each term (e. g., "Term 1 review") to reflect on these principles. It seems that when students had a deeper understanding of the knowledge building principles, they became more willing to contribute and improve ideas.

**Providing an activity structure.** While we observed that an activity structure should be put in place, as students can be easily "side-tracked", "[get] off topic", and "[not] focus much on the task at hand" in an open-ended inquiry process, as pointed out by some physics students, flexibility was also needed. It seems that year levels had little to do with activity structures. All Year 13 classes in this project had a more flexible structure where students had freedom to explore and direct their own investigations than the Year 11 classes, which had a tighter structure. For example, in the Year 11 English class, the topic of discussion and start-up questions were all pre-determined by the teacher for each Knowledge Forum discussion. We found that while teachers needed to guide their students to focus on promising ideas and encourage them to develop these ideas into new knowledge, too much intervention from the teacher would discourage development of epistemic agency.

**Integrating assessment.** All teachers but one (English) undertook NCEA internal assessments in their knowledge building classes. For example, in art history and classical studies, students were asked to synthesise ideas they developed in Knowledge Forum to produce an evidence portfolio for summative assessment. Meredith was impressed by the quality of her students' portfolios:

> In the last internal [assessment] that most of them did, I was quite blown away. There were quite big shifts … I had a couple of students who had jumped Merit into low Excellence and I just didn't think that would happen.

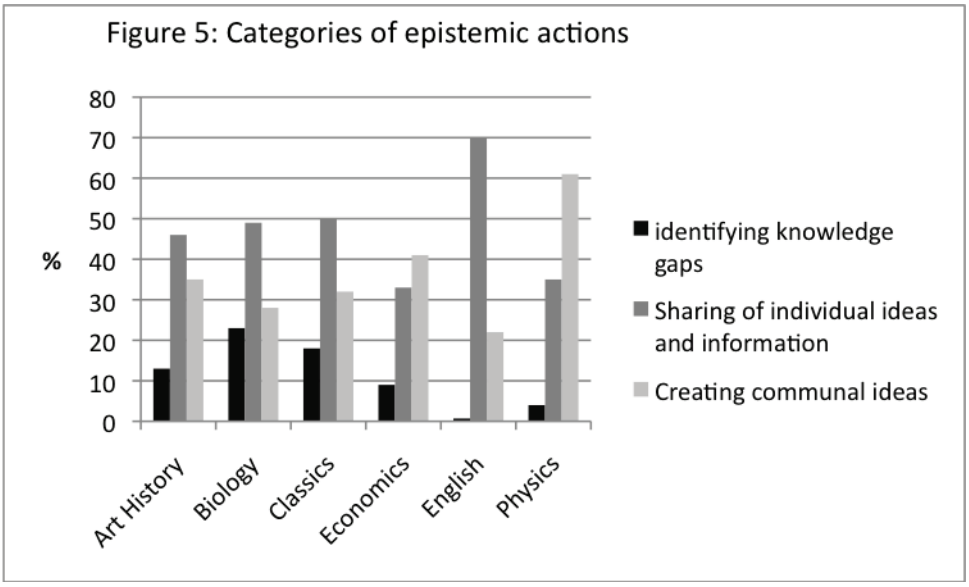
While we found portfolios a good tool for assessing students, using individual portfolios meant it was hard to assess communal ideas, as pointed out by Keith:

> I think the biggest obstacle is that when we think [about] assessment, we are thinking of the evaluation of individual learning and [in] knowledge building, you're really wanting to assess the collective product and there is a bit of a disjoint there of what culturally we're trying to do, which is assess the individual rather than assess the community's building on understanding.

Overall, the teachers in the project were happy with the assessment outcomes.

## What have students gained from the knowledge building process?

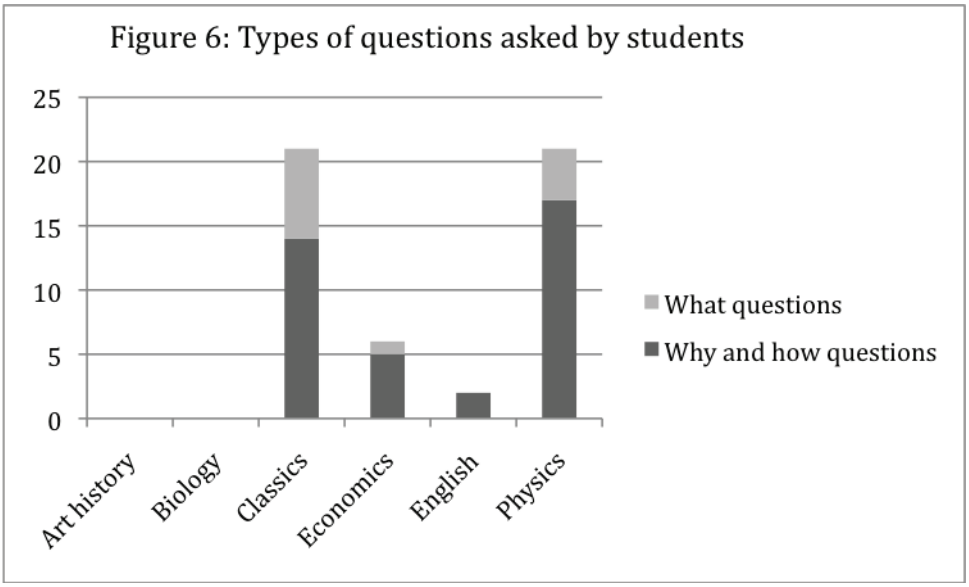
**Developing as epistemic agents.** In this study we were interested in finding out what epistemic actions were undertaken by students in the online discussions, in terms of the types of questions they asked, what information and ideas they contributed individually, and how they engaged in developing ideas communally. Using the coding scheme developed for this project, we found varying degrees in the way ideas were developed individually and communally in the project classes (see Figure 5).




*From each class, the three views that had the highest percentages of "creating communal idea" notes were used to compute the percentages for this table.

As can be seen from Figure 5, students engaged mostly in sharing information or individual ideas, with an average of almost 50 percent of notes belonging to this category. In physics, economics, art history and classical studies, however, the percentages of notes contributing to the development of communal ideas was high (32–61 percent). Nevertheless, it should be noted that the quality and depth of ideas that were developed differed from class to class. In general, ideas contributed by the three Year 13 classes had a lot more depth and breadth, and notes were much longer and more substantial than the Year 11 classes, regardless of subject areas. It seems that whether the subject was content-heavy (e.g., physics) or skill-based (e.g., English) had little relationship to the extent of idea development. We found new ideas emerging from the Knowledge Forum discussions in the Year 11 classes as well, but there was a lack of time for students to develop these ideas further, since two of the Year 11 classes were on-site classes and students only used Knowledge Forum during class time. Also, as suggested by the economics teacher, the literacy level of the class may have accounted for the lack of depth in the discussion.

We observed that whether the topic of study was open-ended and whether explanation-driven questions were asked during discussions were key factors affecting development of ideas. As pointed out by the physics teacher, in order "for some knowledge building to happen", it is vitally important to ask a good start-up question which is open-ended. Asking explanation-driven questions, i.e., "how" and "why" questions, would encourage students to generate theories, while asking "what" questions would usually facilitate information sharing. To understand what types of questions were asked by students, the view in each class which had the highest percentage of Category 3 notes ("Creating communal ideas", see Table 4, p. 9) was selected for analysis. Figure 6 shows that students in the physics and classical studies classes asked a lot of questions, many of which were explanation-driven (how and why) questions. In contrast, very few questions were asked by students in the other classes. In fact, in the biology class, the teacher asked all the questions and contributed 44 percent (16 out of 36) of the notes in this view. The art history view shows that students had asked no questions, however, they did engage in an in-depth and substantial communal idea development process. The teacher only asked one open-ended question, but it was a good question.




The following example from the art history class (View 1) illustrates how ideas were developed in this class. The start-up question posted by the teacher was why "Art is important to every culture on earth". Ten students participated in this discussion and 20 notes were contributed.

| | |
|---|---|
| Student L: | Before I think about why art is valued, I would first like to figure out why it is created in the first place … [it is used for] recording events … it is not solely the art itself that is valued, but its associations and background that give cultures reason to see it as important … |
| Student M: | I believe that art is extremely important … as a mean to record and pass down historical knowledge … |
| Student J: | [Student L] you have extended my thinking on art in culture incredibly … you have made me well aware, art is in fact everywhere … For example … in Native American culture were the woven baskets used for transport of goods such as corn. |
| Student L: | (Synthesis of our ideas) I find your [Student J] idea of functional items being viewed as art very interesting … our current day supermarket baskets will one day be seen as art too! |
| Student C: | You really thought up some interesting points, Student L. I never would have analyzed the question coming from that angle, but it sure[ly] made me think more about what exactly we are answering … |

In this example four students contributed ideas in the dialogue. Instead of just sharing ideas, which is commonly found in online discussion, this excerpt shows the development and improvement of an idea of interest to the community, initially generated by a student (Student L), and then expanded on by others (Students M and J) in the community. The idea that functional items can be seen as art is an idea created and developed by the community and is new to the community.

In contrast, the following example from the Biology class shows how students used Knowledge Forum primarily to share information and ideas. In this excerpt students were investigating the concept of enzymes. Several students were adding ideas and information to deepen their understanding of the concept without new ideas emerging from the discussion.

| | |
|---|---|
| Student KV: | [My theory] … Enzymes are catalysts (make chemical reactions go faster but are not changed by the reaction) … |
| Teacher: | [I need to understand] … But how and why (do we need the reactions to do faster)? |
| Student KC: | [My theory] The rate of reactions are increased by the enzyme lowering the activation energy … without this happening the chemical reactions in your body would occur too slowly to support life processes … |
| Student B: | [New information] I found that an enzyme speeds up the chemical reaction in our bodys [sic] by lowering the activation energy which means the amount of kinetic energy needed to start the reaction is at its lowest. They do this by … |
| Student KV: | [My theory] After a week … Doing some research I found that enzymes work by lowering the activation energy of a reaction, this means that the reaction can now be completed much quicker than it usually would. |

In order to contribute to idea development, students needed to have a good understanding of the knowledge building process. The art history, physics, and classical studies students did have a good understanding, which can be seen from the following comments:

> We sort of collated a few of our own different ideas and we ended up coming up with something that was completely different than any of us had ever initially thought when we looked at [the artist's] work. (S27, art history)
>
> We all sort of used and developed … extended each other's ideas … I drew stuff from the students as a whole … if I used an idea, it might be one person's idea. It might have been an idea that was developed by multiple people. (S48, classical studies)
>
> Some of the students were getting fairly creative with their ideas and, as a group, we work quite well in developing those ideas and then we're making them more realistic. (S12, physics)

**The SPOCK findings.** The SPOCK instrument was used to measure the change in learning styles and preferences in 2013. The number of students who had completed the questionnaire for both Surveys 1 and 2 in the art history and biology classes was too small to make comparisons. In economics and physics, no significant changes were found, but in English and classical studies there were significant differences in some factors. However, when discussing these findings with teachers, they expressed concern that they might not be reliable, as their students did not take answering the questions seriously. It seems that in small case studies, it cannot be ascertained whether a quantitative instrument such as SPOCK can provide useful insights about change.

**Collaborative and community learning.** In the post-questionnaire survey more than half of respondents (52 percent) felt that building knowledge with their classmates was an enjoyable experience, while only 17 percent felt it was not enjoyable. A total of 53 percent of respondents felt that their knowledge about the school subject has increased as a result of the Knowledge Forum discussions, while 24 percent said it had not. In terms of seeing the class as a community, exactly half (50 percent) of participants thought that the class had a strong sense of community, while 21 percent of the respondents reported that it did not. An open-ended question on the questionnaire asked students to write about their knowledge building experience. Of the 62 respondents who provided responses to this question, 28 (45 percent) made positive comments about the community aspect of learning.

In every class we found a few students contributed a disproportionate share of the notes and annotations. Classical studies and economics classes had the most uneven contribution while biology had the most even contribution, followed by art history (see Table 6). We knew that uneven participation was quite common in online discussions, and "active listeners" would be able to gain personal understanding of the topic of inquiry by reading notes contributed by other members of the community. From the student interviews, we understand that some students preferred individual rather than community learning, which may explain why they were not willing to contribute actively to the discussions. However, as a knowledge building community, our goal was to encourage creation and development of ideas collectively by the whole community, and the highly uneven participation and contribution in some classes was a concern for us. For example, some students

in the economics class complained about the behaviour of a specific group of students of taking, but not contributing, ideas and saw it as an equity issue.

The communicative aspect of our knowledge building project has raised a number of interesting questions for further studies. For example, what are the roles of active listeners in the knowledge building process? Would inactive online participants behave differently in face-to-face discussions? Also, the issue of how a knowledge building community can be designed to accommodate different learning preferences (e.g., individual versus community learning) should be investigated further.

Table 6: Contributions of notes and annotations

| Class | Number of students | Contribution by the top contributor (%) | Contribution by the three top contributors (%) | Contribution by half of the class (%) |
|---|---|---|---|---|
| Art history | 12 | 17 | 44 | 68 |
| Biology | 5 | 28 | 80 | 55* |
| Classical studies | 20 | 22 | 56 | 85 |
| Economics | 17 | 18 | 49 | 80** |
| English | 20 | 15 | 37 | 73 |
| Physics | 11 | 23 | 58 | 75*** |

*contributed by 40% of the class
** contributed by 47% of the class
***contributed by 45% of the class

**Self-directed learning.** It was evident that students felt the benefits of self-directed learning in a knowledge building class. In the three senior classes the benefits of self-directed learning were highlighted in the student interviews. Students felt that the knowledge building approach would help their future studies:

> I've thoroughly enjoyed the method that we've used, it's so much focused on us learning … we have to find it out ourselves rather than just being told the answers … I feel a lot more confident going to university now. (S27, art history)
>
> We've kind of had to sort of do it ourselves … [the teacher] giving us an idea of what we need to do but we've had to go and do it ourselves, which I suppose is good for, like, next year when we have university. (S54, classical studies)

# Implications for practice

Implementing knowledge building in senior secondary classes is not an easy task. If a KBC is to be effectively set up in a class then a good understanding of the knowledge building principles is essential. Teachers also need to understand the differences between the knowledge building approach and inquiry learning. Using the knowledge building model involves a change of pedagogical beliefs, and teachers have to be willing to commit to change. Ongoing, sustained professional development supported by school management will be required to support knowledge building teachers. Technical support is also needed. While the KBC model was originally designed to support student learning, the KBC can be used to support teachers' professional learning and development to become knowledge creators.

A practice model (called the PROCESS model) developed in this project can be used to guide teachers in setting up KBCs (see Table 7).

Table 7: The PROCESS implementation model

| | Element | Explanation |
|---|---|---|
| **P** | **Principles** of knowledge building | Teacher and students understand and are committed to knowledge building principles. |
| **R** | **Roles and Responsibilities** | Community focused. Teacher to develop trust, collective responsibility, and a collaborative culture. Teacher as thinking coach, facilitator, and knowledge creator. Students as epistemic agents. |
| **O** | **Open**-ended inquiry | Teacher identifies topics that allow open-ended inquiry of authentic questions/problems. Teacher or student provides starter question. Students ask explanation-driven questions (why and how). Focus on promising ideas—develop, test, critique. Teacher may provide content and direct teaching. |
| **C** | **Conversant with Knowledge Forum** | Teachers and students conversant with Knowledge Forum (scaffolding tools). School provides infrastructural and technical support. |
| **E** | **Evaluate** progress | Teacher encourages and monitors participation, supports investigation of promising ideas, holds debriefing and milestone discussions to evaluate progress of idea creation. Formative assessment. |
| **S** | **Structure** | When to do what? Participation structure (small group/whole class). Activity structure (consult authoritative sources, online/offline dialogues, conduct experiments/field trips). |
| **S** | **Show** evidence of knowledge building | Summative assessment. Students produce epistemic products (e.g., a portfolio) to show what new ideas have been developed by, and for, the community. |

# Conclusion

The aims of this project were to investigate how a KBC could be effectively implemented in senior secondary classes and what students would gain from these communities. A multi-site case study with a design-based approach was employed. The findings of the six case studies show that KBCs could be effectively implemented in both on-site and distance classes. In addition to gaining a deeper personal understanding of the subject content, there was evidence in this project that students were able to generate and develop new ideas and knowledge in their KBCs. We found that the most successful classes were those where teachers were willing to shift epistemic control to students and allow them to work in a less structured environment. There were varying degrees of idea and knowledge development in the six classes, with classes where teachers were most committed to change, and held a deep understanding of the knowledge building principles, being the most successful in fostering idea development. We also found that new assessment methods could be seamlessly integrated into a knowledge building environment, and teachers and students were happy with assessment outcomes. Students also enjoyed knowledge building classes and felt that they had benefited from the class communities. While there were technical issues in some classes, and these did sometimes deter students from more intense interactions, teachers were able to rise above these challenges.

Developing and integrating the knowledge building approach into the school curriculum involves many complex issues, and a 2-year project does not have time to address all of them. For example, the question of how much structure should be provided in a knowledge building class has not been adequately investigated. In the study we also focused on developing new individual assessment methods but were unable to address the challenge of how to assess communal knowledge. While new pedagogical practices and ideas were developed by individual teachers, most of the ideas have not been further developed and improved by the whole community. Since all the teachers (except one) were new to the KBC model when they first joined the project, it took them a long time to understand the knowledge building principles and develop implementation strategies for their teaching. Teachers thus focused their attention and energy on their own classes, rather than

developing ideas jointly with their colleagues in the community, as creating communal knowledge was not an explicit objective of the project. It also took teachers a long time to develop a sense of trust and community. It was only in the second year that teachers felt comfortable in sharing ideas. It was felt that more face-to-face meetings should be scheduled to help build up the community in Year 1. While traditional disciplinary differences could be seen as a barrier for idea exchange, teachers in this project felt that they had a lot to learn from each other and disciplinary differences in fact had widened their perspectives of how a knowledge building class could be set up.

A key finding of this research study is that to be effective in developing a KBC class, the teacher has to play a key role in modelling knowledge building through being creative and innovative in pedagogical practices. Professional learning and development will best be supported when teachers can share, create, and improve new knowledge on teaching, learning, and assessment as a KBC. How teachers can be developed as knowledge creators is a key question that needs to be explored in a future study.

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# Research Team

Professor Kwok-Wing Lai, University of Otago College of Education

Ann Trewern, University of Otago College of Education

Ken Pullar, NetNZ

## Project contact

Professor Kwok-Wing Lai, University of Otago College of Education, PO Box 56, Dunedin.

Tel: 03-4798806, e-mail: wing.lai@otago.ac.nz

# Appendix 1:

## The 12 principles of the Knowledge Building Communities model

| Principle | Explanation |
|---|---|
| Community knowledge, collective responsibility | The aim of a Knowledge Building Community (KBC) is to produce new ideas and knowledge which is useful to, and useable by, the community. Knowledge building is a community process. |
| Epistemic agency | Students take charge of their knowledge building journey. They are responsible to set plan and goals and evaluate their progress in knowledge creation. |
| Knowledge building discourse | Advancement of knowledge is the explicit goal of the community, which is achieved through discursive practices. |
| Real ideas, authentic problems | Ideas developed by the community are considered objects that can be manipulated. Students in a KBC will address problems they "really care about" (p.75). |
| Improvable ideas | Ideas are improvable. There is always room for further discovery. |
| Idea diversity | Ideas need to be connected to a broader knowledge base as "to understand an idea is to understand the ideas that surround it" (p.75). |
| Rise above | Synthesising diverse ideas to "higher planes of understanding". |
| Democratising knowledge | All students are empowered in knowledge creation as legitimate contributors. |
| Symmetric knowledge advancement | Knowledge advancement is facilitated by exchange of knowledge between communities. |
| Pervasive knowledge building | Knowledge building is a way of life, not just done in the classroom. It also means developing the confidence and disposition to contribute ideas and knowledge for today and tomorrow. |
| Constructive uses of authoritative sources | Knowledge builders use knowledge produced in the past critically. |
| Concurrent, embedded, and transformative assessment | Internal and external assessments are part of the knowledge building process. |

Source: Adapted from Scardamalia (2002).