CO-DESIGNING A KNOWLEDGE BUILDING ACTIVITY WITH SECONDARY SCHOOL BIOLOGY TEACHERS

Vanessa L. Peters
Ontario Institute for Studies in Education
University of Toronto
vpeters@oise.utoronto.ca

James D. Slotta
Ontario Institute for Studies in Education
University of Toronto
jslotta@oise.utoronto.ca

Abstract: This goal of this research was to engage high school biology students in a knowledge building activity as part of their regular curriculum. Using a co-design method, the researchers collaborated with two biology teachers to create materials that would support students in generating and developing their own ideas about human physiology. The resulting activity included a scripted wiki environment that provided students with space to create a repository of knowledge resources. These materials became the community resource base used in the knowledge building activity. This paper discusses the design of this activity, the development process, and how teachers exacted this activity in their classrooms.

Introduction

Knowledge building can be described as the production and improvement of ideas that are shared within a community (Scardamalia & Bereiter, 2002). Central to this process is the manner in which is knowledge is constructed. In knowledge building environments, ideas are objects that form the basis of knowledge building activity. These ideas form the basis of shared problems or issues that are available to be worked on by the entire group (Scardamalia & Bereiter, 2002). Through maintaining a shared and sustained focus, members of the knowledge community work jointly to arrive at new meanings and understandings. In this way, ideas are subject to multiple revisions and refinements that ultimately result in an improvement of the original idea. At times, knowledge building may involve disagreement in terms of what constitutes advancement of an idea, and how the limits of understanding should be defined (Scardamalia & Bereiter, 2003). In a knowledge-building community, such issues are dealt with jointly by members, and not prescribed by an individual outside of the community.

In a science classroom, knowledge building can teach students to think deeply about scientific principals, and how they can be applied to everyday life. Despite the pedagogical affordances of knowledge building, it has been difficult to implement this method into secondary schools. Time constraints, assessment concerns, and pressures to comply with Ministry expectations are among the challenges described by teachers. Even in progressive schools, prescribed curriculum documents can interfere with teachers' attempts to employ innovative instructional practices. Conversely, when teachers use curriculum materials that have

predetermined knowledge outcomes, it inhibits students from engaging in the type of creative work that characterizes a knowledge building community.

This study investigates how a knowledge building activity can be successfully integrated into a secondary school science classroom. It aims to create a knowledge community that is idea-based and student driven, yet sensitive to content expectations and individual learning outcomes. Co-design can be defined as "a highly-facilitated, team-based process in which teachers, researchers, and developers work together in defined roles to design an educational innovation, realize the design in one or more prototypes, and evaluate each prototype's significance for addressing a concrete educational need." (Roschelle, Penuel, & Schechtman, 1996). In this study the researchers collaborated with two science teachers from the University of Toronto Schools (UTS) to create an activity that would help students build knowledge about human physiology. A screenshot of part of the opening wiki page of the activity can be seen in Figure 1. The goal of our co-design process was to introduce students to the knowledge building process by designing an integrative activity that fit within the existing curriculum, yet still allowed students to construct and modify their own scientific understandings.

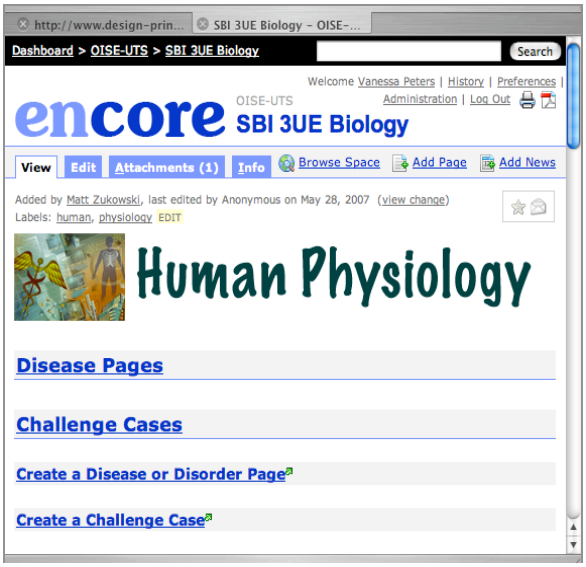

Figure 1. Screenshot of the opening page of knowledge building activity.

Method

This paper reports on a preliminary phase of a larger scale project that will ultimately entail the design of a new unit (approximately 25 percent) of a high school biology course, to be taught in the 2007-08 school year at the University of Toronto Schools (UTS). Here, we report on the co-design process that led to a successful curriculum lesson on human diseases, including a case study of the teacher-research interactions and preliminary analysis of students knowledge building process.

Participants

The investigators for this study included one senior researcher and one doctoral student. The individuals that participated in the co-design process were from the University of Toronto

Schools (UTS). Among these were two experienced science teachers, the Vice-Principal of Academic Programs, and the school Principal. The 102 students that participated in the study were from four periods of grade nine biology. One teacher taught two classes of 26 and 23 students, respectively, and the second teacher taught two classes of 28 and 25 students, respectively.

Materials

For the co-design portion of the study, we used laptop computers and a computer projector to take dynamic minutes within a wiki format. All wiki content was developed jointly within a special wiki space set up within a Confluence brand wiki (produced by Atlassian, Inc.). A separate wiki space was created for students, which included a specialized page creation method that used a Web application developed in the Ruby language that made it quite simple for students to create new wiki pages and specify their metadata. An example of such a page can be seen in Figure 2.

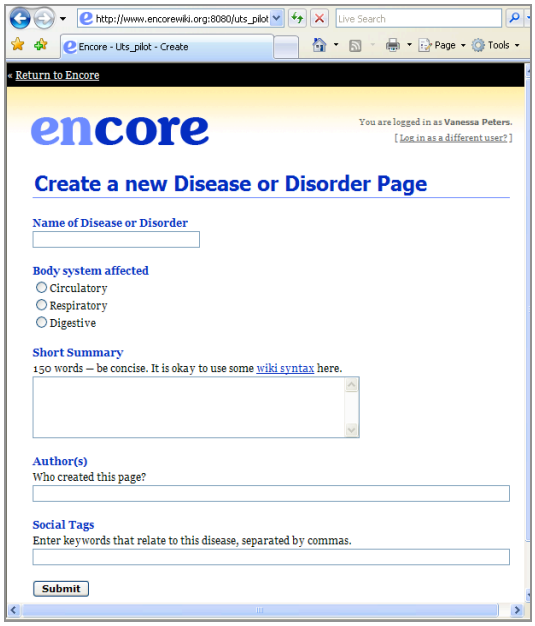

Figure 2. Screenshot of a scripted "Disease Page".

Design

The objective was to implement a knowledge building activity within the context of a ninth grade biology class, engaging four periods of students from two different teachers. In the co-design method, teachers are placed at the center of the design process, and several iterative cycles are repeated, leading to a design that is satisfying to teachers and researchers alike.

The goal of the co-designers was to create a knowledge building activity that was linked to the specific curriculum expectations, in this case for 'human body systems' (e.g., respiratory, circulatory, digestive). The primary activity for the 4 participating class periods was to collaboratively build a wiki space in the relevant topic area. We wanted our design to provide a certain amount of scaffolding, yet allow students to be creative, to search the Web for a variety of resources, and to take ownership of the wiki space. A second major design goal was to allow the created knowledge to be accessed by students in the context of a scripted activity where they

were challenged to solve a problem that required them to use the knowledge created by their community. This scripted activity would be connected to the specific content expectations, and would serve as an assessment item for teachers. For the researchers, the opportunity to connect scripted activities to an emergent knowledge base is seen as a fascinating challenge that will hopefully lead to a more comprehensive approach in subsequent phases of the research.

The resulting curriculum lesson included three distinct phases, which are described in greater detail within the body of the paper. The first phase was that of knowledge building, where students specialized in a specific human body system, and created 'Disease Pages' that captured diseases or disorders of their system. Students collaborated on these pages, and trusted that their peers were creating comparable quality pages. Each successive period inherited the knowledge base from the previous one, and continued to build a coherent set of disease pages that contained all relevant information, particularly that pertaining to the human physiology of the disease. The second phase required students to collaborate with a peer in creating a "challenge case" for their peers to solve. Challenge cases were based on a specific disease, that another group was challenged to diagnose. A wiki template page was developed by the designers to guide the creation of challenge cases, as well as to collect complete solutions. The wiki template included a simple form to guide the creators, and resulted in a new wiki page that included several headers to guide the solvers. The third phase involved solving the challenge cases, in which students were asked to draw on the aggregated knowledge base from the first phase to solve the cases. Successful solutions were those that completely described the disease in terms of its treatment and the underlying physiology.

Procedure

The overall design process was an iterative one, requiring many meetings between the researchers and different members of the UTS community. On one early occasion, the researchers met with the teachers, the Principal, and the Vice-Principal of Academic Programs in the Knowledge Innovation & Technology Lab (KITL) at OISE/UT. This session was used to create a wiki page that described the resources needed for the research study, which included space with wireless Internet connectivity, laptop computers and peripherals, and technical support for both teachers and students. In a subsequent meeting at UTS, the researches and Principal discussed the overarching goals for the school's curriculum, and how the current study might advance some of those objectives.

Overall, there were 22 meetings between the teachers and one or both of researchers between October of 2006 and May of 2007. Wiki pages were created and revised to capture the ongoing design process, and were also used to guide meetings. The meetings generally took one of two forms: a focused design meeting or a field visit to the school. Focused design meetings were concerted efforts to advance the design of the knowledge building activity. During these collaborations productive tensions arose regarding the design and enactment of the proposed activity. At times, the teachers expressed reluctance towards a lesson that turned the responsibility for knowledge creation over to students. During earlier meetings there were frequent discussions about the underlying principles and goals of a knowledge building method. Field visits by the researchers included classroom observations to understand the school culture in which the students were immersed. These visits informed the researchers about the practices that teachers were currently using in the classroom practices, and the interactions that occurred as a result of those practices.

The enactment of the activity required the teachers to first communicate the objectives

and dynamics of knowledge building to their students. Students were told during the knowledge-building phase that their efforts would be very important to peers who would be drawing on the resources they created, and that they would be likewise dependent on the elements created by their peers who worked on the other body systems. Students spent one class period in the knowledge building phase, as well as considerable time at home working on their wiki elements. There was substantial collaborative editing of pages, as students took naturally to the wiki context. Each consecutive period of students built on the same wiki knowledge base, resulting in an extremely rich corpus of disease pages for each of the three body systems. On the second day of the lesson, students created their disease challenge cases, using the same wiki environment. Theses were guided by a template that had been created by the designers. Finally, the third class period required students to choose a challenge case and completely fill in all the requested information. At the time when they began to solve the challenge cases, students were instructed to use the disease pages as their primary resource. It was not possible to track whether students used only the disease pages in solving the challenge cases, but the impression of the researcher who observed all sessions was that most students remained within the wiki space throughout this portion of the lesson -- at least during class. It is noted that students continued working on the challenge cases at home, and may have accessed a wider range of resources from the Web or other sources.

Data Analysis

Co-Design

We analyzed the co-design process in terms of successful engagement of participants as well as the flow of ideas and design elements. One measure of the success of the co-design method was in the enactment of the curriculum. Did both teachers succeed to an equal extent? If they had participated differentially in the co-design process, we might expect one teacher to be in better command of the fine grain details of the design. Were the researchers satisfied in the final product? If not, then it would be difficult to obtain sufficient measures of knowledge building and the connection between the built knowledge and the scripted activity? These questions can be measured through qualitative measures that include classroom observations, interviews, and evaluations of student contributions at various points in the lesson. The student researcher kept detailed field notes of all design meetings and observed all classroom sessions, including the online activities by students. Another qualitative relates to the role of the researcher during enactment. If the co-design process was successful, then she would ideally not be directly involved in any classroom procedure, and the teachers would be fully aware of all relevant research dimensions.

Knowledge building activity

We analyzed the knowledge-building segment of the curriculum in terms of successful enactment, as well as the flow of ideas within a collaborative editing of a disease page, and the flow of ideas from the disease pages to the challenge case pages. Successful enactment can be measured by teacher's ability to communicate the knowledge building methodology to students, and students achievement of the co-editing. It can also be measured in terms of the completion of objectives, such as co-editing the disease pages until they were sufficiently elaborate. The flow of ideas within the knowledge building activity can be measured by tracing the histories of the disease pages, and looking for the addition of new ideas by any student. In this case, analysis

will focus on the life science ideas created within the relevant section of the disease page. A knowledge map of the ideas for each disease page can be created, allowing the researcher to index knowledge elements to see the creation and connection of ideas.

Scripted activity

We analyzed the successful solutions of the challenge cases, and tracked the flow of ideas from the disease pages to the challenge solutions. We also analyzed the changes made to the challenge case solutions in the first period of activity, when students were in class, as well as overall, after they were completed as a homework assignment. Each individual revision made to a disease page was checked for changes in content. Revisions were counted as only those edits where substantial new content was added or reorganized.

Student achievement of content expectations

We analyzed student success on a content exam given at the end of the term, focusing on the items relevant to the human body systems and diseases. Students were assessed for their content knowledge about the circulatory, respiratory, and digestive systems. Students were also asked about their reactions to the knowledge building activity, and how they thought it helped them learn the material.

Findings

Co-design

The teachers were able to successfully enact the curriculum in their classrooms. After the first day, the teachers recognized that two class periods, and one night of homework, would be insufficient to complete all phases of the activity. A third day was added to give students in-class time to solve the challenge cases. During each of the classes a researcher was on hand to make observations and take field notes. The researcher was not directly involved with any classroom procedure. The teachers handled students' questions and comments about the activity, including any technological issues that might have arose.

Knowledge building

Students were successful in creating the disease pages and case challenges that were central for knowledge building. Between the four classes, students created wiki pages for 23 different diseases or disorders. Of these 23 diseases, seven were respiratory, ten were circulatory, and six were digestive. In all four classes, students were engaged with generating new disease pages, or with developing an existing disease page that had been created by a previous class. The researchers anticipated that students would be reluctant to work with their peers' materials, preferring instead to create a new disease or disorder page of their own. However, approximately half the students opted to continue working on an existing page, even when there were many diseases or disorders that had yet to be 'discovered'.

The students also created 50 challenge cases that were based on the knowledge that students created in the disease pages. These challenge cases presented signs and symptoms of a particular disease or disorder that students had to solve. Figure 3 shows a compilation of the different wiki pages that students created as part of their knowledge base. The individual links at the bottom of the page are the 'wiki children' of this page. They are linked individually within the sub-sections of "Disease Pages" and "Challenge Cases." Figures 4, 5, and 6 illustrate the number of page contributors and revisions for each disease page that students created.

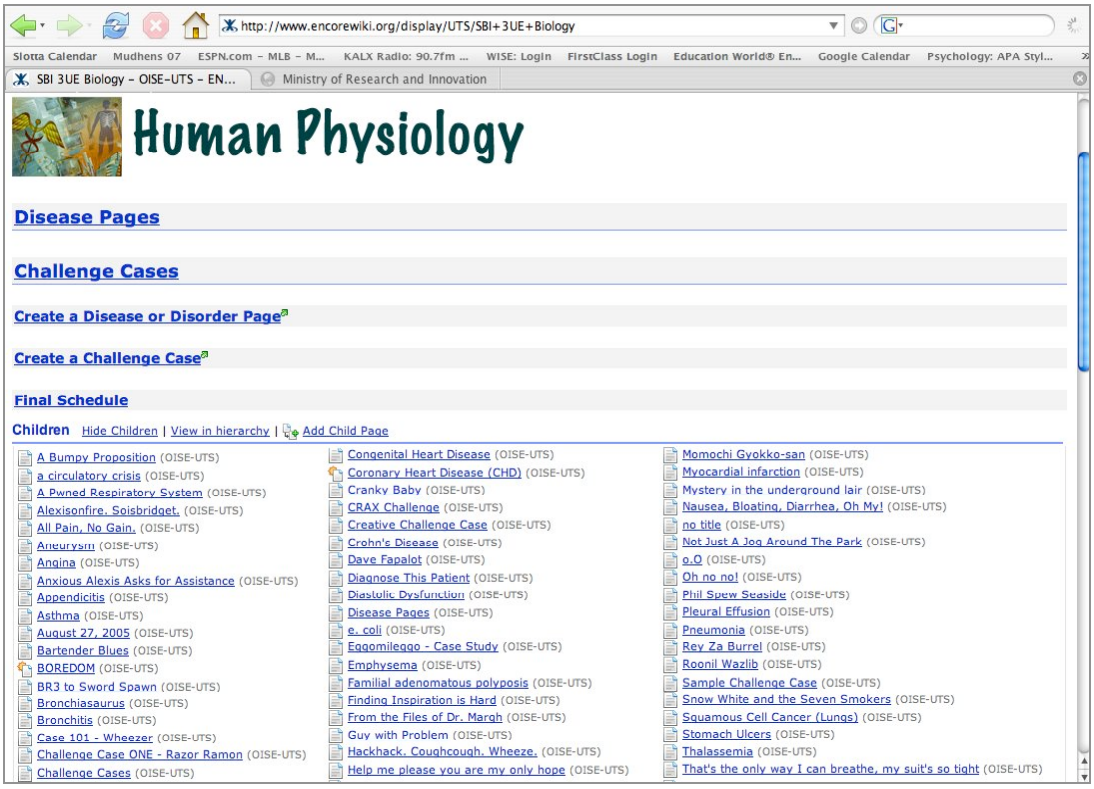

Figure 3. Knowledge base of system diseases and challenge cases.

Metadata

Disease Name	Coronary Heart Disease
Social Tags	CHD, atherosclerosis, cardiac arrest, slow blood flow, calcium buildup, plaque buildup, fat buildup, constricted arteries
Summary	Coronary Heart Disease (CHD) develops when fat, calcium, and plaque build up in the arteries that deliver oxygen and nutrients to the heart. This causes the arteries to harden and constrict, impeding blood flow to the heart. Symptoms include chest pain and shortness of breath on exertion, jaw, back, or arm pain, especially on the left side, heart palpitations. CHD can be treated with drugs such as aspirin, but for extreme cases of CHD the only option is open bypass surgery.
Authors	Lena Bae, Christine Robson
Contributors	Irene Lum, Alice Wang

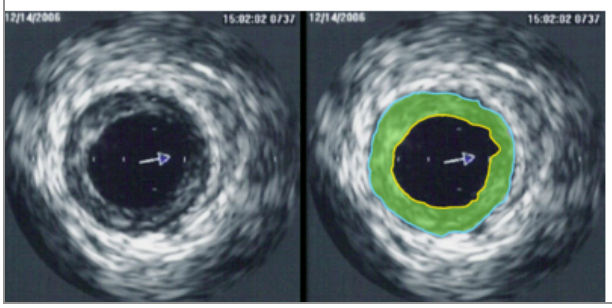

Figure 4. Metadata table for a circulatory disease page.

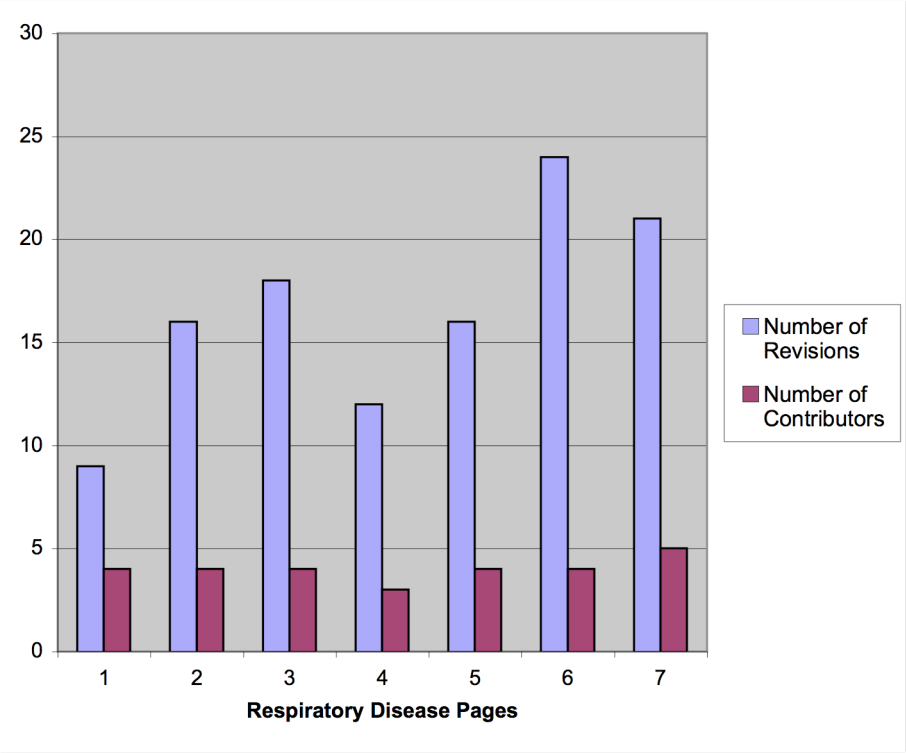

Figure 4. Revisions and contributors per respiratory disease page.

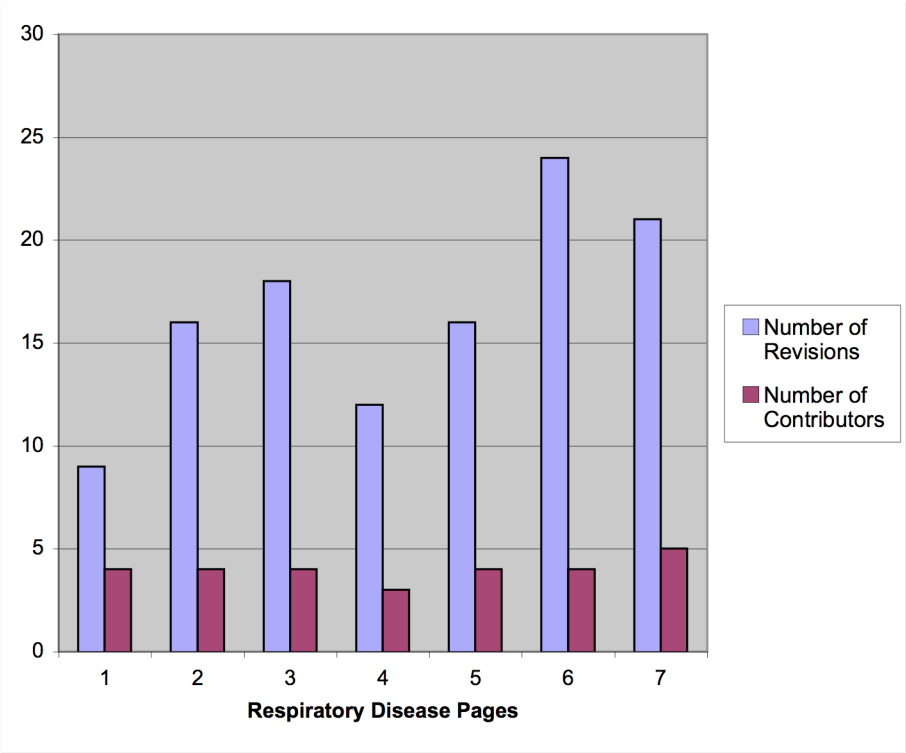

Figure 5. Revisions and contributors per digestive disease page.

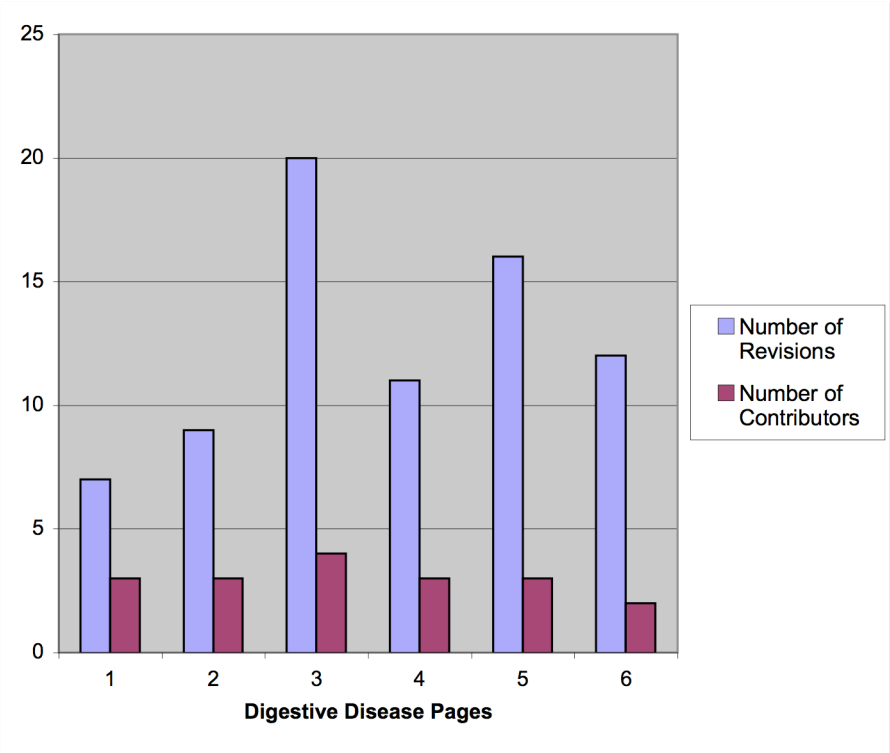

Figure 6. Revisions and contributors per digestive disease page.

Conclusion

This research sought to implement an ecologically valid knowledge building activity into a high school biology classroom. Our ongoing collaborations with teachers and other members of the school community were time-consuming, and at times there seemed to be minimal progress on the research design. Overall, our experience of the co-design process was a positive one. The blend of research partnership and technology was successful in increasing a knowledge community that put students' own ideas at the centre. Teachers' ongoing involvement in the research resulted in materials that were successfully enacted in the classroom. The findings from this study suggest that co-design can play a role in connecting scripted activities that target learning goals to the themes that emerge from knowledge building. This has been elusive and made it challenging for teachers to adopt a knowledge building methodology.

Acknowledgements

This research was supported by funds received from the Connaught Fund and the Social Sciences and Humanities Research Council of Canada.

References

Blumenfeld, P., Fishman, B. J., Krajcik, J., Marx, R. W., & Soloway, E. (2000). Creating usable innovations in systemic reform: Scaling up technology-embedded project-based science in urban schools. *Educational Psychologist, 35*(3), 149-164.

Cobb, P., Confrey, J., diSessa, A. A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher, 32*(1), 9-13.

Ehn, P. (1992). Scandinavian design: On participation and skill. In P. S. Adler & T. A. Winograd (Eds.), *Usability: Turning technologies into tools* (pp. 96-132). New York: Oxford University Press.

Means, B., Penuel, W. R., & Padilla, C. (2001). *The connected school: Technology and learning in high school*. San Francisco, CA: Jossey-Bass.

Muller, M. J., & Kuhn, S. (1993). Participatory design. *Communications of the ACM, 36*(6), 24-28.

Roschelle, J., Penuel, W. R., & Schechtman, N. (2006, July). *Co-design of innovations with teachers: Definition and dynamics*. Paper presented at the International Conference of the Learning Sciences, Bloomington, IN.

Scardamalia, M., & Bereiter, C. (2003). Knowledge building. In *Encyclopaedia of Education*, (2nd ed.). New York: Macmillan Reference.

Soloway, E., Guzdial, M., & Hay, K. E. (1994). Learner-centered design: The challenge for HCI in the 21st century. *Interactions, 1*(2), 36-47.