Canadian Journal of Learning and Technology / La revue canadienne de l'apprentissage et de la technologie, V35(1) Winter / hiver, 2009

Models for Building Knowledge in a Technology-Rich Setting: Teacher Education

Gregory R. MacKinnon
M. Lynn Aylward

Authors

Gregory MacKinnon is a Professor in the School of Education at Acadia University, Wolfville, Nova Scotia. Correspondence regarding this article can be sent to: gregory.mackinnon@acadiau.ca

M. Lynn Aylward is an Associate Professor in the School of Education, Acadia University, Wolfville, Nova Scotia.

Abstract

Technology offers promising opportunities for creating new types of classroom learning environments. This paper describes three technology models used by teacher education interns: electronic portfolios, negotiative concept mapping, cognote-supported electronic discussions. As implemented in the current study, these models invoke graduated attributes of knowledge building and as such serve as a useful continuum of examples of the potential of technology to assist in promoting progressive knowledge construction. A description of the models is followed by a discussion of the relationship of these classrooms to Knowledge-Building principles.

Résumé

La technologie offre des possibilités prometteuses pour la création de nouveaux types d'environnements d'apprentissage en classe. Le présent article décrit trois modèles technologiques utilisés par les stagiaires en enseignement : portfolios électroniques, cartographie conceptuelle de négociation, discussions électroniques avec codage. Tels que mis en œuvre dans le cadre de la présente étude, ces modèles font appel à des attributs hiérarchiques de coélaboration des connaissances et constituent donc en eux-mêmes un continuum utile d'exemples illustrant comment la technologie peut aider à encourager l'élaboration progressive des connaissances. Une description des modèles est suivie d'une discussion portant sur la relation de ces classes avec les principes de coélaboration des connaissances.

Introduction

This teacher education study explores the nature of knowledge building as it relates to teacher intern development. Interns are particularly astute when it comes to observing what the instructor actually does in the classroom rather than just what the instructor says. While preparing interns for the public school classroom involves a) reviewing what is known about teaching and b) practicing skills that span management, speaking and critical thinking, Scardamalia and Bereiter (2003a) suggest that in general, students must collectively construct knowledge "through collaborations designed so that participants share knowledge ... that incorporates features of adult teamwork, real-world content, and use of a variety of information sources" (p.1371). The most relevant classroom experiences as represented by our teacher interns, are those that have a blend of theory and practice and are generally active and engaging. Furthermore in our setting where an abundance of technology is accessible, interns watch very closely the choices the instructor makes around integrating the technology in pedagogically sound ways. It is important to note that teacher educators have a profound responsibility to encourage interns to reflect on the changing nature of classrooms and the appropriateness of applied knowledge. Knowledge building as a guiding principle presumes that interns will challenge existing theory and practice paradigms.

The context for discussing knowledge building as a template for teacher intern development is a laptop university where students bring laptop computers to a technology-rich classroom. They expect to use the computers in productive ways and the instructors experience considerable pressure to be innovative. In this particular teacher education classroom an action research mode (Stringer, 1996) has been assumed to study technology impacts, the formalized studies to be described as part of ensuing models. The instructor has endeavoured to align classroom activities within a constructivist framework (Brooks & Brooks, 1993; Tobin & Tippins, 1993).

In the author's constructivist framework, classroom time is purposely planned to promote socially negotiated construction of knowledge but also personal construction of meaning. Whether one is a constructivist with notions of personally conceived reality or at the other extreme, believing that all knowledge is socially constructed, neither captures the essence of "knowledge building:" the contributions by all community members to the creation and continual improvement of community knowledge (Scardamalia & Bereiter, 2003a). The knowledge once constructed in the community context, should take on a life of its own, subject to scrutiny and improvements by the community. As Scardamalia and Bereiter (2003b) frame it, knowledge building should involve "the creation and improvement of ideas that have a life out in the world, where they are subject to social processes of evaluation, revision, and application" (p. 2). Embedded within this model is the assumption that what "the community accomplishes will be greater than the sum of individual contributions" (Scardamalia & Bereiter, 2003a, p. 1371).

Technology Models in Teacher Education

Three models that aim to support knowledge building, all used in teacher training at a laptop university, will be described. These models range in their adherence to previously defined (Scardamalia, 2002) Knowledge-Building principles (see Table1) from a weak overlay (electronic individual portfolios entered into a community space) to strongest (electronic discussion group coding, with efforts to have students take more collective responsibility for community knowledge). Principles relevant to the models are indicated in italics, to show correspondences. While it is not the purpose of this paper to explicitly map the technology models onto each and every one of these principles, the principles make it clear the definitive nature of knowledge building as an iterative process of constructing knowledge. Nonetheless, inherent in this process as a group effort are many of the aforementioned principles.

Table 1. ***Knowledge-Building Principles***

1) real ideas, authentic problems
2) improvable ideas
3) idea diversity
4) rise above
5) epistemic agency
6) community knowledge, collective responsibility
7) democratizing knowledge
8) symmetric knowledge advancement
9) pervasive knowledge building
10) constructive uses of authoritative sources
11) knowledge building discourse
12) embedded and transformative assessment.

The technology models to which I will refer would be classified by Maddux and Johnson (2006) as Type II applications of technology. Type I, according to this division, includes simple and intended uses of word processing, spreadsheets, databases etc. to be entry level applications, whereas secondary and more elaborate integration of technologies (with respect to pedagogy) has been defined as Type II applications.

Electronic Portfolios

In my science education classroom, teacher interns build an electronic portfolio. This portfolio is assembled throughout the semester on their laptop computers and a rewritable CD-ROM is updated for submission each week. Essentially, interns build up a database of shared materials that have been created and posted to an online environment (ACME). These posted materials can be collected and filed in their portfolio for modification and use in their professional teaching practice. The portfolio is assembled as a hyperlinked webpage with all files and resources local to the CD-ROM. While interns are given some structure to adhere to with regard to the format and the contents, (assignment work which must be submitted for grading) they also have the latitude to add relevant and interesting resources that they have received from other interns or found in their own research. The electronic portfolios include a blend of items prepared by individual interns, intern groups and peers. All submitted assignment work is shared with the interns in two sections of the course by the instructor using a combination of a posting repository (ACME) and distribution list circulation. Typically interns have created portfolios with such items as lesson plans, curriculum integration webs, curriculum concept maps, electronic books, claymations (Witherspoon, 2005), virtual field trips and a variety of assessment tools including scoring rubrics and unit plans.

Within the course, students are encouraged to collect peer-prepared resources, ask for clarification and supplement them for their own use in their teaching practica. The knowledge that is built as a community is a substantial electronic resource which interns continue to use as they enter the teaching profession.

The electronic portfolio in this course relies on several important Knowledge-Building principles. The resources that interns create are largely prepared as a group effort in response to authentic challenges they will face in their teaching practice. As such, these materials are peer-reviewed, the culminating products representing a range of ideas that are intended to be modified and improved upon depending on the context of their teaching task. Much of the revisiting of the portfolio materials will be done in a larger context of school teaching with a new community of experts and contributors. The interns' knowledge of implementation will improve in the field and the resources they developed will be extended as interns access experts in their respective school communities. A critical missing aspect in what has been described so far is a place for the real ideas, authentic problems of the students, and collective responsibility for advancing them. These dimensions of knowledge building, along with others, vary with different implementations of electronic portfolios and journals (also see Brett, Forrester, & Fujita; Niu & van Aalst, this issue).

Negotiative Concept Mapping

Knowledge building as a community is emphasized in the innovation of negotiative concept mapping. Concept mapping as defined by Novak and Gowin (1984) has been used for some time to check for students' understanding of conceptual relationships (Angelo & Cross, 1993). For example, in recent work (MacKinnon & Williams, 2006), we have asked students to prepare a hierarchical concept map of the ideas presented in a course called the Physics of Sound. Using this as feedback we can judge how the student group is assimilating and accommodating new knowledge (Posner, Strike, Hewson, & Gertzog, 1982). However, in terms of knowledge building, the concept map approach has much more potential.

A useful technology known as ICU (not an acronym; instead a play on words i.e., I see you) is used for creating a communication network within a laptop classroom. In this system, interns are linked by their laptops to a campus network. The instructor, using a class list of connected interns can, at any time, access and project to a classroom screen the laptop screen of any student intern.

In secondary science education we have used this capability to engage interns in an iterative process of reflection on the course content. Each week the class time is brought to a close by charging intern groups with the task of updating their concept maps of the course. Interns carefully consider the new concepts introduced in light of past ideas and then reconstruct their concept maps to include their new understandings (both concepts and propositional phrases between concepts). This creates a context for knowledge building in that the next step involves sharing the ideas (maps) with the class through ICU technology. In turn, each of the group maps is projected to the front of the classroom and interns then substantiate the hierarchical placement of their concepts and their inherent relationships. As a class, the content and construction of the updated maps are negotiated through discussion and revision. This is an example of *democratizing knowledge* in that all members of the community are expected to participate in the creation and critique of the concept maps involving *constructive use of authoritative sources.*

Typically at the onset of this activity, concept maps tend to resemble flow charts. Within the maps, clearly visible qualitative improvements that emerge from negotiating meaning include 1) more specific propositional phrases linking the concepts and 2) increased cross-linking between concepts.

This process of building up a community of knowledge around a course is particularly valuable for highlighting misconceptions and as such serves as an excellent feedback tool for the instructor—and potentially for students-- thereby supporting *embedded and transformative assessment*. It should be noted that the intent is not to build consensus as to what individual concept maps should look like but, to reflect on the accommodation of new knowledge and encourage interns to substantiate their understandings. The impact of negotiative concept mapping has most recently been studied in teacher education and medical education. (MacKinnon & Keppell, 2005).

In a similar approach, the capacity of Inspiration® concept mapping software to hyperlink prepositional phrases and concept boxes has been used to study contentious issues in science education (MacKinnon, 2006). In the current work interns were given an instructor-generated concept map that represents the skeleton of what will be engaged in the ensuing lectures around the topic of teaching evolution and creationism. As lectures progress, interns add new concepts and relationships to their concept maps and negotiate the structure as above. However, in addition, students are asked to prepare a map on a rewritable CD-ROM. They substantiate and support their understandings by linking to local files on the CD-ROM from sources such as weekly journal entries, online resources and captured electronic discussions (which they have purposefully coordinated). This engages students in the Knowledge-Building principle of *constructive use of authoritative sources.*

At every stage of the negotiative concept mapping process, the intern's work is shared, challenged, revised and improved by community members. The two-dimensional electronic concept map acts as a rich curriculum guide for engaging this particular topic but also serves as a generic use technology model for reflective and critical thought around a contentious issue (Figure 1).

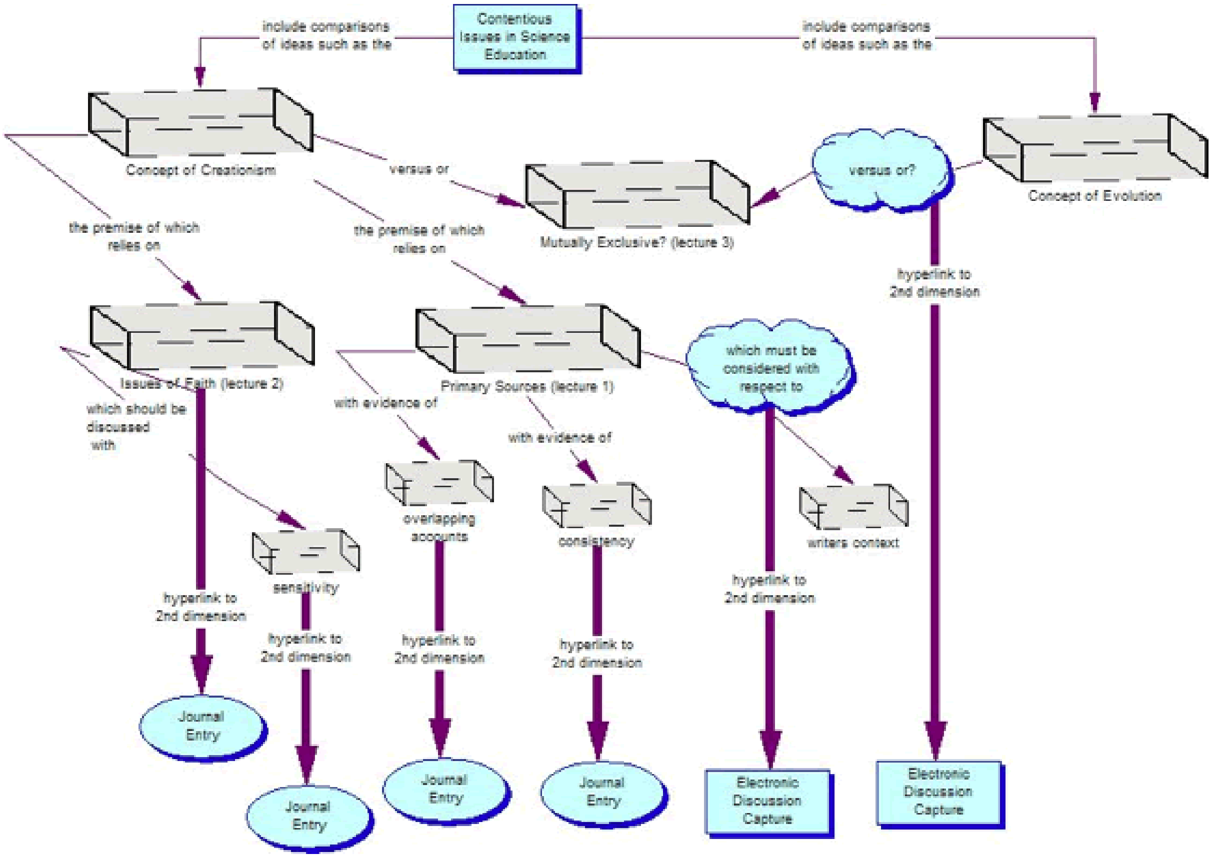

Figure 1. **Two dimensional concept mapping.**

Cognote-Supported Electronic Discussions

In classrooms at the author's university, studies have been undertaken on the application of electronic discussion groups (EDGs) to classroom instruction (Aylward & MacKinnon, 1999; MacKinnon & Aylward, 1999; MacKinnon & Aylward, 2000; MacKinnon, 2000; MacKinnon & Bellefontaine, 2000; MacKinnon, Aylward & Bellefontaine, 2006). The formal study of these EDGs is part of an attempt to encourage teacher education interns to engage in electronic discussion that facilitates higher level reasoning and collaborative meaning making. This objective has been promoted by developing an EDG evaluation scheme that makes use of a hierarchy of codes *(Cognotes)* linked to critical thinking processes. The EDG forum serves as an opportunity for peer teaching and collaborative/cooperative learning.

The cognotes coding system. Within the realm of written exchange between students and their teachers, researchers McTighe and Lyman (1988) have developed systems of icons to cue students to consider more substantive contributions in their writing. These approaches in turn encourage students to think for themselves and define their own questions about the content which they are engaging. Davey and McBride (1986) suggest that the process of generating questions helps students' comprehension and "encourages them to focus attention, make predictions, identify relevant information and think creatively about content" (p 19). This work has been extended by Knight (1990) in the development of pictorial tools to help elementary-age students communicate their understandings in reading journals.

Based on Knight's (1990) work on the coding of written reading journals, an assortment of ten icons and categorical codes (hereafter called *Cognotes*) were developed. These codes were prepared as a new template using macros in Word 7®. The icons and categories *(Cognotes)* and their numerical assessment value are shown in Table 2. Students are told they can accumulate discussion grades to a maximum of ten based on the *Cognotes* assigned to their contributions.

Table 2. *Cognote Icons and Categories*

Specific Interaction Grade	Coding Icon
Acknowledgement of Opinions (evidence of participation) 1	
Question (thoughtful query) 1	
Compare (similarity, analogy) 2	
Contrast (distinction, discriminate) 2	
Evaluation (unsubstantiated opinion/judgment) 1	
Idea to Example (deduction, analogy) 2	
Example to Idea (induction, conclusion) 2	
Clarification. Elaboration (reiterating a point, building on a point) 2	
Cause & Effect (inference, consequence) 2	
Off-Topic/ Faulty Reasoning (entry inappropriate) 0	

Students are led through a series of practise exercises where they apply Cognotes to written work. Students in groups of five then responded asynchronously to a prompt which is placed in their particular EDG. Over a two-week duration the instructor periodically joins each group to provide focus and direction. At the conclusion of the two-week period, the instructor captures the html-based EDG text and saves it as an html document in Word 7®. Cognotes are a form of scaffold.

Using the coding template the instructor assigns *Cognotes* to each student's work in the body of their entire EDG. The coded work is then forwarded to individual students by e-mail attachment. This process is undertaken over two more successive sessions of two weeks in duration. Time is allotted between EDG sessions to discuss the coding process and clarify ambiguities. Student work in this context has less to do with the content knowledge being discussed in the electronic discussion forum and more to do with how interns' discussion patterns improve as a result of continual feedback in the coding exercise. The coder and codee have a relationship in which the notation system acts as a facilitator for critical thinking and expression as a process. The collaboration within the system improves understanding of the nature of the discussion rather than the knowledge itself.

Peer teaching, collaboration, and evaluation. MacKinnon and Bellefontaine (2000) have incorporated the Cognote tool in a middle school education course. In this course students were supplied with a CD-ROM containing case studies on issues relevant to middle school education. The case studies were engaged by students in an interactive system the assessment of which relied on substantive electronic discussion. Students were placed in teams of three (Figure 2). Each team was responsible for taking a role in two electronic discussions. In one electronic discussion the three students would act as "coordinators" leading and promoting the discussion of a first case study. In the second electronic discussion the three students would be "participants" in an electronic discussion around a second case study.

Coordinators (of Case Study One) Participants (in Case Study Four) John Mary Louise	Participants (in Case Study One) Coordinators (of Case Study Two) Donna Philip Arthur

John, Mary and Louise would pose the discussion items around Case Study One to the participants: Donna, Philip and Arthur.

John, Mary and Louise would then independently code/grade the contributions of Donna, Philip and Arthur.

John, Mary and Louise would then independently write a case study report on Case Study One.

Donna, Philip and Arthur would in turn be coordinating Case Study Two with its inherent responsibilities.

Figure 2. **Student responsibilities.**

The discussions were undertaken over three weeks. Each member of the coordinating team was responsible for leading the discussion for at least one of the three weeks. In addition, each member of the coordinating group was expected to code and grade each of the participant's discussion over the three-week period (using the aforementioned cognote system). This amounted to each coordinator coding weekly contributions to the EDG of three individual students and then returning the coded work by e-mail (with a grade) to the student and instructor. From the instructor, the participating student received a grade for their discussion contribution which represented an average of the three coordinators' returned coded transcripts. Because the coordinators returned these coded transcripts to the participants at the end of each of the weeks, the participant had an opportunity to reflect on their past contributions and improve their critical discussion patterns. Past research (MacKinnon, 2000) has demonstrated that instructor feedback in this manner measurably 1) improves substantive discussion through student accessing of higher order patterns, and 2) reduces the quantity of written discussion with concomitant improvement in quality. The *Cognotes* system has the potential to improve the quality of *knowledge-building discourse* which directly impacts the capacity for knowledge building. Improved critical thinking and refined discussion patterns allow for more clearly articulated *idea diversity and epistemic agency*.

Promoting substantive discussion: cognotes and qualitative research. The fact that student's electronic discussion was being coded, has been shown in previous studies to improve the quality of interaction based on the hierarchy of discussion patterns and cognote system alluded to above (MacKinnon, 2000). However an additional assessment item was employed in an effort to lend more intrinsic value to the EDG. Each student in the coordinating group was required to submit a written report on the case study over which they coordinated the EDG. A crucial component of that report was the "hard copy" captures of the EDG sessions they had coordinated. They were expected to use the electronic discussion transcripts as a source of qualitative data in the creation of their final case study report. The students, knowing this in advance, were possibly more motivated to lead a substantive discussion on their case study. In this system students had an educative opportunity to practice the role of EDG leader/evaluator while simultaneously participating in a quality discussion. The model also allowed students the opportunity to experiment in the generation of qualitative data for their individual research case studies. Embedding a rationale for contributing substantively to EDGs pedagogically surpasses the typical token participation grade. In this model both participants and coordinators were encouraged to engage the EDG with a seriousness that is not the norm with EDGs.

Studies have shown that students who have experienced and used the coding system transfer their discussion skills to other settings. In one study (MacKinnon, Pelletier, & Brown, 2002), teacher interns who had undertaken coding exercises in a science education course were (one year later) shown to be more substantive participants in both inclusive education and physical education discussion group settings. Longitudinal studies of greater than two years have not been possible due in part to the length of this teacher education (BEd) program and thus the continued exposure of interns to this technological infrastructure. From observing improved patterns in successive discussion transcripts, the author considered that interns have the potential to be much better knowledge builders because of their metacognitive activities related to *Cognotes.*

Clearly teacher interns in this model engage the technology with a vested interest in promoting a useful and productive community database of discussion. EDGs are typically assigned in a course as simply a place to share ideas. Interns first become better discussants by being participants in a coding system exercise. In a subsequent exercise, they participate and lead discussions in an objective-focused EDG which becomes the product of the community effort to provide analysis of real-world case studies concerning middle school challenges.

In this integration strategy, knowledge building is most evident in the improvement of interns' collaborative idea improvement. It is important to note here that interns will also necessarily negotiate the content through more effective idea exchange; however, the power of this tool is in its generic application to any content area and thus knowledge building is nested in the improved process of substantive exchange.

Reflections

Communication technologies offer opportunities to establish knowledge-building communities in which participants create epistemic artifacts that are recorded and continually improved. The three technology integration examples are intended to reflect increasing centrality of knowledge-building principles. While electronic portfolios involve sharing, building a community resource, and then refining and revisiting that resource in professional practice, it is less grounded in true knowledge building than the later examples of negotiative concept mapping and EDG coding. The later two examples demonstrate that interns in a knowledge-building community have an active part in substantiating and further negotiating new understandings. They assess their own ideas and reflect on the value of peer input through accommodation processes.

In the context of knowledge-building principles (Scardamalia, 2002), the foregoing examples demonstrate in varying extents: authentic problems, negotiated meaning based on the premise that ideas are improvable, accommodation of socially constructed notions and personally-held meanings, contextualized learning through diversity of ideas, wrestling with ill-structured professional problems in their full complexity, collective and shared input and responsibility through democratic participation in the knowledge building, consideration of authoritative sources, building discourse leading to improved readiness for the teaching profession and assessment of self and peer ideas that through negotiation allow for continual reflective assessment by the growing practitioner.

References

ACME (1996). Acadia Courseware Management Environment [Computer software]. Wolfville, NS: Acadia University.

Angelo, T., & Cross, K. (1993). *Classroom assessment techniques* (2nd ed.). San Francisco, CA: Jossey-Bass.

Aylward, L., & MacKinnon, L. (1999). Exploring the use of electronic discussion group coding with pre-service secondary teachers. *Journal of Information Technology for Teacher Education, 8(*3), 335-348.

Brooks, J. G., & Brooks, M. G. (1993)*. The case for constructivist classrooms.* Alexandria, VA: Association for Supervision and Curriculum Development.

Davey, B., & McBride, S. (1986). Effects of question-generation training on reading comprehension. *Journal of Educational Psychology, 78*(4) 256-62.

Knight, J. E. (1990). Coding journal entries. *Journal of Reading, 34*(1), 42-46.

Maddux, C., & Johnson, D. L. (2006). *Type II uses of technology in education: Projects, case study, and software applications.* Binghamton, NY: Haworth Press Inc.

MacKinnon, G.. (2000). The dilemma of evaluating electronic discussion groups. *Journal of Research on Computing in Education, 33*(2), 125-131.

MacKinnon, G. (2006). Contentious issues in science education: Building critical thinking patterns through two-dimensional concept mapping. *Journal of Educational Multimedia and Hypermedia, 15*(4), 433-445.

MacKinnon, G., & Aylward, L. (1999). Six steps to improving the quality of your electronic discussion groups. *Journal of Instruction Delivery Systems, 13*(4), 17-19.

MacKinnon, G., & Aylward, L. (2000). Coding electronic discussion groups. I*nternational Journal of Educational Telecommunications, 6*(1), 53-61.

MacKinnon, G., Aylward, L., & Bellefontaine, J. (2006). Electronic discussion: A case study of the range of applications in a laptop university. *Computers in the Schools, 23*(2), 52-71.

MacKinnon, G., & Bellefontaine, J. (2000). CD-ROM technology and instruction delivery: A teacher education approach. *Journal of Instruction Delivery Systems, 14*(4), 17-23.

MacKinnon, G., & Keppell. (2005). Concept mapping: A unique means for negotiating meaning in professional studies. *Journal of Educational Multimedia and Hypermedia, 14* (3), 291-315.

MacKinnon, G., Pelletier, J., & Brown, M. (2002). Coding electronic discussion to promote critical thinking: A cross-curricular teacher education approach. In D. Willis, J. Price, & N. Davis (Eds.), *Proceedings of the Society for Information Technology & Teacher Education,* (pp. 1372-1374). Charlottesville, VA: AACE.

MacKinnon, G., & Williams, P. (2006). Models for integrating technology in higher education: The physics of sound. *Journal of College Science Teaching, 35*(8), 22-25.

McTighe, J., & Lyman, F. T. (1988). Cueing thinking in the classroom: The promise of theory-embedded tools. *Educational Leadership,45*(7), 18-24.

Novak, J. D., & Gowin, D. B. (1984). *Learning how to learn. ,*New York, NY: Cambridge University Press.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education, 66*(2), 221-227.

Scardamalia, M., & Bereiter, C. (2003a). Knowledge building. In *Encyclopedia of Education.* (2nd ed. pp. 1370-1373). New York: Macmillan Reference USA.

Scardamalia, M., & Bereiter, C. (2003b). Knowledge building environments: Extending the limits of the possible in education and knowledge work. In A. Distefano, K. E. Rudestam, & R. Silverman (Eds.), *Encyclopedia of distributed learning* (pp. 269-272). Thousand Oaks, CA: Sage.

Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal Education in a Knowledge Society* (pp. 67-98). Open Court.

Stringer, E. T. (1996)*. Action research: A handbook for practitioners.* Thousand Oaks, CA: Sage.

Tobin, K., & Tippins, D. (1993). Constructivism as referent for teaching and learning. In K. Tobin (Ed.), *The practice of constructivism in science education* (pp. 3-21). Hillsdale, NJ: Lawrence Erlbaum Associates.

Witherspoon, T. (2005, July 19). *Clay animation made easy.* Available at http://education.wichita.edu/claymation/