

# **Integrating Electronic Forums and Concept Mapping With a Science Methods**

## **Course for Preservice Elementary Teachers**

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### Introduction

In order for teachers to build technology literacy in their students, they must develop competence with technology tools and a positive disposition about the use of those tools to provide instruction. Teachers perceive that they are in great need of professional development on instructional technology and cite insufficient release time from regular responsibilities as a major barrier to learning and using this technology (Meyer, 2001). Almost one-quarter (24%) of schools report that at least 50% of their teachers are beginners with using technology ("Capacity to use technology," 5/9/02). Methods courses for preservice teachers should respond by

providing meaningful experiences where future educators learn with technology (Jonassen et al., 1999) and develop the desire to use technology tools to provide instruction (Flick & Bell, 2000; Neiss, 2001). Kumar and Altschuld (2002) suggest emphasizing technology utilization in preservice education as a means of “providing better training for potential teachers of science” (p. 179). Electronic forums (a type of asynchronous conferencing) and concept mapping software are two technology applications that can be readily employed towards these ends (Rye, 2001).

The International Society for Technology Education (ISTE) “National Educational Technology Standards” (NETS) for Teachers (ISTE NETS Project, 2000-2002) state that all teachers need to demonstrate an understanding of the NETS “foundational” standards for students (ISTE 2000). Electronic forums (alternatively termed bulletin boards, conferences or discussion folders) and concept mapping are especially applicable to the foundational standards of using technology as productivity and communication tools. Further, these applications facilitate literacy in the foundational standard of using technology as a research tool, as they apply readily to organizing and synthesizing information from purposeful Internet searches. These tools can be used individually or in concert to carry out telecollaborative activities that fall within each of Harris’s (1998) genre: interpersonal, informational, and problem solving.

Electronic forums also can be employed to foster a community-based learning environment, where learners have a shared interest in a task or topic and have the common goal of producing knowledge relative to that task or topic—knowledge that is made public and available to future learners (Riel, 2000). Barnett et al. (2002) report a movement amongst teacher educators, discontent with the conventional approach, towards achieving a “community of learners” (p. 299) context in their courses. The community-centered dimension of the learning

environment is especially critical to lifelong learning for teachers, who are isolated from each other by the traditional classroom environment.

Electronic forums and concept mapping programs are “mindtools” that fit well with constructivist approaches to teaching and promote reflection, critical thinking, and “constructive social learning” (Jonassen, 2000, p. 251). The application of these tools can foster science education reform thrusts (National Academy of Sciences, 1996) and are especially suited to introducing technology in the context of science content (Flick & Bell, 2000). More broadly, the integration of these tools with preservice education helps prospective teachers master NETS “Professional Preparation” competencies on using technology for higher order thinking and peer collaborations, and building a portfolio of technology-related products (ISTE NETS Project, 2000-2002).

Kumar and Altschuld (2000) contend that opportunities abound for the evaluation of technology integration and that evaluators of science education “must become active players in guiding the infusion of technology in science teacher preservice programs” (p. 190). The remainder of this paper describes an action research study in which electronic forums and a concept mapping program were integrated with a science methods course for elementary preservice teachers. The course was offered three times over the duration of the study: Fall semesters, 1998 through 2000. Technology integration took the form of technology-supported assignments that interfaced with concurrent practica experiences in Professional Development Schools. Data collected from preservice teachers on these assignments for each year was utilized to enhance technology integration for the subsequent year.

### Description of Preservice Teachers and Teacher Education Program

Preservice teachers (PT) were seniors (over 90% female) in the fourth of a 5-year Teacher Education Program leading to a Masters of Arts degree in Education. All were elementary education majors and a few also were seeking middle level specialization in science. In the Teacher Education Program, practica experiences with “host” teachers in affiliated Professional Development Schools (PDS) commence in the junior year and build progressively through the fifth year. PTs are known as “tutors” during year three, “participants” during their fourth year, and “interns” in year five. Content of the Teacher Education Program courses and associated practica is guided by the Characteristics of the Novice Teacher, which were derived from the Interstate New Teacher Assessment and Support Consortium standards (INTASC, 1992).

### Description of Science Methods Course and Technology Assignments

Two sections of the elementary science methods course were offered each semester (Fall 1998, 1999, and 2000), enrolling a total of 30 PTs (participants) the first year and approximately 40 PTs in years two and three. One of the authors served as the instructor of both sections for all three years. The course placed considerable emphasis on questioning and science process skills and constructivist approaches to teaching, including the learning cycle model. Technology tools employed in the course included electronic forums/discussion lists from TopClass<sup>®</sup> (1998 offering) and WebCT<sup>®</sup> (1999 and 2000 offerings) and electronic concept mapping through Inspiration<sup>®</sup>. Table 1 provides brief descriptions of the technology supported assignments and illustrates how the scope differed across the three offerings (years 1998, 1999, and 2000).

Table 1.

Technology-supported assignments and respective descriptions by year of course offering that employed electronic forums and concept mapping.

Assignment	1998	1999	2000
Learning Cycle and Concept Map	Develop “field-test” ready learning cycle; construct related concept map explicating science understandings lesson seeks to develop; post message summarizing learning cycle and attach field-test ready version and concept map.	Develop draft of learning cycle and related concept map; post message summarizing learning cycle and attach draft for peer critique; field-test in practica and revise learning cycle; post/attach revised learning cycle and concept map.	Same as assigned in 1999 <u>plus</u> option to “showcase” concept map at course web site (as opposed to password protected forum attachment)
Science Education Resources Forum	Conduct Internet search for science education resources; post message describing two resources (include URL).	Conduct Internet search for science education resource to use with Learning Cycle; post message and URL.	---
Science Instruction Issues Forum	Post a question, reflection, or issue that pertains to science instruction; respond to at least one colleague’s post.	Post a Science-Technology-Society (STS) Issue along with relevant URL and your stance and respond to a colleague’s STS issue; OR respond to 2 colleagues’ STS issues.	Initiate and monitor a threaded discussion on an STS issue and participate in the threaded discussions of STS issues initiated by at least two colleagues; include relevant URLs.
Practica, Action Research & Class Chat Forums	---	Post one message to share a practica experience or idea for action research, or to extend classroom discussion	---
Science Short	---	Conduct a short activity in practica that employs a technique especially conducive to science instruction (e.g., “predict-observe-explain); post a mini-lesson that would allow others to carry out the science short and your reflection on how it went.	Same as assigned in 1999
Science Instruction Try Out	---	---	Try out an activity from a science short or learning cycle posted by a preservice teacher in 1999.

The learning cycle project (all three years), science short (years 1999 and 2000) and science instruction try out (year 2000 only) technology-supported assignments were integral with practica, and accordingly, were planned and conducted with input and supervision from host teachers. Approximately two 75-minute class periods were devoted to developing basic competencies in the use of electronic forums (e.g., composing a message, attaching files, replying to colleagues) and concept mapping software. PTs were familiarized with similarities and differences between email and electronic forums and encouraged to construct concept maps that were hierarchically-framed with labeled links (Novak & Gowin, 1984) as opposed to “webs.”

The science short assignment was to be completed before teaching the learning cycle and was intended to provide the PT with an instructional opportunity in practica that did not require extensive planning or classroom time to conduct. Specifically, the science short was to provide the PT with a practica experience in utilizing a strategy that was especially conducive to science instruction, e.g., predict-observe-explain (White & Gunstone, 1992), discrepant event (Liem, 1987), an advance organizer (Novak, 1992), a model, etc. The science short “write-up” was to contain a title, a brief description of the subject matter (including relevant “instructional goals and objectives” from the State curriculum guide) and instructional strategies employed, and the materials and procedural steps in sufficient detail so another teacher who read it could “run with it.” After conducting the science short, the PT was to add to the write-up her assessment of how it went (strengths, limitations, modifications for next time). The science shorts conducted by PT represented a wide range of subject matter (e.g., properties of matter, weather, energy transformation, the senses) and often employed “predict-observe-explain.” Some PT employed more than one strategy, e.g., a science short on “The Properties of Leaves” involved a science

talk (Gallas, 1995), advance organizer, and concept map tool. Following are excerpts from the “assessment” portion of a science short on the concept of carbonation (observe and investigate how properties can be used to identify substances) conducted by a PT in a 4<sup>th</sup> grade classroom. It conveys the essence (and beyond) of what the instructor was trying to facilitate through the assignment: a “successful” practica experience for the PT and children that would build confidence and desire for engaging together in future science instruction.

I felt the science short went really well. I conducted the whole lesson in about 15 minutes. The students were so focused and interested in the experiment. At first, when I placed the raisins in the Mountain Dew<sup>®</sup>, the students thought they were just going to sink. When the raisins began to bob up and down, they were fascinated. All they could say at first was “Wow!” They were eager to share their explanations and learn the real reasoning. At the end of the lesson, I gave each student a box of raisins to enjoy as a snack, or to take home and try the experiment again for a parent. Many of the students saved their raisins to take home, to see if their parents knew what would happen and why. The strength of my science short was having the student’s [sic] practice important science investigation techniques such as predict, observe, and explain. . . . Another strength of the science short that I feel is important, is the extension of the lesson where students could take their box of raisins home and do the experiment for their parents. I feel it is important for parents to become involved in their child’s learning process. By performing the experiment with their parents, the students are also given the opportunity to retell what they learned, which will help them better understand and remember the concepts learned. . . . I like the way you can present important science concepts in a way that is fun and interesting to the students.

The learning cycle project was a more robust assignment in which students developed and field-tested the three instructional phases (exploration, invention, application) in a SCIS learning cycle model (Carin & Bass, 2001). Development of the learning cycle included peer critique, and during 1999 and 2000, PTs were asked to produce a final (revised) learning cycle that was based on the field-test. Additionally, the learning cycle integrated the use of Inspiration: Each PT was asked to produce a hierarchically-framed concept map (Figure 1) to explicate key science understandings that the cycle sought to develop in children. The main

purpose of producing the concept map was to foster critical thinking by the PT prior to instruction on what key science concepts and relationships should comprise instruction.

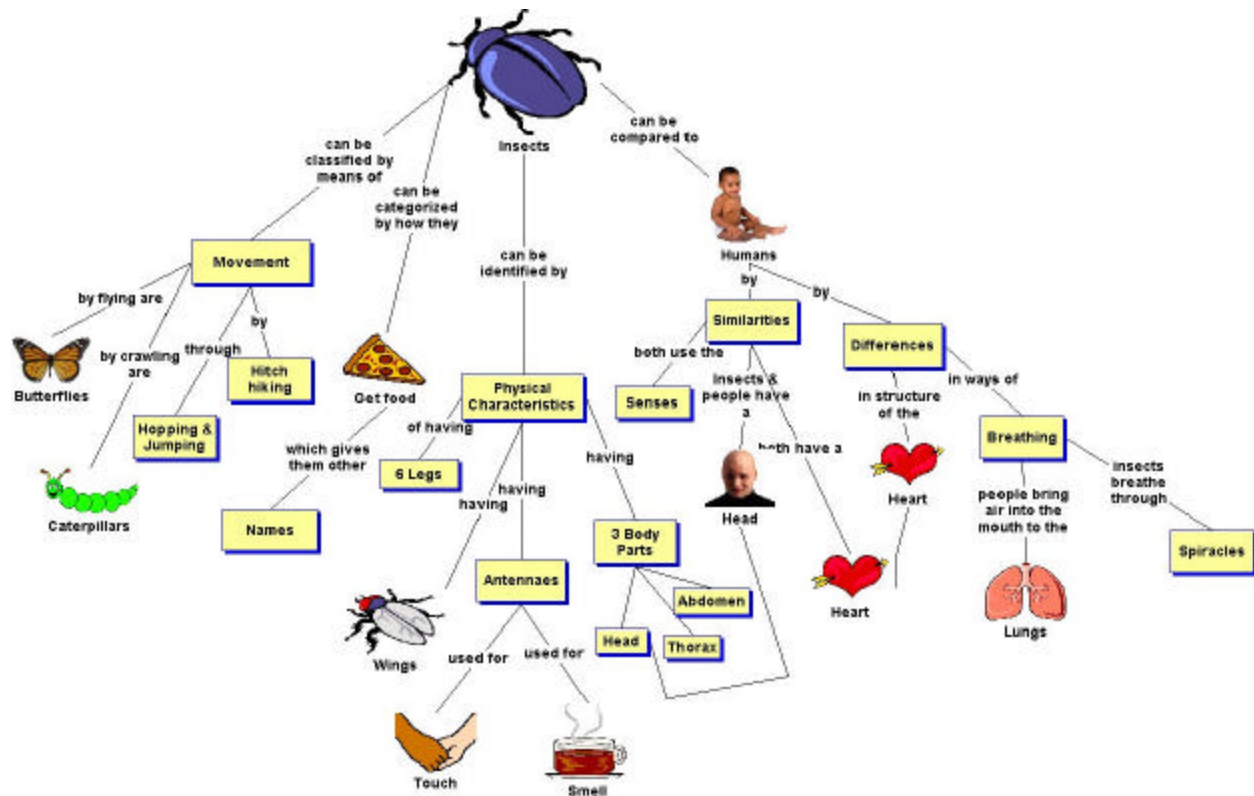


Figure 1. Two-dimensional view of concept map created by preservice teacher illustrating the conceptual understandings that her learning cycle seeks to develop. Not shown by this diagram are the notes embedded in various symbols that elaborate these understandings.

Each of the PTs' science shorts and learning cycles (with concept maps) were posted to a password-protected electronic forum, where they remained as an "archived" resource bank for at least one year. Accordingly, PTs could share instructional plans with their peers and access the m at a later time. In the year 2000 course offering, each PT also was assigned during the first month of the course to visit the course web site with her host teacher, where they were to choose



together an activity from the archived resource bank that the PT would “try-out” in practice. One purpose of the “try out” was to initiate early in the course a dialogue about science instruction between the PT and host teacher. This assignment emerged from an extended conversation between the first author and a host teacher, which was initiated by the host teacher in response to her supervision of an “enthusiastic” PT and interest in what the electronic forums might have to offer. This assignment was intended to acquaint the PT early in the course with examples of two assignments--science shorts and learning cycles developed by the previous year’s PTs--that they also would have to develop and conduct. It was conveyed as a “warm up” and “low risk” assignment where the PT simply “tried out” an activity, which was field-tested and made available through a previous PT, that they thought would be fun to do with the children. Additionally, the assignment placed the PT in a position where she could provide an experience and potential resources for her host teacher by acquainting the teacher with the course web site/archived instructional material.

Topics that were more frequently selected for “try out” by PTs targeted density and buoyancy, pollution, leaf classification, and properties of air. After completing the “try out,” the PT was asked to prepare a reflective report that described (a) what was taught, (b) how it went (students’ reactions, strengths, and problems) and (c) in what ways the PT benefited (e.g., what was learned, ideas gained). Excerpts follow from a preservice teacher's reflection after "trying out" instruction on air taking up space. As with the excerpts from the Science Short, they convey "the ideal" of what the instructor was hoping to realize through the assignment.

I think that doing a “Try Out” was a great way to introduce myself, as a preservice teacher, to science instruction. I had never taught an entire class of students before, but now I have an idea of what it is like. . . . The need to be flexible arose immediately. The science short that was posted on the website began the lesson by going straight into the demonstration. However, as I wrote the words predict, observe, and explain on the board, I realized that I should survey

the class about their understanding of these terms. This resulted in me teaching a mini-lesson about “talking like scientists.” I gave examples of the terms in other contexts (such as predicting the weather) and prompted the students to discover the definitions themselves. As I used these terms throughout the lesson, the students seemed to be proud to use their new vocabulary. From this activity I also learned that I need to be very organized and clear in every aspect of the demonstration. . . .Lastly, I saw the importance of listening to your students. If I had ignored the students' suggestions to try the experiment in a new way, they may have lost interest. By trying something that was suggested by the students, I made them feel more involved in the experiment.

Other electronic forums to which PTs posted, depending on the year of offering, included (a) science education resources, (b) class chat, (c) practica chat, (d) action research and (e) science education issues. The latter became a forum for initiating threaded discussions on Science-Technology-Society issues during the year 1999 and 2000 offerings. All postings to electronic forums were password protected, but open via request to any Teacher Education Program preservice teachers, university faculty, and PDS host teachers.

For the third offering (Fall, 2000) of the course, a more elaborate course web site was developed to organize and facilitate the technology supported assignments. The web site emerged from the first author's participation in an educational technology institute—TREK-21 (<http://www.trek-21.wvu.edu>)—for PDS host teachers and university faculty who service PT. The web site provided links to on-line technology resources, including the electronic forums/discussion lists. The web site also provided instructions for and examples of technology supported assignments (e.g., science shorts) and the opportunity for PTs to showcase their learning cycle concept maps on the Internet (as opposed to only through a password protected forum).

## Research Questions

The technology-supported assignments that integrated electronic forums and concept mapping were a principal focus of inquiry. Research questions of a quantitative nature that emerged were as follows:

1. Do Preservice Teachers' (PT) post-course ratings (1 = not at all to 5 = very) about the value to their education of electronic forums and concept mapping show statistically significant improvements over three sequential offerings of an elementary science methods course?

2. Do PT post-course ratings (1 = not at all to 5 = very) about their plans to utilize as a future teacher electronic forums and concept mapping show statistically significant improvements over three sequential offerings of an elementary science methods course?

3. Do PT post-instructional ratings of their readiness to undertake the technology supported assignments, as a function of their past course work, differ significantly over three sequential offerings of an elementary science methods course?

4. Do PT who report concept map utilization beyond the course requirement perceive that concept mapping was significantly more valuable than PT who do not report utilizing the concept map beyond the course requirement?

Qualitatively, the researchers were interested in the reasons PTs gave to support their post-course ratings about the value and future use of the electronic forums and concept mapping as well as explicit suggestions for improving the technology-supported course assignments. Given the current emphasis on creating learning communities as a part of science teacher professional development (National Academy of Sciences, 1996; Reil, 2000), the researchers also were interested in: How can electronic forums be used to foster a collaborative culture and community of learners amongst PTs?

## Data Sources and Analysis

### Quantitative

A questionnaire (Appendix A) about the technology related assignments was administered during the final week of each course offering (Fall semesters, 1998, 1999, and 2000). The questionnaire was voluntary and the instructor was absent during administration. The questionnaire employed a Likert-type scale (1 = not at all to 5 = very) to solicit PTs perceptions about (a) the value to their own education of electronic forums and concept mapping, (b) their desire to utilize electronic forums and concept mapping as a future teacher, and (c) the degree to which course work taken in prior semesters prepared them to undertake the electronic forums and concept mapping assignments. The final question attempted to ascertain if PT had employed the concept map tool beyond the requirement of developing a concept map for their learning cycle. For the 1999 and 2000 course offering, this final question asked specifically if they had employed the concept map with students in practica, and if so, to explain how. For the 1998 offering, the final question was limited to a yes/no query about only one additional application of the concept map: An assignment in which they were given the option of developing a concept map (instead of providing a narrative about the lesson's concepts) for a guided discovery lesson. The questionnaire underwent content validation by a group of three faculty: one from instructional technology and two who were heavily involved in practica for PTs at affiliated PDS.

For the year 2000 offering, PT also were queried about the course web site for the technology-supported assignments on the standardized course evaluation instrument. The university allows all instructors to add to the course evaluation instrument one item, which was as follows: "The course web site was valuable to my education." PT were asked to respond on a

Likert-type scale (1 = poor to 5 = excellent) and could provide reasons for their ratings at the end of the instrument. Completion of the evaluation was optional to PT and it was administered in the instructor's absence during the final class session.

SPSS™ (9<sup>th</sup> edition) was employed in data analysis, which included (a) one-way ANOVAs with Tukey follow-up to check for statistically significant differences in PT ratings across groups (years 1998, 1999, 2000) and (b) a Pearson's correlation matrix of PT ratings. Additionally, the independent samples t-test was employed to determine differences in group means (PTs who did or did not report using concept mapping beyond course requirement) on (a) their perceptions of the value of concept mapping to their education and (b) their desire to use concept mapping as a teacher. All tests were conducted at the .05 level of significance.

### Qualitative

The questionnaire (Appendix A) described above asked PTs to provide reasons to support their ratings and to describe ways in which they used concept mapping beyond the course requirement of constructing a concept map for their learning cycle. Additionally, the questionnaire asked PTs to provide suggestions on how to improve course assignments. Other qualitative data were PT postings to the electronic forums and open-ended comments about why they rated any items on the standardized course evaluation instrument as excellent or low. A frequency analysis was employed to analyze the open-ended responses on the questionnaires and course evaluation as well as postings to certain forums. An analysis of the postings to the STS forums and follow-up interviews about those postings with PTs are presented elsewhere (Farris, Rye, & Pyle, 2003).

### Findings and Discussion

The answers to each of the four quantitative research questions are presented in concert with the reasons PT provided to support their ratings about the value and future use of the forums and concept map. Relative to research questions one through three, Table 2 provides the group mean ratings and results of one-way ANOVA for each course offering (years 1998, 1999, and 2000), and Table 3 provides the respective results of the Tukey follow-up to one-way ANOVA.

Table 2.

PT perceptions about technology tools employed in course assignments: Mean rating (1 = not at all to 5 = very) by year of offering and results of One-way ANOVA

Question	1998 ( $\underline{n} = 29$ )	1999 ( $\underline{n} = 38$ )	2000 ( $\underline{n} = 37$ )	One-Way ANOVA
How valuable were forums to your education	2.83	3.50	4.19	$\underline{F} = 16.532$ $\underline{p} = .000$
How valuable were concept maps to your education	3.31	3.34	3.97	$\underline{F} = 5.984$ $\underline{p} = .004$
How much would you like to use forums as a future teacher	2.71	3.34	3.60	$\underline{F} = 4.599$ $\underline{p} = .012$
How much would you like to use concept maps as a future teacher	3.59	3.29	4.03	$\underline{F} = 6.063$ $\underline{p} = .003$
How much did prior coursework prepare you to do forum assignments	3.79	3.79	3.29	$\underline{F} = 1.961$ N.S. ( $\underline{p} = .146$ )
How much did prior coursework prepare you to do concept map assignment	4.10	4.18	3.64	$\underline{F} = 2.908$ N.S. ( $\underline{p} = .059$ ) <sup>a</sup>

<sup>a</sup>Violation of Levene's Test for Homogeneity of Variances was found ( $\underline{p} = .016$ ).

Table 3.

PT perceptions about technology tools employed in course assignments: Tukey follow-up (significance levels) to one-way ANOVA.

Question	1998 vs. 1999	1998 vs. 2000	1999 vs. 2000
How valuable were forums to your education	.014 <sup>a</sup>	.000 <sup>a</sup>	.007 <sup>a</sup>
How valuable were concept maps to your education	.989	.011 <sup>a</sup>	.009 <sup>a</sup>
How much would you like to use forums as a future teacher	.085	.010 <sup>a</sup>	.617
How much would you like to use concept maps as a future teacher	.385	.134	.002 <sup>a</sup>

<sup>a</sup>Mean difference is statistically significant at .05 level.

Value of Forums

Mean ratings of the perceived value “to your education” of electronic forums increased progressively over each of the three offerings ( $M = 2.83$  for year 1998 group to  $M = 4.19$  for year 2000), and one-way ANOVAs revealed that there were statistically significant differences among the means: ( $F = 16.532$ ,  $p = .000$ ). Tukey follow-up revealed that the group mean difference between each year was statistically significant (e.g., for 1998 to 2000,  $p = .000$ ).

The significant increases in each group mean might be explained by the progressive changes each year in course assignments to reflect the diverse uses of electronic forums. For example, in 1998, the forums were not employed to complete peer critiques of the draft learning cycles nor did the forums provide examples of completed learning cycles from a prior year’s offering. In 1999 and 2000, the forums did provide these features and also an on-line exchange of views on Science-Technology-Society (STS) issues. The year 2000 offering reflected the most robust use of the forums, which included (a) engaging each PT in initiating and monitoring her

own threaded discussion on an STS issue, (b) providing a resource bank of learning cycles and “science shorts” from PTs in the 1999 course offering, and (c) engaging the PT and her host teacher in choosing some science instruction to “try out” from the resource bank of learning cycles and science shorts.

The year 2000 PT ratings of how much they valued forums were significantly higher than PT ratings from both of the previous years. In addition to the very diverse nature of the forums for the year 2000, all of the assignments that required the use of forums in 2000 had a clearly articulated purpose beyond just posting or replying. For example, PT were not asked to post just to share a resource they found on the Internet (the "Science Education Resource Forum" was eliminated). Also, the Science Instruction Issues Forum assignment was highly structured: It required each PT to compose a rather comprehensive posting to initiate a threaded discussion on an STS issue of her choice, to participate in (post to) the threaded discussions initiated by two colleagues with whom she had been grouped, and to monitor her own threaded discussion by replying to the colleagues who had responded to her initiating post. This structure may have given PT a better appreciation for what constitutes "threaded discussions" and the value of electronic forums towards that end. Additionally, PT likely were more vested in the assignment, given that they had responsibility for facilitating a threaded discussion on an issue of personal interest (Farris, Rye, & Pyle, 2003).

In the 1999 offering, one of the posting assignments provided PTs with a choice of three forums: Action Research, Class Chat, or Practica. Another of the assigned postings was to choose a post in any forum and reply to that post. The majority of PT chose to post and reply to messages in the Class Chat forum. An inspection of these postings suggested reasons as to why PT in 1999 may have valued forums more than PT from the 1998 offering; the postings also



revealed the value to PT of the science short assignment. The most frequent topic posted to the Class Chat forum was some aspect of the learning cycle or science short course assignments. The science short was a new assignment beginning with the 1999 offering, and PT postings suggested that it was well received. Of the 15 PT who mentioned the science short in their posts, only one PT was exclusively skeptical. Most PT posted positive anticipations about doing or experiences they had while conducting this assignment, and the postings generated enthusiasm as revealed by the following excerpts from threaded discussions:

I would like to take this time to discuss the Science Short assignment. I think this is a great idea to do in the elementary classroom. As a novice teacher I assume that there is always time for science in the instructional day. However, there is not always time to do a complete lesson. . . .If anyone has any ideas or examples I would be glad to hear them.

I wanted to respond to Jenny's (fictitious name) posting on the science short assignment. I was able to complete my science short last week at my PDS Suncrest Primary. It went so well! I did my science short on the topic "Does Air Take Up Space?". . . .It took me about 15 minutes total and students were able to understand the concept being taught. How rewarding is that? When the science short contains a Discrepant Event, it is great to see the kids get excited when something happens that they didn't expect to happen. . . .Check out my science short if you have time and you'll understand what I'm talking about. So, if you are feeling overwhelmed with our work load this semester, this is really a fun, exciting assignment that your students will really love, and you'll feel great about!

I will be teaching my science short next week and I am looking forward to it because I have read great feedback from all the students who have already taught their science short.

The second most frequent topic among the postings to the Class Chat forum in 1999 concerned the electronic forums--often that the postings to the forums provided good ideas and information. Excerpts from PTs' postings in support of the latter follow; they are taken from threaded discussions initiated by PTs on "Posting to WebCT" and "Keeping Connected Through Web-CT:"

I have found the WebCT postings in this class an excellent way to communicate with other colleagues. It also provides the preservice teachers with a wide variety of ideas that

can be used in the classroom. The use of the WebCT definitely fosters a "community of learners." I have also found it very helpful for other colleagues to review our learning cycles. . . . At this time, I am looking for ideas for my science short. My learning cycle focuses on atoms (what are atoms and what do they look like). I would like to relate my learning cycle with my science short if possible.

I think that the webCT is very beneficial. I have received so many new ideas to help me with my project. I also find it helpful when I need feedback on an assignment. The responses that I have gotten have really helped me out. I received a few ideas that I am going to put in my learning cycle [sic]. This is a good way to collect new ideas as well as give others my input.

The nice thing about the WebCT postings is that they are always there to look back upon. . . . I have found myself actually exploring other preservice teachers learning cycles. This surprised me, because with the listserv I generally just hit delete.

It is so nice to have others in the cohort review our lessons and ideas. I love to hear how other people would teach a lesson and try to incorporate their good ideas into my lessons. I also hope that this can be used in the school systems to help out especially novice teachers.

The Class Chat postings by PT in the 1999 offering affirmed the value of employing the electronic forums for the year 2000 offering to nurture the "community of learners" concept-- especially for networking about and sharing learning cycles and science shorts.

The frequency analysis of the reasons PT provided to support their ratings about the value of forums was highly congruent with the statistically significant increase in the group means between the 1998 and year 2000 offerings. Of the 29 PT who completed the questionnaire in 1998, 13 (45%) provided reasons to support their ratings and only 4 (31%) of the 13 were exclusively positive in their reasons. Over 60% of year 1998 PT who provided reasons were partially or totally negative, e.g., "I enjoyed getting a chance to view others lessons but as far as being valuable to my education, it was not" and "nobody really looked at those discussion lists." Of the 37 PT who completed the questionnaire in 2000, a greater percentage (63%--23 individuals) were motivated to provide reasons and only 2 (9%) of the 23 commented negatively.

Conversely, over 90% of the year 2000 PT who provided reasons were exclusively positive in their comments. The majority of these PT spoke to the value of sharing or viewing others' work and over 33% believed the forums enhanced their technology skills, e.g., "The postings gave me experience with WebCT bulletin boards and enhanced my computer skills. It was very helpful to use others' posts as references, too." Many of the comments provided evidence that the forums helped foster the "community of learners" concept, e.g., "It is an excellent way for colleagues to share ideas-collaboration among educators is important."

#### Future Use of Forums

Mean ratings of "how much would you like to use (as a future teacher)" electronic forums increased progressively over each of the three offerings:  $\underline{M} = 2.71$  in 1998 to  $\underline{M} = 3.60$  in 2000. One-way ANOVA revealed that there were statistically significant differences among group means ( $\underline{F} = 4.599$ ,  $p = .012$ ); Tukey follow-up documented that the mean increase was significant ( $p = .010$ ) only between the year 1998 and 2000 offering. Reasons for the significant increase in the group mean for "future use" of forums are likely similar to those reasons given above for value of forums.

A comparison of group means for each year on the educational value of forums as opposed to the future use of forums (Table 2) reveals that the means for future use are lower (e.g., for the year 2000,  $\underline{M} = 4.19$  as opposed to 3.6, respectively). The lower means for the future use as opposed to the value of forums may be due to the fact that all PTs were elementary majors and they perceived that the use of forums with elementary-level students would be somewhat limited--this was verified by at least 3 PT in the year 2000 offering through their reasons to support their ratings about the future use of forums, e.g., "If I had older students. I plan to teach K-1." A considerably greater percentage of PT (57%) in year 2000 provided

reasons to support their ratings than did PT in the 1998 (24%) and 1999 (32%) offerings.

Amongst year 2000 PT and across all three offerings, the most frequent future use of forums was for getting/sharing ideas and resources. However, approximately 1/3 of year 2000 PT who provided reasons implied that they would use the forums with students, e.g. for peer review, posting student work, communication, and to debate.

### Value of Concept Mapping

The group mean ratings of the perceived value “to your education” of concept mapping were similar for years 1998 ( $\underline{M} = 3.31$ ) and 1999 ( $\underline{M} = 3.34$ ) and higher in 2000 ( $\underline{M} = 3.97$ ). One-way ANOVA revealed that there were statistically significant differences amongst the means ( $\underline{F} = 5.984$ ,  $\underline{p} = .004$ ); Tukey follow-up revealed the year 2000 mean was significantly greater than the 1998 and 1999 means ( $\underline{p}$ 's = .011 and .009, respectively). PTs' comments to support their ratings about the value of concept mapping also were consistent with the findings of statistically significant increases of the mean rating in the year 2000 compared to the year 1998 and 1999 groups. For example, about 70% of year 2000 PT were motivated to comment (and the majority were exclusively "positive" in their reasons) as opposed to 50% or fewer commenting in the previous years. Additionally, in the year 1999, over 40% of those commenting were exclusively negative about the value of concept mapping. Concerns expressed by students in the 1998 and 1999 offerings included that they already had learned the Inspiration software or concept mapping in a previous offering, that the type of maps (hierarchically framed with linking words) expected were too rigid or complicated (e.g., "[I]t doesn't assist me in writing the way he thinks and not the way I think"), that the instructor was overzealous, (e.g., "I personally do not view concept mapping as so important as the instructor"), and that the assignment to make the maps was just not important (e.g., "Waste of time").

The significantly greater value attributed to concept mapping in 2000 might be partially explained by the modified approaches taken by the instructor in response to concerns expressed in the previous offerings. The instructor spent more time in year 2000 on advanced features of the software, specifically the “multidimensional” features to embed text (notes) and graphics (including additional concept maps) within concept symbols. For example, the “Insects” map (Figure 1) embeds notes in eight concept symbols, with the “Wings” note stating various purposes such as flying, swimming, protecting, and body temperature control. Additionally, in 2000, PT had the option to “showcase” their learning cycle concept maps at the main course web site as opposed to only attaching them to a password protected bulletin board.

#### Future Use of Concept Mapping

Mean ratings of “how much would you like to use (as a future teacher) concept mapping” did not increase progressively over each year of the course offering, however, the mean rating for the year 2000 offering ( $M = 4.03$ ) was greater than in 1998 and 1999. One-way ANOVA showed statistically significant differences among the group means ( $F = 6.063$ ,  $p = .003$ ), with Tukey follow-up revealing that the mean difference was significant ( $p = .002$ ) only between 1999 and 2000.

Only about 25% of PT from the 1999 offering stated a reason that conveyed the intent to use concept mapping in the future, some of which were quite general, e.g., “this could be fun” and “review concepts.” Conversely, over 55% of PT from the year 2000 described a future use of concept mapping, and the scope of uses covered considerable breadth, e.g., authentic assessment, organizing, summarizing, and developing projects. Several students gave reasons that conveyed wide applicability, e.g., “great tool for all grades” and “use in all school subjects.” Although not mentioned by PT, an additional reason to explain the significantly higher rating during year 2000

might be that the instructor introduced in 2000 the idea of “concept circles” (Wandersee, 1990) as a modification of concept mapping for young learners.

### Ways to Improve Technology Supported Assignments

Given that PT from the 2000 offering ranked the value and use of forums significantly higher than those in 1998, one might expect the 1998 group to provide more suggestions for improvements. This was not the case: Only about one-third of 1998 PT were motivated to provide suggestions for improving forum assignments, and 30% of those who did simply said the forums were of no use or importance or to get rid of them. The response suggested the forum assignments lacked meaning for many of the year 1998 PT. The instructor attempted to connect the forum assignments more so to practica in the year 1999 and 2000 course offerings. Over one-half of PT in 1999 and 2000 provided suggestions, and those given by the 1999 group further informed changes in the forum assignments. The most frequent suggestion in 1999 was to require fewer postings or categories of forums; accordingly, four forums (Resources, Practica, Action Research, and Class Chat) were eliminated, with more attention given to the Learning Cycle and Science Shorts forums in the year 2000. Interestingly, as the perceived value of forums increased across the three sequential offerings, so did the percentage of PT that stated they wanted more directions/training on forums. In 2000, an equal number of PT also implied that no changes were needed and that the forums were a meaningful component, e.g., "I liked having the discussions over the website because I felt that I posted something that could be read and evaluated by one of my peers." PT in 1999 and 2000 may have been genuinely more interested in mastering the forums technology because of the perceived value of that technology.

Suggested improvements to the concept mapping assignment by the 1998 PT reinforced comments discussed above about the lack of flexibility in the assignment: Over 40% (5 out of

12) of the PT who commented as to improvements said to let the students do it their way or to not grade so harshly or according to how the instructor wants it. The type of concept map (Novak & Gowin, 1984) emphasized by the instructor was sophisticated compared to webs, to which PT may have been exposed prior to the science methods course. At least some of the 1998 PT viewed the maps as a tool to show "how I see it" and that the requirements as to map structure may have been too rigid. In the year 2000, no PT suggested that the assignment lacked flexibility; the most frequent suggestion (50% of those providing comments) was for more instruction and support, e.g., give a booklet. This finding was consistent with the differences between year 1998 and 2000 PT relative to the value of forums and how to improve them: PT in 2000 rated concept mapping significantly more valuable to their education than did 1998 PT, yet expressed considerably more concern for additional instruction on using the tool. As with electronic forums, this suggests PT in the year 2000 may have been genuinely more interested than year 1998 PT in learning how to use the electronic concept mapping tool.

#### Readiness to Take on Technology Assignments

Differences in PT perceptions about their readiness to take on assignments that employed electronic forums and concept mapping, as a function of prior course work, could be a confounding variable in examining for differences in perceptions about the value and future use of these technology tools across the three course offerings. Although group means on preparedness to use forums and concept mapping were lower in year 2000 than in 1998 and 1999, one-way ANOVA revealed that there were not statistically significant ( $p < .05$ ) differences among group means. However, Levene's F-test did reveal a violation ( $p = .016$ ) of homogeneity of variance for the concept map ratings.

#### Use of Concept Mapping Beyond Course Requirement

For all three offerings, 43 (about 40%) of 104 PTs reported that they used concept mapping beyond the course requirement of constructing a concept map to show the understandings that they sought to develop in students through their learning cycle. The question may not have revealed the true extent of additional use for 1998 PTs, because the question only asked about one additional use: Did they also develop a concept map for their guided discovery lesson. For the two groups of PT who did or did not go beyond concept map course requirements, the independent samples  $t$ -test revealed that there was not a statistically significant difference on the educational value they attributed to concept mapping ( $M = 3.6$  and  $M = 3.52$  for those going or not going beyond requirements) or their plans to use concept mapping as a teacher ( $M = 3.7$  and  $M = 3.58$  for those going or not going beyond requirements). The year 2000 offering had the greatest percentage (46%) of students who reported going beyond the required use of concept mapping whereas the year 1999 had the smallest percentage (26%). This is congruent with the finding reported above that the year 2000 group mean for “future use” of concept mapping was significantly higher than for the year 1999. The most frequent use of the concept map beyond the course requirement for year 2000 PT was in some aspect of field-testing their learning cycle (e.g., used in invention phase or students created maps). Five PT explicitly stated that students created concept maps.

Table 4.

Correlations amongst PT ratings ( $n = 101-103$ ; 1 = not at all to 5 = very) of technology tools employed in course assignments.

	Value	Like to	Value	Like	Advance	Advance
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	of Forums	use Forums	of Concept Map	to use Concept Map	Preparation on Forums	Preparation on Concept Map
Value of Forums	1.000	.709 <sup>a</sup>	.389 <sup>a</sup>	.321 <sup>a</sup>	.164	.027
Like to use Forums	.709 <sup>a</sup>	1.000	.293 <sup>a</sup>	.263 <sup>a</sup>	.346 <sup>a</sup>	.088
Value of Concept Map	.389 <sup>a</sup>	.293 <sup>a</sup>	1.000	.759 <sup>a</sup>	.160	.104
Like to use Concept Map	.321 <sup>a</sup>	.263 <sup>a</sup>	.759 <sup>a</sup>	1.000	.231 <sup>b</sup>	.262 <sup>a</sup>
Advance Preparation on Forums	.164	.346 <sup>a</sup>	.160	.231 <sup>b</sup>	1.000	.499 <sup>a</sup>
Advance Preparation on Concept Map	.027	.088	.104	.262 <sup>a</sup>	.499 <sup>a</sup>	1.000

<sup>a</sup> Correlation is significant at the 0.01 level (2-tailed)

<sup>b</sup> Correlation is significant at the 0.05 level (2-tailed)

#### Correlations Amongst PT Ratings of Technology Tools

Table 4 presents a Pearson correlation matrix of the dependent variable measures (PT ratings) in research questions one through three. The highest correlations observed were between perceived “Value of Concept Map” and “Like to Use Concept Map (as a future teacher)” ( $r = .759$ ,  $p = .01$ ,  $n = 102$ ) and between “Value of Forums” and “Like to Use Forums (as a future teacher)” ( $r = .709$ ,  $p = .01$ ,  $n = 101$ ). This suggests that investing time in creating preservice learning experiences with technology that are perceived as highly valuable by PTs “pays off” in that PTs are inclined to want to use the tools as future teachers. As might be expected, statistically significant ( $p = .01$ ) correlations also were observed between “Advance Preparation

on Forums” and “Like to Use Forums” ( $r = .346$ ,  $p = .01$ ,  $n = 101$ ) as well as between “Advance Preparation on Concept Map” and “Like to Use Concept Map” ( $r = .262$ ,  $p = .05$ ,  $n = 102$ ). The significant correlation ( $r = .499$ ,  $p = .01$ ,  $n = 102$ ) between “Advance Preparation on Forums” and “Advance Preparation on Concept Map” suggests that PTs who rated their preparation highly (i.e., 4 to 5) on one technology tool, were likely to feel prepared to use other technology tools. The four statistically significant correlations ( $r = .263$  to  $.389$ ,  $p = .01$ ,  $n = 101 - 103$ ) between valuing and liking to use forums and valuing and liking to use concept maps suggest that PTs who valued and wanted to use one technology tool also are likely to value and want to use other technology tools.

#### Evaluation of Course Web Site

Only PTs in the year 2000 offering of the course were asked to evaluate the course web site on the standard course evaluation instrument. The mean rating by PTs ( $n = 38$ ) on the item “educational value of the course web site” was 4.5 (where 5 = excellent). The distribution of ratings was: 22 “excellent,” 14 “good,” and 2 “satisfactory.” PT were asked to expand on any course evaluation items for which they gave an excellent or low rating by making comments at the end of the course evaluation instrument. Amongst the total of 30 comments made by PT under “excellent,” four were positive comments on the course web site or technology, with one stating: “The course web site was the BEST thing about this class. Every class should be like that.” Amongst the total of five comments under “low,” one was negative about technology, stating that the course placed too much emphasis on technology. An inspection of all open-ended comments on course evaluations for the first (1998) and second (1999) year offerings revealed only one comment about technology--a positive comment about the discussion folder (forum) postings.

## Conclusions and Implications

Faculty in higher education feel the push to integrate instructional technology with their courses. Moreover, teacher education faculty are challenged to develop preservice teacher competence in an extensive set of National Educational Technology Standards (ISTE, 2000) and, at the same time, not sacrifice other important course content (e.g., in elementary science methods, this includes safety, nature and processes of science, inquiry-based models and strategies, authentic assessment, and so on). Integration is key: When educational technology becomes primarily an "add-on" to existing course content and assignments, the instructor is faced with more to correct and the students are likely to perceive the assignments as a burden. An overzealous approach to technology integration runs the risk of doing so "just to use technology," and, even worse, compromising course content and creating negative attitudes in future teachers about technology use.

In this action research study, electronic forums and concept mapping were the instructional technologies selected for integration with course assignments. Meaningful integration of educational technology with these assignments did not come quickly. Over the duration of the three course offerings, the instructor learned that the utility of electronic forums extends far beyond "posting and replying" and, to be meaningful to preservice teachers, need to be a vehicle to accomplish course assignments that PT "expect" in a methods course and associated practica. For example, electronic forums became a tool to facilitate peer critiques of learning cycle lessons prior to field-testing the lessons and a resource bank of example learning cycles and science shorts for PT to examine in subsequent course offerings. Related to the latter, forums were employed by PT to "showcase" field-tested instructional plans and their reflections about the instruction that they provided. Further, forums were utilized to facilitate a positive

initial teaching experience in practica where PT and host teacher could choose an activity for the PT to "try out" from instructional plans and reflections posted the previous year. Barnett et al. (2002) stress that technology applications need to "provide access to resources and knowledge that typically cannot be gained through a traditional methods course" (p. 311) in order to enhance preservice teachers' perceptions of those applications.

PTs' postings to forums also can provide feedback to the instructor on how a new assignment or practica experience is perceived by PT. Such was the case with the "Class Chat" forum, which revealed the utility of the "science short" assignment relative to fostering a positive disposition in PT about teaching science:

I did my science short in a fourth grade classroom. . . . I began by asking them what I had in my hands. Almost every hand went up. . . . I was really excited that so many students wanted to participate!! They came up with many different responses. What I really had in my hands though were 3 different igneous rocks. Then I asked them to predict what was going to happen when I put these rocks in water (one of them was pumice). . . . And finally I asked them to explain why they thought what they did. I really liked completing my science short. I believe I had every students' attention for 10 or so minutes. When I went back into my PDS I had students asking me when I was going to teach them again.

Additionally, as revealed by the above excerpt and those shown previously, the "class chat" forum served to build enthusiasm amongst PT about the science short assignment. Further, these postings suggested that the forums were facilitating a community-based learning environment (Riel, 2000) amongst the enrolled PTs:

I believe that this site is a constant resource for us preservice teachers who are always looking for ideas and examples to stem off of. . . . I really do hope that everyone else in 2001 feels the same about the Web-CT as I do because then we can really serve as quality resources for one another, and make proper use of this site.

I totally agree with you! I think the Web-CT is a great resource for us, and a great place for us to share our thoughts, experiences, and opinions. . . . Everyone has some wonderful ideas, and the entire class of 2001 can benefit from them. I have gained a lot from using the WebCt, and I hope more of our classes have web boards similar to this one in the future.

The instructor learned that when forums are employed for "post and reply" (i.e., threaded discussions), it is critical to provide (a) a fair amount of scaffolding in terms of what elements should comprise "initiating" posts and "responding" posts as well as dates by which these posts must be made, (b) the opportunity for each individual to initiate a threaded discussion on a topic in which she has considerable interest and the responsibility to monitor that discussion, (c) small group structures for the threaded discussions as opposed to allowing individuals to choose all of the posts to which they will respond, and (d) a sense of commitment to making the threaded discussions "work." Instructors need to be cognizant of the time commitment to grade threaded discussion assignments, which can result in many postings. Simply giving credit for posting a given number of times is not a meaningful assessment. The instructor will want to have a grading system that does not require examining all of the postings for each student and, for those postings that are selected to be graded, a rubric with specific dimensions/criteria and corresponding statements/levels of quality. Bauer and Anderson (2000) describe rubrics that can be used to assess students' online written performance relative to the criteria of content, expression, and participation. Within the context of initiating threaded discussions on STS issues, one specific criterion could be "explanation of controversy" with statements of quality ranging from "provides only one viewpoint and little to no supporting information for that perspective" to "provides and contrasts multiple viewpoints along with supporting information for each perspective." Another option for assessing threaded discussions is to have students write a reflection paper on what they felt they learned and contributed, making reference therein to specific postings that they read and composed. Rubrics and reflective papers such as these are applied by the instructor to grade the STS threaded discussion assignment in current offerings of the elementary science methods course.

Relative to getting elementary PT to value and use electronic concept mapping to provide science instruction, it is critical that they have a positive initial experience: This goes beyond the process of using the software to feeling good about the product they produce. Hierarchically framed maps that utilize separate symbols for individual concepts, make explicit all concept relationships with linking terms, and are parsimonious in total use of words are ideal relative to the theory of meaningful learning (Novak & Gowin, 1984) as well as facilitating comprehension of the maps by other viewers. However, the reality is that these types of maps are novel to some (probably most) elementary PT and may be perceived as complicated and/or tedious to make. From a practice perspective, an important goal is to foster positive dispositions about using concept mapping and educational technology to support and enhance mapping. Such technology enhancements include the multidimensional features (embedding notes and maps within maps) afforded by some software programs. So, given that several hours of course time often cannot be devoted to instruction and practice on making maps, the recommendation to instructors is to (a) model the ideal but keep it simple, (b) emphasize that mapping provides an opportunity to be creative, (c) be flexible and reasonable as to expectations and feedback provided to PT and (d) provide each PT the opportunity to showcase her product (e.g., a web-type map that only labels some concept relationships) regardless of the degree to which it conforms to the ideal structure. Indeed, over the three course offerings, one of the most positive experiences in terms of the use of electronic concept mapping by a PT was a science short on leaf characteristics in which the PT utilized a web-type concept map. In her assessment of this science short, she reflected:

Additionally, it seemed pretty easy for the students to "get" the idea of a concept map. They seemed to understand that there is a main idea that we focused on, there are headings that supported our main idea, and there are examples that supported our headings. I told them that this was another way of writing a paragraph on the information we gathered from our talk. They definitely could see the connection for some of them started to tell me. I was also proud of my

students for some of them got done earlier than others with copying the information and completing their concept map, so they took it upon themselves to do some leaf rubbings with the leaves I had brought in and the crayons they had. They turned out great! This particular Science Short was a good way to show the students a different way of organizing information other than just listing and showing some of the properties of a leaf and its rubbing.

Faculty who substantially integrate instructional technology with their courses are faced with maintaining and improving what they currently utilize as well as mastering software updates and considering emerging innovations. Therefore, it is critical that post-secondary institutions offer a sustained program of professional development and related support on instructional technology and that faculty incentives are provided. These professional development efforts need to bring together novice through advanced users, where the latter share their experiences and where applications by all users can be showcased and archived in a resource bank. Further, as more faculty integrate technology with on-campus courses, institutions must upgrade and expand their infrastructure (including hardware) to enable more students to learn with technology.

Insert Cycle Image	<b>A Learning Cycle</b>
Insert Image to Reflect Title	<i><b>TITLE OF LEARNING CYCLE</b></i> <i>Grade Level</i> <i>by Preservice Teacher's Name</i>

References	<p><b>CELLS TO THE LEFT:</b> Each cell to the left lists the name of a separate page you will develop for <i>that</i> component of your learning cycle. After you develop each page, link the word in the cell to that respective page.</p> <p><b>THIS LARGE CELL:</b> Use the space in this large cell to provide a brief summary of your learning cycle. You want to intrigue the reader to examine your learning cycle! Boast about it--make it shine!! You might begin your summary with an "attention grabbing" question or statement and follow with exciting highlights about what happens in some of the phases of your learning cycle. You could even include a link to some aspect of your learning cycle (e.g., a data collection form) or a related web site that helps to illustrate the importance of your learning cycle. You also could insert here an image that conveys some aspect of your learning cycle.</p> <p><b>RESTRICTIONS:</b> Do not place copyrighted forms, images, or other material in your web pages unless you have written permission from the publisher. For any copyrighted forms that are needed to implement your Learning Cycle, make sure to give a complete reference so the teacher knows where to obtain them. Also, do not include photographs of people (children and adults): To do so requires permission via photograph release procedures which we do not have in place.</p>
WVIGOs	
Objectives	
Concept Map	
Materials & Preparation	
Safety	
Engagement	
Exploration	
Explanation	
Elaboration	
Evaluation	
<p><i>The Learning Cycle is a Constructivist-based Teaching Model</i></p>	

Figure 2. Template for index web page of learning cycle.

Towards those ends, the TREK-21 instructional technology institute in our college has been invaluable. Recent collaborations with other Teacher Education Program faculty who participate in this institute has led to web authoring of learning cycles (see Figure 2 for template) and thematic literacy units by many PT for their electronic portfolios.

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APPENDIX A

Survey on WebCT Bulletin Board Postings and Concept Mapping

As part of the “technology strand” in your Teacher Education Program, this course included: (a) posting to bulletin board forums, using WebCT®; and (b) creating concept maps, using Inspiration®. These questions are about those experiences.

1. On a scale from 1 to 5, with 1 representing “not at all” and 5 representing “very,” please rate (circle corresponding number) each experience as to how valuable it was to your education.

(a) Posting to bulletin board forums:

<u>Not at All</u>				<u>Very</u>
1	2	3	4	5

Please give reason(s) for your rating (use back for more space):

(b) Creating concept maps:

<u>Not at All</u>				<u>Very</u>
1	2	3	4	5

Please give reason(s) for your rating (use back for more space):

2. How much would you like to use the following tools as a future teacher? (Use rating scale described in question 1.)

(a) Bulletin board forums like those in WebCT®:

<u>Not at All</u>				<u>Very</u>
1	2	3	4	5

Please describe ways (if any) that you envision using bulletin board forums (use back for more space):

(b) Concept mapping:

<u>Not at All</u>				<u>Very</u>
1	2	3	4	5

Please describe ways (if any) that you envision using concept mapping (use back for more space):

3. Considering your past course work in the Teacher Education Program, did you feel “ready” to take on these assignments? (Use the rating scale described in question 1.)

(a) Posting to bulletin board forums:

<u>Not at All</u>				<u>Very</u>
1	2	3	4	5

(b) Creating concept maps:

Not at All

1

2

3

4

Very

5

4. Please provide suggestions as to how these experiences might be improved as part of this course or as part of the overall Teacher Education Program. (Use back for more space.)

(a) Posting to bulletin board forums

(b) Computer-based concept mapping

5. You were asked to develop a concept map to accompany your science learning cycle. In addition to this, did you use concept mapping with students in practica this Fall semester? (circle one)?\*

YES    NO    If "yes," please briefly explain how you used concept mapping (Use back for more space).

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\*See text for how this question differed for Preservice Teachers (PT) in the 1998 offering.