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Using Technology Tools to Engage Students with Multiple Learning Styles in a Constructivist Learning Environment

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Abstract

This research study investigated the use of technology tools to support constructivist learning experiences in a preservice teacher education reading methods course. Learning opportunities based on Kolb's learning styles model were used to support understanding of course content in the constructivist environment. Technology tools were used during class presentations to communicate, scaffold, and clarify course concepts and content while engaging students with information. Technology was used outside of class as a collaboration tool in mediating and negotiating learning between the instructor and students as well as between students and students. In addition to demonstration and application of reading methods, students' perceptions of their learning experience and understanding of course content were considered in analyzing the effectiveness of technology used to address multiple learning styles in a constructivist environment.

Preservice teachers are expected to be both learners and teachers. Within the university classroom preservice teachers learn theory, content, and methods that will prepare them to become teachers. They also observe teaching models of professors in program courses. These experiences provide a medium (Dewey, 1916) through which students develop knowledge (cognitive abilities), skills (behaviors), and dispositions (affective learning) for application in elementary and secondary classrooms.

University instructors consider methods of reaching learners to connect them with content in meaningful and purposeful ways. Consideration is given to questions of how to make conceptually difficult content easier to grasp, to understand, and to retain, all the while making effective use of time. Deliberation also involves how to move responsibility to the learner, to help him or her take responsibility for learning as support is gradually

withdrawn. Questions as to how acquisition of new information and application of skills learned is best accomplished relate to pedagogical practices that take into consideration the content to be delivered, the environment, and the learning styles of students. Examination of these mediums prompted the research reported in this article.

The context of this study involves reading methods courses, which prepare preservice teachers to teach elementary school students how to read. The instructor sought ways of reaching students to help them connect with the content as they explored theory and practical application of reading instructional strategies. Through a project at the University of Minnesota, Morris, supported by an Archibald Bush Foundation Grant, technology tools were used to address the learning preferences of students and create a constructivist setting. The course instructor planned the content and instructional design of the reading methods course based on research in the areas of reading methods, professional standards for the field, and federal and state mandates for reading instruction.

Throughout a 4-month period just prior to the beginning of the reading methods course, Bush grant facilitators and other grant participants provided direction in decision making, training, and support in use of technology tools selected for the project, including a discussion board, wikis, and course Web pages. Participating in the study were students enrolled in two sections of a 16-week long reading methods course (27 females and 3 males, 6% cultural diversity). Both sections received identical treatment throughout the research project.

Background for the Study

Goals for this project included creation of a constructivist learning environment that targeted learning styles in the presentation and understanding of content. Additional goals incorporated provisions for preservice teachers to construct knowledge of theory and instructional strategies, reflect on content and pedagogical practices, and articulate their knowledge and understanding to and with others in the course. These goals addressed the instructor's need to both present to and have students apply information on reading methods as required by the *No Child Left Behind Act* and Minnesota Statutes (Minnesota Statutes 2002, revised 2005, Chapter 122A.18 Subd. 2a. Reading strategies, subpart b.).

The findings of this study as they relate to technology-enhanced learning experiences and student self-efficacy may prove useful to other instructors, not only of reading methods in education, but of other disciplines as well. Generalizability to other courses may be limited due to research limitations of this study, including small sample size, lack of control group, and variables present in terms of the number of technology-assisted and unassisted activities and assignments in the study.

Theoretical Framework

This project draws on the research of three theoretical foundations: constructivism, learning style theory, and technology integration in education. Each of these has influenced the direction of this study.

Constructivism

Constructivism refers to bodies of knowledge as human constructs, as Phillips (2000) described, built up over time and influenced by politics, ideologies, values, and power structures that work to preserve this knowledge. In this way constructivism refers to social construction of knowledge, as well as to knowledge about the external world. Preservice teachers consider material presented to them (external bodies of knowledge) and construct meanings and understandings, as they reflect on and make sense of what they have experienced, thereby creating knowledge, not simply acquiring it (Phillips, 2000; Taylor & Hsueh, 2005).

The instructor in the constructivist classroom attends to the learners present in the course, taking into account the experiences that have shaped their thinking over time. Such experiences are influenced by historical and cultural practices but are also influenced and reshaped by the social relations and social conditions present in the classroom (Cope & Kalantzis, 2000). Constructivist learning environments (Brooks & Brooks, 1999; Gagnon & Collay, 2000; Howe & Berv, 2000; McCarty & Schwandt, 2000; Phillips, 2000) are established with the belief that learner control or autonomy (Vansteenkeiste, Simons, Lens, Deci & Sheldon, 2004) is important in the learning process. Although the instructor serves as a coach or an expert guide leading and scaffolding students' learning in their construction of knowledge, others in the learning environment, as Cope and Kalantzis explained, help to shape and reshape (reproduce and transform) knowledge, social relations, and identities.

Transformation occurs that involves new uses of old materials through rearticulation and recombination of the existing content. The instructor may provide tools and experiences, modeling, and feedback (Vygotsky, 1978) through which students come to understand content and contexts. These along with students' metacognition and self-reflection lead to individual as well as social construction of knowledge. Construction of knowledge is supported as preservice teachers engage with material to make connections to prior knowledge, view material from multiple perspectives, and add to an existing schema.

Learning Styles

Knowledge of learning styles, or ways students prefer to grasp and process information, was used to plan and scaffold students' work in the constructivist setting. David A. Kolb's cognitive learning style model (Kolb, 1984, Kolb & Kolb, 2005) was selected for use in this study because of its roots in experiential learning, which is closely tied to constructivism. Based on the work of John Dewey, Kurt Lewin, Jean Piaget, and Paulo Freire, interaction between the learner and the environment is central to experiential learning, as learners examine and test ideas and then integrate these ideas as part of the learning process. Viewing learning as a process and not a product, developing inquiry skills, acquiring knowledge as opposed to memorizing, and applying knowledge and skills in the context of relevant settings reflects experiential learning. Experiential learning also holds that transformation takes place as ideas are formed and reformed as a result of experiences, feedback, and reflection.

These constructs are central to transformed practice and part of situated learning in sociocultural settings, in which students also critically examine, extend, and apply information in old and new settings as well as use information to innovate in new contexts (Cope & Kalantzis, 2000). A learning style model associated with Kolb's theory points out that learners cycle through four stages in the learning process: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Creating conditions in which students interact with experience leads to experiential learning and construction of knowledge.

Technology

The third piece of the theoretical framework informing this project was technology. Technology aligned to learning styles has been used to engage students and support learning (Chen, Toh & Ismail, 2005; Larsen, 1992). Technology tools also serve to enable (Pittman, Rutz, & Elkins, 2006) through creation of learning objects and extend learning by providing "learning by doing" or "learning by seeing" experiences (Bruner & Olson, 1973). They also affect the manner in which students respond to, contribute to, and demonstrate understanding of content (Chen, et al, 2005). Along with content delivery, this last description of technology use in education describes the role of technology in this study.

Technology tools used to create a constructivist setting and shape, model, extend, scaffold, and clarify learning in this study included use of video and audio clips, a Simple Machines Forum discussion board, a wiki, PowerPoint (presentation software), SMARTBoard and SMARTNotebook software, Inspiration (concept mapping software), and a course Web page.

Methodology

This research study was an inquiry into the connection between technology tools and construction of knowledge in a preservice teacher methods course. The following connections were explored:

1. Would technology-enhanced learning experiences aligned to learning styles of students support a constructivist setting and students' understanding of course content?
2. To what extent do students understand and use knowledge of learning styles and technology tools to guide their own learning as they construct knowledge?
3. What are the affordances of particular technology tools for particular learning expectations (psychological and/or sociological constructs)?

To answer these questions, researchers used a single-group design in which 30 preservice teachers in the reading methods course volunteered to participate. Information from Kolb's learning style model and learning cycle was used to design course activities and assignments that included technology tools, specifically selected to address characteristics of each learning style to support students' construction of knowledge. Students engaged in individual and group activities in and outside of class, making use of technology tools, and completed individual and group assignments to fulfill course requirements. Data were then collected on students' learning style preferences, use of technology tools, and student performance in the class. Researchers looked for relationships as construction of knowledge on the part of students was considered.

Selection of Technology Tools: Cognitive and Social Expectations and Affordances of Technology Tools

Consideration of the effects of electronic resources on social and cultural literacy practices (Cope & Kalantzis, 2000; Street, 1995) influenced selection of tools for the four modes of learning, concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 1999). Following Brian Street (1995), who emphasized that "social and material conditions affect, if not determine the significance of a given form of communication" (p. 1), technology tools were chosen to influence social interaction and communication along with cognitive development within the constructivist classroom. Medium (tool), mode (concrete experience, reflective observation, abstract conceptualization, and active experimentation as type of interaction, and senses used), discursive practice (group size, in class or online), level of support (instructor, peers, resources provided), and subjectivity (relations of power, choice, and visibility) with regard to the tools were considered in selection and use of the tools.

The appendix identifies activities and assignments planned and used in the course during the four stages of the learning cycle. Bolded items distinguish technology-enhanced activities and assignments from those where technology played an indirect role in the presentation and use of information. The cognitive and social expectations associated with the assignments are discussed further in what follows in relationship to their fit with particular learning expectations.

Constructivism and Concrete Experiences

A number of concrete experiences were planned to provide background information and awareness in authentic learning contexts. Cognitive expectations of students with regard to the concrete experiences included acquisition of information relating to literacy development, reading instructional practices, and decision-making in the classroom. Students were also expected to make connections to prior knowledge and their own literacy development within the context of authentic experiences and an ever-increasing schema relating to reading instructional practices.

Social expectations involving concrete experiences had to do with sharing knowledge within the group—sometimes the instructor or expert guide, models presented on video clips, or students in the course who provided examples or models of reading instructional practice. Students were asked to participate as a group in the concrete experiences and speak about them within the group.

To assist students in constructing knowledge both individually and socially with regard to addressing the cognitive expectations related to concrete experiences, an electronic whiteboard (a SMARTBoard), use of audio clips on a course Web page, and video clips viewed in class and posted for review on the course Web page were incorporated.

The SMARTBoard was used to present model lessons for viewing and discussion in the course. The SMARTBoard engaged all students not only in viewing the model lessons but also in drawing them in as if they were elementary students who might be hearing the lesson. Text with a variety of fonts and colors, shapes in the form of selected graphics or drawn on the board during the lesson, and ease of movement through touch to new pieces of the lesson provided support and scaffolding but also appealed to multiple sensory modalities of the students. At other times video clips (Harris, Reutzel, & Cooper, 2004; InTime, 1999) served as modeling. These clips were used to view and analyze lessons in large and small groups in class.

Through use of these tools to provide concrete experiences, individual construction of knowledge would be supported during the model lessons as students acquired information relating to literacy development and made connections to their own prior knowledge through journal writing or graphic organizers used in class. The model lessons presented on the SMARTBoard and the video clips of lessons were designed to prompt individual construction of knowledge and would be followed up with discussion and critique in small groups and then in the large group to aid social construction of knowledge. Social construction of knowledge would be supported as the preservice teachers discussed episodes in the video clips, sharing insights with their peers. Discussion and critique of particular sections of the viewed lessons would help students become more adept at noting effective practices and more observant for teaching behaviors that were deemed less effective. Question prompts on the part of the instructor in the classroom were planned to scaffold and lead students to consider additional points.

Audio clips, prepared by the instructor, were used in class and provided for review on the course Web page. Audio clips were used for instruction on phonemic awareness, phonics, and reading assessments that were a part of the reading and writing analysis project. Text documents with graphemes were made available for students' viewing while listening. Listening to the audio clips was planned as an individual task to encourage individual construction of knowledge with support from the instructor on the clips. The clips served as scaffolds, helping individual students extend their learning and skill by hearing the phonemes, differentiating between sounds, and pronouncing them correctly.

Constructivism and Reflective Observations

Cognitive expectations for students in reflecting involved metacognitive skills, in which students think about their own thinking with regard to literacy development and reading instruction. Additionally, students were to consider information from multiple perspectives and consider the interrelatedness of topics in the field. To help students react to the concrete experiences and to reflect on information gained as a result of these experiences, as well as from reading and lectures, concept maps were prepared by the instructor using Inspiration software. The concept maps were used to provide broad overviews of topics and concepts that would be detailed and discussed throughout several class sessions. The maps were also used to demonstrate how subtopics fit within the larger main topics of discussion. The concept maps were planned to "ground" both field dependent and field independent students. In this way students needing to view the big picture and students who benefit from seeing details would receive direction in meeting their individual needs in understanding and reflecting on information in the course.

In addition to using the concept maps as individuals to guide their own learning, students created concept maps using the software in completion of the wiki assignment. The wiki assignment required students to work in collaborative groups to prepare and present information on six different approaches to reading instruction. Concept maps along with a narrative report detailing the approach and a reading instructional strategy specific to

the reading approach were components of the wiki document that group members wrote and rewrote collaboratively online. The concept maps were planned to extend individual reflection and support social construction of knowledge as students worked together in small groups to create and edit the maps for display and discussion within the larger class group. In this project the work of the expert guide (the instructor) in building a foundation for students' further exploration was extended as students supported each other in the joint activity. The technology tools served as scaffolds in the cognitive processes and collaborative social exercise (Gee, 2000).

To further encourage reflection a Simple Machines Forum discussion board was organized by topics the instructor had entered at the beginning of the semester. Discussion board posts replaced writing assignments students in previous semesters had submitted to the instructor. Students were required to post six times throughout the semester in response to questions the instructor used as prompts. Students were asked to read and respond to these prompts and to classmates' posts. For two of the required postings, students were paired for discussion. The discussion board prompts provided students opportunities to use vocabulary of the field to speak about topics related to reading instruction. Students had time to reflect on course readings and class discussions prior to posting to the board and were encouraged to use course materials in preparation for posting. Social construction of knowledge was supported as students reflected on the postings of their peers and responded by extending the posts of their classmates.

Constructivism and Abstract Conceptualization

Cognitive expectations for students in abstract conceptualization included getting information from authoritative sources, using research and methods, and engaging in reading of theory. To support students in this work a course Web page was used as a repository of resources for research and review. For example, PowerPoint and SMARTNotebook presentation software were used by the instructor for model lessons, focused discussions, and lecture with discussion. The PowerPoint presentations were then posted on the course Web page, along with hyperlinks to resources for students' review and extension of literacy topics discussed in class. These hyperlinks included text on the Web page, Word and PDF documents, and additional sites.

PowerPoint presentations and audio and video resources were continually uploaded throughout the semester as new topics were introduced. A link on the course Web page to electronic reserves with research articles selected for the course was also made available to students. Although some of the articles were required reading, students were free to access these along with other resources for their individual construction of knowledge. Shared knowledge that resulted from discussion and shared experiences were planned to facilitate social construction of knowledge, knowledge that would build on, strengthen, and extend individual construction of knowledge.

Constructivism and Active Experimentation

Active experimentation refers to students making use of concrete experiences, their reflective observations, and knowledge gained through abstract conceptualization in new settings. The cognitive expectations for students in active experimentation include assuming learner control, or in other words, taking responsibility to bring the pieces of their learning together to problem solve and apply what they have learned in new settings. For preservice teachers this involved agency (Cope & Kalantzis, 2000), with students demonstrating their knowledge and skills, as well as redesigning or transforming information as they used and applied it through writing lesson plans, presenting and evaluating lessons, and speaking about their work.

Students also created short videos using iMovie or Windows MovieMaker to illustrate their work in designing a classroom environment that supported literacy development. The movie clips also demonstrated their teaching abilities, which they described and critiqued. Audio clips created by the students were used to discuss fluent reading or interactions between them and their students.

Students used the SMARTBoard, SMARTNotebook software, and PowerPoint as tools to prepare and present slideshows demonstrating their knowledge of literacy development and instruction. These tools helped students organize information for presentation and discussion. In addition to the modeling provided in class, students were encouraged to obtain assistance with creation of the SMARTNotebook and PowerPoint presentations through use of reference materials and people who would provide direction, but more importantly, feedback on their projects.

In addition to video and audio clips, SMARTBoard hardware and software, and PowerPoint, students used Inspiration software and the discussion board as tools to apply principles or theories in problem-solving assignments. These included discussion of their work in making instructional decisions regarding children's reading and writing development and sharing their own knowledge of instructional approaches and strategies to promote strategic reading on the part of students they worked with in practicum classrooms.

Data Collection

As part of the inquiry process investigating connections between technology tools and construction of knowledge in this course, data were gathered on students' use of technology tools, their use of information on learning styles to guide their own learning, and student performance in the course. On the first day of class students completed a learning style inventory based on Kolb's model, which entailed answering 12 questions about their preferred way of learning. Responses were categorized into the four learning style modes—concrete experience, abstract conceptualization, active experimentation, and reflective observation.

Data sources for this study were raw scores on the learning style inventory; scores on four course exams, a reading and writing analysis project, and a literacy PowerPoint project; scores from discussion board posts; and midsemester and end-of-semester 5-point Likert scale questionnaires.

Description of Data Sources

The 5-point Likert Scale questionnaires allowed students to identify how well they believed technology tools and course activities supported their learning. Four open ended questions provided opportunities for students to reflect on what was effective and less than effective in supporting their construction of knowledge (What has been particularly helpful for you in this course up to this point? What in particular has hindered your developing understanding of course content? What would you like to see continued? and What would you like to see changed?).

The four course exams were short answer and essay assessments. The exams were comprehensive, assessing both new and previously covered concepts. The reading and writing analysis assignment required students to collect raw data on an elementary school student's reading and writing progress using assessment instruments and protocol preservice teachers had learned in class. Preservice teachers were required to analyze the

data, write up their analysis, and make recommendations as to next teaching steps or treatment for the student. The literacy PowerPoint project required students to use text and audio and video clips to compile information on literacy development and effective instructional practices. Students made use of knowledge and skills gained over the course of the semester to complete the project, which was presented to their peers and the instructor for feedback.

Procedures and Analysis

Technology tools, class activities, and assignments were designed to target learning modes to support all learners. Raw scores for each of the learning modes on students' learning style inventories were plotted along two dimensions, concrete/abstract and active/reflective, yielding a learning style preference. These scores provided information on the students' preferences for multiple learning styles.

K-Means Cluster

A k-means cluster analysis (Everitt & Dunn, 2001; Moore & McCabe, 2004) was run on the performance scores and again on the learning style mode scores. The students were sorted into one of three learning style clusters. Cluster 1 (the "active experimentation" cluster; $n = 19$) is characterized by above average scores on active experimentation, average scores on abstract conceptualization and concrete experience, and below average scores on reflective observation. Cluster 2 (the "reflective observation" cluster; $n = 6$) is characterized by reflective observation scores that are well above average, active experimentation scores that are well below average, and abstract conceptualization and concrete experience scores that are average.

Cluster 3 (the "reflective observation/abstract conceptualization" cluster; $n = 5$) is characterized by above average reflective observation and abstract conceptualization scores and below average active experimentation and concrete experience scores.

The students were also sorted into one of three performance clusters. The high-achieving cluster $n = 19$ was characterized by above average or average scores, based on group means on the assessments used for the analysis. The average achieving cluster $n = 8$ was characterized by average or below average scores on these assessments. The low-achieving cluster $n = 3$ was characterized by scores that were well below average on every assessment with the exception of the literacy PowerPoint project score, which was average.

T-test

A *t*-test (Everitt & Dunn, 2001; Moore & McCabe, 2004) was run using the performance cluster scores and the raw learning style mode scores. In the three different performance clusters, the group mean scores for the learning styles modes were calculated yielding these results:

- Those in the high-achieving group had scores indicating that they did not have strong learning style preferences (mean scores = 3.316, 2.684, 3.737, 2.263, respectively)
- Those in the average achievement group had scores indicating that they had slight learning style preferences (mean scores = 4.750, 1.250, 4.625, 1.375, respectively)
- Those in the low-achieving group had scores indicating that they had the strongest learning style preferences (mean scores = 5, 1, 5, 1, respectively)

The results indicated the students with the strongest and most rigid learning style preferences also had lower scores on the four exams, the reading and writing analysis project, and the literacy PowerPoint project. The students found to have strengths in more than one learning style performed better on these particular assessments.

Analysis of Variance and Discussion Board Posts

Raw scores from the learning style inventory were also related with students' performance on discussion board assignments using an analysis of variance or ANOVA (Everitt & Dunn, 2001; Moore & McCabe, 2004). Students were assigned points based on the concepts and vocabulary used that demonstrated knowledge and understanding of the literacy topic. Results were significant $p = 0.023$. As shown in the appendix, students in the abstract reflective cluster did much better than those in the active cluster or the reflective cluster. Students who scored high on reflective observation and abstract conceptualization and low on active experimentation and concrete experience showed higher scores in discussion board posting. Characteristics of these modes align with the nature of the discussion board assignments, which was to reflect on course readings and discuss concepts central to reading instruction.

Review of Likert Scale Questionnaires

The Likert scale questionnaires used a rating scale of 1-5 with 1 = *strongly disagree*, 3 = *not sure* and 5 = *strongly agree*. These were completed by students two times in the study, once at midterm and once at the end of the semester. The questionnaires were designed to collect information on students' use of learning style information, how well they believed technology tools were supporting their understanding of course content, and whether or not use of technology tools in and outside of class were supporting their construction of knowledge. Students' responses provided descriptive statistical information on students' preferences for particular technology tools. Mean scores are shown for students within each learning style cluster. T-tests used to compare the mean scores to each other by cluster showed no significant differences among the students in the learning style clusters.

Learning Styles

Although students in all learning style clusters indicated they believed class presentations and course requirements addressed a variety of learning styles and that course assignments provided multiple and varied opportunities to demonstrate knowledge and understanding of course content, few students used information about their identified learning style to guide their study and preparation for class (see Table 1).

Table 1
Learning Styles and Supports

Question	Cluster 1	Cluster 2	Cluster 3
Class presentations address a variety of learning styles			
Midterm	4.6	4.2	4
End of semester	4.1	4.2	4
Course requirements address a variety of learning styles			
Midterm	4.3	4.2	3
End of semester	3.2	4.2	4
I use information about my identified learning style to guide my study and preparation for class			
Midterm	3.4	3	1.6
End of semester	3.1	2.8	1.8

Table 2
Technology Tools as Supports for Construction of Knowledge

Question	Cluster 1	Cluster 2	Cluster 3
Technology used in this course is supporting my learning style			
Midterm	3.8	4	3.6
End of semester	4.1	4	3.4
Technology used in this course is helping me understand course content			
Midterm	3.9	4.4	3.6
End of semester	4.1	4.2	3.8
Technology used during class is helpful for me in understanding course content			
Midterm	4.4	4.3	4
End of semester	4.8	3.7	4
The resources provided outside of class are helpful for me in understanding course content			
Midterm	4.1	4.3	4
End of semester	4.1	4.3	3.5

Table 3
Mean Scores for Three Learning Style Clusters: Technology Tools Used Outside of Class

Question	Cluster 1	Cluster 2	Cluster 3
The resources provided outside of class are helpful for me in understanding course content.			
Midterm	4.1	4.3	4
End of semester	4.1	4.3	3.5
The Course Web Page			
Midterm	4.4	4.4	4
End of semester	3.9	4.7	4.2
The Discussion Board			
Midterm	3.3	4.4	3.4
End of semester	3.4	4.7	3.2
Concept Maps (on the course Web site)			
Midterm	3.5	4.2	2.6
End of semester	3.5	3.5	2.8
Word Documents and PDFs (on the course Web site)			
Midterm	4	4.5	4
End of semester	3.9	3.5	4
Audio Clips of Alphabet and Phonogram Sounds			
Midterm	3.5	4.4	4
End of semester	3.6	4.5	4
Running Record Tutorial (Video Clip on the course Web site)			
Midterm	4	4.6	3.8
End of semester	3.4	4.3	3.8
Text with Audio Clips for Running Record and RMI Practice (on the course Web site)			
Midterm	3.8	4.6	4.4
End of semester	3.6	4.2	4.4
Resource Links for the Reading and Writing Analysis (on the course Web site)			
Midterm	3.7	4	3.8
End of semester	3.9	3.7	4
PowerPoints of Presentation/Lectures (on the course Web site)			
Midterm	4.5	4.8	4
End of semester	4.3	4.7	4.2
Text Information (on the course Web site)			
Midterm	4.9	4.4	4
End of semester	4	3.8	3.8

Technology Tools for Construction of Knowledge

Students' perceptions of how technology was supporting their learning style varied. Perceptions of whether or not technology was supporting their understanding of course content also varied (see Table 2).

When asked what technology tools used in class and resources provided outside of class were helpful in understanding course content, the means for particular technology tools varied. Students indicated they were not sure as to the helpfulness of some tools to be used outside of class in understanding course content. This uncertainness is evidenced in a number of 3's for mean scores shown in Table 3. High mean scores for the course Web page, the discussion board, and PowerPoints posted on the course Web page were reported by students in Cluster 2.

When asked about technology tools that were helpful in supporting understanding of course content during class, the means also varied, as noted in Table 4. Across all three clusters, students indicated that audio and video clips used in class supported their learning. Students in Clusters 2 and 3 evidenced the highest means.

Although responses to the four open-ended questions provided a picture of how adaptive individual students were in adjusting to or making use of a variety of tools in the course, these comments are not reflective of the entire group and are not reported here, with the exclusion being information on use of video clips.

Narrative comments in the course questionnaire from all three learning style clusters regarding video clips and modeling were much more frequent than any other comment. Students reported video clips and modeling as being helpful in supporting their understanding of course content. Reflections on use of video clips in the course did represent differences in learning styles. Some students emphasized the importance of seeing or visualizing examples or models of classroom instructional strategies, while others emphasized analysis of the videos in discussion that took place as being very important. These comments were not specific to learning style clusters.

Discussion: Tying Learning Styles, Technology Tools, and Constructivism Together

In reviewing again the inquiry questions guiding this study, the findings point to three important aspects to be discussed.

The Match/Mismatch Between Claims About Technology and Learning Styles in Constructivist Settings

Technology tools were selected and organized as part of the course design to match learning style preferences and, therefore, support students' individual and social construction of knowledge, skills, and dispositions necessary to be a teacher of reading. Characteristics of the tools were aligned to characteristics of four modes of the learning cycle. Use of these tools within the learning cycle provided access for all students to content, as all learning modes were targeted. Discussion and social interaction associated with these tools throughout the learning cycle supported individual and social construction of knowledge.

Although no significant differences were found among the participants in preferences for particular technology tools among the three learning style clusters, students' responses

on the Likert scale questionnaire indicated they believed technology tools were assisting them in the construction of knowledge. It seems preferences for technology are not as indicative of performance as is a match between characteristics of the tool and learning styles. For example, when isolated, as the discussion board was in this study, differences in performance as linked to learning styles were noted. Although this is an important finding in the study, performance may also be related to students' social/cultural practices with respect to their expectations about valid forms of knowledge and valid forms of class participation.

Table 4
Mean Scores for Three Learning Style Clusters: Technology Tools Used in Class

Technology Tools Used in Class	Cluster 1	Cluster 2	Cluster 3
Technology used during class is helpful for me in understanding course content			
Midterm	4.4	4.3	4
End of semester	4.8	3.7	4
Use of the SMARTBoard to demonstrate and explain information.			
Midterm	4.5	4.2	4
End of semester	4.4	4.5	3.8
Use of the SMARTBoard to move to topics within the presentation most pertinent to students.			
Midterm	4.4	4.2	4
End of semester	4.2	4.5	3.2
Videoclips (Viewing model lessons)			4.8
Midterm	4.5	4.8	
End of semester	4.5	4.6	4.4
Audioclips (Phonics and text samples for Running Record and RMI exercises.)			
Midterm	4.4	4.6	4.8
End of semester	4.4	4.3	4.6
PowerPoint with ability to write over the text during class discussions			
Midterm	4.4	4.4	4.2
End of semester	4.4	4.2	3.8
Visuals (Pictures, charts and diagrams displayed in PowerPoint or SMARTNotebook Software)			
Midterm	4.4	4.8	4.2
End of semester	4.0	4.5	4.2

All students completed activities and assignments making use of technology, but their differences in scores and their non-use of technology resources when it was a matter of choice could relate to issues of resistance in using technology and, again, to what they believed to be valid forms of knowledge and class participation. Similarly, the manner in which the instructor presented the tools may have affected how they were valued in comparison to the value students attributed to them. In other words the ways assignments, activities, and technology are structured and presented work to shape the ways tools are used and their use is mediated (Luke, 2000).

Course exams, the discussion board, and the wiki assignment, for example, involved differences in discursive practices, levels of support present, and subjectivity with respect to the tools (being viewed by the instructor and others, for example, on the discussion board verses being viewed by the instructor alone on exams, and sharing power within the wiki to construct, revise, and edit). The manner in which the social practices of the classroom, including the instructor and the students themselves, work to situate and shape the social practices of the classroom that affect performance and the overall construction of knowledge through use of these technology tools needs further research. Although the match between characteristics of tools and learning styles is important, this connection can be strengthened by addressing the additional factors discussed here.

Expanding Learners' Expectations From Rigid to Flexible Stances

Learning within the reading methods course was contextualized, related to the experiences the students had as learners learning to read, as well as to their experiences in learning to become teachers of reading. Metacognition was important as students engaged with content, technology tools, and others to construct knowledge. The technology tools provided opportunities for students to consider the viewpoints of others, think about them in terms of their own experiences with reading, and transfer these viewpoints to new experiences in working with elementary school children.

This cognitive flexibility, the result of both individual and social construction of knowledge was encouraged through use of technology tools in all four modes discussed here. However, tools selected to address a variety of learning style preferences benefited most those learners who had multiple preferences in learning style. In other words, these students may have used their abilities to adjust their learning to meet the requirements of the task. As a result of having multiple preferences these students also had more tools available that supported their learning. (This is consistent with other research on learning styles and student performance. See Chen, et al, 2005, Kolb, 1984; Kolb & Kolb, 2005; Larsen, 1992).

As a result of this study it seems more needs to be done to support students' ability to adjust to meet the requirements of tools and tasks. To do so, metacognition, use of metalanguage to consider their own thinking and learning in relation to expectations for the tasks to be completed, individual responsibilities for learning, and responsibilities to the social group for construction of knowledge need to be examined with students. Perhaps reflective activities associated with each tool used and task completed would be useful for this purpose. For example, with further experience, additional scaffolding, and analysis of tasks associated with use of the discussion board and topics discussed on it, the discussion board as used in this course might support both individual and social construction of knowledge to a higher degree for all students.

Student and Instructor Roles in Technology-Enhanced Constructivist Classrooms

Agency refers to power to act. "Conscious awareness and control over what is being learned" (Cope & Kalantzis, 2000, p. 33), is important in construction of knowledge. Understanding what is being learned as well as how learning takes place is necessary to develop agency. Making this agency visible through discussions of learners' and the instructor's responsibilities to self and to the group in metacognition, reflection, and assimilation of knowledge when using technology tools will benefit those involved in constructivist settings.

A related issue is the tension or balance between the roles of students and instructor in constructivist classrooms. Scaffolding and providing expert guidance are roles of the instructor. The instructor provides tools and resources to support learning and also alters planned experiences to address learning needs of students. Technology tools provide multiple opportunities for the instructor to model and share feedback as part of the scaffolding process in the constructivist classroom. Provision of tools and activities that increase opportunities for students of all learning styles to be engaged and challenged in the learning process is also important. However, selection and use of tools is still a choice by students, and unless their use is required they may not influence student achievement to the extent possible if students do not continue to make use of them on their own or outside of class.

Based on the findings of this study in which few students reported actually using information about their identified learning style to guide their study and preparation for class, more should be done to help students understand the particular cognitive and social demands of tools and tasks in relationship to learning modes associated with learning styles. In this way students may be supported in developing the ability to adapt to new learning situations or contexts for the purpose of constructing knowledge to the full extent possible. Such discussions and increased use by students would exemplify the gradual release of support and increasing responsibility for students that is part of the tension or balance in constructivist classrooms.

As students construct knowledge of literacy development and instructional practices, they also begin to codefine social practices and valid learning for themselves as a group in the context of the course. Examples in this study are students who shared skills in use of tools, insights about reading instruction, and their own personal development as readers. Others were then prompted to become engaged, which led to a strengthening of the whole group. Similarly, when some in the group did little to contribute the work of others overall construction of knowledge was affected.

The tension or balance between the roles of the instructor and students in individual and social construction of knowledge also concerns issues of power (Street, 1995). Students are asked to participate and to respond to others, and yet the instructor is observing, recording, and grading responses through use of the technology. This process is especially evident in the discussion board and wiki work, where the instructor may view and review student responses, response time and date, and interaction with others. Although this information may be used to provide feedback to individuals and the whole group for purposes of supporting their learning, such monitoring may affect what the group views as valid and valued forms of knowledge. This monitoring may encourage particular responses in some while limiting others. Similarly, discussing who selects tools, organizes the information, and monitors, whatever the mode of learning, will be important as social practices are constructed and negotiated in the constructivist classroom.

Conclusions and Recommendations

Technology tools have the ability to address students' learning needs in terms of learning style preferences, as students work as individuals and groups to construct knowledge. Selecting these tools to match the characteristics of the modes of learning and discursive practices that are a part of individual and social construction of knowledge is critical. Using the four modes of concrete experience, reflective observation, abstract conceptualization, and active experimentation, technology tools can be successfully integrated to support student's construction of knowledge. However, negotiation between instructors and students as to how technology tools will be used and the use monitored is also important as social practices are shaped in the constructivist classroom.

Helping students see how particular tools may support the construction of knowledge is necessary. Changing strategies and methods to address students' learning styles and helping students develop the ability to adapt to new learning tools, situations, and contexts by bringing to these situations necessary skills and dispositions to perform well in the given situation is important. Students must also have knowledge of task requirements for modes of learning, knowledge of how to use technology tools effectively, and knowledge of responsibilities for individuals to self and others in the construction of knowledge. Making visible the mode, the discursive practices, level of support, and subjectivity present in each medium will strengthen engagement and thus the construction of knowledge. Continued research on affordances of technology aligned to learning needs is necessary to support appropriate and effectual use of technology enhanced learning experiences that are beneficial for all learners.

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Appendix

Alignment of Assignments and Activities to Learning Cycle Stages and Learner Characteristics

Learning Cycle Stages and Learner Characteristics Within Each Mode (Kolb, 1984)	Reading Methods Course Assignments and Activities
Concrete Experiences (CE) Engage in experiences outside the classroom such as interviews, complete activities with people in the field, or engage in these experiences vicariously, share feelings and receive personalized feedback, apply skills to real life problems, act in a self-directed and autonomous context	Role play **Use of the SMARTBoard** for modeling **Audio clips**-Clips of phonogram sounds and reading analysis components) **Video reviews**-Clips of model lesson presentations and reading instructional strategies) Classroom observations in the University and Practicum classroom. Collection of reading and writing data in the practicum classroom. Lesson presentation (guided reading)
Reflective Observation (RO) Reflect or react to experiences, use expert interpretation and guidance	Quickwrites/double entry journals In-class cooperative group work Class discussion of reading assignments and practicum observations **Concept mapping** **Discussion board** on course topics Reflection on lesson presentation

Learning Cycle Stages and Learner Characteristics Within Each Mode (Kolb, 1984)	**Reading Methods Course Assignments and Activities**
Abstract Conceptualization (AC) Get information from authoritative sources, use research and methods, engage in reading of theory	Reading course text and professional articles Lectures (**PowerPoints on the course Web page**) **Electronic reserves** Analysis of a comprehensive scientifically based reading program Phonics review Lesson plan development (Read-aloud, Shared Reading, and Guided Reading) Strategies guide Exams **Wiki assignment** **Course Web page (accessing audio/video clips, PowerPoint presentations, and text resources)**
Active Experimentation (AE) Apply principles or theories in problem-solving assignments or field experiences, have small group discussions, complete projects, receive peer feedback; observe/use the teacher as a model of the profession	Analysis of children's reading and writing Lesson presentation/analysis of student learning (following lesson presentation) Text leveling Literacy **PowerPoint** project/presentation Concept maps, graphic organizers, and **Inspiration** **Discussion board** **SMARTBoard** presentation tool **Audio and video clips**