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Constructivism and Teacher Epistemology: Training Teachers in Classroom Computer Use[1]

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Abstract

The NASA Classroom of the Future™ sponsored a residential training course to help teachers learn to use computer-based educational tools and explore constructivist instructional approaches. Researchers hypothesized that creating a living-and-learning environment for the training would foster rapid changes in teachers' epistemological beliefs.

Pretest-posttest differences on an epistemology inventory indicated that teachers changed significantly on three of four factors related to constructivist teaching philosophies (Simple Knowledge, Quick Learning and Certain Knowledge). The fourth factor (Fixed Ability) did not reveal significant changes.

These findings have two implications: 1) constructivist approaches to training teachers may promote epistemological change, and 2) epistemology may be a less stable trait than was previously supposed.

Background

Recently there has been a growing interest in understanding what teachers believe about the nature of knowledge and learning, and how these beliefs, or epistemologies, impact their curriculum implementation and instructional approaches (e.g., Clark, 1988; Clark & Peterson, 1986; Hofer & Pintrich, 1997; Kagan, 1990; Lyons, 1990; Pajares, 1992; Prawat, 1992b). Teacher epistemology has been shown to affect teachers' use of teaching strategies (Hashweh, 1996), their use of problem-solving approaches (Martens, 1992), their efforts in curriculum adaptation (Benson, 1989; Prawat, 1992a), their use of textbooks (Freeman & Porter, 1989), their openness to student alternative conceptions (Hashweh, 1996), their preservice training needs (Many, Howard & Hoge, 1997), their students' reading practices (Anders & Evans, 1994) and their students' use of higher-level thinking skills (Maor & Taylor, 1995).

Schommer (1990) proposed that personal epistemology is a belief system comprised of five more or less independent dimensions: the structure, certainty, and source of knowledge, and the control and speed of knowledge acquisition (see also Schommer, Crouse, & Rhodes, 1992). From Schommer's perspective, a teacher who holds "naive"[3] epistemologies along all five dimensions generally believes that knowledge resides in authorities and is thus unchanging, that concepts are learned quickly or not at all, that learning ability is innate, and that knowledge is simple, clear, and specific. She suggests that a teacher who holds "sophisticated" epistemologies

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[3] The terms "naïve" and "sophisticated" are taken from Schommer (1990).

along all five dimensions believes that knowledge is complex and uncertain, can be learned gradually through reasoning processes, and can be constructed by the learner.

One reason epistemological belief research has become important is an increase in the use of the constructivist learning model in K-12 classrooms (Prawat, 1992b; Yager, 1995). In general, the constructivist learning model emphasizes the creation of "active learning environments"—environments that permit critical thinking, discovery, and collaboration. Such environments typically engage students in solving real-life problems, collaborating on group projects, writing articles or stories, developing models or diagrams, journaling, and investigating solutions to research questions. Recent advances in software technologies have also created unique opportunities for critical thinking, discovery, and collaboration. However, evidence suggests that success is not solely the result of effective technologies; rather, success may be partly dependent on teachers having sophisticated epistemologies (Maor and Taylor, 1995).

The constructivist learning model is often contrasted to the transmissionist, or objectivist, learning model, which views the teacher as the source of knowledge and students as passive receptacles of this knowledge (Duffy & Cunningham, 1996; Duffy & Jonassen, 1992; Prawat, 1992b; Tobin, Tippins, & Gallard, 1994).. The objectivist learning model emphasizes learning by receiving information, especially from the teacher and from textbooks, to help students encounter facts and learn well-defined concepts.

Insert Table 1 about here.

In this study, we draw parallels between Schommer's proposed epistemological dimensions and constructivist-objectivist learning models. See Table 1 for a comparison of the two learning models and their relationship to epistemological dimensions. Arredondo and Rucinski (1998) and Brooks and Brooks (1993) draw similar parallels. We believe Schommer's naïve epistemologies are parallel to objectivist epistemologies and her sophisticated epistemologies are parallel to constructivist epistemologies.

Training Purposes

Many teachers are in favor of adopting constructivist instructional approaches but are unsure of where to begin. In addition, many are interested in taking advantage of new computer capabilities and recent hardware purchases at their schools. To help teachers explore constructivist approaches and improve their ability to use computers as instructional tools, the NASA Classroom of the Future™ (COTF) sponsored a 6-credit graduate-level course for K-12 teachers in multimedia computer-based technologies and Internet communication. Teachers were exposed to communications packages, multimedia tools, authoring software, and computer-based curriculum supplements that use constructivist methodologies. This course was the first in a masters program in instructional design and educational technologies.

The group of teachers chosen by trainers for the program was called the 2001 Master Teacher Cadre™. Cadre members were selected from a national pool of 250 applicants recruited via word of mouth, e-mail, and the Internet. They were chosen on the basis of a competitive essay, evidence of administrative support, advanced technology know-how, exemplary classroom practice, distinctions and honors, passion for teaching and learning, desire to pursue graduate coursework, and desire to try new things, particularly new technologies. They were not chosen on the basis of their instructional philosophies (epistemologies).

The Cadre lived for four weeks in neighboring rooms of the campus residence halls. The trainers' goal was to create a "community of learners" in which class time and social interactions created frequent opportunities for teachers to dialogue with like-minded professionals. Such discussions frequently centered around the application of instructional theories and methods, common experiences, and personal teaching philosophies. Trainers also relied on the varying technological expertise of Cadre members. That is, Cadre members who had experience often tutored those with less experience.

Each week, classes were held every morning and afternoon, with the exception of Sunday morning. Cadre members were graded on daily software assignments and on a final multimedia "product" which they had designed and authored to be used in their own classrooms. During a typical morning session, training focused on learning particular aspects of software tools such as Adobe PageMill®, Adobe Photoshop®, Adobe Premiere®, Eudora®, HyperStudio®, and Microsoft® PowerPoint®. Occasionally, mornings were devoted instead to a demonstration of constructivist methodologies used in a current educational software product. As teachers designed their instructional modules, trainers emphasized the application of theories of learning and instructional design. A typical afternoon was spent in individual or small groups working on daily assignments or final products. A typical evening involved dinner together, volleyball, and frequent late-night computer lab sessions. One important feature of the computer lab time was the fact that Cadre members were asked to take turns being lab managers, which offered them valuable practice at tutoring others and solving technological problems. In the discussion section, we explain additional features of the living-learning context which might have promoted changes in teacher beliefs.

Researchers expected that the teachers' experience of being away from distractions at home and being immersed with other high caliber teachers in a living and learning environment would promote changes in teaching philosophies. In particular, it was hypothesized that teachers would show significant changes in epistemology in areas related to constructivist teaching philosophies.

Method

We sought to investigate how teacher epistemological beliefs might be changed as a result of the training program. To do so, we administered an epistemology questionnaire both before and after the training, and examined the pretest-posttest differences. It should be noted that the researchers did not divulge any information regarding the research hypotheses to those who conducted the training, nor were trainers aware of the specific purposes of the research instruments.

Participants

Participants included 41 "master teachers" selected from a national pool of applicants for a graduate training program in instructional design and educational technologies. There were 20 females and 21 males. Six teachers (15.8%) had less than five years of teaching experience, seven (18.4%) had between five and ten years of experience, nine (23.7%) had between ten and twenty years of experience, and sixteen (42.1%) had more than twenty years of experience. For analysis purposes, we excluded 3 participants who were not current teachers and who did not live in residence.

Materials

Epistemological Questionnaire. The Epistemology Questionnaire Form B (EQ) (Schommer, 1990) was administered on the first and last days of the training program. The EQ is comprised of 63 items, which represent twelve subscales or epistemological orientations. The

inventory asks respondents to rate their level of agreement for each item on a scale from 1 (strongly disagree) to 5 (strongly agree).

Schommer (1990) proposed that epistemological beliefs are comprised of five dimensions that have to do with the structure, certainty, and source of knowledge, and the control and speed of knowledge acquisition. Four of these five dimensions have been empirically validated as factors within the EQ (Schommer, 1990; Schommer, Crouse, & Rhodes 1992; Schommer & Dunnell, 1994). The fifth dimension, source of knowledge, hypothesized by Schommer (1990), has not yet been validated, and was not examined here. The four factors and the twelve subscales are listed in Table 2, along with a sample item. In Schommer's theoretical framework the four factors are referred to from the naïve end of a continuum. That is, the factors are labeled, Fixed Ability, Simple Knowledge, Quick Learning, and Certain Knowledge.

Insert Table 2 about here.

Results

In Schommer (1990), twelve subscales were used as variables in the factor analysis. Schommer used an orthogonal varimax rotation and an eigenvalue greater than one as a cutoff point, and found that a principle factoring extraction generated four factors, which accounted for 55.2% of the variance. Table 3 gives means and standard deviations for factor scores used in the present analyses. These scores may be interpreted by understanding that raw scores from subscales are converted to z-scores and then combined into factors using the factor score coefficient matrix presented in Schommer (1990).

Insert Table 3 about here.

One-tailed t-tests revealed that teachers demonstrated significant changes on three of four factors in the direction of a greater constructivist epistemology, including: Simple Knowledge, $t(37) = 1.94$, $p = 0.031$, Quick Learning, $t(37) = 2.29$, $p = 0.014$, and Certain Knowledge, $t(37) = 3.23$, $p = 0.002$. Fixed Ability did not show a significant change, $t(37) = -0.35$, $p = 0.439$. The changes in epistemology on Simple Knowledge, Quick Learning, and Certain Knowledge factors have negative valences, as expected. These findings indicate that teachers moved from objectivist epistemological orientations to more constructivist ones.

Discussion

We believe these findings have two primary implications. The first implication is that constructivist approaches to training teachers may actually produce epistemological changes in line with constructivist philosophies. The second implication is that epistemology may be a less stable trait than was previously supposed—with the teachers here demonstrating major changes in only a four-week period. Each implication is discussed below.

Implications for Constructivist Training

Teachers learned about constructivism by doing constructivism. That is, trainers used high levels of discussion, peer-to-peer tutoring, and learning by doing. Trainers introduced teachers to the possibilities of the technology for constructivist instruction and multimedia development and provided them all the resources necessary to adapt the technologies for their own use. Individually and collaboratively, teachers learned how to use the technologies by incorporating them into the design of lesson plans. Teachers were provided time, software and

hardware resources, and access to technology experts and subject matter experts. In retrospect, trainers observed that one of the most powerful influences for epistemological change was the teacher-to-teacher encounters.

Training also utilized several important strategies that have been demonstrated to be important for changing beliefs (Posner, Strike, Hewson, & Gertzog, 1982). The first strategy was creating opportunities for reflection. Writing, reflective activities, and informal discussions concerning their implicit teaching beliefs were encouraged on a daily basis. The second strategy was challenging existing beliefs. Teachers' implicit beliefs were challenged through the formal feedback of the instructor, informal comments of peers, and through learning to use computer software that used constructivist teaching approaches. The third strategy was supporting the accommodation of new beliefs. As part of the class, teachers were given time to create lesson plans that embedded constructivist approaches. When these new approaches were juxtaposed against teachers' usual approaches, the support of the community of learners helped alleviate the resulting cognitive dissonance.

The present research does not explain whether teachers' epistemological changes were primarily due to the training content or if they were due to the training context (the living-and-learning environment). It was the belief of the course designers that both content and context were essential. Future studies should focus on explicating the components of instruction and the living-learning environment that teachers found most meaningful. In addition, further research should focus on creating and testing models of strategies future teacher trainers can use to support changing beliefs.

Implications for Theory Related to Epistemology

To our knowledge, no other researchers have reported significant changes in epistemology over such a relatively short period of time. Contemporary researchers describe epistemology as a unidimensional construct that changes slowly along a developmental continuum in conjunction with cognitive growth (e.g., Belenky, Clinchy, Goldberger & Tarule, 1986; Baxter Magolda, 1992; Kegan, 1982; King and Kitchener, 1994; Perry, 1970). Within the framework of these theories, epistemology would not be expected to change unless the intervention created substantive changes in cognitive development as well. There is some evidence to support this notion. For instance, Arredondo and Rucinski (1998) and Roskos and Walker (1993) both report slight changes in epistemological development for preservice teachers over one semester. In each study, training interventions resulted in increased complexity in cognitive development.

In contrast to the notion of epistemology as unidimensional, Schommer (1990; 1994) has asserted that epistemology is comprised of a set of multiple independent dimensions and has demonstrated the validity of four epistemological dimensions. Until now, there has been little evidence regarding the stability of these dimensions. This study provides compelling evidence that the epistemological dimensions hypothesized by Schommer are subject to change.

The three factors which showed significant differences (Simple Knowledge, Quick Learning and Certain Knowledge) have also consistently been shown to be significant predictors of learning and other academic behaviors (Schommer 1990; 1993a; 1993b; Schommer, Crouse, & Rhodes 1992; Schommer & Dunnell, 1994; Schommer & Walker, 1995). Fixed Ability, however, has not shown the same consistency. Hofer and Pintrich (1997) propose that Fixed Ability measures beliefs about the nature of intelligence and not so much the nature of knowledge. They state that views of intelligence "have not typically been thought of as part

of the construct of epistemological beliefs." In retrospect, we believe that training in constructivist approaches was only indirectly related to Fixed Ability and that changes along this dimension would have been slight, compared to changes in other dimensions. Future studies should pay close attention to what is being measured by epistemological inventories, as researchers seek to better understand teacher epistemology and its stability.

Conclusion

In summary, we sought to demonstrate the effectiveness of a teacher training program for promoting epistemological change. The training program involved the two-pronged approach of combining specific content with a living-learning context. Course content exposed teachers to constructivist-oriented curricular supplements and software tools for authoring, multimedia development, and Internet communication. The course context was residential and allowed for frequent, intensive teacher-to-teacher interactions. Results indicated that teacher epistemology became significantly more constructivist on three of four measured epistemological dimensions. We believe this finding is important because no previous research has reported such major changes in so short a time. The fact that epistemology, a trait assumed to be stable, changed so dramatically indicates that the training program was very effective and that certain epistemological dimensions are subject to change.

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Table 1
Epistemological Dimensions Compared to Contrasting Learning Models

Epistemological Dimension (Schommer, 1990)	Objectivist Learning Model (sample method)	Constructivist Learning Model (sample method)
Structure (Simple....Complex)	Simple: Teachers define concepts; Students memorize these and other facts. (teacher lectures)	Complex: Students examine complex knowledge and draw their own conclusions. (students have small group discussions)
Certainty (Certain....Tentative)	Certain: Students learn the concepts as presented and are penalized for misconceptions (students read textbook and write answers to chapter questions)	Tentative: Students are allowed to develop alternative conceptions. (students create and test models)
Source (Authority....Reason)	Authority: Teacher answers all questions or refers students to textbook. (students watch video programs by experts)	Reason: Students apply a critical eye to what they read and hear. (students ask questions of one another)
Control (Innate....Acquired)	Innate: Teacher believes that students understand only according to their level or ability. (use of ability groupings)	Acquired: Students can learn to learn. Learning is process- oriented. (use of strategies for reading comprehension)
Speed (Quick....Gradual)	Quick: Students learn from well-designed curricular materials and presentations. (students watch multimedia presentations)	Gradual: Students learn by discovering or doing. (students assigned ill-structured, problem-solving tasks)

Table 2
Epistemological Questionnaire- The Four Factors and the Twelve Subscales

Factor Title • Subscale Title sample item in quotes	
Fixed Ability • Can't learn how to learn "A course in study skills would probably be valuable." (reverse coded) • Ability to learn is innate "An expert is someone who has a special gift in some area." • Success is unrelated to hard work "The really smart students don't have to work hard to do well in school." • Learn the first time "Almost all of the information you can learn from a textbook you will get during the first reading."	Simple Knowledge • Seek single answer "Most words have one clear meaning." • Avoid ambiguity "I don't like movies that don't have an ending." • Avoid integration "When I study I look for specific facts." • Don't criticize authority "People who challenge authority are over-confident." • Depend on authority "How much a person gets out of school depends on the quality of the teacher."
Quick Learning • Learning is quick "Successful students learn things quickly." • Concentrated effort is a waste of time "If a person tries too hard to understand a problem, they will most likely just end up being confused."	Certain Knowledge • Knowledge is certain "Scientists can ultimately get to the truth."

Table 3
Inventory Factors, Means and Standard Deviations

	Pretest			Posttest				
Epistemological Questionnaire	Range	M	SD	Range	M	SD	Difference in Means*	
Fixed Ability	-1.86 to 1.20	-.0003	.73	-1.84 to 1.45	.03	.71	.0303	t = -.35 p = .439
Simple Knowledge	-2.39 to 1.86	-.0008	.85	-2.15 to 1.73	-.2242	.80	-.2234	t = 1.94 p = .031
Quick Learning	-1.53 to 1.84	-.0004	.73	-1.75 to 1.81	-.2498	.74	-.2494	t = 2.29 p = .014
Certain Knowledge	-1.07 to 1.31	-.0005	.60	-1.45 to 1.03	-.2507	.59	-.2502	t = 3.23 p = .002

Note. n = 38.
*A difference which has a negative valence indicates that teachers were more likely to agree with the constructivist epistemological view at posttest time.

Contributors

The Classroom of the Future™ (COTF) program at Wheeling Jesuit University is NASA's premier research and development center for educational technologies. The COTF mission is to support educational reform in math and science by providing K-12 schools with advanced instructional software and teacher professional development, and by conducting research on the learning sciences. Please see http://www.cet.edu/research/main.html for a description of research projects.

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