Implementing a Virtual Learning Environment to Enhance Modeling skills and Collaboration in a Pre-service Teacher Education Science Program: Students' Ideas about a Blended e-Learning Approach.

Iolie A. Nicolaidou
Department of Educational Technology, Concordia University, Canada,
iolie_ni@alcor.concordia.ca

Christiana Th. Nicolaou, Constantinos P. Constantinou
Learning in Physics Group,
Department of Education, University of Cyprus, Cyprus
{chr.nic,c.p.constantinou}@ucy.ac.cy

Abstract: This paper reports on a research study targeted at a) the development of modeling skills of pre-service teachers, through the use of Stagecast Creator™ and b) the enhancement of collaboration among students, through the use of WebCT™. Participants were 20 pre-service teachers who attended a science course at the University of Cyprus (spring semester 2004). A blended e-learning approach was used, as the course incorporated e-learning through the use of WebCT™ combined with face-to-face teaching. The study took advantage of platform functions for presentation of information, synchronous and asynchronous communication and students' access to models developed by other students for assessing and refining them. Means of data collection include students' reflective journals, reports of the synchronous discussions, and a questionnaire. Data analysis indicates that students believe that the blended e-learning approach critically enhanced the development of modeling skills and the collaboration among them.

Introduction

Pre-service teacher education in natural sciences usually takes place through conventional programs of study, which significantly limit the probability of initiative undertaking on behalf of teachers and students (Fensham & Northfield 1993). Moreover, pre-service teachers are unable to correspond to the requirements of the established curriculum guidelines and standards concerning the teaching of natural sciences (McDermott et al. 2000). During the last years there has been an increasing interest concerning the preparation of teachers in natural sciences (NRC 1996, European Commission 2000). Simultaneously, there is a need for a paradigm shift in education, focusing on the development of thinking and communication skills, in order to better respond to the needs of a modern technological society (Harlen 1999, Harlen 2000, Saat 2004). Several researchers emphasize the critical role that technology can play in restructuring education, through expressing the need for the utilization of new technologies (Wang & Holthaus 1997) and the incorporation of technological tools for the enrichment and support of teaching and learning (NRC 1996, European Commission 2000).

According to this new paradigm, a teacher education program in the natural sciences should aim to support the professional and scientific development of individuals through the enhancement of reasoning and thinking skills. Among the reasoning skills that contribute to an individual's attempt at knowledge construction are modeling skills. The development of strategies such as modeling can form the basis for the development of transferable skills supporting learning in the natural sciences (Constantinou 1999). However, the development of modeling skills is often not addressed in teacher education programs. The University of Cyprus (UCY) teacher education program is no exception. The teacher education program in natural sciences at the UCY includes a) two compulsory content courses, which follow the inquiry approach (McDermott et al. 1996) and revolve around the basic natural science concepts, b) a teaching natural sciences methodology course, in which reasoning skills are emphasized, and c) a school experience course, which focuses on the implementation of research-based curriculum in a classroom environment. For a specialization in the teaching of natural sciences, students have to follow four courses, one of which is EDU477: Applications of Information Technology in the Teaching of Science at Elementary School.

To address the need deriving from the lack of modeling skills in teacher education programs, the present study focuses on the development of a curriculum which implements Stagecast Creator™ (SC) for helping pre-service teachers develop modeling skills. Moreover, the study seeks to address the technological need of implementing virtual learning environments (VLEs) in teacher education, through the implementation of a blended e-learning approach via WebCT™. The research questions of this study are the following: a) in what way can a VLE enhance the development of modeling skills of pre-service educators in natural sciences, and b) in what way can such an environment support student collaboration in pre-service education?

Literature Review

The use of open-ended teaching and learning strategies that are based on internet technologies seems to be promising for pre-service teacher education and may constitute a new approach to replace traditional ways of teaching that fail to promote effective learning. Distance learning appears to offer a functional solution to the need for professional teacher training (Carr-Chellman & Duchastel 2000, Frank et al. 2002) and as such it may be thought of as an integral part of university instruction (Hench 2003).

A VLE, an electronic environment in which learners and teachers participate, interact and learn online, may constitute an example of this new approach. VLEs have several advantages: for example, they contribute to an effective teaching and learning process through the promotion of active learning, course organization, and instant feedback for students and teachers. Furthermore, they allow tracking of students' understanding of the subject matter, facilitate the design of inquiry problem-solving situations, and encourage students' discussion of their ideas and learning experiences (Juuti et al. 2003). They can also support distance learning through providing flexibility in time and space of instructional activity. The disadvantages of VLEs stem from the lack of instant communication between teachers and students. Because of the latter, the educator needs to invest more time and put more thought in developing the course material of a distance-learning course compared to the time he/she would need to invest in designing a traditional course. Additionally, problems of responding to unpredictable students' reactions may be faced in such an environment (Frank et al. 2002).

This study aims at the development of pre-service teachers' modeling skills as a scientific process and as an instructional schema through the use of SC. According to Constantinou (1999) and Papadouris and Constantinou (2001) modeling is a reasoning skill, which refers to the development of the ability to construct and improve models. The modeling approach to learning is iterative in that it involves continuous comparison of the model with the reference physical system. The purpose is gaining feedback for improving the model so that it accurately represents as many aspects of the system as possible. It is also cyclical as it involves the generation of models of various forms until one can be found that successfully emulates the observable behavior of the system. Therefore, modeling could be considered as a backbone for understanding in natural sciences (Constantinou 1999, Papadouris & Constantinou 2001, Chapman 2000, Gilbert 1993, Gilbert 1995, Gilbert & Boutler 1998). The software implemented in this study, SC (http://www.stagecast.com/), is a computer-based programming environment that was designed for young learners building their own microworlds. As such, it is an ideal tool for constructing models in natural sciences. Students work in a fully graphical environment, which allows creation of characters to which they apply rules of behavior.

The present research also aims at enhancing the collaboration among students through the use of WebCT™. Contemporary conceptions of technology-supported learning environments "assume the use of a variety of computer-mediated communications to support collaboration among communities of learners" (Scardamalia et al. 1994, as cited in Jonassen 1999, p.228). Careful implementation of synchronous and asynchronous communication tools may facilitate students' active learning through constructivist and reflective discussions in a collaborative environment. Should the implementation of a VLE in a course be in accordance with a constructivist approach in learning, such an environment can "support collaboration within a group of participants, shared decision making about how to manipulate the environment, alternative interpretations of topics and problems, articulation of learners' ideas, and reflection on the processes they used" (Jonassen 1999, p.230).

Methodology

The research was conducted via a blended e-learning approach, which combines the VLE of WebCT™ with face-to-face instruction. An inquiry-oriented curriculum was implemented, according to which students worked in small groups to collect and study moon observations and construct a series of successive models of the moon phases using SC. Specifically, students' groups shared their models with other groups through WebCT™, and provided feedback about each other's models, indicating model limitations and suggesting possible improvements.

The functions of the platform that were implemented in this blended e-learning approach are the following: (a) *content delivery*, through which content material was available (b) *delivery of students` assignments*, including reflective journals, models through SC and concept maps, (c) *assessment tests*, (d) *synchronous discussions*, through which 9 one-hour discussions on given topics took place, (e) *asynchronous discussions*, mostly used for communication regarding the content and logistics of the course, and (f) *material exchange space*: that allowed students' access to materials developed by other students for assessing and refining it.

The participants of this study were twenty (20) fourth-year (senior) pre-service teachers who attended the course EDU477: Applications of Information Technology in the Teaching of Science at Elementary School at the UCY, during the spring semester of 2004. Students worked in 6 heterogeneous groups (2 groups of 4 and 4 groups of 3 students) formed according to an informal evaluation of students' level of computer competency.

Students completed *reflective journals* after each class. Reflective journals constitute one of the principal ways through which pre-service teacher education programs focus participants' attention on the metacognitive process of conceptual understanding. Students were asked to reflect and comment on concepts and aspects of the course that were valuable for their learning experience and to relate the course with pertinent theoretical perspectives and teaching practice applications.

Another means of data collection used were the *synchronous discussions* that took place among students beyond the actual class time. The instructor's role in these discussions was restricted to coordination. She did not intervene unless that was considered necessary for further stimulating the discussion. The first synchronous discussion took place with all 20 students; however due to coordination problems, students were randomly divided into two groups of ten, which alternately participated in the eight discussions that followed. Synchronous discussions revolved around the critique of current research on modeling skills. Both students' reflective journals and synchronous discussions provided data on students' thoughts on modeling skills and collaboration in VLEs.

A *questionnaire* focusing on student's attitudes towards e-learning was also administered upon the completion of the course. Students answered nine open-ended questions regarding the support that WebCT™ provided for the course, the platform's advantages and disadvantages and the technical difficulties encountered. Content validity of the questionnaire was tested by a panel of 3 experts, 2 experts on e-learning and 1 expert in Curriculum and Instruction.

For the analysis of the reflective journals, procedures and techniques suggested by the Glaser and Strauss grounded theory were used. This methodology offers a qualitative means for understanding and evaluating subjects' reflective thought. The following steps were implemented: (a) breaking down of the data, (b) conceptualizing data, and (c) putting them back together (Strauss & Corbin 1998). Data from both the reflective journals and the synchronous discussions were analyzed in three stages. During the first stage, a critical reading of the written copies of the discussions and journals took place. Then followed their analysis and the identification of the themes discussed. The last stage consisted of a graphical representation of each theme, which included each student's flow of thoughts and ideas. Data from the questionnaire were analyzed qualitatively, in order for students' answers to be coded in categories that emerged through the analysis and then quantitatively, as descriptive statistics were applied to the categories formed.

Results

The results of the data analysis that followed are presented in an integrated way, based on content themes identified rather than the means the data came from. The first research question relates to the use of a VLE to enhance the

development of modeling skills by pre-service educators. With respect to this question, it is important to note that 5 pre- and post-tests were administered to students throughout the course's duration to assess the development of their modeling skills. Multivariate analysis of Variance (MANOVA) for all pre- and post-tests indicated significant differences in a number of modeling skills, such as the ability to construct [$F(1, 19)=33.876$, $p<0.01$, $?^2=0.641$], test and improve models [$F(1, 19)= 58.188$, $p<0.01$, $?^2=0.754$], extract important information from a model [$F(1, 19)=84.444$, $p<0.01$, $?^2=0.816$], compare and contrast different models of the same phenomenon [$F(1, 19)=31.792$, $p<0.01$, $?^2=0.616$], and appreciate the usefulness of models [$F(1, 19)=47.598$, $p<0.01$, $?^2=0.715$]. There will be no further commenting on this analysis due to space limitations. Interested readers may contact the researchers for access to the MANOVA analysis.

Students' thoughts on the use, value and potential of a VLE to support the development of modeling skills reflected a positive contribution of WebCT™ to this objective. One of the prominent features of the environment that was repeatedly characterized by students as crucial was access to the other groups' models through WebCT™ during the repetitive process of each group's model construction, comparison of a model with the phenomenon represented, providing and receiving feedback, construction of an improved version of the model and so forth. This has significantly helped the development of modeling skills primarily by making students realize that one of the fundamental stages of the model-based learning cycle is model deployment (Constantinou 1999) and by providing a way to facilitate this process. All students made this clear in their reflective journals, characteristic extracts of which follow: "*The process for constructing and improving our models had several advantages. We could see the perspective of another group that used alternative ideas and techniques. We made suggestions for improvement, but realized that they were sometimes hard to actually implement. We also changed some things on our model based on the feedback received from another group. I found (this process) to be consistent with constructivist approaches to learning*". "*The fact that the models of all groups were accessible through WebCT™ and the fact that we had to evaluate the model of our fellow students made us more careful in our comments. We observed and compared another group's model with ours even though they did not relate to the same aspect of the phenomenon of moon phases and discovered that there were some things we hadn't thought about…*" "*…even though group 1's evaluation did not help much, we were able to receive feedback from other groups, because all models were uploaded in the platform for us to comment on…since some groups developed their own model for the same phenomenon we saw a number of different ways of constructing a model based on the exact same data…*".

Students' comments on the model construction process implemented in the course were positive. "*The process of constructing a model from scratch was interesting and useful…the evaluation process of the model of another group helped us deal with matters of functionality and clarity of a model… (this process) offered new knowledge and skills and made me feel that all the time we devoted to this did not go to waste*". "T*he whole process was interesting but time-consuming. Through bi-directional feedback we saw different ways of adjusting models of the same phenomenon, applied critique, identified strengths and weaknesses, provided ways for improvement, realized our own mistakes, and practiced our modeling skills…overall it was an effective process*".

Concerning both students' experience with using the platform and the probability of replicating this experience at a future stage, a large percentage of students (85%) refer to their experience as one that provided knowledge that is transferable and usable. One student stated: "*of course it offered something that can be used at a future stage. It constituted a positive experience even though I have my doubts as to whether it can be implemented at the elementary school level, because of technical difficulties and limitations, such as the lack of computers/hardware*". Regarding the same issue, the reflection of another student is interesting: "*knowledge of concepts is not the most important thing in natural sciences. What is important is to find a teaching approach that will make our students capable of constructing, refuting and evaluating models of the world based on data*".

With respect to the second research question of this study, which refers to the use of a VLE to enhance collaboration among students, there is strong indication that the environment of WebCT™ helped in communication as well as collaboration and mutual support among students. One student stated that: "*using the online discussion forum, I provided my fellow students with my ideas on how to construct their models. It's a rewarding feeling to help other learners in this way. Furthermore, I had a chance to think of some things that may prove to be useful in our model, as well.*" Another student referred to the advantage of asynchronous communication: "*I've never had a similar experience in any of my courses. …communication took place via WebCT™ over the Easter holidays, during which each group member was in a different city. Lastly, we read the comments and critique of our support group and based on them tried to improve our initial model.*"

It is important to note that students recognized the online collaboration as an indispensable part of their learning experience. It is interesting to note that several of them commented on the fact that in an instance they had to work without access to a computer, in a negative way, in their reflective journals. Students also referred to a positive gain with regards to their interaction with the learning materials and their peers made possible through the enhanced collaboration capability of the VLE: "*…another positive thing is the fact that it was easier for us to accept comments about our model because they came from our peers*" *"very original and helpful process, it helped us see things spherically…we came across ideas applied by another group and that was helpful for everyone. Had the models not been uploaded on WebCT™, this process would have been really difficult to implement*." "*We were able to discuss and exchange ideas in an informal and spontaneous way…through which I feel that I learned a lot, in a surprisingly pleasant way.*" "*I thought that technology use would be limited to communication, but this was the most effective use of technology we've had so far in our courses*" *"I find that this process encourages communication and collaboration both between and within the groups"*.

Some students furthermore identified the value of this environment for the transfer of these skills in teaching modeling in elementary school: *"it was a very useful process because all group members did not have a choice but to contribute to the group's project. This is the type of process that should be used in elementary school for two important reasons. First of all, this approach develops collaboration and mutual support among children. The second reason is the fact that it makes explicit to children that in order for model construction to be successful, the model needs to go through several stages of refining, to which several people contribute, in order for the model to represent a phenomenon in a sufficient way*".

Despite, however, several students' positive comments regarding online collaboration, it is important to note that there hasn't been a consensus over the superiority of this approach. It is therefore interesting to compare students' preferences regarding face-to-face and online communication and collaboration. Overall, 40% of students state that they have a strong preference towards direct, face-to-face discussions and do not prefer synchronous online discussion. An additional 20% of students think that one of the disadvantages of the platform is the fact that it constitutes an impersonal way of teaching. Students' comments include the following: "…(this way of teaching) *excludes the dialogue developed when two or more people are in the same physical space", "…the interaction in this instructional approach is more impersonal*".

The debate contrasting face-to-face and online communication is related to students' thoughts on the potential of extending the use of WebCT™ to encompass all stages of the course so that the latter can be offered fully online. 35% of students argued that this is feasible. Among them, 15% stated that support from other information technology tools, such as teleconferencing, is considered necessary for the platform to be implemented successfully in an online course. 45% of students argued that this is not feasible because student-teacher face-to-face interaction is irreplaceable. Among them, 15% of students expressed their concerns regarding the risk of having an e-learning course that will end up being impersonal. It is interesting to note, however, that the vast majority of students (95%) are in favor of implementing internet technology in other courses.

With regards to both research questions of this study, students furthermore identified the strengths and weaknesses of the platform of WebCT™ in terms of its potential use to enhance the development of modeling skills and support collaboration among students. Students identified the following advantages of the platform (the percentage in parenthesis corresponds to the percentage of students who identified each advantage through the written questionnaire provided at the end of the course): effortless electronic submission of assignments (75%), constant communication (70%), 24hour access to the course (65%), familiarization with computer and information technologies (40%), easy access to course materials (35%), reducing costs of transportation and resources e.g. paper (25%) , saving of time (25%), stimulating environment (20%), flexibility/independence of students' chosen working space (20%), instant evaluation and feedback (20%), encouragement for active involvement in the course (10%), facilitation of model construction (10%), access to the teacher's announcements (10%), facilitation of the learning process (5%), access to other students' work (5%), saving assignments (5%), an easy way to comment on the course's content (5%) and flexibility (5%). A blind student who uses a computer at home that "reads" the material to him commented that: *"it was easy to have access to learning materials and to directly submit assignments. It was also easier for me to read the material, since it was in digital form and easier to exchange ideas through synchronous communication*". The last comment reveals an additional advantage of the WebCT™ platform, its capability to accommodate for students with special needs.

Among the disadvantages of the platform identified by students are the following: face-to-face discussions preferred over online interactions (40%), impersonal way of teaching (20%), teacher support preferable via face-to-face interactions (10%), need for independent learning skills (10%), electricity dependency (10%), difficulty in finding an answer to questions (5%), no face-to-face feedback (5%), not very effective interface (5%), more conventional rather than innovative features (5%), need for information technology skills to participate (5%), difficulties in performing experiments (5%) and difficulty in participation if no computer access is present at home (5%). It is interesting to note that even though the question asked that three disadvantages of the platform be named, several students provided either a minimal number, or no disadvantages.

As far as technical difficulties are concerned, it seems that the main difficulty faced by students involved internet connection problems, most probably at home rather than at the university setting. More specifically, a small number of them faced difficulty connecting to WebCT™, participating in synchronous communication, and uploading files. It is important to note that only one student identified a problem related to the platform in particular, when he referred to the overwhelming pace of exchanging messages and comments in the synchronous discussions function of the platform.

Discussion

According to Frank et al. (2002), contemporary distance learning courses may have pedagogical benefits such as active learning, course organization and instant feedback. The need to take advantage of the capabilities offered by VLEs is also emphasized by Silverman (1995). In accordance with recommendations from previous research, the present study constituted an attempt to make the most of the capabilities offered by VLEs in order to enhance the development of modeling skills by pre-service educators. The use of WebCT™ in this study strengthened the connection between natural science teaching and information technology and allowed pre-service teachers to develop skills that are useful and potentially transferable to elementary school. With respect to the first research question of this study, which refers to the use of a VLE to enhance the development of modeling skills, students' views reflect the positive contribution and potential of such an environment to support their learning experience. The blended e-learning approach implemented in the course has been effective, since most students characterized the functions of WebCT™ as useful in resolving their questions regarding constructing and improving models. Students also argued that an element that contributed to the development of modeling skills in a positive way is the fact that they had continuous access to their fellow-students' models through WebCT™. This capability of the VLE allowed students to complete the model-based learning cycle (Constantinou 1999). After the first stage of the model-based learning cycle, namely the initial model construction, students had a chance to exchange ideas and evaluations. This led to model evaluation, revision and refinement, which corresponds to the second stage of this cycle. It is important to note that all students reflected on the added value of the use of the platform in developing models as well as understanding concepts. What is more is the fact that WebCT™ seems to be appropriate and to accommodate for students with special needs, according to a blind student's evaluation.

According to McDermott et al. (2000), currently in effect teacher education programs for students specializing in natural science are not effective and inhibit progress of both students' learning as well as their ability to transfer acquired skills and knowledge. The use of open-ended learning and teaching techniques that are based on internet and communication technologies seems to constitute a promising solution to the problem concerning the failure of traditional teaching methods to promote effective learning (Glenn 2004, Boone & Anders?n 1995, Jaeger 1995). With respect to the second research question of this study, which refers to the use of a VLE to enhance collaboration among students , there is strong indication that the VLE of WebCT™ supported communication, collaboration and mutual support among students, since the latter recognized the online collaboration as an indispensable part of the learning environment. The integration of internet technologies through the use of a VLE in this study showed that contemporary distance learning programs can have a pedagogical benefit in terms of both: a) structuring and organizing the learning process to develop students' understanding of science concepts and b) creating an instructional environment that allows for and promotes students' mutual support in learning through enhancing communication and collaboration. This was made feasible due to the fact that the use of WebCT™ provides a medium for storing, organizing, and reformulating the ideas that are contributed by each group of learners and furthermore provides for and encourages conversation about the problems and projects the students are working on.

This study furthermore showed that there is a number of important considerations in order for a VLE to be used in an effective way. Concerning model development specifically, the combined use of the platform with an internet compatible model construction software program, such as SC, is considered necessary for the effective implementation of the model-based learning cycle. This process became feasible due to the fact that sharing and viewing SC files through the internet is fully compatible with web-browsers. We suggest that the process of model deployment was practically made possible due to the combined use of SC and WebCT ^{TM}.

Several other considerations apply to the use of this environment. One of these refers to the fact that the capabilities of online synchronous or asynchronous discussion forums should be employed in an attempt to maximize the benefits of a virtual environment to learning. Students' views support the idea that there is an added value in the use of these online communication tools. In particular, these encourage a student's written reflection on his/her personal views on understanding concepts and draw attention on the way this understanding changes through meaningful interactions with other learners, the instructional material or the teacher.

Collaboration in a virtual learning situation involves exchanging, negotiating and critiquing ideas for the purpose of building new, more refined knowledge. Another consideration that applies to both research questions refers to the fact that this collaborative process is facilitated through specific features of the platform: the ones that enable uploading information to be shared with all learners, posting evaluations that are accessible by all, offering and receiving online feedback during the learning process, clarifying concepts through negotiating meaning and actively participating in the repetitive stages of model deployment in order for a successful model to be achieved.

The last consideration refers to the use of a blended elearning approach as opposed to both a traditional instructional approach and an entirely online learning approach. The traditional instructional approach in higher education is in most cases teacher-centered, since it derives from a transmissive conception of learning. Such a conception of learning assumes that knowledge can be transferred from teachers or transmitted by technologies and acquired by learners. If such an approach employs technology, its use is often limited to presentational tools for the instructor's lectures and does not refer to the implementation of technology as a learning tool. An entirely online learning approach on the other hand does not include any face-to-face communication and requires that a student be a disciplined independent learner with strong motivation and self-regulation skills. On the contrary, the blended e-learning approach implemented in this study, which was based on a constructivist conception of learning, maximized the benefits of both approaches. "Constructivist conceptions of learning assume that knowledge is individually and socially constructed by learners based on their interpretations of experiences in the world. Since knowledge cannot be transmitted, instruction should consist of experiences that facilitate knowledge construction" (Jonassen 1999, p.217). Hence, the approach used in this study was student-centered, it involved the implementation of technology as a learning tool used for both students' cognitive development and the enhancement of collaboration among them and controlled for the disadvantages of distance learning that result from the lack of instant communication, face-to-face support and timely feedback between the teacher and the students. This research also showed that the blended e-learning approach serves the needs of the students, since they argued against the fully online implementation of university courses. As an institution-wide implication of this study with regards to policy making, a blended e-learning approach may be viewed as a transitional phase for a university course that may eventually be offered fully online.

This study furthermore revealed some of the disadvantages and weaknesses of the use of the platform. A concern is that the educator -or the students- may not respond promptly to discussions or questions in the asynchronous discussions part of the platform. A comment for improvement refers to the capability of sending an email notification every time a new message is posted to the platform to keep the learners informed and up to date. Another concern refers to the fact that at the present stage, when the educator uploads files to the platform, a list is created, which often becomes fairly long and therefore dysfunctional. It would be best if a hierarchical structure that includes sections and subsections could be imposed to this listing feature in order to enhance organization, structure and presentation of information. As far as the instructor's control over the platform's functions is concerned, the educator cannot interfere in the number of students who have to submit an assignment. A last comment for improvement refers to enhancing the platform's capability to accommodate for students' individual needs, by providing the capability of having diverse assignments targeted at different individuals.

This study showed that a VLE seems to be of great importance for the application of the learning cycle for the development of modeling skills of pre-service teachers. It is important, however, to conduct further research to

verify whether its effectiveness is prominent with regards to the development of other reasoning and thinking skills, such as control and manipulation of variables, analogical reasoning, probabilities and scientific method skills (measurement, observation, construction of operational definitions etc).

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