Stagecast Creator™ and Webct™: An integrated use of computer programming and a virtual learning environment for developing modelling skills

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STAGECAST CREATOR ™ AND WEBCT ™: AN INTEGRATED USE OF COMPUTER PROGRAMMING AND A VIRTUAL LEARNING ENVIRONMENT FOR DEVELOPING MODELLING SKILLS

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ABSTRACT
This paper reports on an effort to use Stagecast Creator™ as a means for developing modelling skills among undergraduate students taking an introductory course in science that took place in a virtual learning environment (WebCT™). An inquiry-based curriculum was implemented, which guided students working in small groups to collect and study moon observations and construct a series of successive models of the moon phases using Stagecast Creator™. Students' reflective journals and reports of synchronous discussions were the means for collecting data. The findings show that the WebCT™ platform supported the on-line collaboration among students in the course that was used to help them improve their models through the use of Stagecast Creator™. 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 results also suggest that students believed that the on-line collaboration supported their learning growth as well as the process of developing modelling skills. Students found it extremely fruitful to exchange ideas with other groups, to read and make suggestions for model improvements and to collaborate with almost all students in the course – which would have been impossible without the on-line collaboration tool. Collaboration in learning situations like the one presented in this paper involves exchanging, negotiating and critiquing ideas for the purpose of building new, more refined knowledge. This collaborative process became feasible due to the fact that sharing and viewing Stagecast Creator™ 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 Stagecast Creator™ and WebCT™.

KEYWORDS
Modelling, Collaboration, Teachers Education, On-line learning.

INTRODUCTION

A widely repeated finding in research in science education pertains to students' failure to attain a functional understanding of concepts in physical sciences and to develop the reasoning skills necessary to transfer and apply this understanding in everyday situations (McDermott, 1991; McDermott and Shaffer, 1992). Research findings demonstrate that even students studying at prestigious universities often fail to exhibit fundamental understanding with respect to basic concepts and fairly easy physical systems (Mazur and Wheeler, 2000). Modelling is a reasoning skill which refers to the development of the ability to construct and improve models

(Constantinou, 1999; Papadouris and Constantinou, 2001). Reasoning skills are considered to be one of the constituent components of Learning in Physics, which is viewed as a complex and multidimensional enterprise. Learning in Physics is analyzed into conceptual understanding, experiences, epistemological awareness, processes, reasoning skills and attitudes. Moreover, according to AAAS (1993) and NRC (1996) science education improvement should be achieved through *situated instruction* in a context that highlights the importance of helping students to reason with others in order to generate and make sense of observations and data (Hogan, 1999), facilitation of learners to *share ideas and information*, and *encouragement* of students to explore questions in order to develop in-depth understandings of science as a process of inquiry (Crawford et al., 1999). Finally, several researchers emphasize the critical role that technology can play in restructuring education, through expressing the need for the utilization of new technologies (Wang and Holthaus, 1997) and the incorporation of technological tools for the enrichment and support of teaching and learning (NRC, 1996; European Commission, 2000).

To address the need arising from the lack of modelling skills in teacher-education programs, the present study focuses on the development of a curriculum which implements Stagecast Creator™ for helping pre-service teachers to construct modelling skills. Moreover, the study seeks to address the technological need of using virtual learning environments in teacher-education, through the implementation of a blended e-learning approach in WebCT™. The present study aims to address the following research questions: a) in what way can a virtual learning environment enhance collaboration and modelling skills of pre-service educators in natural sciences, and b) in what way can Stagecast Creator™ support collaboration and the development of modelling skills of pre-service educators in natural sciences?

LITERATURE REVIEW

Modelling

This study aims at the development of pre-service teachers' modelling skills as a scientific process and as an instructional schema through the use of Stagecast Creator™. According to Constantinou (1999) and Papadouris and Constantinou (2001) *modelling* is a reasoning skill, which refers to the development of the ability to construct and improve models.

The modelling approach to learning is iterative in that it involves continuous comparison of the model with the reference physical system, also known as *the model-based learning cycle* (figure 1). 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, modelling could be considered as a backbone for understanding in natural sciences (Constantinou 1999, Papadouris and Constantinou 2001, Chapman 2000, Gilbert 1993, Gilbert 1995, Gilbert and Boutler 1998). Moreover, it is important to state that modelling is not a part of either the elementary or the secondary education (Penner et al. 1997).

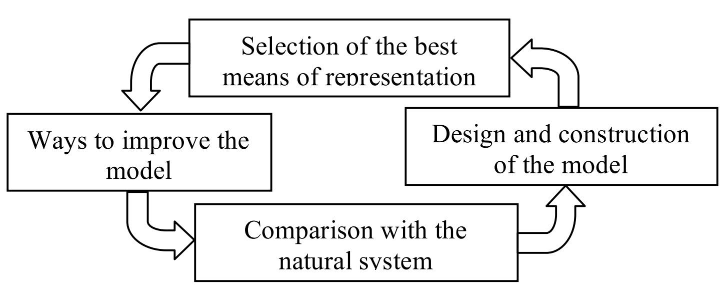

Figure 1. The model-based learning cycle

Stagecast Creator™

Stagecast Creator™ (http://www.stagecast.com/) is a computer-based programming environment that was designed for young learners building their own microworlds. It is based on a movie metaphor, where users create a cast of characters who interact and move within a simulation microworld in Stagecast Creator™. It embodies some important programming concepts, such as conditional execution, subroutines, iteration, and variables, but it is at the same time an ideal tool for constructing models in natural sciences. Generally, students work in a fully graphical environment, which allows creation of characters to which they apply rules of behavior (figure 2)

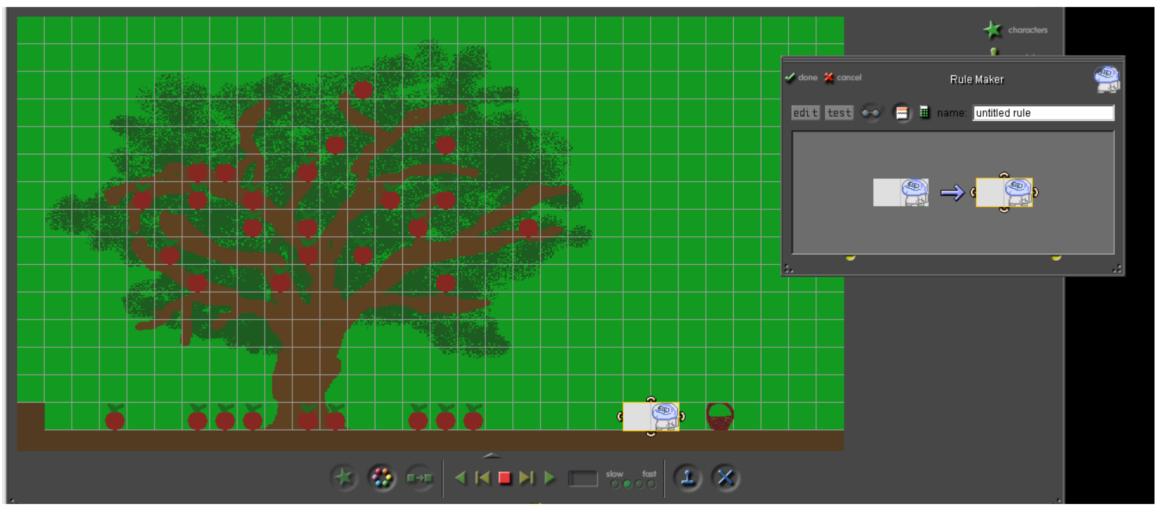

Figure 2. The interface of Stagecast Creator™: applying rules to a character

Collaboration

Traditionally, the learning experience is seen as individual and unique to each learner and a face-to-face activity, which involves tutors in charge of troubleshooting, that is, solving problems as learners encounter them. However, research indicates that learning occurs when seen as a continuous collaboration between the learner and what surrounds him/her. As such, collaboration is seen as a result of successful interaction between parties, especially when the participants can agree on the majority of issues, or agree to disagree.

Computer-supported collaborative learning (CSCL) has been considered for support of collaborative learning in a web-based environment (Jonassen, 1999). 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 virtual learning environment 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). Collaboration provides an excellent metaphor and venue for conjoint action towards mutually beneficial solution. Consequently, collaboration in learning communities through the use of virtual learning environments involves students exchanging, negotiating and critiquing ideas for the purpose of building new knowledge, distributing knowledge, and gaining social responsibility (Magnusson and Palinscar, 1995).

According to Kayama and Okamoto (2004) there are two approaches for developing CSCL: one which emphasizes the interactions between learners, and one which emphasizes the efficiency and the certainty of knowledge acquisition. The present research utilized the first approach in both a local and a global level. The first level refers to the collaboration which occurs among students within a group (local collaboration) and the second level refers to the collaboration between two or more groups of students (global collaboration) that work on the same knowledge domain.

METHODOLOGY

The research was conducted via a blended e-learning approach, which combines the virtual learning environment of WebCT™ with face-to-face instruction[1]. An inquiry-oriented curriculum was implemented, according to which students worked in small groups[2] to collect and study moon observations and construct a series of successive models of the moon phases using Stagecast Creator™. 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 Stagecast Creator™ and concept maps, (c) *assessment tests*, (d) *synchronous discussions,* through which 9 one-hour discussions on given subjects 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 material developed by other students for assessing and refining it.

Sample

The sample of the research consisted of twenty fourth-year pre-service teachers who attended the course *EDU477: Applications of Information Technology in the Teaching of Science at Elementary School* at the University of Cyprus, during the spring semester of 2004.

Means of Data Collection

Students completed *reflective journals* after each class. Reflective journals are 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. Students' reflective journals provided data on students' thoughts on both modelling skills and collaboration in virtual learning environments.

Another means of data collection used was 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. Synchronous discussions revolved around the critique of current research on modelling skills. The first synchronous discussion took place with all twenty students; however due to coordination problems, students were

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[1] WebCT™ is a flexible web-based learning system that enables students and teachers to participate in interactive learning and teaching (Ebenezer et al., 2003).

[2] 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.

randomly divided into two groups of ten, which alternately participated in the eight discussions that followed.

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 and Corbin 1998). Data from the synchronous discussions were analyzed also in three stages. During the first stage, a critical reading of the written copies of the discussions 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.

RESULTS

Support of Collaboration

With respect to the first research question of the study, which refers to the use of a virtual learning environment to enhance collaboration among students and between the students and teacher, there is strong indication that the environment of WebCT™ helped in communication as well as collaboration and mutual support among students both in a local and a global level. One student stated that:

> "*using the on-line discussion forum, I provided my fellow students of other groups 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.*"

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 virtual learning environment:

> "*…another positive thing is the fact that it was easier for us to accept comments about our model because they come 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™, the collaboration 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 more than that, it was real collaboration, 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 the members of my group and within all the six groups…".*

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.

Enhancement of Modelling Skills

Both research questions relate to the support of collaboration and the enhancement of modelling skills by pre-service educators. With respect to the second half of both questions, 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 modelling skills. Multivariate Analysis of Variance (Repeated Measures) for all pre- and post-tests indicated significant differences in all aspects[3] of modelling skills, such as the ability to construct [$F(1, 19)=33.876$, $p<0.01$, $\eta^2=0.641$], test and improve models [$F(1, 19)= 58.188$, $p<0.01$, $\eta^2=0.754$], extract important information from a model [$F(1, 19)=84.444$, $p<0.01$, $\eta^2=0.816$], compare and contrast different models of the same phenomenon [$F(1, 19)=31.792$, $p<0.01$, $\eta^2=0.616$], and appreciate the usefulness of models [$F(1, 19)=47.598$, $p<0.01$, $\eta^2=0.715$][4].

Students' thoughts on the use, value and potential of a virtual learning environment to support the development of modelling 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 modelling 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…*"

[3] For the purposes of this study we identified 5 critical aspects of modelling skills: (a) model construction, (b) model deployment, (c) extraction of important information from a model, (d) comparison of different models of the same phenomenon, and (e) appreciation of the usefulness of models

[4] Interested readers may contact the researchers for access to the MANOVA analysis.

Students' comments on the model construction process implemented in the course were also 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*".
>
> "*The 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 modelling skills…overall it was an effective process*"

Other students expressed some interesting ideas regarding the modelling tool. More specifically, some students commented on the advantages of programming with Stagecast Creator™. A student stated that:

> *"…my enthusiasm grew bigger when I realized that Stagecast allows great flexibility to the user. Unlike other software, it does not pose constraints regarding the kind of models a user can construct. Moreover, the totally graphical way of programming, and the fact that the users don't have to use programming languages makes Stagecast Creator™ different comparing to traditional programming software like Logo for mathematics etc. In my opinion, this fact proves that it was designed following educational and not just computer programming standards."*

Another student stated:

> *"When constructing our model, we had to choose between two totally different mental models of the phenomenon: (a) the moon (in Stagecast Creator™) should spin around the earth, and (b) the earth should spin around its axis while the moon should stay still. We decided to do the second. It is cool that Stagecast supported that, because we could not really understand the first mental model."*

Apart from the advantages of the software, some students identified the possible uses of Stagecast Creator™ in teaching natural sciences:

(a) Teacher prepares interactive simulations in order for the students to use them. A student stated that:

> *"Students (at the elementary level) will gain a lot when using Stagecast Creator™. Even though it is hard enough for the students to use Stagecast to construct a model, they could use a constructed simulation of a natural phenomenon with which they will interact and observe the results of their actions."*

(b) Students construct their own models about a phenomenon. Here are some characteristic extracts:

> *"…it is easy for the children to use Stagecast Creator™ to construct their own sims-models. Given that the teacher is well prepared, children could by playing with the software discover learning in the frame of Natural Science"*
>
> *"…I realized that this software is especially useful when used in the upper level of the elementary school. By using Stagecast Creator™ students could construct their own rules and consequently their own models about a given phenomenon. Moreover, they could change the rules of given models to check the changes caused to the phenomenon under study."*

Support of Collaboration and Enhancement of Modelling Skills

Finally, many students commented on the positive contribution of Stagecast Creator™ to the double process of model construction and collaboration which aimed to provide feedback for improving the model (model deployment). They realized that this double process was made feasible due to the fact that the modelling tool they used was Stagecast Creator™, as sharing and viewing Stagecast Creator™ files through the internet is fully compatible with web-browsers. Here are two examples of students' thoughts on this issue:

> *«…the fact that the models of all groups were placed in a common place (on WebCT™) in which all students had access was the main advantage of this process. Moreover it is important to note that had the models not been constructed on Stagecast Creator™, this process would be really difficult to be completed. If for example one would choose to make his model using real material, or draw it on paper etc, the first step of the process, exchanging models, would have been really not feasible."*

> *"…I believe that the software we used was a crucial factor to the success of the process of constructing and deploying our model. Not only it provided a more realistic way of presenting and studying the phenomenon, comparing for example with a painting or just a verbal explanation of the phenomenon, but it also helped to the process of model refinement as Stagecast Creator™ is compatible with the internet."*

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 virtual learning environments 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 virtual learning environments in order to enhance the development of modelling skills by pre-service educators.

Other researchers emphasize the need to introduce modelling and programming software in the teaching of natural sciences (Sabelli, 1994; Stratford, 1997; Stratford et al., 1998; Barab et al. 1998; Barab et al, 2000). The potential provided by Stagecast Creator™ regarding modelling development was used in the frame of this study aiming at the development of the ability to construct and deploy models. The use of WebCT™ and Stagecast Creator™ 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 virtual learning environment to enhance the development of modelling skills and support collaboration, 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 modelling skills in a positive way is the fact that they had continuous access to their fellow-students' models through WebCT™. This capability of the virtual learning environment 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 the model-based learning 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), current teacher-education programs in natural science are not effective – they inhibit progress of both students' learning and 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 and Anderson, 1995; Jaeger, 1995). The integration of internet technologies through the use of a virtual learning environment 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.

With respect to the second research question of this study, which refers to the use of Stagecast Creator™ to enhance collaboration and promote the development of modelling skills, there is strong indication that the integrated use of the two tools both supported communication, collaboration and mutual support among students and provided a ground basis for students to complete the learning cycle of modelling The combined use of the platform with an internet compatible model construction software program, Stagecast Creator™, 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 Stagecast Creator™ 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 Stagecast Creator™ and WebCT™.

Finally, the last consideration refers to the use of a blended e-learning approach as opposed to both a traditional instructional approach and an entirely on-line 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 on-line 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 maximized the benefits of both approaches since it was based on a constructivist conception of learning. "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 on-line implementation of university courses. Recognizing that the option of offering a course fully on-line or implementing a blended e-learning approach is available to the instructor, a blended e-learning approach may be viewed as a transitional phase for a university course that will eventually be offered fully on-line.

This study showed that a virtual learning environment seems to be of great importance for the application of the learning cycle for the development of modelling 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 definition etc).

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