The use of a Course Management System for the investigation of the relationship between collaboration and students' achievement in a course of Physics

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Abstracts

English Abstract

In this paper we investigate the relationship between task structure, collaborative group interactions and students' achievement when a Course Management System is used.

For this purpose we use the Moodle course Management System (http://www.moodle.org) during a postgraduate course titled "the use of ICT in Physics". The choice of the particular software was made as it promotes interaction which contributes to incremental learning. The aim was to examine the relationship between task structure, collaborative group interactions and students' performance when the moodle platform is used within a constructivist approach to learning. In addition to Moodle, we use a networked application, created by the author (called Science Search), for the collection and classification of relevant web pages needed by the students during their work.

Finally, a set of indicators were used as a measure of interactivity in the group. Results from our study suggest that groups using the platform have better performance and that the competencies relating to group problem orientation and generation of alternative solutions are more crucial for student's achievement.

Greek Abstract

Στην εργασία αυτή διερευνούμε τη σχέση ανάμεσα στο τύπο του καθήκοντος, την αλληλεπίδραση στη διάρκεια της συνεργατικής μάθησης και τη γνωστική επίδοση των μαθητών όταν χρησιμοποιούνται συστήματα διαχείρισης της μάθησης.

Για το σκοπό αυτό χρησιμοποιήσαμε τη πλατφόρμα Moodle (http://www.moodle.org) κατά τη διάρκεια ενός μεταπτυχιακού μαθήματος με τίτλο "η χρήση των ΤΠΕ στη Φυσική". Η επιλογή της συγκεκριμένης πλατφόρμας έγινε γιατί θεωρούμε ότι προάγει τη συνεργατική και επαυξητική μάθηση.

Ο στόχος μας ήταν να εξετάσουμε τη σχέση ανάμεσα στο τύπο του καθήκοντος , την αλληλεπίδραση στη συνεργατική μάθηση και τη γνωστική επίδοση όταν χρησιμοποιείται η πλατφόρμα moodle μέσα σε εποικοδομητικό περιβάλλον.

Επιπρόσθετα με τη πλατφόρμα χρησιμοποιήθηκε και ένα δικτυακό εργαλείο (το Science Search) που δημιουργήθηκε από τον συγγραφέα με σκοπό την ταξινόμηση των δικτυακών τόπων που χρησιμοποιήθηκαν από τους φοιτητές.

Τέλος, χρησιμοποιήθηκαν δείκτες για τη μέτρηση της αλληλεπίδρασης μέσα στην ομάδα. Τα αποτελέσματα της έρευνας δείχνουν ότι η χρήση της πλατφόρμας ευνοεί τη γνωστική επίδοση και ότι οι δείκτες που σχετίζονται με τον "προσανατολισμό στο πρόβλημα" και την "παραγωγή εναλλακτικών ιδεών" είναι οι δείκτες που συνεισφέρουν περισσότερο στη γνωστική επίδοση.

Key words

Collaborative Learning, ICT, Course Management, Physics

Introduction

Collaboration is not a static but a dynamic social process that goes well beyond coordination of separate efforts (Adams & Hamm, 1990).It actually involves shared awareness and understanding as well as constructions through interactions among peers.

Basic issues of group dynamics that are critical to the success of any collaborative learning project are social solidarity, joint responsibility for reaching group goals, active participation and student-to-student support (Hamm & Adams, 1992, Shrage, 1990).

The aim of this article is to investigate the influence that task structure has on group dynamics and its effect on cognitive performance of students.

Cohen (1994) identifies two dimensions of collaborative group work tasks that impact group interactions:

a. number of solutions (variable-answer or single-answer) and
b. cooperation (true-group or individual-helping).

Single-answer tasks have a unique, correct answer while variable-answer tasks provide the chances for different correct answers with a variety of routes to reach the correct solution (Chizhik, 2001).The design of computer-supported group-based learning is based on subjective decisions regarding tasks, pedagogy and technology and collaborative learning. The critical variables in the interaction of such systems are essentially the relationship(s) between the different outcomes and group (expected or unexpected) interactions as well as the crucial aspects that affect interaction, like task characteristics, level and kind of guidance, design interface, computer support etc.

Another critical element of collaborative environments is the fact that the concept of cognitive development includes the notion that language (as a tool for organisation and reorganization) affords individuals a means of developing their ideas (Vygotsky, 1962).

In this context, cooperation in learning environments could provide the means for explanations and expressions of thoughts as well as active participation. The motivation of computer use for pedagogical practices (communication and collaboration) is based to a large extent on constructivism. In this framework, the instructional principles associated with this emergence include requiring learners to:

a. solve problems,
b. work together,
c. examine problems from multiple perspectives,
d. become responsible for their own learning process and
e. become aware of their role in the instructional process (which is actually a metacognitive skill)

(Reiser 2001, Strijbos et.al 2004).

Group Based Learning Environments are also widely used to resemble authentic working processes (Bastiaens & Martens, 2000, Milosevic et.al, 2006).

Another major issue regarding these environments is the relationship between the quality of interaction and the learning outcomes, the choice of research methodology, the choice of the unit of analysis as well as the task or work methods that should be used. (Van Berlo, 2000, Lipponen, 2001).

In this article a framework is proposed, which focuses on the elicitation of interaction when open source platforms are implemented. Using this platform, we created a number of activities and examined their impact on the quality of cooperation in accordance with variable-and-single answer tasks.

In addition to the Moodle platform, we employed a network tool created by the author of this paper, to be used by students in the classification of websites they searched and used during the project.

The level of collaboration of the students was measured using specific indicators. The indicators used to measure the activity in the group were: Problem Orientation, Establishing of Criteria, Generating of Alternatives, Solution Evaluation, Establishing Operating Procedures (Swigger et al 1994).

These indicators allow us to measure the degree of cooperative behaviour among the students. For example, a group's competency score for Generation of Alternatives is obtained by examining the data recorded for the percentage of times that students exchanged ideas about Alternatives using the chat facility for the explanation of a phenomenon. The correlations of the five indicators with the cognitive performance and task characteristics are presented in the results of the research.

Virtual Learning Environments

Virtual learning environment (VLE) is an integrated software system designed to facilitate teachers and students in the management and administration of educational content. The system can track the learners' progress, which can be monitored by both teachers and learners and can be used for distance education, to supplement the face-to-face classroom as well as blended learning. VLEs are defined as "computer-based environments that are relatively open systems, allowing interactions and knowledge sharing with other participants and instructors" and providing access to a wide range of resources (Wilson, 1996). The value of a VLE is to fully bring out the characteristics of both "Learning Any Where" and "Learning Any Time," and the purpose of a VLE is to emphasize ,for example, diffuse thinking models, diverse viewpoints, independent thinking etc.(Chou & Liu, 2005).

Moodle is an open source e-learning platform (also known as a Course Management System (CMS) or Virtual Learning Environment (VLE)

Figure 1. Moodle Learning Management System with a navigation system and online community building tools

Moodle is designed to help educators create online courses with opportunities for rich interaction. Its open source license and modular design means that many people can develop additional functionality, and development is undertaken by a globally diffuse network of commercial and non-commercial users, spearheaded by the Moodle company based in Perth, Western Australia. Moodle runs without modification on Unix, Linux, FreeBSD, Windows, Mac OS X, NetWare and any other systems that support PHP, including most web host providers. The underlying principle of Moodle corresponds to a constructivist and social constructionist approach to education, emphasising that learners (and not just teachers) can contribute to the educational material in many ways. Moodle's features reflect this in various design aspects, such as making it possible for students to comment on entries in a database (or even to contribute entries themselves), or to work collaboratively in a Wiki.

Among others, the advantages of using Moodle are:

- The instructor has full control of all settings of a particular course
- There is a flexible table of activities related to a particular subject – Discussion panels, journals, questions, sources, options, research.
- Recent changes to the subject since last recorded login may be presented in the homepage of that subject.
- Most textboxes may be changed using a WYSIWYG HTML

The Science Search Application

Science Search is an Internet application created by the author which has the role of a scientific addresses list. That is, it creates a data base with listed web sites where the user can:

a. search for information in relation to a variety of subjects,
b. be informed about the most updated results of his/her search,
c. review the previous contents of his/her listed websites in order to compare the contents of a chosen site at different times,
d. enrich the websites list according to his/her own interests.

It is worth noting here that this application is independent of the particular subjects and is therefore not limited to the Natural Sciences, but can be extended to every cognitive field. In other words, Science Search is an Internet program which permits keeping up with the material published on web sites that the user has selected and filing websites of interest as well as their content, at regular time intervals whereas the application itself is controlled through the Internet by means of a simple browser (Psycharis, 2007). This programme's advantage is its ability to create a data base while it also offers the opportunity of classification according to the users' choices.

Science Search work environment: Upon entering the application, the "authentication process" screen appears (Figure 2) where the user enters his/her personal identifier and password. The "Entrance" function is selected afterwards, and the system presents the user's central personal screen after having checked the given data. In order to see the listed websites, the user selects the function "view the websites" which leads to the required list. Here, the user can simply enter a new website, work on a previously existing one by altering its data or delete one that is no longer of interest.

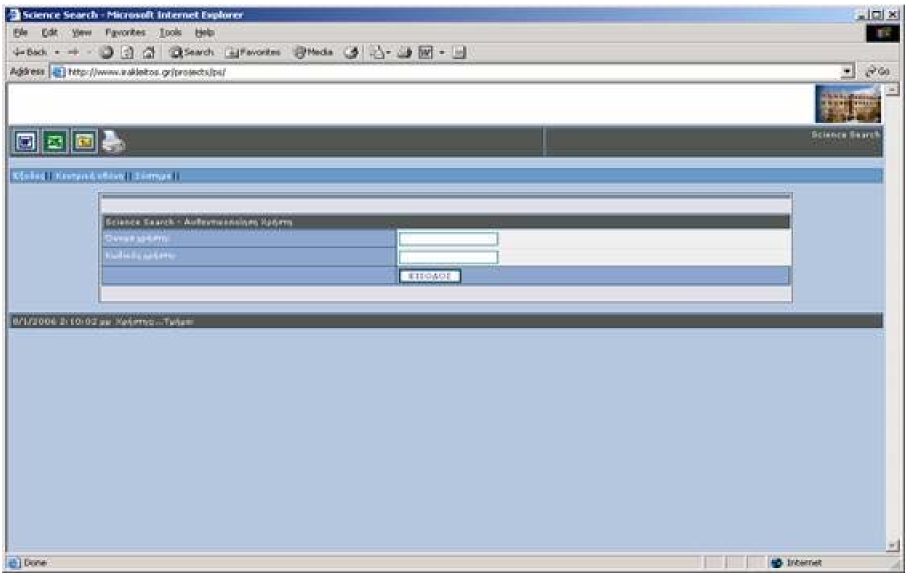

Figure 2. The initial interface of the system (developed in the Greek Language)

In the interface of the application there is an additional function "Check" which controls the website's content and works as follows:

- If the content has not been altered, the latest update of the website is presented.
- If the content has been altered, the new edition is listed on the data base, we are informed about the latest change and the new date of change is listed.

When the student/teacher wishes to end the programme, the function "exit" on the upper left part of the screen has to be selected and the programme ends.

The Research Methodology

There were 12 postgraduate participants and everyone attended the course "ICT and Didactics in Natural Sciences". Four (4) students were primary school teachers, three (3) were ICT programmers, two (2) engineers and three (3) physicists.

All students had some understanding of the topics (Waves, Mechanics) from their undergraduate studies but, according to comments during the discussion period at the beginning of the session, some had not been taught these topics using ICT.

Out of the 12 students, 6 did not participate using the Moodle platform, but instead followed the traditional teaching method with the following distinction: Students initially talked about the procedure with the Instructor and the splitting of groups occurred voluntarily. The splitting was as follows:

Team A (3 students) followed a traditional teaching approach while, during the course, the assignments set by the instructor were of "single answer tasks".

Team B (3 students) followed a traditional teaching approach while, during the course, the assignments set by the instructor were of "variable answer tasks".

Team C (3 students) followed a teaching approach using the platform, while during the course, the assignments set by the instructor were of "single answer tasks".

Team D (3 students) followed a teaching approach using the platform, while during the course, the assignments set by the instructor were of "variable answer tasks".

At the end of the "experiment", which lasted a total of 3 months, all students participated in an examination with questions of an open nature, while, for teams C and D, the degree of collaboration was measured using the 5 indicators mentioned above.

In teams C and D, the instructor used the platform and taught the various topics using simulations, animations etc, while students were asked to participate in the process using the forum of the moodle.

For groups A and B, the instructor followed the procedure outlined below:

The instructor presented the material in his lectures in the traditional face-to-face fashion while students had to collaborate using sources from the library, the Internet etc

For the teaching process of groups C and D, the process was as follows:

The instructor initially used the Moodle environment and uploaded material relevant to waves (motion, dynamics in the plane, interference, diffraction) while applying the stages of constructivism during the teaching of these topics which lasted 3 months (36 contact hours)

For this reason, the instructor developed educational activities containing animation, video, educational games, reports, questionnaires, pictures, simulations etc., all of which were uploaded in the Moodle environment. Special attention was paid to Java and Flash Animation due to their ability to change the parameters of a particular problem and their ability to display the results on the user's screen.

Furthermore, he created a webpage using the ASP technology, where postgraduate students had the opportunity to be informed by the instructor on the current topics they had to do, to discuss with each other about issues on Physics relative to Mechanics and Waves, and to create working plans on the specific topics covered by the instructor. The tool Science Search tool was implemented as a link to the web page. The instructor demonstrated how to use this tool and uploaded websites with topics relevant to waves.

At every stage of the process the instructor used elements from the training material existed in the webpage and from time to time he tested the URL addresses of the Science Search to investigate if the material of some WebPages included in the database of the Science Search has changed

At the engagement phase, the instructor presented java applications and flash animations to trigger students' interest.

During the explanation phase, students began to put the abstract experience through which they had gone into a communicable form and students started to analyze the data from different graphs provided by the instructor.

In addition, students encouraged to participate in the forum of the platform to discuss issues presented in the class and ask questions for further help.

During the elaboration phase, students expanded on the concepts they had learnt, made connections to other related concepts and applied their understandings to the world around them to the so called authentic-real life problems. The instructor presented pictures, animation and video of phenomena of the real world related to waves and asked students to enter data from simulations to excel sheets to plot graphs (the excel sheets were prepared by the instructor) in order to verify, for example, the probability amplitude of the two sources for the double slit experiment.

Finally the instructor encouraged the students to participate in the forum of the platform to discuss the different ways they used the material provided, to discuss on the different misconceptions they had before the course and –more importantly- to collaborate in order to present their results on certain problems asked by the instructor.

Furthermore, the instructor asked students to discuss in the forum the reasons for changing their conceptions on certain terms and explanations regarding different issues and concepts involved in the thematic units under consideration. During the course, students of Group C were involved in single –answer tasks while students of Group D were involved in variable –answer tasks.

For example for group D students had to investigate the function of velocity v(t) during the landing of a plane , to construct the function and to create a small program in Interactive Physics or Modellus to simulate the motion of the plane during landing.

In contrast, students of group C had the function, i.e. $v(t) = 50 + 50\exp(-0,5t)m/s$

and they had to use the questionnaire provided by the instructor to solve problems related to that using the material provided in the Moodle environment, while they had as a duty to construct small software programs in Interactive Physics or Modellus to simulate the motion.

For the Waves one variable answer task was to find data for stars and to use tables and the diffraction pattern to calculate the distance between stars.

During the process all students of groups C, D used the software material provided by the platform.

Furthermore, students were asked to search for and find material (animation, video, simulations etc) and to upload this on the Moodle platform as well as to upload the websites on Science Search.

Towards the end of the lesson, students of groups C,D were asked to present a constructivist model of teaching using the material of the platform similar to the way the instructor presented during the course. For the group splitting, it was decided that each of groups C and D should have a postgraduate student with a relatively advanced knowledge of ICT.

After the end of the procedure, the instructor analysed the platform's log files with the help of another two people belonging to the Natural Sciences Laboratory, in order to collect the data for the use of the indicators relative to the level of collaboration.

Finally, all students participated in the exam consisting of 20 open-nature questions.

Results

The two main research questions underlying this investigation were: (1) Did groups interacting with the Moodle environment perform equally well as the groups who used a face-to-face technique? And (2) in terms of specific performance indicators, what are the traits of those groups who were more successful in the Moodle environment (i.e., What kinds of groups did well in the computer-aided environment)? The data source for the first question corresponded to students' scores for the specific test. The data sources corresponding to the second question were detailed computer history data of all group actions. These data were subsequently used in computing values for the performance indicators for each group.

Table 1. Scores of groups

Group A	34%
Group B	39%
Group C	59%
Group D	70%

Applying a t-test on the data, it showed that the difference in scores was significant at $p< .001$.

The indicators allowed us to measure the degree of cooperative behaviour among the students and are counts of different types of actions that a group performs while using Moodle. For example, a group's competency score for Generation of Alternatives is obtained by examining the data recorded for the percentage of times the platform was used, the number of different interactions that occurred while this tool was used relative to the alternative ideas for the study of a process or a phenomenon and the number of modifications made to the items in this tool. The correlations of the five indicators with students' achievement scores are presented in Tables 2, 3, 4, 5. From these data, it is apparent that the indicators relating to problem orientation and generation of alternatives were the most highly correlated with successful cooperation in this environment.

Table 2. Correlation between Achievement of Students and Network Indicators-Group A

	Problem Orientation	Establishing of Criteria	Generating of Alternatives	Solution Evaluation	Establishing Operating Procedures
Achievement of Students	0.15	0.10	0.20	0.10	0.10

Table 3. Correlation between Achievement of Students and Network Indicators-Group B

	Problem Orientation	Establishing of Criteria	Generating of Alternatives	Solution Evaluation	Establishing Operating Procedures
Achievement of Students	0.20	0.10	0.25	0.10	0.10

Table 4. Correlation between Achievement of Students and Network Indicators-Group C

	Problem Orientation	Establishing of Criteria	Generating of Alternatives	Solution Evaluation	Establishing Operating Procedures
Achievement of Students	0.50	0.15	0.60	0.15	0.15

Table 5. Correlation between Achievement of Students and Network Indicators-Group D

	Problem Orientation	Establishing of Criteria	Generating of Alternatives	Solution Evaluation	Establishing Operating Procedures
Achievement of Students	0.65	0.20	0.70	0.30	0.15

Students of groups C, D worked for about three months to learn how to use the platform, participate in chats, forums etc and search for relevant material on the topics under consideration and to prepare their presentation.

A. Regarding the material produced, groups C, D presented very good material, they uploaded videos, simulations, animations etc on the platform and presented a standard teaching approach in the framework of the learning theory of constructivism.
B. Students with single answer tasks (C) commented that cooperation began once discussion on the topic had commenced. They also commented that they used the forum only once a week.
C. Students with variable answer tasks (D) communicated at least 4 times per week and exchanged URLs and training material. They also commented that they wanted more help from the instructor on the contents of the material, while they believed that misconceptions they possessed had been resolved. In addition, they felt the passion of research throughout the task.

Discussion

Research results have revealed that online instruction has led to significantly better results on examinations in solving complicated problems and in perceived learning outcomes (Daugherty & Funke, 1998) and (Hiltz, 1994)

In addition studies regarding the effectiveness of online education found that mastery of course material was equal or superior to that of conventional courses (Hiltz 1994) while student's involvement in e-learning courses increased and in general produced higher satisfaction. Research on the effectiveness of e-learning courses has shown that students' ability to deal with complex problems is improved and levels of interest in the content of the course increased. Hartman et al. (2000) found that in an Asynchronous Learning Network (ALN) course there were lower withdrawal rates and higher success rates. Navarro & Shoemaker (2000) found that online learners learn as well as or better than traditional learners, regardless of gender, ethnicity and academic background and computer skills.

Task-related participation contributes to achievement gains, according to previous research (e.g., Cohen, 1994), while other studies suggest that giving explanations, and not task-related participation, may contribute to achievement gains (e.g., Webb, 1991).

From the results of the research, it appears that students who followed the traditional face-to face teaching process had a lower overall performance than those who followed the process using the platform.

In addition to that, the level of collaboration does not appear to have an influence on their performance, but the indicators Problem Orientation and Generation of Alternatives appear to have a stronger correlation with the cognitive performance. Group D was involved with variable task answers (not only, for example, to explain the motion of oscillation but also to find motions in every day life which obey the equations of motion of oscillation) using the Moodle platform. Members of this group found the whole process quite tiring at the beginning but very fascinating after a couple of months and had the best performance of all groups

The role of ICT in education has changed radically, through its extensive use in schools and the curricula. The latest research approaches have focused on improving computer technology as an educational tool on the one hand, and on exploring collaborating responses and individual beliefs on the other (Johnson, et al 2006; Schubert, S. 2003; Jung I, 2005).

Web based Educational Systems provide the information about the interactions that take place during learning and aim to support learners without being directive (Brusilovsky and Peylo, 2003).

From the results, it appears that the Moodle platform and the material provided plays an important role in the performance of the students and encourages participation in problems with variable answer tasks. Using this platform, we can present ideas, multiply through various modalities and modal combinations providing a means for students to deepen their understanding of the data and ideas presented. Such new representational capabilities may help broaden the framing of "styles" and interrelations among factors such as cognition, effect and perception (Strohecker, 2005) and it seems that Moodle platform favours these factors especially for variable answer tasks.

Computer supported collaborative learning is based on hypothesis that software applications can support processes for knowledge sharing and construction (Paavola et al., 2002). At these processes students are involved in activities, discussion on external representations concepts, ideas, exchange of views etc. (Suthers & Hundhausen, 2002).

Results of our research indicate that the above processes are more supported when variable answer tasks are used during the teaching process while further research is needed to relate the tasks characteristics with the cognitive styles of students.

Science search tool proved to be a serious variable during the process, especially for students of Group D.

Students of this group created a list of web based locations and very often they had to visit these in order to take information. For example they visited sites with data from astronomy in order to collect information about the luminosity of stars, the distance between them etc. The content of these sites change quite often and students were informed –using the Science Search tool- for the updating of the content of the site.

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