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Investigating Computer-Supported Cooperative Learning: Applications for Flexible Learning Environments

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Abstract

The key findings of investigations concerned with e-learning computer systems and the establishment of a technology framework for a new generation of applications are described. The paper initially discusses an e-learning system that incorporates the infrastructure of the Global Campus (GC) programme. It is reviewed in light of four studies on attitudes towards learning, patterns of Virtual Learning Environment (VLE) use, Computer-Assisted Assessment (CAA) and learning tasks and patterns of communication. Finally, a set of guidelines and a technology framework for the classification and the evolution of e-learning applications are proposed.

Keywords

Computer-Assisted Assessment, Computer-Mediated Communication, e-Learning Applications, Virtual Learning Environments

1. Introduction

Strong support for a learner-centred e-learning environment is essential in higher education where learning involves knowledge and skills acquisition. It is in this sector that e-learning is believed to have considerable potential in the near future (Iahad and Dafoulas, 2004b). Initially, the shift from instructor-centred to learner-centred e-learning was the immediate effect of the radical increase in student numbers and the struggle to find a sufficient number of experienced instructors with suitable skills. The instructor inevitably became a facilitator of the overall learning process (Lin and Hsieh, 2001). Additional incentives for the transition towards a learner-centred paradigm are “the appreciation of different learning styles and the need for increased collaboration and communication among learners” (Hobbs, 2002). In that context VLEs emerged, as learning management systems encompassing the functionality of computer-mediated

communications software and on-line methods of delivering course materials (Britain & Liber, 1999).

The successful implementation of an e-learning environment depends on the development of the appropriate infrastructure and the support environment (Iahad et al, 2004). Such an environment must ensure the relevance and quality of the Content, Assessment, Course Management and Communication. In the next sections of this paper a number of studies are presented that attempt to investigate pedagogical, educational and technological aspects of e-learning. The findings of such a holistic approach could establish a solid foundation for identifying the requirements of a new generation of e-learning systems and supporting applications.

This research is applied to an international programme called Global Campus (GC) which uses Web technologies to offer a distance learning mode for both undergraduate and postgraduate degree programmes. These programmes also run in the conventional, face-to-face mode. GC is discussed in detail and its e-learning infrastructure and the underlying model for supporting remote learning is summarized. In the following sections four studies are briefly described and their key findings are presented.

2. The Global Campus Programme

With overseas partners, Middlesex University is involved in an international distance learning project called (GC). Web technologies are used to offer a distance learning mode for both postgraduate and undergraduate degree programmes which also run in the conventional, face-to-face mode. The key objectives of this project are first, to exploit the advantages brought by the development of flexible learning arrangements for home students and second, to efficiently deliver high-quality courses to partner institutions abroad. The GC team had to devise a pedagogy that would facilitate Web-based content delivery and provide adequate support for students who must take

more responsibility for their learning than they would have done in the conventional mode of delivery (Murphy et al, 2001). This section focuses on the GC infrastructure, presents the distance learning model currently adopted and describes the use of a VLE within GC.

2.1 Infrastructure for e-learning

GC was established in May 1999 between the School of Computing Science of Middlesex University (MU) in London and the Regional Information Technology and Software Engineering Centre (RITSEC) in Cairo. The students are supported locally by a learning support centre (LSC). The GC Site Management can be broken down to three activities: (i) providing hotline support and general communications, (ii) creating and maintaining of learning materials and (iii) establishing and running a Virtual Student Office as an interface between distance learning students and the central student offices. The existing system interacts with (i) students and the LSC (ii) course management and link management referred to as Strategic Partnerships and (iii) processes which extend or improve learning materials referred to as Pedagogy and Curriculum.

2.2 Supporting model for remote learning

There was the need from its early stages for GC to establish a pedagogy supporting the learning process. In light of a constructivist approach the I CARE system pioneered at San Diego State University was adopted initially (Hoffman and Ritchie, 1998). The original I CARE system is a five-step instructional model, representing the components Introduce, Connect, Apply, Reflect and Extend. The typical structure of the created e-learning material follows the five steps mentioned above. Recently, the I CARE pedagogical model was replaced by the SCATE model which was deemed more effective based on findings from studies similar to the ones discussed further in this paper (Sadler et al, 2002). The SCATE model has five stages as shown in figure 1. Initially it focuses on the Scope of the module and its learning outcomes. Next it presents Content that is delivered during a particular unit. The following two stages are Activity and Think respectively, and consist of a number of review questions, discussion topics and activities through which students attempt to apply what has been learned to actual case studies. Finally, an Extra stage provides external resources.

2.3 Use of Virtual Learning Environments

Apart from the online version of each module shown in figure 1, students have access to WebCT which offers online quizzes, threaded discussions, frequently asked

questions and other supportive tools. It is the responsibility of the support tutors assisting students during delivery of the learning material. The consequence for tutors is that they take on a facilitator role in the delivery of the modules. The lecturers also must give special attention in the learning materials they produce to 'explicitness' (Murphy et al, 2001). This includes:

- the lucid delineation of the learning outcomes of the unit
- a more precise view of the time and effort requirements of different pieces and types of work
- greater clarity about the nature and scope of assessment

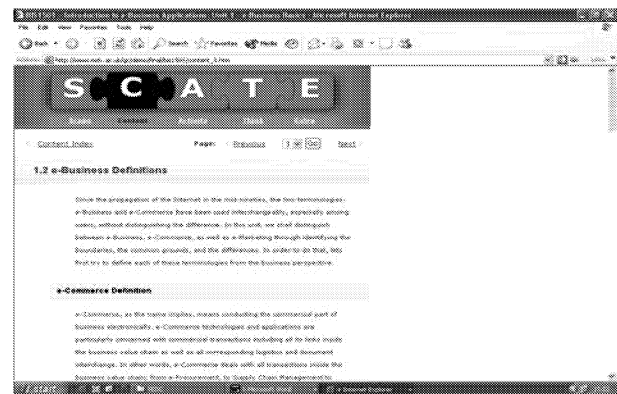


Figure 1: The SCATE pedagogy model

3. Data gathering

The findings from the four following studies are used to suggest a framework for optimising e-learning applications.

3.1 Attitudinal Components of Learning

The first study focused on the attitudinal components of learning. Semi-structured interviews were conducted to provide qualitative data regarding students' learning experience in the GC learning environment. Student attitude and opinion towards the VLE and face to face environment, communication patterns with peers and lecturers and solutions to problems commonly experienced in the setting were investigated. Several students from Hong Kong or Cairo enrolled in a Masters in Computing Science took part in the interviews.

Attitude towards the VLE: This research was designed to investigate not only the student attitude towards WebCT but also the use of the bulletin board. In general, students appreciated the tool for the purpose of receiving information from the lecturer based in the UK but did not see the point of using it for communicating with the local tutor or students (see table 1).

Attitude towards locally held seminar sessions: GC provides a local tutor to give a several hour lecture once per week in the LSC for students enrolled in a module. Sixty-eight percent (68%) of the students interviewed felt that the seminar sessions are useful. The students reported that the skills of the tutor are likely the most important factor in attitude towards the seminar (see table 1).

Communication style with module leaders and peers: Sixty-three percent (63%) of the students were in favour of greater communication with the module leader based in London; some students preferred email while others wanted phone or even face to face contact. Of the students who did not express a desire for increased communication with the module leaders, some claimed that they simply asked questions of the tutor and/or wanted the tutor to be in regular contact with the module leader. Students are satisfied with communication modes and communication frequency they have with their peers. There is, however, a general interest in increasing communication between the module leaders and the students (see table 1).

Student solutions to the problems: Few of the students were able to articulate how they solve the module problems. Some students were more singularly focused, reporting that they would contact the tutor primarily. Others contacted the GC administration and a final respondent discussed concerns with his classmates. What is interesting to note is that none of the students contacted the lecturer for advice in the lecturer's module.

Topic: Attitude towards VLE	
(+)	<ul style="list-style-type: none"> • "useful facility...helpful to some sort of students" • "good place to get the information"
(-)	<ul style="list-style-type: none"> • "am not quite used [to the environment]" • "use phone [with other students because] students in Hong Kong too easy to touch each other"
Topic: Attitude towards seminars	
(+)	<ul style="list-style-type: none"> • "tutor has speciality and can help us" • "idea about how to do things, how to do our studies, and how to look at topics"
(-)	<ul style="list-style-type: none"> • "[I] think why do I need to pay them [the tutor] to read me out the PowerPoint"
Topic: Communication	
(+)	<ul style="list-style-type: none"> • "[when the module leader did come to the classroom] people had a jump in their scores just because of these three days...tremendous merit in the module leader actually establishing contact with the students"
(-)	<ul style="list-style-type: none"> • local instructor...should have a very, very solid level of communication with the module leader to fully understand and be able to convey to the students what the module leader wants"

Table 1: Attitudinal learning components

An increase in contact between the module leaders based on London and the locally based students would

enhance student opinions of the programme. Alternately, as has been suggested previously, it may be useful to have the module leader log-in at a mutually convenient time so that communication may be increased. In general, taking greater advantage of the VLE for the purposes of the lecturer-student contact would enhance attitudes towards the VLE, modules and impressions of the communication channels. Suggested guidelines are:

- Lecturers should log-in to the WebCT environment at specific times and respond directly to students on module topics.
- Use the VLE to engage students in discussions with the administrative components GC so that concerns may be addressed (e.g., timing of exams, questions regarding log-in).
- Facilitate more frequent contact between lecturers and tutors so that students feel the tutor is regularly in contact with the main lecture, leading to possible better tutor preparation.

3.2 Patterns of VLE use

Three modules examined the GC environment (two Business Information modules and a Computing and Multimedia Technology module). Data were extracted from the log files generated by the software (Mimirinis et al., in press). The analysis of log files was facilitated by retrieving relevant data from the system and the distribution of students according to location is presented in table 2.

Location	Registered	Used VLE	Percentage
London	111	97	87.39%
Hong Kong	14	11	78.57%
Singapore	12	9	75%
Egypt	25	13	52%
Total	162	130	80.24%

Table 2: Distribution of students and WebCT users

The analysis of the number of accesses reveals that 80.24% of the module students have used the system for a wide range of purposes and with varied frequency. Levels of participation, measured by number of accesses, differed across different locations; the highest participation level was observed in local students in London (87.39%) with Shanghai closely following (85.71%). With similar participation levels, Hong Kong (78.57%) and Singapore (75%) have slightly lower rates, while approximately half of students have used the system in Egypt (52%).

The number of total accesses is also an indicator of the extent to which students used the online learning environment. There was an average of 166 accesses per student which refers only to those who have actually used WebCT. London student records indicate a higher number of log-ins (192) whereas students in Egypt have the lowest

number of accesses (70 log-ins). Table 4 illustrates the actual figures for each location. Only 25 students completed any of the quizzes available within the system. Of these, 15 students were from London (15% of those who have used WebCT), 5 from Singapore (55%), 3 from Hong Kong (27%) and 2 from Egypt (15%). Table 4 displays the descriptive statistics of the WebCT accesses.

Location	N ¹	Mean
London	13	70
Hong Kong	97	192.53
Singapore	11	86.09
Egypt	9	122.44

Table 4: WebCT accesses according to location

Discussion board messages of one of the modules were analysed both quantitatively and qualitatively. The distribution of the discussion boards' messages unveiled a wide range of activities. Students use the system equally for administrative purposes and collaborative communication (see table 5).

Collaborative communication	17
▪ Student to tutor	3
▪ Student to student	7
▪ Student to all students	7
Administrative issues (deadlines, technical support)	17
▪ Assessment	2
▪ Queries on coursework extension	5
▪ Submission of coursework / Identification	9
▪ Password	1
Suggestions (regarding course improvement)	1
Total	35

Table 5: Discussion boards' posts according to content

Based on these findings, certain recommendations can be made:

- Wide usage of system indicates that use of the VLE is incorporated into the existing pedagogical paradigm to a large extent. This provides a first class opportunity for fully developing effective pedagogical approaches online.
- Communication paths' diversity can be used for further promotion of online collaboration.

3.3 Computer-Assisted Assessment

One of the most common applications of e-learning is to enable and facilitate assessment mainly through the use of automatically marked multiple choice questions (MCQ). The key objectives of this study were to: (i) investigate the role of feedback in interactive learning systems, (ii)

identify any differences in online assessment between theoretical and practical modules and (iii) address issues relating to the provision of feedback from instructors to learners.

The overall process of the CAA study described here has a number of distinct steps. Initially, the socio-demographics of each module considered as a case study are investigated. However, it is important to comply with certain constraints such as: follows a computer related theme, spans at least eight weeks, involves more than 100 students, is supported by a VLE and includes a formal examination.

The second step of this study is to assist instructors in identifying several assessment questions. Each question has four possible answers that are stored in a repository used for the creation of a dynamic online test with a varying number of MCQs. The instructor has to suggest a marking scheme, provide guidelines for ranking and create a number of helpful and explanatory comments for additional feedback regarding each one of the test questions. The assessment participants may take the online test as many times they wish. At the end of each test feedback is provided to all participants. Feedback includes the actual mark, module rankings, instructor comments and suggestions and links to relevant course material. Finally, the participants evaluate the assessment methodology, the provision of feedback and the module's VLE. More specifically, the assessment scores and evaluation results from the first two modules, the theoretical e-Commerce and the practical Java programming ones are displayed.

Marks	SD ²	D	N	A	SA
	31%	11%	28%	13%	17%
9	18%	—	15%	—	—
10	9%	25%	5%	—	—
11	9%	12.5%	10%	11%	8%
12	18%	25%	5%	22%	8%
13	4.5%	—	10%	—	8%
14	9%	—	10%	11%	16%
15	1.4%	25%	5%	33%	—
16	—	—	10%	—	16%
17	—	—	5%	—	16%

Table 6: Marks – Preparation cross-tabulation

One of the findings indicates the marks that students received with respect to their preparation for the specific test and their previous experience of similar online assessment. Table 6 shows that 42% (31+11) of e-Commerce students were prepared for the online test, while 30% (13+17) of them were rather unprepared. Interestingly enough, the breakdown of marks follows an

¹ Length of use in days

² Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree

increasing pattern for well-prepared, experienced in online assessment students. The findings from the second module are similar, further supporting what was observed during the theoretical e-Commerce module. During the practical module, the study provided findings with respect to the number of attempts that students made for the same online test. Table 7 provides a comparison of the students who took the same test more than once. There is a sharp decrease that takes place after the second and third repetition. There is a clear difference between the practical and the theoretical modules, with more students attempting the Java test multiple times.

No of repetitions	2	3	4	5	6	7	8	9	10
Java Students	26	14	8	5	6	5	2	1	3
e-Com. Students	56	8	2	–	1	1	–	–	–

Table 7: Classifying students repeating the assessment

Most participants' comments and suggestions convey three main messages. First, the usefulness of online tests for assessing performance is identified. Next, the need for frequent and repetitive assessment as well as for richer feedback is outlined. Hence, a number of guidelines could be provided following this computer-assisted assessment pilot study:

- Multiple types of feedback are required for CAA.
- Self-paced study can be achieved by using CAA.
- Personalisation of feedback is currently achieved only through social interaction with the instructor.

3.4 Learning tasks and patterns of communication

The key objectives of this study are to identify those factors that trigger alternative communication patterns within the same module. A second objective is to understand criteria that should be used for introducing a structured communication mechanism to assist the content clarification and feedback provision process in VLE.

During the evaluation of a typical Computer-Supported Cooperative Work (CSCW) course that took place in 2000 and was supported by a VLE (WebCT), an observation was made for the way that students were using the threaded discussion tool. One of the assessment methods required the formation of 16 teams, each consisting of six students. Each group had a dedicated threaded discussion with a general topic for various housekeeping issues. Moreover, all groups had a number of sequentially available, identical topics starting each week according to the tasks of their group project.

Initially the number of posts, responses, views as well as the frequency of interaction, preferences to certain posters and lurking were used to classify each group and its student members. Also, an association of communication patterns with learning tasks and group formation emerged. It became obvious that certain tasks attracted more posts in

the group discussion either for clarification or for interaction to accomplish a specific task. It seemed that certain tasks made groups proactive, motivated and innovative. It also became obvious that certain groups had a maximum capacity of effective communication while others could side-track to endless discussions without achieving the actual goals. The later groups were usually quite heterogeneous, with personal and cultural conflicts leading to failure to reach rapid consensus. A communication protocol had to be invented in order to make decisions and solve problems.

Following from the main findings of this study, some guidelines regarding communication patterns associated with learning tasks include:

- There are certain communication patterns that are directly affected by difficulty of a learning task.
- Group formation is a factor affecting communication frequency.
- Demonstrator tasks can be used to identify any communication conflicts in early stages.

4. A framework for building flexible learning applications

Following the above sections discussing the four research studies, a number of specific guidelines have been suggested. The main objective of current work is to draw some conclusions on the effectiveness of the SCATE methodology used in GC and investigate possible alternatives that could be implemented for a flexible learning environment. The outcome of such an investigation is a framework that could assist in the conceptualisation of future applications supporting flexible learning environments. This paper attempts to validate the framework presented in figure 3.

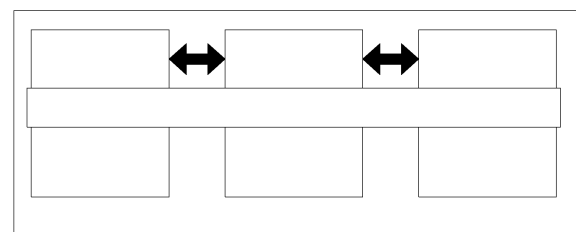


Figure 3: Virtual Learning Environments – a framework for building flexible learning applications (as cited in Iahad and Dafoulas, 2004a)

Initially, the results from the attitudinal learning components study justify the presence of a number of 'authentic activities' that are imposed during all three phases of content delivery, interaction and assessment. The findings on patterns of VLEs use show that even culturally diverse students primarily engage in interaction with instructors and colleagues and assessment tasks when

not concerned with the taught content. It is important to record the various types of interaction as shown in table 5 and attempt to provide different levels of user support. Sections seven and eight provide some guidelines for addressing issues that relate to more specific functions usually present in VLEs such as interaction and communication mechanisms as well as online assessment tools and record keeping. The CAA study lends credibility to the idea that it is essential to support both formative and summative assessment through quantitative and qualitative methods. Finally, the patterns of communication in the learning tasks study emphasises the different ways that tools such as email, message boards and threaded discussions are used based on varying modules or even slightly different tasks.

5. Conclusions

While addressing four distinct areas, these studies lead to the conclusion that flexible learning environments could be modified to further assist students. The next generation of flexible learning environments need to take into consideration how the students use the VLE. The study in section five provides a good foundation on which to begin modification. The attitudinal study provides support for the idea that even as higher education moves more towards a computer-based design, psychological factors such as opinions must be considered. To ignore components such as comfort with format could also potentially intimidate students from using a virtual learning platform. As education increasingly is based on virtual learning platforms it would be unfortunate if students were not willing to migrate to the new system. Recommendations suggested here provide a framework by which to begin working to modify the existing GC VLE but also to optimise future e-learning applications.

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