Teaching Educational Software Design by engaging Students in the evaluation of a project-based Adaptive Educational System

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Educational Software Design is a postgraduate course which deals with the design, implementation and evaluation of Educational Systems. A main focus of the course is the human-centred design methods for the development of Educational Software. Based on this approach at the final assignment some students were involved in the formative evaluation process of the AES "MyProject", as a representative type of educational software, undertaking both the roles of learners and system evaluators. The purpose of the assignment project was twofold: (a) to help the students explore some of the basic concepts of the course and attain particular learning objectives, (b) to involve students in the evaluation process of a real web-based educational system developed on principles imposed by particular learning theories and provide feedback for further improvements. In this paper, the particular project and the way the students' activity was organised, are described. The results indicate increased student participation and involvement as well as the different ways that students utilized specific functionalities of MyProject. The efficiency of the particular approach in succeeding the learning objectives posed is also discussed, as well as the derived results for the system's further revision.

Keywords

Adaptive Educational System, Educational Software Design, Formative evaluation, Project based learning

1. Introduction

Educational Software Design is a postgraduate level course offered simultaneously in two postgraduate programs of the University of Athens: a MSc in New Technologies of Informatics and Telecommunications and an Interdisciplinary Program in Basic and Applied Cognitive Science. The scope of the course is to discuss the basic concepts concerning the development of Educational Systems. More specifically, the course deals with the design, implementation and evaluation of educational systems based on modern learning theories and the effective use of educational software in the educational process. A main focus of the course is the human-centred design methods [1] for the development of Educational Software. Human-Centred Design (HCD) approach suggests, among others, the involvement

of end-users in the evaluation process and the application of an iterative development cycle, where design solutions are implemented, evaluated and revised in order to meet technical and functional requirements [2]. Thus, the system's evaluation is not considered only as the last phase of the development process (summative evaluation), but also as an important source of information within the complete development cycle (formative evaluation) [3].

The last part of the course is dedicated to the study of a representative type of educational software: Adaptive Educational Systems (AESs) [4]. Especially, learning objectives of the course include the design of AESs involving the architecture and the way different pedagogical approaches may influence the development of the structural modules of an AES as well as the way these systems may support web-based or blended learning. Students through the course worked out specific activities concerning AESs. At the final project-assignment of the course some students were involved in the formative evaluation process of the AES "MyProject". MyProject (http://hermes.di.uoa.gr:8080/myproject) is a web-based AES which is based on the case-based [5] and project-based learning theories [6]: students work out a specific project and through this process they study real cases, communicate with peers, review their peers work and receive comments from peers.

The purpose of this project was twofold. On the one hand to promote students to investigating the main concepts of the AES area such as adaptation, learner model, domain model and the way a particular instructional design reflects to the main modules of an educational system. On the other, to involve students in the evaluation process of a real web-based educational system developed on principles imposed by particular learning theories and provide feedback for further improvements.

In this paper, we present a project-based approach for organising students' activity around specific learning objectives of a course for Educational Software. In this approach students work with and evaluate the project-based AES MyProject. The particular system and the way the students' activity was organised, are described. The results indicate increased student participation and involvement as well as the different ways that students utilized specific functionalities of MyProject. The efficiency of the particular approach in succeeding the learning objectives posed is also discussed, as well as the derived results for the system's further revision.

2. The project: Evaluation of the AES MyProject

2.1 The context: The course's curriculum

Nineteen students of the MSc program in New Technologies and Telecommunications and nine of the Interdisciplinary Program in Basic and Applied Cognitive Science participated in the Educational Software Deign course during the fall semester 2006-07. The goal of the course is to enable participants to design and evaluate Educational Software so that it encompasses a series of qualities. The audience had a particular interest on the topic of the course both by the technological point of view, as approximately half of the participants were professional programmers, and by the pedagogical point of view, as many of them, especially those from the Applied Cognitive Science program were teachers of various disciplines. Thus, there is a high probability for them to participate in Educational Software Development teams in the future, either as professional programmers or as Instructional designers. Furthermore, as many of the students were teachers, they might find the course helpful in choosing educational software to enhance their instruction and/or even create their own applications using simple authoring tools.

The course was organized around weekly lectures and also contained three laboratory sessions, three homework activities and one final project assignment. The students' grading

was calculated by their performance on the three homework activities (30%) and the final project (70%). The lectures dealt with the categorization of educational software, the characteristics of educational technologies that promote learning, the learning environments' major design dilemmas, software engineering issues and finally examined in detail a representative category of educational software: Adaptive Educational Systems. Among the software engineering issues discussed in the course, was the Human-Centred Design (HCD) approach, which was proposed for the Educational Systems' design. Thus, the need for iterative design solutions integrating feedback from end-users was underlined. During the laboratory sessions, the students had the opportunity to create small educational applications, using educational software such as *The Geometer's SketchPad*, *Microworlds Pro* and *GameMaker*. For example, in the first laboratory class, which lasted four hours, the students were informed about the principles of Dynamic Geometry and were taught the use of Dynamic Geometry software like "The Geometer's SketchPad" by creating easy, intermediate and advanced educational scenarios. The first two lab sessions were followed by the assignment of equal in number homework activities that covered the respective topics. In the first activity the students were asked to prepape their own educational scenario based on didactics of Mathematics, Physics or Informatics, using Dynamic Geometry software. In the second activity the students had to fulfil a questionnaire about the instructional use of the Educational software *Microworlds Pro*, which is a Logo-like environment that can be used to create microworlds. The third activity engaged the students in the comparison of two adaptive systems. The students had to explore a web-based Adaptive Educational System (either INSPIRE [7] or ELM-Art [8]) and then compare it with a general purpose web-based Adaptive System: the electronic store Amazon.com. For the final course assignment, the students could choose among four proposed projects, which are described in detail in section 2.2.

The use of project assignment in the framework of the course was decided as projects are highly engaging and motivating activities, prepare students for the work world, offer the opportunity to apply theoretical knowledge to produce deliverables, supports various skills' development concerning problem solving, communication and self-assessment [9]. The projects should be authentic, as, according to Vosniadou (2001), it is proven that 'people learn best when they participate in activities that are perceived to be useful in real life' [10].

2.2 The final assignment

The four alternative assignments were presented to the whole class during two successive lectures, in order to help students decide which one they would prefer to conduct. The assignments' subjects were selected from the range of topics discussed in the course. More explicitly, the students could choose i) to create a microworld and an educational scenario using Microworlds Pro, ii) to develop educational material for the dialog-based Educational System ReTuDiS [11], iii) to design an educational game, or iv) to evaluate the Adaptive Educational System MyProject. In the two latter projects the students had to work individually, whereas in the two former ones they could choose to work either individually or in pairs. In this paper we focus on the fourth assignment concerning the evaluation of the Adaptive Educational System MyProject and we present its implementation in detail.

The assignment was presented during a two hour lecture. The lecture included a brief presentation of the Educational System MyProject and a detailed description of the specific requirements namely the evaluation process, the tools, the deliverables and the time schedule.

According to the assignment's scenario, the students would have to undertake the double role of a learner, who uses the AES MyProject to learn programming and of an evaluator. In

particular, they had to use the system for a two month period, working as learners on the subject matter of Computer Programming and more specifically on the loop structure. Working as Computer Programming learners, the students had specific responsibilities: study the educational material, fulfill and submit specific tasks proposed by the system, submit their solutions on a project on loop structure, evaluate the submitted solution of a peer and finally submit a revised solution. This was the system's test session. The students could access MyProject whenever and from wherever they wanted during the test session, as the system is web-based. At the same time, they had to work as evaluators. The methods selected for the evaluation process were questionnaires and interviews [12]. Their use was rather complementary than overlapping as they examined different aspects of system's design. The questionnaire focused on the design rationale of the system. It was created by MyProject's designing team in order to investigate users' opinions about how MyProject confronts or could be modified/extended to confront to the four design principles for project-based curricula proposed by Barron et al. (1998). Thus, the questions were organised around four basic axes, one for each design principle for project-based curricula [6]: (a) Defining learning-appropriate goals that lead deep understanding, (b) Providing scaffolds adapted to the learner's needs (c) Ensuring Multiple opportunities for Formative Self-Assessment and Revision (d) Developing Social Structures that Promote Participation and a Sense of Agency. A few days after the test session, the students granted a semi-structured individual interview to the researchers-system designers. The interviews were structured around specific open questions about the students' personal opinions concerning the role of the learning cycle in the system, the paths they actually followed while traversing the learning cycle, the interaction with peers through the system, the usefulness of the current learning model, the possibility to share this model with peers and usability strengths and weaknesses of the system. Additionally, ambiguous answers to open-ended questions of the questionnaire were clarified. The questionnaires and the interviews were also used for the students' assessment as the answers given reflected the degree of the project's learning objectives achievement.

The assignment's particular learning objectives were: (i) The students to be able to evaluate a Learning Environment concerning its usability, instructional design and supports offered to enhance learner control (ii) Identify the functionality of an adaptive learning environment and design issues raising for the introduction of adaptivity and adaptability in an educational system (iii) Identify strengths and weakness in the system design.

The appropriateness of the assignment for the course was based on three features:

i) it involves students in the development cycle of a real AES, ii) it constitutes a case study of an actual AES iii) it engages students in an authentic task.

i) students' involvement in an AES development cycle

The participation of the Software Development course students to the evaluation process as end-users helps them acquire a first-hand experience of the application of Human Centred Design approach to a real-world system. Moreover, their active involvement to a discrete phase of the Systems development cycle fosters particular skills and prepares them to participate in Software Development teams in the future.

ii) case study of an actual AES

During the evaluation process the students are asked to argue on both the *design rationale* of the system that is "the information that explains why a computer system is the way it is, including its structural or architectural description and its functional or behavioural description" [13] and its *usability* which is defined by International Standards Organization in terms of a systems' effectiveness, efficiency and user satisfaction in a given context of use [14]. Furthermore, through the study of MyProject, the students examine the structural

modules of *AESs* that is *the domain model, the adaptive engine, the student model*. Thus, they have the opportunity to explore many of the concepts discussed in the course in an applied setting.

ii) student's engagement in an authentic task

This project is authentic and the usefulness of the produced outcomes was obvious to the students. MyProject which constitutes the revised version of the AES ProSys [15], is an Adaptive Educational System based on constructivist theories. The redesign process of ProSys that lead to the development of MyProject was completed one month before the beginning of the evaluation project. The empirical evaluation of MyProject conducted in the framework of the course, was of great importance for the System's development team as it was the first evaluation of the revised version. Weibelzahl (2003) underlined the need for empirical evaluations of AS in real world scenarios, where the most salient criterion is the system's usability [16]. The results from this preliminary empirical evaluation would be used for the system's further redesign. In other words, this project constituted a formative evaluation of the Educational System.

The proposed assignment was positively welcomed by the course audience and this was reflected at the fact that almost half of the participant students (13 out of 28) selected to work on it. The youngest was 24 years old and the eldest 47. Three students were novice programmers while ten of them were programming experts due to their undergraduate studies and/or vocational experience. Four of them were professional teachers. The overall number of participants was adequate for the evaluation process as, according to studies, 5 to 8 users are enough to identify 85% of major usability problems in most software systems [17].

2.3 The Adaptive Educational System MyProject

MyProject (Figure 1) is an Adaptive Educational System, which is designed, based on constructivist theories. Especially, constructivist learning environments engage learners in meaning making (knowledge construction) having as a focus a problem, a question, or a project, and surround it with various types of support [18]. In MyProject, learners work with a *project* and the system proposes them a *learning cycle* to follow. In particular MyProject proposes learners to follow a *learning cycle* of different stages (Introduction, Generate Ideas, Multiple Perspectives & Research, Solution and Evaluation) with the aim to make them progressively understand the implicit issues of the project, and become able to complete the project, reflect on and monitor their learning. Through this cycle several *supports for reflection* on the learning process are provided: (*i*) learners are stimulated to submit and argue about their actions/selections, explain the strategies they use, see and comment on their peers' opinions. Commenting on their peers' ideas requires consideration of how the ideas of others work. Comments from others encourage deeper thought about the implications of their own ideas, (ii) learners are able to see their learner model and reflect on their performance and contributions at the different stages of the cycle.

Educational content in the form of realistic cases [5] is provided at the "Multiple Perspectives & Research" stage. Adaptive navigation support through the content is offered in the form of visual cues informing learners about (a) the material they have already completed or need to complete, (b) the concepts they are ready to study next.

Lastly, the "Solution and Evaluation" stage is based on a peer review [19] approach: (i) students submit their project, (ii) reviewers are assigned pseudo-randomly by the system, (iii) authors have a chance to submit revised versions in response to reviewers' comments.

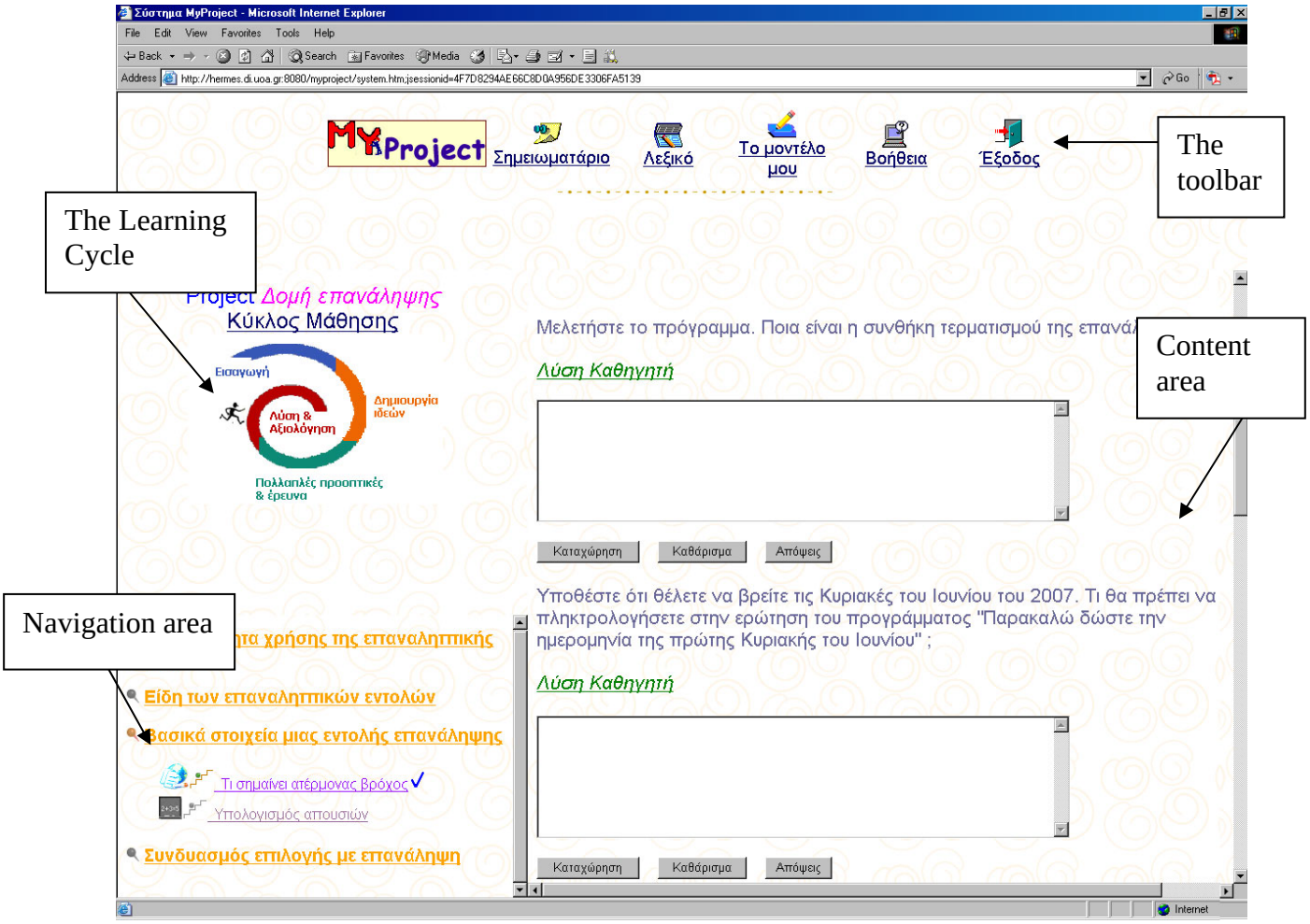

Figure 1 The Adaptive Educational System MyProject.

3. Evaluation results

The assignment managed to motivate the students and engage them in the role of the system end-users and reviewers successfully. According to their statements, the average time of interaction with the system was about 9 hours. Their interaction was confirmed by their accurate and thorough answers to all the questions in the stages Generate Ideas and Multiple Perspectives & Research of MyProject. Besides, all of them managed to submit a solution at the final stage 'Solution & Evaluation' to the loop structure project. Indicatory of the degree of students' involvement in the role of learners, was the fact that three students posed questions to the designers during the interview concerning the submitted answers to MyProject tasks, although it was clear that the correctness of their answers to these tasks was not taken into account to the grading process.

The "Evaluation of the AES MyProject" project was very fruitful for both its purposes. Students managed to achieve adequately the learning objectives and to provide feedback of high quality to the development team for the system evaluation.

As far as the course's learning outcomes are concerned (see Table 1), the success was identified by the users' answers in the open ended questions of the questionnaire and the interview. The majority of the students (11 out of 13) produced elaborate answers with adequate justification to the questions concerning the system's instructional design, supports offered to enhance learner control, design strengths and weaknesses included in the questionnaire. Moreover, all the students were able to discuss thoroughly similar questions posed during the interviews. Furthermore, the interviews revealed that all of the students were able to define concepts as adaptation and 6 out 13 went further suggesting new adaptive features. 10 out of 13 students were able to describe what the learner model is and 6 of them made specific suggestions for extending it in order to include information about the students' learning style [20] and knowledge level (either beginner or advanced). On the contrary, only 3 out 13 students were able to define open learner modelling, which was partially expected as this concept was not fully implemented in the current version of the system. Moreover, 9 out 13 students were able to identify major usability problems and propose possible solutions as revealed through the interviews.

Table 1: Evaluation results based on project objectives

Project objectives	**Observed outcomes** The students were able…	**Number of students**
(i) The students to be able to evaluate a Learning Environment concerning its usability, instructional design and supports offered to enhance learner control	…to identify usability problems	9
	…to provide explicit answers to open-ended questions of the questionnaire concerning the instructional design	11
	…to provide explicit answers to questions concerning the system instructional design during the interview	13
	…to comment on the proposed learning cycle during the interview	13
(ii) Identify the functionality of an adaptive learning environment and design issues raising for the introduction of adaptivity and adaptability in an educational system	…to define the term *adaptation*	13
	…to suggest new adaptive features	6
	…to define the term *learner model*	10
	…to make suggestions for the learner model expansion	6
	…to define the term *Open learner modelling*	3
(iii) Identify strengths and weaknesses of the system design.	…to provide explicit answers for the justification of strengths and weaknesses of system design in the questionnaire	11

The evaluation process provided useful feedback to the development team as well. Two major usability problems were identified and corrected immediately, before the final release of the system. The first, and more severe one, concerned the Generate Ideas stage of the learning cycle where the learner has to submit his/her opinion to the project's driving questions. The screen was designed to contain both the initial answer of the learner and his/her current one in a set of driving questions. Thus, the learner would be supported to keep track of his/her progress comparing the two opinions at any time. However, this design was proven to be rather confusing for 7 out of the 13 students who submitted only an initial solution. Consequently, these users could not exploit the system full functionality as some of its rather critical features, such as the possibility to comment on other learners' opinions were

disabled. Another feature of the same screen that received negative comments from the students during the interviews, was the fact that the initial solutions could not be altered after their submission. This option was characterized by the students as very restrictive. Some students assumed that they had only one opportunity to submit their answers to the system and were very stressed and careful in their subsequent interactions. The second usability problem was reported by 3 students and concerned the navigation guideline messages through the stages of the learning cycle. The messages were rewritten in order to be more helpful.

Apart from the detected problems, the evaluation process provided the designers with a series of interesting design issues that could be considered in future versions of MyProject. For example, although none of the students questioned the usefulness of the learning cycle, 5 out 13 admitted that they did not follow the proposed sequence of stages for the accomplishment of the project. Moreover, 4 students expressed the opinion that the sequence of stages within the learning cycle should be adapted according to the learner's level, a student proposed the removal of the stage Generate Ideas for the advanced user and another supported that beginner learners should not be able to navigate within the different stages of the cycle. As more that one third of the students reported the use of alternative paths in traversing the learning cycle, the development team decided to further investigate this option through several empirical studies. These studies will concentrate on the usefulness and necessity of adapting the sequence of the stages, and on the learner characteristic(s) that could be used as sources of adaptation.

One of the issues that the students found interesting and useful in supporting self-evaluation was the "social aspect" of the system, that is the possibility to read and comment on other learners' opinions in the stages of Generate Ideas, Multiple Perspectives & Research and the peer assessment process during the Solution and Evaluation stage of the learning cycle. In particular, all of them expressed positive comments on the peer assessment process. They also found appealing the possibility to get feedback from their peers on their answers, although none of them submitted his/her agreement or disagreement to peer's answers. In this point, it has to be mentioned that only 6 students could have used this functionality of MyProject, since the rest 7didn't manage to enable it due to the aforementioned usability problem. Nevertheless, 11 out of 13 students admitted that they would provide feedback to their peer answers only to express disagreement and support them in correcting their answers rather than criticize them. More specifically, 7 students underlined the need for the submission of elaborate comments on their peer's opinions - functionality not currently supported by the system. The incorporation of a forum was suggested by 4 students. When asked about the current learner model, the students commented that in its current status it cannot support reflection adequately and that it has to be extended to include more information. Eight students were asked whether they would share their model with others. All of them responded affirmatively, one of them said that he would do it only anonymously, but only two of them where able to justify the usefulness of this possibility.

4. Conclusions

The results from students' involvement in an authentic project concerning the formative evaluation of a real Learning Environment in the framework of an Educational Software Design course was very promising. Not only had it proven to be highly motivating but also lead to positive results both concerning the course's learning objectives and the feedback provided to the development team. The evaluation results will be taken into account for the system improvement. In the future, we plan to further involve students to Human-Centred Design processes in the framework of authentic project assignments. For example, the students could be involved in projects concerning the early design stages of Educational Systems. Additionally, similar projects can be assigned to students of relative Software Engineering courses, offering them the opportunity to approach software development models through experiential learning.

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