Evaluation of the Effectiveness of a Web-Based Learning Design for Adult Computer Science Courses

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***Abstract*—This paper reports on work undertaken within a pilot study concerned with the design, development, and evaluation of online computer science training courses. Drawing on recent developments in e-learning technology, these courses were structured around the principles of a learner-oriented approach for use with adult learners. The paper describes a methodological framework for the evaluation of three main educational issues involved in the learning process of Web-based computer science training courses, and analyzes the results of this study with the aim of providing an improved learning design, and environment, for these courses. The findings highlight a number of potential barriers to learning and indicate the failed indicators that need to be improved in order to enhance effective performance. The authors give their views both on ways to improve the proposed learning environment and on the need for an optimal balance between asynchronous and synchronous activities, enhanced collaboration, and interactions among adult learners and e-tutors.**

***Index Terms*—Adult education, computer science education, evaluation, learning design, lifelong learning.**

I. Introduction

E-LEARNING offers a tremendous opportunity to learn without being subject to limitations such as time or location. It has the ability to accommodate multiple educational strategies and learning using a variety of delivery methods. The availability and broadband of the Internet have made learning opportunities available to adult learners in both distance and conventional education by using learning activities management systems with asynchronous and synchronous tools.

Distance education and e-learning are becoming an increasingly important part of higher education. This type of education can take place over the Internet, through which the instruction and educational content are delivered. The North American Council for Online Learning (NACOL) surveyed over 30 countries, aiming to highlight international trends in distance learning mainly for K–12 students to identify distance-learning initiatives and projects in individual countries and to promote international dialog for future collaboration [1]. The survey results showed continuous growth in the use of distance-learning programs in all countries.

Various Learning Management Systems (LMSs) have been used for distance-learning programs offered by higher education institutes. Distance-learning critical success factors (CSFs) have been specified as they are perceived by university students. A survey of 538 university students revealed eight categories of distance-learning CSFs, each including several critical acceptance and success measures [2]. The effects of message constraints and labels on collaborative argumentation in asynchronous discussions via Blackboard LMS have been examined [3]. After almost a decade of LMS experience in the higher education sector, educators and administrators are beginning to question the effectiveness of a LMS. What it does it do well and how well does it do it, what should it do, and how might it do this?

Despite the effort, existing e-learning systems and authoring tools have several limitations with respect to support provided and usability and cannot accommodate the needs of teachers who increasingly look for more intelligent services and support when designing the instruction for and learning of their students. Traditional LMSs offer their greatest value to the organization by providing a way to display a sequence content and statistics, such as "students enrolled in the LMS" and "learning objects viewed by students," as an indication of the effectiveness of the learning process. The underlying assumption is that if students can just be exposed to the content, learning will happen. There also appears to be a large communication gap between authoring tools and learning systems and between teachers and learning designers. Learning-activities-based environments are a recent trend that addresses the limitations of a LMS.

In Greece, Technological Educational Institutes (T.E.I.) comprise the technological sector of higher education. T.E.I. of Lamia provides distance-learning opportunities to adults, who are computer science graduates, or computer science students, or graduates who use computers as a tool in their work. In this paper, an e-learning training activity is described, which was implemented by T.E.I. of Lamia over two semesters [4], [5]. The curriculum contains training courses mainly in computer science (such as Programming with C, Operating Systems, Computer Security, Electronic Commerce), but there are also some interdisciplinary courses (such as Educational Technology, Geographical Information Systems, Health Information Systems). This paper presents an evaluation methodological framework that assesses the learning methodology used, the educational and some of the technical issues involved, and

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the solutions chosen to provide an easier-to-use learning environment to enhance the learning experience. The evaluation framework analyzed the overall distance-learning setting, taking three important axes into consideration: *information and support provided to learners at the start of and during their studies*, *learners' performance*, and *learners' satisfaction*. Specifically, Section II presents related works. Section III describes the learning methodology and the technical environment. Section IV focuses on the evaluation framework, while Section V presents the results obtained. Section VI presents conclusions and future work.

II. Literature Review

It is widely acknowledged that more must be done to bridge the education/computer science divide and create a genuinely interdisciplinary way to present learning design, if teachers are to be persuaded to work with this approach, since the technical complexities involved are often not perceived by teachers as being relevant to their needs. Interaction is the key to achieving successful outcomes in finding the right mix of human and technical elements, which is crucial to teaching students how to learn online. Special attention should also be directed to nontraditional students who have the additional pressure of resolving time conflicts between e-learning, work, and family life [6].

Learning design is a comparatively new field deriving from Rob Koper and his colleagues' work at the Netherlands Open University in the late 1990s and their development of "Educational Modeling Language" (EML) [7], which was subsequently adopted for standardization by the IMS Global Learning Consortium in the IMS Learning Design specification [8], intended to help technologists and instructional designers. Dalziel states that "learning design" is activity-based and "more concerned with context rather than content," supporting collaborative as well as individual learner approaches to e-learning [9]. Britain agrees with Dalziel that learning design is a reaction to the use of virtual learning environments as repositories for content delivery [10].

The Learning Activities Management System (LAMS) is one of the most popular learning design systems, which provides simple features for authoring (and sharing) learning designs, running learning designs with students, and monitoring student progress through a "running" learning design [9], [10]. In the majority of trial projects (such as EDIT4L, eLISA, and ALeD), the teachers considered that LAMS supported differentiation, revision, self-paced, and collaborative learning and that it promoted independent learning. They also felt that it aided their students' learning, understanding, and cognitive skills and enhanced their motivation, and that this remained high "even after the students had been using LAMS for more than a year" [11], [12]. However, the JISC DeSILA (Designing and Sharing Inquiry-based Learning Activities) Project in 2007 concluded that LAMS is not flexible enough to support advanced inquiry-based learning in higher education [13].

Different frameworks have been suggested for the evaluation of e-leaning-based courses. Most of them focus on two aspects: The first concerns the evaluation of the learning environment, and the second deals with the evaluation of the students' performance. Benigno and Trentin considered factors such as student characteristics, student–student interaction, effective support, learning materials, learning environment, and information technology [14]. The framework proposed in this paper takes this one step further by evaluating two more aspects besides learners' performance: information and support provided to learners at the beginning of and during their studies, and the learners' satisfaction.

III. Methodology and Tools

The learning model adopted was a traditional learner-oriented approach. The number of students enrolled in each semester (cycle) was 407 and 379, respectively. To facilitate the learning process, at most 20 learners were allowed to attend a class. The learning content of each course was organized into units and consisted of theory, examples, self-rating tests, unit tests, and midterm and final tests. The learning content included presentations, documents, animations, and audio/video files, all stored in LAMS.

In all courses that follow the learner-oriented scenario, the availability of learning content is combined with tests, projects, and (both synchronous and asynchronous) interaction between tutors and learners. The scenario is implemented on a weekly or fortnightly basis, using LAMS as the main teaching platform for both semesters [5]. At predetermined intervals, the tutor provides the learning content of each course unit in LAMS and gives learners a sufficient amount of time to study it. Learners interact with the tutor synchronously in online sessions and asynchronously by using LAMS tools (chat, forum) and/or media server functionalities (Helix Server). The media server has been found very useful for synchronous interaction between tutors, learners, and streaming material. The main purpose of interaction between learners and the tutor is for the tutor to scaffold and facilitate learners in their mastering the course units.

IV. Methodological Framework for the Evaluation of Distance-Learning Services

The aim of the approach used was to set the evaluation process in a well-grounded base, through both the definition of specific axes and indicators (criteria) that measure each axis adequately and the application of quantitative and qualitative means to interpret the results. To this end, three main evaluation axes were defined: 1) information and support provided to learners at the beginning of and during their studies; 2) the learners' performance; and 3) the learners' satisfaction.

A. Definition of a Methodological Evaluation Framework of Learning Services

1) Information and Support Provided to Learners at the Beginning of and During Their Studies: This axis concerns the degree of information and support that learners can receive when they choose to enroll in a chosen course. This should be measured and evaluated not only during the period when the learners first express their interest and during the first days of the course (information that should be treated in a special way), but also throughout the semester. Furthermore, it is necessary to consider how consistent learners are in their studies, which is defined as the level of their participation in the enrolled courses

and in the academic program as a whole. This axis can be measured by specific indicators that show the degree of support learners felt they received during their studies and how this has affected the degree of consistency they showed in their studies. Consequently, the percentage of learners who drop out of a course is also considered.

2) Learners' Performance: A learner's performance is defined by the measurement of those parameters that illustrate, in an approximate way, all these elements that a student has learned as a result of a teaching or training process; this is considered to be the degree of achievement of the learning goals set by the course and the academic program in general. In particular, this axis is described and measured by indicators that show the degree of achievement of students' learning goals with regard to factors that influence their performance, such as the degree of difficulty that students faced in their course with regards to the content of the course or the technology used, as well as the type of assessment that followed (final exam, continuous evaluation, or alternative methods).

3) Learners' Satisfaction: This can be considered as the most important axis, and for this reason, a more thorough analysis is provided. To this end, specific subaxes are defined so as to achieve a better and more detailed study of all the possible aspects that influence this axis. In turn, each subaxis is described and analyzed separately.

a) Subaxis "General Satisfaction": The proposed indicators allow the measurement of "transactional" elements, such as the following.

- *Enjoyment*: This indicator assesses whether students really enjoy what they do during their studies. To measure this indicator, parameters such as the students' personal opinion of their degree of satisfaction are considered, as well as the detection of the main factors that result in this degree of satisfaction.
- *Compensation*: This indicator is concerned with the time and the effort that students dedicate to the course. As such, this indicator allows an assessment to be made of the balance between the resources (means) that students invest and their personal and professional tradeoffs resulting from this investment of resources. In measuring this indicator, the fact that students only gradually assess the relationship that exists between the resources invested, the tradeoffs made, and the benefits obtained is taken into account.
- *Benefits* obtained by students: This indicator assesses the degree of students' satisfaction with respect to the different benefits they obtain from their studies. These benefits include the knowledge obtained, the acquisition or improvement of skills, and the diploma obtained upon completion of their studies. In other words, this indicator assesses the degree of utility, applicability, reevaluation of the working situation, facilitation of learning, or other factors that contribute to the acquisition of these skills that influence the personal, academic, and professional development of students.

b) Subaxis "Content": Here, the indicators consider the content material, which includes both the learning material itself and the class environment in general (links, bibliography, and digital library). More specifically, the indicators that assess content are the following.

- *Suitability*: This indicator concerns the appropriateness of the content to the students' expectations. To measure this indicator, it is considered that students evaluate how the content is adapted to the expectations that the material has given them in terms of the learning goals set, the acquisition level, and the difficulty of the material.
- *Sufficiency*: This indicator investigates whether the content of the different types of material that are presented to the students are sufficient to accomplish the goals.
- *Applicability*: This indicator evaluates the usefulness to the student of both the learning material and the complementary teaching and learning resources. To measure this indicator, an assessment is made of the satisfaction that students feel with regard to the application of the acquired knowledge to their professional, academic, and personal environment.

c) Subaxis "Support to the study/learning": Here, the indicators defined allow the assessment of the opportunities, appropriateness, and sufficiency that are offered by the elements that support the study/learning that a student exercises during his/her learning process. The following elements were identified and categorized in specific groups.

- *Tutor action*: This group contains those indicators giving information about the assessment that the student performs with regard to the competencies and the suitability of the tutor actions. Such specific indicators are: 1) Sufficient knowledge of the course material; 2) Pedagogical competencies; 3) Personalization/adaptation of learning; and 4) Planning.
- *Communication*: These indicators reflect the way the student assesses the different relations and interactions that the virtual community offers to him/her, as well as the different means and resources that contribute to the accomplishment of good communication (easiness, rapidness, frequency, suitability, etc.). Such specific indicators are: 1) Communication tutor–student/group; 2) Communication student–student; and 3) Communication student–group
- *Methodological elements (strategies, learning resources/ help of teaching and learning)*: These indicators show the student's satisfaction with regard to all these methodological elements that aim at facilitating his/her learning (different activity types, case studies, learning objects, lectures, links, etc.) as well as the learning material itself in all of its aspects (pedagogical, technological, visual, and functional), for either it concerns digital or printed material. Such specific indicators are: 1) Methodological planning of the learning resource (pedagogical conceptualization); 2) Structure and organization; 3) Technological issues; and 4) Usability: functionality, services, and graphical design.
- *Evaluation model*: These indicators show how the student assesses the evaluation models that were used in terms of and are related to the suitability, coherence, and feedback. Such specific indicators can be: 1) Suitability (with regard to the difficulty, content, and goals of the learning service); 2) Flexibility (adaptability with regard to the rhythm of

learning and the students' personal needs); and 3) Feedback of constructive type.

- *Virtual learning environment*: These indicators show how students assess the various information, services, and functionalities provided to them, in all their aspects (pedagogical, technological, visual, functional). Such specific indicators are: 1) Technological issues; 2) Usability; and 3) Pedagogical use of the environment (methodological planning of the different virtual spaces that support and enhance student's learning most appropriately).

V. Results and Analysis

All the results derived from the questionnaires and presented in this section were calculated by considering only the students who completed the courses. In order to evaluate the first axis of the evaluation framework, that is information and support provided to learners at the beginning of and during their studies," a set of 14 multiple-choice questions was used, distributed in three questionnaires (at the beginning, middle, and end of the term). In particular, the analysis of the initial questionnaire (the one provided at the beginning of the semester) showed the following.

- The vast majority of learners preferred to follow a distance-learning course mainly because no face-to-face classes were required, and secondly because the course was free of charge and included interesting topics.
- The learners' decision to enroll in a specific course was principally based on their motivation to enhance their scientific background, and secondly to use the acquired knowledge/diploma for improving their professional activity.
- Most of the students replied that the program Web site contained sufficient information on the content of the courses, but they would also like to have had more detailed information on the goals and the scientific material of the courses.

The aim of the midterm questionnaire was to compare learners' opinions to those that they had at the beginning of the semester. This comparison showed the following.

- Of the students, 78% replied that the nature of the course corresponded well or very well to their initial expectations, which was very encouraging.
- The main difficulties they faced during the first half of the semester were mostly related to technical problems with the distance-learning environment (missing passwords, losing connection), lack of administrative support, and the high scientific level of the courses.
- The majority of learners would have liked to have had more support from their tutors as they studied their learning material.

The end-of-term questionnaire contained three basic questions designed to assess the difficulties that the learners faced during the courses. In this response, the following was showed.

- About 75% of the learners answered that they faced at most moderate difficulties, which were not hard to overcome. The rest of the learners reported that the difficulties encountered were quite hard to overcome (6% of them even thought of abandoning their course).
- The main difficulty reported by the learners was lack of time, while a very small number reported difficulties with the scientific level of the courses.
- As a general conclusion, 55% of them felt very satisfied with the courses, while only 5% of the learners felt disappointed.

Finally, the analysis showed that 196 students dropped out of their courses during the first semester (48.16% of the initial number of the students enrolled), and 186 (49.1% of the initial number of the students enrolled) during the second semester of the program.

In order to evaluate the second axis of the evaluation framework, that is "the learners' performance," a set of 14 multiple-choice questions was distributed between the three questionnaires (beginning, middle, and end of term). The five questions of the first questionnaire distributed in the beginning of the courses were intended to record the learner's skills, capacities, and scientific level. Analysis of the answers showed the following.

- About 76% of the participants expected to face at most moderate difficulties with the scientific level of the courses.
- There was 94% of the learners who reported extended experience on the use of personal computers
- Almost 50% of the learners had already followed distance-learning courses in the past, and only 10% did not have any experience with distance learning or other ways of online communication using personal computers.
- There was 60% of the learners who reported that they intended to spend from 1 to 3 h per week for studying, and only 5% expected to work less than 1 h or more than 5 h per week.
- More than 70% of the learners felt sure or very sure that they would complete their courses successfully.

The goal of the six questions of the midterm questionnaire was to compare the learners' opinion of their performance after completing the first half of their course.

- About 53% of the learners judged that their performance was satisfactory, and 40% believed that they could do better.
- There was 45% that faced moderate or significant difficulties with the course scientific level.
- Of these, 55% attributed these difficulties to their insufficient scientific background.
- There was 58% of the learners who found that the interaction with their colleagues in the same course was very helpful, while 41% found the interaction to be neutral.
- Regarding the time that the learners spent in studying for their courses, 28% reported spending less than 1 h per week, 45% from 1 to 3 h, and 38% from 3 to 5 h.
- There was 56% who felt confident or very confident that they would complete their courses successfully.

Finally, the analysis of the corresponding questions of the end-term questionnaire showed the following.

- Of the learners, 75% were positive about their overall performance during the courses, and 25% believed that either they should have put in a greater effort or were not satisfied at all.

- Only 20% of the participants felt that they did not accomplish the personal goals they had set at the beginning of the course.
- Moreover, only about 10% of the learners said that the learning goals, set by their tutor at the beginning of the course, were finally not met.

The final results showed that of the 211 students who completed their courses in the first semester, 161 passed (76.3%), while 50 students failed (23.7%). In the second semester, the results were less successful: Of 193 students, 123 passed (63.7%) and 70 failed (36.3%). Students who abandoned the courses were not included in these results. On average, it can be said that the overall "learners' performance" was satisfactory, though the dropout rate was rather high (almost 50%). As a result, more effort should be made to improve the whole learning process and the learning achievements.

The third axis of the evaluation framework "*The learners' satisfaction*" and the corresponding subaxes were evaluated by means of 22 questions distributed between the three questionnaires. The questionnaire distributed at the beginning of the courses aimed to explore whether the learners expected to feel part of a real class and gain some benefits from the courses. The answers of its responses to the five questions led to the following conclusions.

- The majority of students (77%) had great expectations with regards to the knowledge and skills that they would gain from the courses, while almost 50% were confident that they would also progress in the use of information and communication technologies (ICT). Another particular interest they showed (31%) was to be engaged with collaborative work and learning.
- Although 73% of the students expressed their desire to be members of a small learning community, such as the class, the great majority (91%) wanted to communicate with the other class members only once per week.
- Finally, 50% of students indicated that they preferred to be evaluated once or twice during the course semester, while 32% preferred a continuous evaluation.

The goal of the six questions of the midterm questionnaire was to identify possible problems encountered during the course semester, the utility of basic course elements such as the forum, the learning material, and the assessment methodology, while asking the students' opinion about any aspects that may need improvement. These responses indicated the following.:

- The main difficulties that the learners had during the course were related to technical problems (difficulty in connecting, losing connection), while 15% also reported a lack of motivation and feelings of discouragement. This final point was further justified by the fact that the learning platform forum was used frequently by only 25% of the learners (33% of students hardly used the forum at all).
- Regarding the learning material, the vast majority of the learners found it satisfactory or adequate. However, 53% suggested that it should include more learning activities.
- Although at the beginning of the courses the learners seemed to prefer to be evaluated once or twice during the courses, at the midpoint they believed that the continuous evaluation applied to their courses had been more appropriate and had helped them to control their progress as well as to maintain an appropriate studying rate.
- The main aspects that needed improvement mostly concerned communication factors: 1) solution of technical problems in online meetings (reported by 40% of the participants); 2) greater participation of students in online meetings in order to enhance interaction between them (since this seems to play an important role in the learning process); 3) need for voice and video conversations; and 4) more frequent communication with the tutor.
- In general, more than 80% of the learners judged the whole learning process as satisfactory.

The end-term questionnaire helped to assess different aspects of learners' satisfaction that were included in the three aforementioned subaxes and described in detail in the methodological framework. As such, the analysis showed the following results.

- Subaxis "General Satisfaction"
  - *Enjoyment*: Most of the students (76%) reported that they really enjoyed the courses.
  - *Compensation*: Almost 80% considered that the rewards they received from the courses were really worth both the effort they had to put in and the personal and professional sacrifices.
  - *Benefits*: Just 50% of the students stated that the knowledge and skills related to the use of Web technologies were really worthwhile. However, most (65%) judged that the knowledge and skills obtained from the courses were directly applicable at both a personal and professional level. Finally, less than the half of the students (47%) considered that this experience created substantial beneficial relationships with people related to their professional level, while most (61%) believed that the diploma awarded was very important for their further professional advancement.
- Subaxis "Content"
  - *Suitability*: Almost 85% of the learners considered that the learning material was well adapted both to the students' expectations and the course needs, helped them to deepen their knowledge, and was easy to understand, while the great majority of learners agreed that the learning material was suitable for distance learning.
  - *Adequacy*: Almost 90% of the learners judged the learning material to be sufficient for supporting the course learning goals.
  - *Applicability*: The great majority of students (88%) reported that the learning material was useful for improving their personal, academic, and professional level.
- Subaxis "Support for the study/learning"
  - *Tutor action*:
    - Of the learners, 94% judged that their tutor had sufficient knowledge of the course content and, as a consequence, he/she provided competent answers to all the questions that he/she was asked.
    - There was 73% who found that their tutor applied excellent pedagogical methodologies, as shown by

the didactic competencies, procedures, dynamics, and communication strategies he/she followed.
- There was 80% who agreed the tutor followed a personalized approach of learning, adapted to the particular needs of each student.
- Almost 73% of the students reported that the planning of both the course and the learning activities was excellent.

— *Communication*:
- Of the students, 80% stated that the tutor communicated frequently with them during the course using all the means available (forum chat, email), while almost 92% reported that the tutor responded fast and pertinently to all the questions that they asked.
- Only 38% of the students reported that they had frequent interaction with the other members of the class, although 87% of them reported that the tutor encouraged them to do so.

— *Methodological elements (strategies, learning resources/help of teaching and learning)*:
- With regards to the pedagogical conceptualization of the courses (that is, the methodological planning of learning), 80% of the students were quite satisfied by the pedagogical methodology designed and applied by the tutor.
- Concerning the structure and organization of the teaching and learning sources, more than 85% of the students agreed that it was satisfactory, whereby the means and type of source chosen for their realization were suitable, as it was their incorporation into the general organizational framework of learning.
- With regards to the suitability of the learning sources from a technological point of view, their correct functionality was examined in terms of their reliability and consistency, as well as their allowing students' rapid and problem-free access. Most of the students (more than 75%) were quite satisfied in this respect.
- The usability of the learning sources (either digital or printed material) was explored with respect to their ease of use, the services they offer, and their graphical design. More than 75% of the students indicated that they were able to understand the functionality and structure of the resources, they found the set of actions provided by the resources as well as by the corresponding tools sufficient and suitable, and the visual behavior of the sources and their various elements were also adequate and acceptable.

— *Evaluation model*:
- There was 86% who reported that the evaluation model was suitable with regard to the difficulty, content, and goals of the learning process.
- Almost the same percentage of students agreed that the evaluation model was flexible (that is, well adapted to the rhythm of learning and the students' personal needs).
- There was 80% who found that the activities of the evaluation model provided constructive feedback regarding their progress and contributed to improving their learning.
- Finally, the majority of students (almost 90%) agreed that the learning activities and exercises were adequately designed and contributed toward the learning and consolidation of the course contents.

— *Virtual learning environment*:
- Just 50% of the students found that the learning platform was sufficient from a technological point of view (easy to access, fast in responsiveness). Only 18% found these characteristics excellent.
- There was 76% who found that the platform was easy to use (good graphics, functional virtual spaces, etc.), while almost the same number judged that it contained sufficient tools.
- Concerning the pedagogical use of the environment (that is, the methodological planning and use of the different virtual spaces), 76% the students agreed that this achieved its purpose of supporting and enhancing students' learning and allowed them to carry out their activities in the most appropriate way.

VI. Conclusion and Future Work

Technology-enhanced learning, to be fully effective, requires a synthesis of insights from the learning sciences and computer science. Traditional LMS cannot meet all needs in all contexts. This paper described the authors' experiences with 22 e-learning training courses given over two different semesters. The courses were based on a sequence of learning activities, mainly in LAMS, on which students had to work periodically. In the context of nonformal education, these experiences proved that a learning design methodology that provides support to tutors allows them to teach and assess students more effectively. The dropout rate was similar to the average dropout rate in distance-education studies in nonformal education. Teachers found LAMS activities useful in terms of supporting their learning, and most of them would like to use it again. The overall learning design model was generally received very positively by both teachers and students. Most of them were in general satisfied with its impact on the teaching and learning process. Some teachers were enthusiastic about being able to guide distance-learning students through structured, relatively linear sequences of learning problem-solving activities, and they welcomed the learning design model as being more effective than previous ones.

Future work will take into account the results of the evaluation approach and will continue with research into an improved learning design model that will be structured around the principles of problem-based collaborative learning (PBCL) and compare the two sets of results.

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