Evaluation of usability and assessment capabilities of an e-Learning System for Nursing Radiation Protection

Ioannis Hatzilygeroudis[1], Constantinos Koutsojannis[2], Nikolaos Papachristou[1]*
[1]*Department of Computer Engineering & Informatics, School of Engineering*
University of Patras, Greece
[2]*Departmen of Nursing, School of Health Sciences*
Higher Technological Educational Institute of Patras, Greece
{ ihatz, ckoutsog, papaxris}@ceid.upatras.gr

Abstract

In this paper, we present the initial evaluation of EX-COFALE, an extension to an existing open-source, web-based adaptive e-learning system, namely COFALE developed and used for web-based education on Radiation Protection in our Nursing Department. COFALE, although offers facilities for adaptive content presentation, adaptive use of pedagogical devices and adaptive communication, it lacks facilities for adaptive student assessment. EX-COFALE remedies this deficiency of COFALE by allowing for automated test creation and assessment based on the students' knowledge information. To technically achieve the above, expert systems technology is used. The system is currently used by the students of our Nursing Department and has been initially evaluated for usability of the e-learning environment and effectiveness the educational content management including assessment capabilities.

1. Introduction

Most health care institutions and educational departments typically schedule radiation protection training classes for selected groups of their stuff or their students. Computers can provide a possible alternative radiation safety training in the form of a computer-based training program that can be accessed or downloaded via the Internet. Some University Radiation Safety Programs already use the Internet as a means to provide computer based radiation safety training to radiation workers employed at their facilities [1, 2]. On the other hand recently, there has been a large research activity on web-based intelligent educational systems (WBIESs) [3]. WBIESs use Artificial Intelligence (AI) Techniques in order to adapt mainly to student needs for self-study. As WBIESs we consider either web-based intelligent tutoring systems (ITSs) [4, 5] or adaptive hypermedia education systems (AHESs) incorporating intelligent techniques [6]. E-learning environments provide facilities mainly for helping course generation and management and refer to both the tutors and the students. Adding facilities (intelligent or not) for tutors in WBIESs make them a kind of intelligent e-learning systems (IELSs) [7, 8]. COFALE (Cognitive Flexibility in Adaptive Learning Environments) is an open-source adaptive e-learning system [9]. According to [10], a system, in order to facilitate adaptive support, should be designed to meet the following operational criteria for adaptability in: (a) presentation of learning content, (b) use of pedagogical devices, (c) communication support, (d) assessment,. COFALE manages to successfully accommodate the first three requirements [9]. In order to help tutors to be able to create courses with adaptive assessment capabilities, we modified and extended it to provide such functionalities.

The paper is organized as follows. In Section 2, a short overview of COFALE with an emphasis to its adaptive capabilities is presented. Section 3 deals with the proposed extensions to COFALE, mainly concerning adaptive assessment, whereas Section 4 with

*The order is alphabetical.

Twentieth IEEE International Symposium on Computer-Based Medical Systems (CBMS'07)
0-7695-2905-4/07 $20.00 © 2007 IEEE

implementation aspects. Section 5 presents related work Section 6 present the initial evaluation results and finally Section 7 concludes the paper.

2. The COFALE environment

COFALE is an adaptive e-learning environment supporting cognitive flexibility that is a learning theory which emphasizes a case study based approach to learning, involving context-dependent and realistic situations [9]. COFALE is based on ATutor, an open-source, web-based learning content management system (LCMS) designed and maintained by ATRC [12]. Compared to contemporary adaptive learning systems, COFALE seems to fulfill all the needed criteria for cognitive flexibility. COFALE gives the tutor the ability to implement student models. The learning content in COFALE can be decomposed into quite primitive content (or learning) units, so that the system can present each student different content units. For example, simpler examples for a "novice" learner and advanced for an "expert" one. This implements adaptive presentation of learning content. At the end of each content page, the student is encouraged and guided to do a number of learning activities, depending on his/her current "mental model" about the concept of study. This means that COFALE allows for a second level of student modeling, that of "mental models" of the students, which are related to the type of the concepts to be taught. Given the type of first-level student model (novice, expert), certain types of mental models may be excluded. So, COFALE may suggest activities based on simpler mental models to a "novice" learner, but based on more complex models to an "expert" one. This implements adaptive use of pedagogical devices. Moreover, while learning with COFALE, students can use a tool to search for peers who could help them to overcome difficulties about acquiring the concept of recursion. For example, COFALE may suggest some "expert" students to a "novice", so that he/she can ask them questions about problems, or may suggest an "expert" student to another "expert" student, so that they can exchange ideas about advanced concepts or activities. That implements adaptive communication support.

3. Extending COFALE

To make COFALE meet our needs, we made some modifications and extensions to it, calling the new system EX-COFALE (Extended-COFALE) presented in next subsections:

3.1 Domain Knowledge

COFALE uses a tree-like structure to represent domain knowledge. COFALE can alter the domain knowledge tree presented to the user depending on the user model. In Figure 1, a partial such domain knowledge tree, which we constructed implementing a course on 'radio safety' from the health care domain, is presented [1, 2]. Actually, what it can do is to hide certain subtrees, which are not appropriate for a certain user. EX-COFALE goes a step further. It can re-arrange the branches of the tree, based on the user's model, thus achieving something like 'concept sequencing'.

3.2 Evaluation Test Creation

First, we modified the test manager. We added more functionality as far as test construction is concerned: (a) The tutor can associate a test to a specific learning goal (set of concepts) and (b) The system can now automatically create a test. The tutor should only create and store questions in the system's database. Also, he/she may define the number and the difficulty levels of the questions to be included in a test for each concept. This is done via a rule-based expert system. As far as creation of test questions is concerned, we added the capability of defining associations between a learning concept and corresponding questions. This way a test has each question associated with a specific learning concept. More than one question may refer to the same concept. Questions may have different difficulty levels assigned to them.

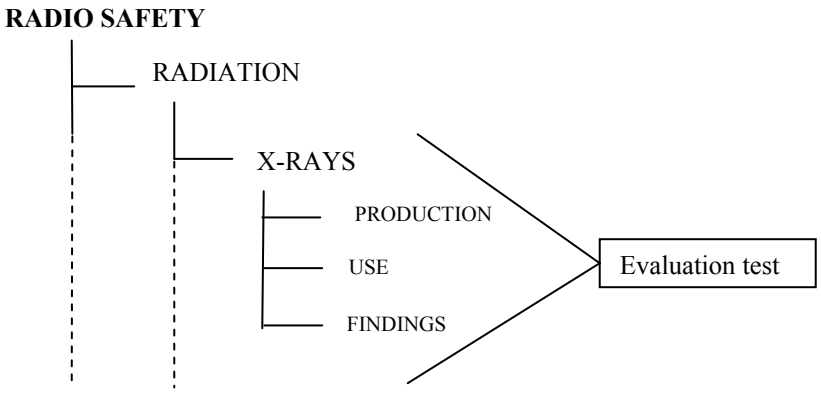

Figure 1. Part of a Domain Knowledge Tree

The tutor is able to insert, delete or modify all the parts/attributes of a question (i.e. the body of a question, its answers, possible help hints, the associated concept, the difficulty level etc). We must note here that two types of questions, multiple-choice and true-false, can be automatically marked. There is a third one, open-end questions, which are manually marked.

3.3 Student Assessment

One of the most important functions of an intelligent e-learning system is student evaluation (or assessment) of the knowledge level of a student after having dealt with a learning goal. In EX-COFALE, a student is evaluated at two levels: (a) the concept-level and (b) the goal-level. The concept-level evaluation deals with the level of understanding of the individual concepts of a learning goal test, whereas the goal-level evaluation deals with the level of understanding of a learning goal as a whole. Furthermore, EX-COFALE allows for on-line test creation, even if a student has not completed the study of all of the concepts related to a learning goal. This is achieved via the above mentioned rule-based expert system. The knowledge level of a student, as far as a concept is concerned, is classified in one of the following three categories: (a) low (0-49), (b) medium (50-70) and (c) good (71-100), whereas, as far as a learning goal is concerned, in one of the following five categories: (a) low (0-30), (b) average (31-49), (c) good (51-70), (d) very good (71-85) and (e) excellent (86-100) (within the parentheses are the corresponding ranges of the marks to be achieved). The knowledge level of a student for a concept, called concept level (CL), is calculated via the built-in formulas that use question weights. The weight of a question is related to the difficulty level of a question and the composition of the set of questions used for testing the concept.

4. Implementation Architecture

EX-COFALE is a modification of that of COFALE [9]. The functionalities of the architecture are as follows: (a) The user uses a Web browser to log into the system and make a request, (b) Taking into account the user's request, the browser sends a HTTP request to the Web server in which a set of PHP scripts were installed, (c) Depending on the kind of the HTTP request, the Web server creates new data or update existing data or retrieve existing data by connecting the MySQL database server in which all data of the user, learning content, tests, forums, and so on are stored and indexed. Then, the Web server formulates a HTML file including a CSS format and sends it back to the browser. (d) On the basis of the HTML file and the CSS format received from the Web server, the browser creates a Web page and presents it to the user. (e) For the tests' evaluation a rule-based expert system is used, which is implemented in Jess, a java based expert system tool [6]. PHP scripts make all the appropriate communication between the expert system and the browser. PHP scripts also bridge the expert system with the MySQL database server to store the results of the tests evaluation. A core prototype of the system has been implemented, which does not offer at the

moment all designed functionalities and is currently accessible via the Internet (http://150.140.142.79/).

5. Evaluation results

The first version of the system was released in December 2006 and used by the class of the Nurse Informatics and Biostatistics courses, in Nursing Department, which consisted of seventy students. The students had not been taught about Radiation Protection during the course lectures. They used the system, they evaluated themselves and finally they were asked to fill in a questionnaire, including questions for evaluating usability and learning [11, 13, 14]. The questionnaire was created on the basis of well known systematic evaluation procedures for interactive multimedia and Intelligent E-Learning Systems with Authoring and Assessment Mechanisms for Education and Training, and consisted of two parts [15, 16]: (a) The overall reaction to the educational website (Q1-9) and (b) The educational content of the system (Q10-16). Questions 1 to 15 based on Likert scale (agree-1: not at all, agree-5: very much) [17, 18]. Finally, question 16 was of multiple choice one and concerned on further improvement suggestions for the system. The results can be seen in Table 1. Their answers showed that the students in general the system was easy to use (Q2), most of them reported that they felt very confident using the system (Q8) and that they didn't need to learn a lot before they could effectively use it (Q9). On the other hand, the students agreed that the system helped them in learning because the course objectives are clear (Q10), activities stimulated learning (Q11), the tests were accurate and fair (Q13). Finally according to the students Ex-COFALE was a good way to learn Nursing Radiation Protection (Q15).

Table 1. Questionnaire Results

Q	QUESTIONS	ANSWERS (%)				
		1*	2*	3*	4*	5*
1	I think I would like to use this website frequently.	0,0	8,1	29,7	41,1	20,3
2	I thought the website was easy to use.	0,0	5,4	24,3	44,6	25,7
3	I found the website unnecessarily complex.	29,7	35,9	28,3	6,8	0,0
4	I think I would need Tech Support to be able to use this site	29,7	36,5	14,9	10,8	8,1
5	I thought there was too much inconsistency in this website	35,1	29,1	35,1	0,0	0,0
6	I would imagine that most people would learn to use this website very quickly	0,0	5,4	21,6	70,3	2,7
7	I found the website very cumbersome to use.	25,7	23,0	17,6	24,3	9,5
8	I felt very confident using the website	4,1	8,0	29,2	38,4	20,3
9	I need to learn a lot about this website before I Could effectively use it.	8,1	39,2	27,5	23,8	1,4
10	The course objectives are clear to me.	0,0	10,8	1,3	73,0	14,9
11	The course activities stimulated my learning.	0,0	0,0	25,7	58,1	16,2
12	Ex-COFALE was essential in the course.	17,6	6,8	32,4	27,0	16,2
13	The test(s) in this course were accurate and fair.	0,0	1,4	27,0	58,1	13,5
14	The difficulty level of this course is appropriate.	6,8	9,5	23,0	60,8	0,0
15	Ex-COFALE was a good way for me to learn Nursing Radiation Protection	0,0	10,0	21,6	41,4	27,0

** agree-1: not at all, ..., agree-5: very much*

The multiple choice question (Q16) revealed that the system needs some improvements as for example the use of more videos and photographs throughout each of the modules could provide helpful visual aid to the training experience and reinforce the topics.

6. Related Work

Worldwide there are in use only a few e-learning systems for Radiation Protection. For example at Princeton University, the Office of Environmental Health and Safety developed an

instructive computer-based radiation safety training program, accessible to anyone via the Internet (http://www.princeton.edu/~ehs/) [1]. Their web site, which focuses mainly on the fundamentals of radiation safety and physics, is used only by radiation workers at the University as an adjunct to the traditional classroom radiation safety training they receive [2]. Additionally there are in use a number of e-learning systems (or environments) that can produce adaptive courses with a few of them provide facilities for adaptive student assessment. ALE (Adaptive Learning Environment) is an e-learning environment (implemented in the context of the WINDS project [19]) that integrates an intelligent tutoring system, a computer instruction management system and a set of cooperative tools that does not support any facility for student assessment management. aLFanet (Active Learning For Adaptive interNET) is an e-learning platform created in the context of an IST project [20] that although provides facilities for test/questionnaire creation, it does not seem to provide any facilities for student assessment. In [13] a system that integrates course authoring and student assessment capabilities is presented, focusing on the assessment issue. The presented assessment method is based on SPC (Student-Problem-Course) table but it does not seem to offer automatic test creation and it does not take into account the difficulty of the questions. The system presented in [8, 10] provides content presentation and student assessment adaptivity alongside extensive authoring facilities. It uses three levels of assessment (paragraph, sub-chapter, and chapter). Tests can be adaptively (i.e dynamically) created. Questions are not distinguished by difficulty level; all are considered as equally contributing to the final mark. Finally, there is a mark threshold associated with each learning item that should be overtaken by the student in order to consider that he/she has successfully passed it. The system is rather examination-oriented.

7. Conclusions

In this paper we present the initial evaluation of a web-based e-learning system that would provide Nursing Radiation Protection education program including a broad overview of common hospital radiation sources, safety procedures, health risks associated with most radiation related departments as well as National and European Radiation Safety regulations for nursing students [4]. EX-COFALE, is an extension to an existing open-source, web-based intelligent e-learning system called COFALE incorporating automated test creation and assessment based on the students' knowledge information. COFALE has been modified to allow for representation of associations between test questions and learning concepts. Assessment is done at the concept and the goal level. In the assessment process, the difficulty level of questions is taken into account, which is not the case in existing systems. To technically achieve the above, expert systems technology is used. The system was also designed as an alternative tool for hospitals to use in assisting them in complying with requirements of its radiation safety program. A practical easy-to-use computer-based radiation safety training program could prove to be an instrumental and economic alternative in the training of nurses while making a significant impact on radiation safety awareness within the medical facility. A web-based training program focused on radiation safety could assist medical facilities in (a) complying with regulatory training requirements, (b) increasing hospital worker participation in radiation safety training, (c) providing more flexibility in the scheduling of health care workers to complete training; and (d) ensuring that the number of routine patient services are not significantly affected by temporary staffing shortages.

Acknowledgements

This work was partially supported by the European Social Fund (ESF), Operational Program for Educational and Vocational Training II (EPEAEK II), 2.2.2.a (Nursing Department of the Technological Educational Institute of Patras, Greece).

8. References

[1] Dupree, S. M. Development of web-based radiation safety training to meet the needs of a small academic institution. Abstracts of papers presented at the Forty-Fourth Annual Meeting of the Health Physics Society, Philadelphia, Pennsylvania. Health Phys. *76:5146;* 1999.

[2] Daniel S. Hamilton, Matthew M. Peck, Hao Yu, and Kimberlee J. Kearfott. Computer- Based Radiation Safety Training for Hospital Radiation Workers. Health Phys. 78(Supplement 1):S4-S8; 2000

[3] Kazi, S. A., "A Conceptual Framework for Web-Based Intelligent Learning Environments Using SCORM-2004", Proc of the IEEE ICALT-2004, Aug. 30-Sept. 1, 2004, Joensuu, Finland, IEEE Com Society, 2004, 12-15.

[4] Hatzilygeroudis I. (Guest Editor), Special Issue on AI Techniques in Web-Based Educational Systems, International Journal on AI Tools (IJAIT), 13(2), 2004.

[5] Brusilovsky, P., "Adaptive and Intelligent Technologies for Web based Education", In C. Rollinger and C. Peylo, *Special Issue on Intelligent Systems and Teleteaching, Künstliche Intelligenz, 4*, 1999, 19–25.

[6] Friedman-Hill, E., *Jess in Action: Rule-Based Systems in Java*, Manning Publishing, 2003.

[7] Freedman, R, "What is an Intelligent Tutoring System?", *Intelligence* 11(3), 2000, 15–16.

[8] Christea, P. D., Tuduce, R., Savescu, I. A., Grogorin, C. A., Tomozei, D.-C., Gradinescu, V. R. and Rangu, C. M., "Prototype Implementation of an Intelligent E-Learning System", Proceedings of the IASTED International Conf on Web-Based Education (WBE-04), Febr. 16-18, 2004, Innsbruck, Austria, Acta Press, 441-446.

[9] Chieu, V.M. and Milgrom, E., "COFALE: An Adaptive Learning Environment Supporting Cognitive Flexibility", The Twelfth International Conference on Artificial Intelligence in Education, 2005, 491–498.

[10] Chieu, V. M., Anh, D. T. V. and Hung, P. K., "An Operational Approach for Analyzing ICT-based Constructivist and Adaptive Learning Systems", 4th IEEE International Conference on Computer Sciences: Research, Innovation & Vision for the Future (RIVF'06), February 12-16, Hochiminh City, Vietnam, 1-10.

[11] Christea, P. D. and Tuduce, R., "Test Authoring for Intelligent E-Learning Environments", First International Workshop on Authoring of Adaptive and Adaptable Educational Hypermedia, 2004. (http://wwwis.win.tue.nl/~acristea/WBE/416-805_WBE-PCristea_RTuduce_6pg.pdf)

[12] Adaptive Technology Resource Center, "*ATutor learning content management system"* (http://www.atutor.ca/), 2004.

[13] Avouris N., Tselios N., Fidas C., Papahristos E., (2003a). Website evaluation: A usability-based perspective, in Y. Manalopoulos et al. (ed.) LNCS No 2563, pp. 217-232, Springer Verlag, Berlin.

[14] Y. Psaromiligkos, S. Retails, (2003) Re-Evaluating the Effectiveness of a Web-based Learning System: A Comparative Case Study. JI. of Educational Multimedia and Hypermedia Barker, P. & King, T. (1993) «Evaluating interactive multimedia courseware – a methodology». Computers & Education, 2, 4.

[15] Thomas S. Tullis and Jacqueline N. Stetson, "A Comparison of Questionnaires for Assessing Website Usability", UPA 2004, Hum Interf Design Dep, Fidelity Center for Applied Technology, Fidelity Investments

[16] Knussen, C, Tanner, G. & Kibby, M. (1991) «An approach to the Evaluation of Hypermedia». Comp Educ, vol. 17, iss.1

[17] Reeves, T. C. (1994) «Systematic Evaluation Procedures for Interactive multimedia for Education and Training». Στο Reisman, S. Multimedia Computing: Preparing for the2 1st century. Harrisburg, PA: Idea Group.

[18] Shih, T. K., Lin, N. H., and Chang, H.-P., "An Intelligent E-Learning System with Authoring and Assessment Mechanism", Proceedings of the 17th International Conference on Advanced Information Networking and Applications (AINA'03)

[19] Kravcik, M and Specht, R., Pesin, M. and Klemke, R., "Authoring Adaptive Educational Hypermedia in WINDS", Online Proc. ABIS 2001 Workshop (Adaptivitat und Benutzermodellierung in interaktiven Softwaresystemen), Dortmund, Germany, 2001. (Available at http://www.kbs.uni-hannover.de/~henze/ ABIS_Workshop2001/ABIS_2001.html).

[20] Santos, O. C., Boticario, J. G. and Barrera, C., "aLFANET: An Adaptive and Standard-Based Learning Environment Built upon DotLRN and Other Open Source Developments", Calvo, R.A., Ellis, R.A. and Peters, D. Internationalisation and ElearningSystems: .LRN Case Studies. In Delgado Kloos, C. and Boticario, J.G. (eds) Proceedings of Foro Hispano .LRN, Madrid 2005.