INTELLIGENT MOOC FOR THE DISASTER RESILIENCE DPROF PROGRAMME

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Abstract

The CADRE Project offers Intelligent MOOC for the disaster resilience DPROF programme (MOOC-DPROF). MOOC-DPROF aims at unlimited participation and open access via the Virtual Environment for the Built Environment Research to reduce knowledge shortfalls across the EU. PhD students registered in MOOC-DPROF differ by their knowledge levels, preferences, interests, goals, cognitive styles and learning styles. The basis of MOOC-DPROF is individual learning. The design of MOOC-DPROF is for it to run within the Moodle platform. PhD students are offered personalised learning materials in the form of digital textbooks, videos, audios as well as calculators, software, computer learning systems, an intelligent testing system, affective intelligent tutoring system, etc. A personalised MOOC-DPROF adapts the studies to individual needs. Upon completing the analysis of globally developed resilience management MOOCs, it was noticed that there is still no MOOC developed by applying biometric and intelligent systems in an integrated manner, something that has already been implemented with the MOOC-DPROF. The subsystems and a Case Study are briefly analysed in this paper.

INTRODUCTION

Local and international organizations throughout the world, such as the United Nations Environment Programme (UNEP), Center for Natural Resources and Development (CNRD) along with universities, such as the Cologne University of Applied Sciences or Global Universities Partnership on Environment for Sustainability (GUPES) are developing resilience (disaster) MOOCs. Such MOOCs appear in the Internet as separate systems (MOOC 2014) or MOOC List Directories. For example, by undertaking a search in the MOOC List Directory (https://www.mooc-list.com/) by the keyword “resilience”, the finding totalled 285 results and, by the word “disaster”, 200. Certainly, not all of these systems fall into the area of resilience (management), but some actually do. Next, there are brief descriptions of three, serving as examples, of these MOOC List Directory systems (Building Resilience; Introduction to Sustainability, Resilience and Society and Disasters and Ecosystems). Building Resilience learning outcomes are as follows: students will be able to define resilience, risk factors and preventative factors; explain the benefits of resilience; demonstrate the ability to utilize specific skills to optimize their well-being and develop a resilience map for utilizing in college and life after college. The course "Introduction to Sustainability, Resilience, and Society" introduces the complex but critical concepts of sustainability and resilience, and proceed to include a self-analysis of your impact on our environment and a case study of a societal evolution in sustainability. Emphasis will be on translating theory to individual impact and comprehension. Disasters and Ecosystems MOOC enhances knowledge and skills for tackling complex issues such as resilience and transformation, sustainable development, ecosystem management, disaster risk reduction, climate change adaptation and how they can be operationalized. The course is delivering through a series of lectures and case studies, quizzes, peer-reviewed exercises, along with additional study materials provided to the students. Students will be provided the opportunity to enhance their critical thinking through real life and fictitious problem solving exercises. Each week will feature an international expert who will be available to respond to questions and interact with students.

Population growth, environmental degradation and climate change will likely exacerbate disaster impacts in many regions of the world. What role do ecosystems play in reducing disaster risks and adapting to climate change? This is the topic of a Massive Open Online Course, "Disasters and Ecosystems: Resilience in a Changing Climate". It was developed jointly by the UNEP, the CNRD and the CUAS. This is UNEP's first MOOC, developed through its engagement with universities worldwide including the GUPES. The MOOC covers a broad range of topics from disaster management, climate change, ecosystem management and community resilience. Students have the opportunity to enhance their knowledge through quizzes, real life and fictitious problem-solving exercises, additional reading materials, videos and a discussion forum (MOOC 2014).

Currently the Intelligent MOOC for the Disaster Resilience DPROF programme (MOOC-DPROF) encompasses one module, "Knowledge management". Special attention regarding this module is paid to community resilience by multiple criteria decision making for a built environment by applying biometric and intelligent technologies. However, a DPROF programme can operate at full capacity by supplementing MOOC-DPROF subsystems—Domain Model, Student Model, Tutor and Testing Model and Database of Computer Learning Systems—with respective information. One more module will be supplementing the MOOC-DPROF in the nearest future named "Multi-stakeholder approach, inclusion and empowerment". Upon completing an analysis of globally developed resilience management MOOCs, it can be asserted that not a single "Knowledge management" MOOC with special emphasis on integrated intelligent and biometrics technologies has been developed in the areas of resilience or disaster. Furthermore there have not been any MOOCs developed that would apply biometric and intelligent systems in an integrated manner. This would be innovative on a global scale.

Numerous intelligent tutoring system (ITS) definitions are used in practice as well as in scientific research. For example, Neji et al. (2008) states that ITS is a computer-based educational system that provides individualized instruction like a human tutor. A traditional ITS decides how and what to teach based on the learner pedagogical state (Neji et al. 2008). Kazi et al. (2012) ITS defines as interactive software applications that present a problem to the students in a particular domain. Verdú et al. (2012) states that ITS are efficient tools to automatically adapt the learning process to the student's progress and needs. According to Salvucci (2014), ITS are computer-based tutors that aim to infer a student's knowledge during all stages of the learning process.

A variety of affective tutoring systems definitions could also be found in literature. For example, according to Sarrafzadeh et al. (2008), affective tutoring systems are ITS, that are able to adapt to the affective state of students. According to Mao and Li (2010), affective tutoring system is an ITS incorporating affecting computing, which refers to the process of learning where the emotional status of the student is monitored and the feedback and reactions are given when appropriate so to correct individual's state of emotion during learning. As reported by Moga et al. (2014), the concept of Affective tutoring system involves both collecting the emotion (which has an affective time from seconds to 3 minutes) and collecting the mood (which may last from minutes to days or weeks).

Intelligent tutoring systems application in MOOC has not yet been widely analyzed. Conforming to Wasfy et al. (2013), Intelligent Tutoring Massively Open Online Courses (ITMOOCs) can seamlessly deliver entire curricula while ensuring that students achieve and maintain the required level of proficiency in every curriculum topic. The ITS continuously adapts the course's delivery to the needs of each student by skipping over topics that the student demonstrates proficiency in, and reviewing topics that are determined to be the cause of assessment failures in downstream course nodes. Ketamo (2014) presents a next generation ITS, Learning Fingerprint. Learning Fingerprint enables conceptual level Learning recommendations in real-time in order to help student with his/her metacognitive skills and motivation. Aleven et al. (2015) presented a case study in which a widely used ITS authoring tool suite, CTAT/TutorShop, was modified so that tutors can be embedded in MOOCs. Specifically, the inner loop was moved to the client by reimplementing it in JavaScript, and the tutors were made compatible with the learning tools interoperability e-learning standard. The feasibility of this general approach to ITS/MOOC integration was demonstrated with simple tutors in an edX MOOC "Data Analytics and Learning" (Aleven et al. 2015). The developed MOOC-

DPROF integrates the main MOOC components for intelligent and affective tutoring systems (Kaklauskas et al. 2015). These are described next.

INTELLIGENT MOOC FOR DISASTER RESILIENCE DPROF PROGRAMME

The analysis at the start of the development of the MOOC-DPROF involved naming the platform that could be used to build the module "Knowledge management". The MOOC-DPROF platform is whatever the MOOC-DPROF is designed to run within, in line with its constraints, while making use of learning management systems facilities. The analysis involved five free widespread alternative MOOC platforms (EdX, Moodle, CourseSites by Blackboard, Udemy and Versal) according to six indicators—maximum class size, brandable, user analytics, monetization, mobile and hosting—for building a MOOC-DPROF for oneself.

Harvard and MIT use EdX to offer courses to 100,000+ students, allowing users to use plug-ins to expand the core functionality. Moodle allows users to build and offer online courses. CourseSites by Blackboard has most of the features that Moodle has, including extensive teaching tools, reporting features and SCORM compliance. Udemy is specializing in the private MOOC. Instructors can build and host their own courses on the Udemy platform and then offer them to users for free or for a fee. Open source Versal major strengths are a sleek, intuitive user interface and a robust drag-and-drop functionality. Versal cannot fairly be called a MOOC platform, because it lacks certain MOOC elements, such as a forum or discussion functionality (Swope 2014). The Moodle platform was selected. Now MOOC-DPROF utilizes the Moodle platform to deliver available modules.

Descriptions of MOOC, intelligent and affective tutoring systems consisting of typical MOOC-DPROF components appear in Chapter I. Intelligent and biometric subsystems were also integrated, as the traditional elements of the MOOC, intelligent and affective tutoring systems were being combined into the MOOC-DPROF. Psychological, physiological, ethical, emotional, religious, ethnic, legislative, infrastructural and other aspects were analyzed for the "Knowledge management" module. The diversity of aspects under assessment should follow a diversity of ways for presenting data needed for decision making. Suitability of the form for education is also a factor, because presentation of the learning process can be in different forms. Therefore, the following media and subsystems are used in Intelligent MOOC for Disaster resilience DPROF programme (MOOC-DPROF): digital textbooks, video, audio, as well as calculators, software, computer learning systems, intelligent testing system, affective intelligent tutoring system (Kaklauskas et al. 2015), computer conferencing, computer networks, discussion forum and 'face-to-face' contact (see Figure 1). Students can select the most effective format, because these different media and systems formats can represent the same learning process differently.

The MOOC-DPROF consists of six subsystems (see Figure 2): Domain Model, Student Model, Tutor and Testing Model, Database of Computer Learning Systems, Text Analytics, Decision Support Subsystem and Graphic Interface. These subsystems are similar to existing MOOC, intelligent and affective tutoring systems (Kaklauskas et al. 2015). The subsystems are briefly analysed below.

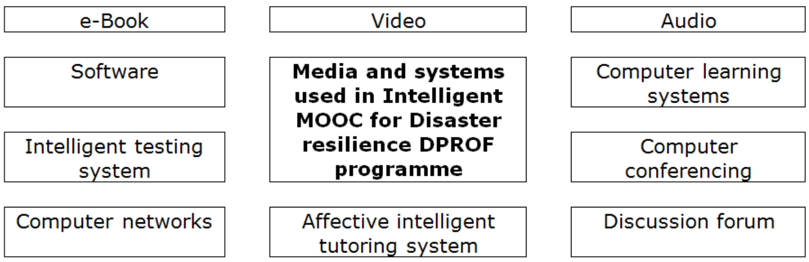

Figure 1. Media and systems used in MOOC-DPROF

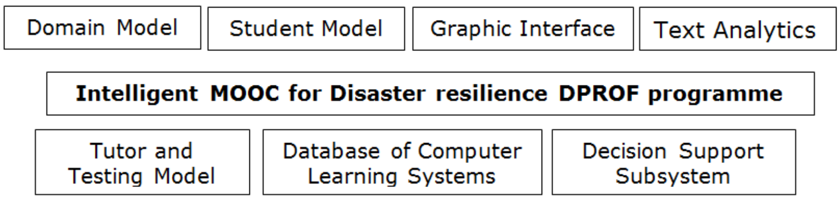

Figure 2. An Intelligent MOOC for Disaster resilience DPROF programme

Domain Model contains information and knowledge that the tutor is teaching. The system can offer study materials to students according to the repetitive key words. Curricula" is adapted to each individual learner's needs, depending on their knowledge level, age, habits and difficulties. The personalized scenario is dynamically generated with emphasis on the weakness of each PhD student. In this case the knowledge acquisition is efficiently facilitated by interaction with the system under the control of the learner. Mixed initiative interaction between user-student and system affords the student substantial control in exploring areas for which he or she may require a tutor.

Student Model stores data that is specific to each individual student. The Student Model is used to accumulate information about the education of a student, his/her study needs, training schedule, results of previous tests (if he/she has studied earlier in the above-listed e-learning MSc programmes or qualification improvement courses) and study results. Therefore, the Student Model accumulates information about the whole learning history of a student. The Student Model starts by assessing the student’s knowledge of the subject or what the student already knows. Student Model uses that data to create a representation of the student's knowledge and his/her learning process and represents the student's knowledge in terms of deviations from an expert's knowledge. On the basis of these deviations the system decides what curriculum module, or chapter (subchapter) of a module should be incorporated next, and how it should be presented (text, multimedia, computer learning system, etc.).

Decision Support Sub-system is used in mostly all components of the MOOC-DPROF (Domain Model, Student Model, Tutor and Testing Model, and Database of Computer Learning Systems) by giving different levels of intelligence for these components. Decision Support Sub-system was developed by applying multiple criteria decision making methods developed by authors (Kaklauskas 1999). Decision Support Sub-system aids and strengthens some kinds of decision processes.

Database of computer learning systems enables the use different Web-based computer learning systems. Further, the Desertification Modelling Computer Learning System (DM-CLS) is described briefly. By means of DM-CLS students can accumulate necessary experience in desertification modelling field. Using DM-CLS such experience can be accumulated faster than in real life activities and without unnecessary financial loss.

DM-CLS consists of the Domain Model and the Computer Learning System. The Domain Model provides theoretical knowledge related to desertification modelling, and the Computer-aided Learning System helps to master the knowledge practically. Information and knowledge contained in the Domain Model is provided in the form of e-books, video materials, calculators, open source software. Practical training is a critical issue for stakeholders responsible for the efficient desertification life cycle. With a well-designed DM-CLS, the need for a lecturer is minimized and the student may readily and efficiently take, in real-time the modelling of desertification modelling with appropriate messages he (she) gets from the system.

DM-CLS is a Desertification Modelling Computer Learning System that was developed by the authors and can be found at the following web address: http://iti.vgtu.lt/ilearning/simpletable.aspx?sistemid=690). Major BR-KDDSS functions include creation and maintenance of user�be personalized desertification modelling objectives, preferences, and evaluation criteria; participation of various stakeholders in joint determination of criteria defining desertification (criteria system, values and weights); search for desertification project’s components according to the user requirements; find alternatives and make an initial negotiation table; multiple criteria analysis of the desertification project’s components; provision of recommendations (see Table 1); make electronic negotiations based on real calculations; determine the most rational desertification project’s components; develop up to 100,000 whole desertification modelling scenarios; multiple criteria analysis of all desertification modelling scenarios and selection the most efficient versions; what should the value of the Use Drought Tolerant Lawns be for this project to be the best among those under deliberation (see Table 2).

The fragment of recommendations for bettering the desertification alternatives under comparison appear in Table 11. If, for example, it would be possible to increase the degree of protection for alternative "Switch to crops that consume less water" a_5 (28.57%) from the 7 points up to the best 9 points, then the utility degree N_5 for a_5 would increase by 2,765%.

Table 1. A fragment of quantitative recommendations submitted in a matrix form

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Quantitive and qualitative information pertinent to alternatives												
Criteria describing the alternatives	*	Measuring units	Weight	Compared alternatives Possible improvement of the analysed criterion in % Galimas alternatyvos rinkos vertės padidėjimas %, įtakojamas pirmiau padidėjusios kriterijaus vertės								
				Replacing water-hungry turf grass	Grass removal	Use Drought Tolerant Lawns	Drought Tolerant Landscaping	Switch to crops that consume less water	Consider alternative on-farm related businesses	Poison All Alfalfa Crops	Biochar As An Alternative to Irrigation	Race the price for water
Investments	-	$/sq. ft.	0,93	1,44 (0%) (0%)	50 (97,12%) (48,56%)	3 (52%) (26%)	3,75 (61,6%) (30,8%)	1000 (99,86%) (49,928%)	1000 (99,86%) (49,928%)	1000 (99,86%) (49,928%)	135 (98,93%) (49,4667%)	400 (99,64%) (49,82%)
Potential profit	+	$/sq. ft.	0,29	2011 (190,4%) (29,6865%)	790 (639,24%) (99,6665%)	3750 (55,73%) (8,6896%)	5840 (0%) (0%)	1143,75 (410,6%) (64,0184%)	1450 (302,76%) (47,2043%)	1203,5 (385,25%) (60,0661%)	168,5 (3365,88%) (524,787%)	3510 (66,38%) (10,3498%)
Income shares	+	Points	0,19	7 (14,29%) (1,4593%)	7 (14,29%) (1,4593%)	7 (14,29%) (1,4593%)	7 (14,29%) (1,4593%)	8 (0%) (0%)	8 (0%) (0%)	8 (0%) (0%)	7 (14,29%) (1,4593%)	8 (0%) (0%)
The degree of protection	+	Points	0,18	9 (0%) (0%)	9 (0%) (0%)	9 (0%) (0%)	8 (12,5%) (1,2097%)	7 (28,57%) (2,765%)	9 (0%) (0%)	7 (28,57%) (2,765%)	9 (0%) (0%)	6 (50%) (4,8387%)
Poverty rate	+	Points	0,06	8 (12,5%) (0,4032%)	8 (12,5%) (0,4032%)	8 (12,5%) (0,4032%)	8 (12,5%) (0,4032%)	7 (28,57%) (0,9217%)	8 (12,5%) (0,4032%)	8 (12,5%) (0,4032%)	2 (350%) (11,2903%)	9 (0%) (0%)
Per capita income	+	Points	0,07	8 (12,5%) (0,4704%)	8 (12,5%) (0,4704%)	8 (12,5%) (0,4704%)	8 (12,5%) (0,4704%)	8 (12,5%) (0,4704%)	9 (0%) (0%)	8 (12,5%) (0,4704%)	8 (12,5%) (0,4704%)	9 (0%) (0%)

What should be the value of the Use Drought Tolerant Lawns for this project to be the best among those under deliberation? The calculations in this example are the approximation e cycle to determine what the value x11 cycle e of Use Drought Tolerant Lawns a1 should be for this project to become best among those under deliberation a1-a9. The price of this project continues being reduced until N3e becomes equal to 100%. It can be stated that this project can become the most effective among the projects under comparison once the value x11 cycle e of the Use Drought Tolerant Lawns reaches 1.7 $/sq. ft.

Table 2. The investment value calculations of Use Drought Tolerant Lawns for this project to become the best among those under deliberation

Investment value $x_{11\ cycle\ e}$ ($/sq. ft.)	**Utility degree**								
	N_{3e}	**N_{1e}**	**N_{2e}**	**N_{4e}**	**N_{5e}**	**N_{6e}**	**N_{7e}**	**N_{8e}**	**N_{9e}**
3	62.98%	100%	16.63%	59.70%	14.60%	18.10%	16.22%	12.71%	22.44%
2	88.80%	100%	18.30%	62.14%	16.39%	20.32%	18.21%	14.14%	25.17%
1.8	88.80%	100%	18.30%	62.14%	16.39%	20.32%	18.21%	14.14%	25.17%
1.7	100%	94.98%	18.40%	60.51%	16.66%	20.65%	18.51%	14.31%	25.57%

The use of multiple criteria computer learning systems in solving various problems encountered in the course projects and thesis was also aimed at determining: student's knowledge that is acquired at the university, student's general level of education, student's keenness of mind, student's ability to quickly and adequately respond to changing situation.

The Tutor and Testing Model presentation appears below in brief. The Domain Model presents frames to the student. The Tutor and Testing Model provide a model of the teaching process and supports transition to a new knowledge state. For example, information about when to test, when to present a new topic, and which topic to present is controlled by this model. The Tutor and Testing Model reflect teaching experiences of associate professors or professors. The Student Model is used as input to this component, so the Tutor and Testing Model's decisions reflect the differing needs of each student in optional modules.

The Tutor and Testing Model formulates questions of various difficulties, specifies sources for additional studies and helps to select literature and multimedia for further studies and a computer learning system to be use during studies. A student can select the level of difficulty at which the teaching takes place. For example, the chapters of modules with mathematical orientation are quite difficult for some students. Traditional testing systems evaluate a learner's state by giving them a mark and do not provide a possibility to learn about one's own knowledge gaps or to improve knowledge in any other way. The Tutor and Testing Model compares the knowledge possessed by a student (test before studies) and knowledge obtained by a student during studies (test after studies) and then it performs a diagnosis based on the differences. By collecting information on a history of a student's responses, the Tutor and Testing Model provides feedback and helps to determine strengths and weaknesses of a student's knowledge, and his/her new knowledge obtained during studies is summarized and then various recommendations and offers are provided. After giving feedback, the system reassesses and updates the student's skill's model and the entire cycle is repeated. As the system is assessing what the student knows, it is also considering what the student needs to know and which part of the curriculum is to be taught next. Also, there are options for selection of the following question in a test, which depends on the correctness of answers to the previous questions. Correct answers lead to more difficult tasks, incorrect – to easier ones.

The obtained knowledge is the difference between the possessed knowledge (test before studies) and the final knowledge (test after studies). The Tutor and Testing Model also explains why one or another answer is correct/incorrect and offers certain additional literature and multimedia related to the incorrectly answered question/s. Tutors can monitor their students' progress and communicate with their students during the course.

The system provides information on testing process in a matrix and graphical form: information on correct and incorrect answer, time distribution to every question, number of times a student has changed an answer to each question of a test, etc. An incorrect answer is evaluated by zero and a correct is evaluated by one (see Figure 3 (*right*)); intermediate answers score from 0 to 1, the difficulty of a question is determined on the basis of the results of previous tests taken by other students (see Figure 3 (*left*)), links to the study material that is related to the question and time allocated for testing.

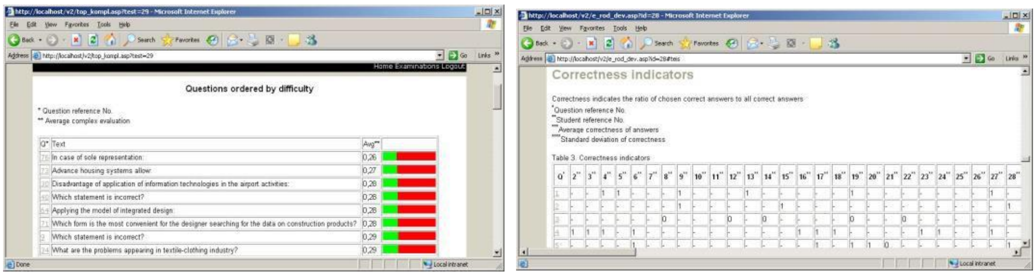

Figure 3. Questions sorted according to difficulty (*left*) and information on the correctness of an answer (right)

By using statistics provided by the Tutor and Testing Model, students can see the question's difficulty, average the evaluation of the whole group and learn about their position in the group before and after studies. Saving the data on a question's difficulty provides the opportunity of giving easier questions first of all and later moving on to more complicated ones. Similarly the topics can be selected – from the simpler to the more difficult by repeating the most complicated topics.

MOOC-DPROF has a graphic interface: icons in windows opened in the computer screen show data, models and other objects available in the system. The expert review method of graphic interface usability testing was applied for this work. Fourteen experts evaluated the graphic interface and justified it as the most suitable.

CONCLUSIONS

The e-learning Master degree studies "Construction Economics" were introduced at Vilnius Gediminas Technical University (VGTU) in 2000. Different multimedia and communication means are used during these studies, namely: electronic format of textbooks, video and audio, as well as computer-software, computer learning systems, intelligent testing systems, intelligent tutoring system, computer conferencing, computer networks, a discussion forum and 'face-to-face' contact. In order to increase the efficiency and quality of e-learning studies, an Intelligent Tutoring System for Construction Economics Master Degree Studies (MOOC-DPROF) was developed. MOOC-DPROF consists of six subsystems: Domain Model, Student Model, Tutor and Testing Model, Database of

Computer Learning Systems, Decision Support Subsystem and Graphic Interface.

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