E-Learning Recommender System for Teaching Staff of Engineering Disciplines

E. Soldatova, U. Bach, R. Vossen and S. Jeschke
RWTH Aachen University, Aachen, Germany

Abstract—**Studies show that Learning Management Systems at university level often are lacking necessary for teaching staff member features such as support of various didactical approaches, consideraion of different specifics of engineering disciplines, user-friendly interface. In this paper, a new recommender system aimed at teaching staff of engineering disciplines who wish to use E-Learning tools in their courses is proposed. The system will take into consideration the level of user experience, assess the elements of a teaching scenario and provide guidlines on the contents of the particular element with regards of the engineering specifics. As a result a lecturer should be able to create his E-Learning course that then will be running as a course within the university LMS. The novelty of the recommender system is that criteria used by the system are based on standards for engineering education in conjunction with the framework for pedagogical evaluation of Virtual Learning Environments.**

Keywords—*e-learning, engineering education, teaching staff, recommender system*

I. INTRODUCTION

Several studies analysing the usage of Learning Management Systems (LMSs) by the teaching staff of engineering disciplines [1] have revealed problems such as the lack of collaboration among the lecturers in terms of the LMS usage and the lack of help available on the LMS usage. Studies at the University College of Borås/Sweden, Duke University/USA [2] and the University of Alberta/Canada [3] show that most LMSs lack flexibility, interactivity and the possibility to take into account staff expertise and institutional needs. As a result, most of the times a LMS does not permit teaching staff to exploit the education potential of state of the art E-Learning technologies. Moreover, some staff members loose intention to user LMS further.

In conclusion, lecturers in general need more support when starting to use a LMS. Therefore, an appropriate recommender system that addresses the level of lecturer expertise as well as the subject that he/she is teaching is needed. Although the proper use of the LMS by students is another important aspect, the target audience of this article has been restricted to teaching staff of engineering disciplines.

The IMA/ZLW&IfU has almost fourty years of experience in collaborating with the teaching staff of the engineering faculties of the RWTH in the area of developing better teaching approaches. Our communication with the teaching staff of the RWTH also has revealed the same drawbacks of LMSs as stated above. Furthermore, it has also been observed that local course websites and FTP servers are preferred over university LMS quite often. Some faculties are even known to have their own LMS.

Our goal is to create an E-Learning recommender system that can help teaching staff of engineering disciplines by providing recommendations on a selection of suitable E-Learning tools based on the criteria defined. The problem has been elaborated by using the framework for the pedagogical evaluation of virtual environments [4] in order to assess the needs of a teaching staff. Furthermore, the suitability assessment scenario for the recommender systems has been described and the as object diagram for future software engineering purpose has also been provided.

II. BACKGROUND

A. Theory

There is a commonly used division of E-Learning tools into Learning Management Systems (LMSs) and Course Authoring Tools (CATs). The E-Learning software overviews show that more than 400 LMSs and CATs are available [5]. Such systems require serious time investment in order to create the course and to educate at least one member of computer support on how to install and maintain the software [6].

A LMS provides mainly course management functionality and basic facilities of course authoring tools. For example, the most widely-used LMSs such as Moodle, Blackboard, Camillo and Sakai have a storage space, space for course description and WiKi as a tool for course contents. Course Authoring Tools provide to a course instructor functionalities to create an E-Learning content. Currently LMSs are much more adopted than CATs, although being only a part of wide E-Learning tools spectrum. Consequently, a lot of research about usage of LMSs is available.

The LMS/CAT division is sometimes problematic to apply in practice, for example Facebook, Twitter, Youtube do not perfectly fit into it, however these tools are included in the rating of the top 100 e-learning tools [7]. These tools as well attract users with their ease of use and intuitive interfaces.

We will stick to more suitable for us classification of E-Learning Tools consisting of three levels [8]: the usage of internet, the usage of a platform and interactive contents. A „Level 1" is achieved when internet is used, "Level 2" is achieved when a platform and internet are used. A "Level 3" is achieved when all three criteria have been fulfilled, i.e. the internet, a platform, learning videos, multimedia and interactive elements are used in the E-Learning scenario. For later scope of the article we will

focus on the "Level 3". Scenarios corresponding to the "Level1" and the "Level 2" are used for a long time at the RWTH, the "Level3" scenarios such as MOOCs, Virtual Laboratories are now being introduced at a big pace [9], [10].

B. Vision

The following working hypothesis is used for future work: "There are a number of well-defined and assessable criteria which assure the E-Learning tool suitability („Level3" according to the above classification) for a course and an institution once they have been applied systematically."

Our goal is with regards to the hypothesis to elaborate number of criteria which assure the E-Learning tool suitability ("Level 3" according to above claassification) for a course and an institution once they have been applied systematically.

The system is aimed at teaching staff members of engineering faculties who wish to use E-Learning tools in their courses. Therefore the system will take into consideration the level of user experience when providing recommendation on course design. The system will assess the elements of a teaching scenario and provide guidlines on the contents of the particular element with regards of the engineering specifics. As a result a lecturer should be able to create his E-Learning course that then will be running as a course within the university LMS. The course delivered should be answering to the characteristics of the Level3 E-Learning (be interactive, running on the platform, using internet).

C. Problem Elaboration

According to the definition [11], „E-Learning is learning facilitated and supported through the use of information and communications technology (ICT)". Consequently, both aspects of learning and of ICT tools need to be taken into account for criteria elaboration and for creating the recommender system.

We consider the following elements of the teaching process: design of the course, delivery of the course. The course is assumed to be consisting of learning scenarios [12].

The parameteres needed taken into account by the recommender system can be divided into the three categories: teacher (level of expertise), course (design, delivery, engineering discipline specifics, division of a course to learning scenarios), E-Learning tools (requirements of the Level 3 of the E-Learning).

As a result, the course delivered will be used by the students in their local LMS. The delivery of the course will be assessed by the means of students questionnaire.

However, it should be clearly stated that questions pertaining to the efficiency of the selected E-Learning tool in the learning process have been completely left out of the scope of our research.

Quite remarkable is the experience of the "Best Practice" project of the Swiss Distance University of Applied Sciences [13]. The project was aimed to help lecturers to improve didactical qualities of their E-Learning courses and to stimulate interactivity and collaboration. As a result, students activity in e-learning activities within a course has increased from 2 to 14 times.

D. The framework for pedagogical evaluation of Virtual Learning Environments

The framework for pedagogical evaluation of Virtual Learning Environments (VLE) is described in the article [4]. A VLE is a collection of tools enabling the management of online learning, providing a delivery mechanism, student tracking, assessment and access to resources. As a VLE includes E-Learning tools therefore this framework is applicable to the scope of our work.

The framework is said to provide a clear set of requirements for evaluating the system's suitability for supporting the processes that form the basis of interactive learning. This framework is based on a system approach and therefore it has been chosen upon the other articles that were analyzing selected qualities of a learning process [14], [15], [16], [17], [18].

The framework combines a conversational model applied to the teaching learning and a viable system model applied to the course management. Therefore „it helps in supporting pedagogical innovation (programme level), institutional management of programmes (module level) and students management of their own learning (learner level)".

III. RESULTS

A. Criteria profiling for engineering education

The VLE framework has a universal character, therefore it can be used for engineering education. There are a number of standards of engineering education such as EC-2000 [19], CDIO [20], ABET [21], SPEC [22] that are used for the accreditation of engineering universities in the USA (ABET), UK (SPEC) and internationally (EC-2000, CDIO). These standards also serve as a basis for courses, goals identification, curriculum creation in the respective universities. We will stick to the CDIO standard and the framework criteria will be profiled according to the CDIO; this will be discussed later in the article.

Therefore the novelty of the recommender system suggested in this article lies in the choice of pedagogicaly sound criteria that are used to assess E-Learning tools and needs of a teaching staff member with regards to the course. Moreover, his/her current scenarios in E-Learning tools usage are assessed and new tools will be suggested basing on the Engineering educational standards with regards to the subject specifics. Therefore the scenarios and tools suggested will be pedagogically biased, scientifically explained and compliant with the requirements to the quality of course when based on engineering standards.

B. Criteria Elaboration

The main idea is to use the framework [10] for the evaluation of E-Learning tools and to finding out the expectations of the teacher. The CDIO for engineering education standard allows to evaluate the E-Learning tool with regards to the engineering specifics and allows tuning the criteria for a concrete engineering area. The CDIO standard as well will be used in order to provide a recommendation about the contents of the E-Learning course and a specific scenario.

The criteria used by the framework [10] for suitability evaluation at the module level are as follows: degree of presentation and re-presentation of key concepts and ide-

as, degree of coordination of people, resources and activities, resource negotiation and agreement monitoring of learning, degree of self organization amongst learners and the adaptability of the module and the system. At the learner level the criteria are: learner-centredness, coordination of people, resources and activities, time management/planning, monitoring of own learning, adaptation/reflection. At the institution level the criteria are: extensibility and integration, coordination of people and activities, resource negotiation and agreement, monitoring of modules, self organisation of teachers, adaptability of programme.

C. Rationale towards the recommender system

Suitability assessment and evaluation can be automated therefore we suppose to build a recommender system software. Herein below the suitability assessment scenario for a recommender system has been suggested and explained (Fig.1). To begin with, here are examples of questions from the framework that correspond to the „Programme level" and criteria „resource negotiation and agreement": "Does the system allow specification of programme rules for delivering a module? Does it permit or provide a space for negotiation etween programme managers and module tutor on resource questions? What tools does the system provide for teachers to present/express their ideas to students?"

Secondly, the CDIO standard imposes specific guidelines which will shape the specifics of question. As a result, the VLE assessment will be superceeded with the CDIO assessment in applicable parts.

Requirements collection phase; From the criteria a set of questions (similar to [23]) shall be formulated in order to identify the needs of the teaching staff member towards the E-Learning tool at all the three educational levels (module, learner and programme). As well his/her current experience with E-Learning tools will be assessed basing on the VLE framework criteria. Every answer will be assigned with a specific score. In order to quantify the answers the recommendations of the CDIO standard will be used in applicable parts. An exemplary screenshot is provided in the Fig.1.

Recommendation phase; A logical mapping between the needs of the teaching staff member identified and the criteria in evaluation framework is perfomed. Basing itself upon the values obtained in a requirements collection phase the match to E-Learning tools database shall be performed for each criteria. The E-Learning tools database will contain records for various E-Learning tools which are evaluated using the framework [6]. However, the benchmarking shall be used in order to have a score for each of the three levels (module, learner and programme). The tools included in the database will then be chosen based on tools ratings, engineering specifics and by making a questionnaire of the teaching staff. As a result, the relevant pieces of advice can easily be provided.

The exemplary representation of the E-Learning tools database is provided in the Fig. 3. Each of these tools have been added to the database are multiply assessed according to the criteria of the framework [6]. The criteria are contained in the left column of the table. Each criterion gives a score from 1 to 10 for the said tool. The scoring will be done on basis of expert interviews and by using the recommendations for benchmarking the E-Learning Tools
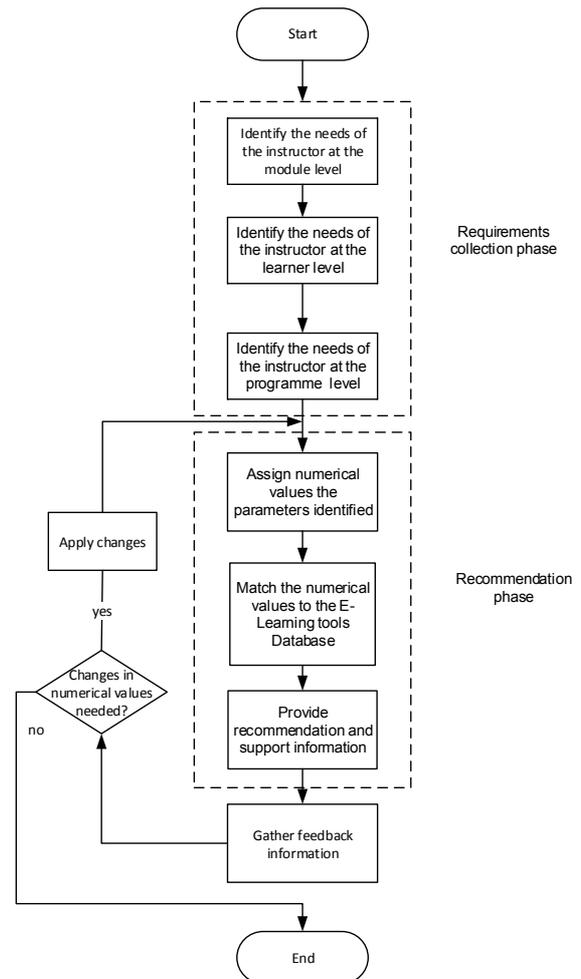

Figure 1. Suitability assessment scenario

in [21] . However, one must note that the content of the database provided in the Fig.4 simply aims at giving an idea of the inner view of the database; the scores themselves are not real.

The possibility of a feedback which may be needed when the instructors are not satisfied with the recommendation has also been well provided. The decision for changes can be made by a person after theprocessing of comments.

In the output screen of the system, the tool shall be suggested to the user and he/ she will have an opportunity to obtain more information about the tool itself; to understand the reason behind the recommendation and to correct the recommendation by adjusting the criteria according to his/ her personal feelings.

D. The recommender system structure

A structural diagram (Fig.5) illustrates the division of the system into the three layers: Representation layer, Business Logic Layer, Data Layer. Representation layer displays the information for users. Therefore, it consists of the database editor, the HTML Form Generator and the HTML Editor. The Business logic layer performs the logic calculations in the Recommendation phase with the help of a Recommendation Unit. The Data layer shall contain the E-Learning Tools Database that are to be used in Recommendation phase.

E-Learning Recommendation Tool

1. How many students are there in your class?

2. How much classroom time do you spend on each of the following during a typical week within one course?

	None	30 min	1 Hr.	2 Hr.	More than 3 Hr.
Lecturing to the class	○	○	○	○	○
Leading discussion	○	○	○	○	○
Student work in small groups	○	○	○	○	○
Having students do seatwork on homework, workbook or text assignments	○	○	○	○	○
Providing individualized instruction	○	○	○	○	○
Having students use E-learning elements	○	○	○	○	○

3. What is your preferred didactical approach?

- ☐ Behaviorism
- ☐ Constructivism
- ☐ Cognitivism
- ☐ Mix of the elements
- ☐ I'm not really sure

Figure 2. Screenshot for the requirements collection phase

IV. CONCLUSION

The goal of this work was to address the problem of recommending E-Learning tools for teaching staff of engineering disciplines by defining criteria that will be used to create an E-Learning recommender system.

The chosen criteria are based on the engineering standards of engineering education and the framework for the pedagogical evaluation of virtual learning environments. The suitability assessment scenario for the recommender system has also been presented. The novelty of the recommender system lies in applying the framework to the engineering education, using the engineering standards to derive the questions for requirements collection phase and using the benchmarking of tools for the recommender phase.

The concept of the recommender system is presented at the early stages of system development. Therefore, future work must include a proper formulating of questions for the recommendation phase, the assignment and scoring of user answers and the careful benchmarking of available E-learning tools. A questionnaire of the teaching staff has also been planned. The questionnaire shall serve the following purposes: reveal new tools which should be included in the system, find out the various needs of the teaching staff in the E-Learning tools and reveal the level of expertise of the teaching staff in terms of E-Learning tools usage.

REFERENCES

[1] R. Garrote and T. Pettersson, "Lecturers' attitudes about the use of learning management systems in engineering education: A Swedish case study," *Australas. J. Educ. ...*, vol. 23, no. 3, pp. 327–349, 2007.

[2] (The LMS Review Subgroup/Duke University), "Learning Management System (LMS) Review Summary of Findings."

[3] S. Delinger and R. Boora, "Learning Management Systems Evaluation for the Univeristy of Alberta," 2010.

[4] S. Britain and O. Liber, "A framework for pedagogical evaluation of virtual learning environments," 2004.

[5] P. Berking, "Choosing Authoring Tools," no. March, pp. 1–57, 2012.

[6] Ghirardini, *E-learning methodologies*. Rome, 2011.

[7] "Top 100 Tools for Learning." [Online]. Available: http://c4lpt.co.uk/top100tools/.

[8] J. Handke and A. M. Schäfer, *E-learning, E-Teaching und E-Assessment in der Hochschullehre*. 2012.

[9] U. Bach and S. Jeschke, "Next Generation Engineering Education." Tagungsband der TeachING-LearnING.EU, Aachen, 2011.

[10] A. E. Tekkaya, S. Jeschke, M. Petermann, and D. May, *Innovationen für die Zukunft der Lehre in den Ingenieurwissenschaften*. 2013.

[11] JISC, "e-Learning Pedagogy programme," 2007. [Online]. Available: http://www.jisc.ac.uk/whatwedo/programmes/elearningpedagogy.aspx.

[12] E. E. González, F. B. García, A. H. Jorge, and A. G. Sanz, "AN E-LANGUAGE LEARNING EVALUATION CASE STUDY," 2007.

[13] A. ; Hediger and J. Sadiki, "Designing Model Courses for a Process of eLearning Optimization," *Vasa*. pp. 1–12, 2010.

[14] A. Diwakar, M. Patwardhan, and S. Murthy, "Pedagogical Analysis of Content Authoring Tools for Engineering Curriculum," *2012 IEEE Fourth Int. Conf. Technol. Educ.*, pp. 83–89, Jul. 2012.

[15] G. D. Angelo, "FROM DIDACTICS e-Learning Paradigms , Models and Techniques."

[16] A. Granić and M. Ćukušić, "An Approach to the Design of Pedagogical Framework for e-Learning," pp. 2415–2422, 2007.

[17] R. Irfan and M. U. Shaikh, "Framework for Embedding Tacit Knowledge in Pedagogical Model to Enhance E-Learning," *2008 New Technol. Mobil. Secur.*, pp. 1–5, Nov. 2008.

[18] "Design for Learning Programme," 2009. [Online]. Available: http://www.jisc.ac.uk/elp_outcomes.html.

[19] M. Besterfield-Sacre, L. J. Shuman, H. Wolfe, C. J. Atman, J. McGourty, R. L. Miller, B. M. Olds, and G. M. Rogers, "Defining the outcomes: a framework for EC-2000," *IEEE Trans. Educ.*, vol. 43, no. 2, pp. 100–110, May 2000. http://dx.doi.org/10.1109/13.848060

[20] E. Crawley, J. Malmqvist, S. Ostlund, and D. Brodeur, *Rethinking Engineering Education: The CDIO Approach*. Springer, 2007, p. 300.

[21] *UK STANDARD FOR PROFESSIONAL ENGINEERING COMPETENCE*. Engineering Council, 2013.

[22] R. M. Felder and R. Brent, "THE ABC ' S OF ENGINEERING EDUCATION : ABET , BLOOM ' S TAXONOMY , COOPERATIVE LEARNING , AND SO ON," 2004.

[23] University of Michigan Miller, *Teacher Questionnaire: Science and Mathematics Classes L.S.A.Y.* Spring, 1991.

AUTHORS

E. Soldatova, M.Sc. is a scientific researcher at the research group Didactics in STEM Fields at the IMA/ZLW & IfU Institute Cluster of the RWTH Aachen University, Germany (e-mail: elena.soldatova@rwth-aachen.de).

U. Bach, Dr. phil. is the leader of the research group Didactics in STEM Fields at the IMA/ZLW & IfU Institute Cluster of the RWTH Aachen University, Germany (e-mail: ursula.bach@ima-zlw-ifu.rwth-aachen.de).

R.Vossen, Dr. rer. nat. is the managing director of the Assoc. Institute for Management Cybernetics e.V. (IfU) at the IMA/ZLW & IfU Institute Cluster of the RWTH Aachen University, Germany (e-mail: rene.vossen@ima-zlw-ifu.rwth-aachen.de).

S. Jeschke, Univ.-Prof. Dr. rer. nat. is Head of the IMA/ZLW & IfU Institute Cluster of the RWTH Aachen University, Germany. S. Jeschke is as well Vice Dean of the Faculty of Mechanical Engineering of the RWTH Aachen University, chairwoman of the board of management of the VDI Aachen, a member and consultant of numerous committees and commissions, alumni of the German National Academic Foundation (Studienstiftung des Deutschen Volkes) and IEEE Senior Member. (e-mail: sabina.jeschke(at)ima-zlw-ifu.rwth-aachen.de).

Criteria vs. Tool	Moodle	Blackboard	Twitter	Youtube	MS Word
Module level					
presentation and re-presentation of key concepts and ideas	10	8	6	10	8
coordination of people, resources and activities	10	7	10	1	8
resource negotiation and agreement	10	5	3	1	7
monitoring of learning	5	10	8	0	0
self organization amongst learners	10	10	8	0	0
adaptability of module and system	5	3	0	0	0
Learner level					
Learner-centredness	10	10	0	0	0
coordination of people, resources and activities	10	10	10	0	0
time management / planning	10	10	0	0	0
monitoring own learning	9	3	0	0	0
adaptation / reflection	7	10	0	0	0
Programme level					
Extensibility and integration	6	7	3	2	1
coordination of people, resources and activities	10	8	0	0	0
resource negotiation and agreement	10	8	0	0	0
monitoring of learning	10	8	0	0	0
self organization amongst learners	10	8	2	0	0
adaptability of module and system	10	8	0	0	0

Figure 3.   E-Learning tools database

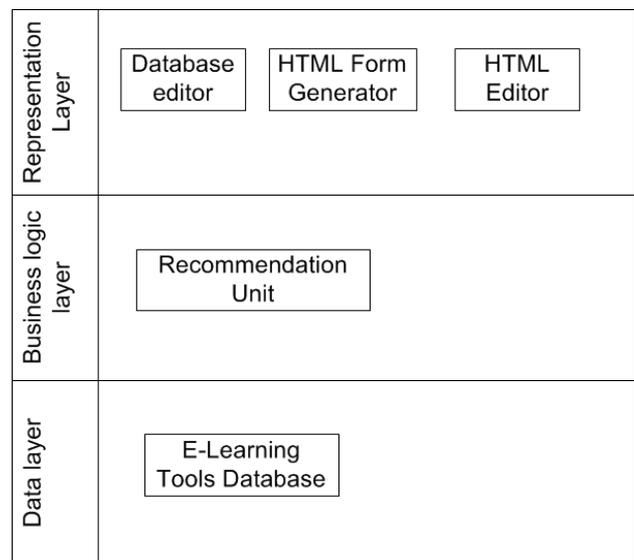| Criteria vs. Tool	Recommended Tool
Module level	
presentation and re-presentation of key concepts and ideas	8
coordination of people, resources and activities	8
resource negotiation and agreement	8
monitoring of learning	7
self organization amongst learners	10
adaptability of module and system	5
Learner level	
Learner-centredness	7
coordination of people, resources and activities	6
time management / planning	7
monitoring own learning	7
adaptation / reflection	7
Programme level	
Extensibility and integration	
coordination of people, resources and activities	8
resource negotiation and agreement	8
monitoring of learning	8
self organization amongst learners	8
adaptability of module and system	8

Figure 4.   An example of the Recommendation Unit Output

Figure 5.   Structural diagram

Representation Layer: Database editor, HTML Form Generator, HTML Editor

Business logic layer: Recommendation Unit

Data layer: E-Learning Tools Database