An Integrated Model for e-Assessment of Learning Experiences Enriched with Complex Learning Resources

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Abstract—The emergence of Web 2.0 and the influence of Information and Communication Technology (ICT) have fostered e-learning to be more interactive, challenging, and situated. As a result, learners felt empowered when they are engaged in collaborative learning activities and self-directed learning. Given the different learning styles of students, educators are faced with the challenge of having to develop assessments which are required to appraise the students’ learning process. Therefore, assessment models of learning experiences enriched with complex learning resources such as: simulations, serious games, and collaborative and virtual experiences are required. In this paper, an Integrated Model for e-Assessment (IMA) of learning experiences enriched with such complex learning resources is proposed. Moreover, a bottom-up framework of how to use IMA is discussed. A case study of developed tool and experiment is shown to more explain the model and the framework.

Keywords- e-Assessment, Assessment Model, Complex Learning Resources

I. INTRODUCTION

Our research group in Graz University of Technology (TUG) is collaborating with other researchers in an EC-funded project entitled ”Adaptive Learning via Intuitive/Interactive, Collaborative and Emotional System” (ALICE) from 2010 to 2012. TUG is responsible for developing the “New Forms of Assessment” work package, where an integrated model for e-assessment (IMA) based on rich learning experience is provided.

The rest of this paper is organized as follows, section 2 explains the IMA. Section 3 proposes a bottom-up framework of how to use IMA in instructional design and educational tools development. Section 4 presents a case study of how we have used IMA and the bottom-up framework to develop and evaluate a tool entitled “Co-Writing Wiki” for collaborative writing and peer-review as part of our contribution to ALICE project. Section 5 concludes this paper and provides insight on future work.

II. INTEGRATED MODEL FOR E-ASSESSMENT (IMA)

According to the proposal of the ALICE project, an enriched learning experience is a new form of learning experience that is composed by complex learning objects (e.g., collaboration, simulation, digital stories), assessing material (cognitive and affective-emotional) and that is able to generate an effective kind of learning (e.g., reflective learning, experiential learning, or socio-cognitive learning).

Fig. 1 shows the abstract level of a model that represents such an enriched learning experience. The model will mainly identify possible tools, practices, guidelines for providing enhanced forms of e-assessment for complex-learning objects (CLO) such as serious-games and simulations, virtualized collaborative learning, storytelling, and consideration of affective or emotional aspects. The model consists of four main components: the didactical objectives, complex learning resources, assessment activities (including feedback), and indicators for its evaluation and validation. Such an enriched learning experience is influenced by several components like pedagogical and psychological aspects, technical issues and existing standards and best practices (see red arrows in Fig.1).

Furthermore, quality criteria have to be defined to ensure a high quality standard of all activities in this complex learning environment. Therefore, quality assurance which addresses all components of the enriched learning experience is considered in the model. The quality assurance is also relevant with respect of indicators that are expected to result from the enriched learning experience: indicators for its educational efficiency and effectiveness. Finally, in order to ensure that the learning experience allows adaptivity, the model also interacts with three other important models: the learning model, the knowledge model, and the didactic model, respectively. Nevertheless, an extensive literature review has been conducted on e-assessment in general and e-assessment practices to support and reinforce the ALICE work package [1].
IMA Main Components

1) Didactical objectives

The main didactical objective is to achieve the immediate learning goal which is typically defined by the instructor of a course. Learning goals can be defined e.g. using Bloom’s Taxonomy [1], [3]. Didactical objectives affect the type of learning resources and assessment activities that are chosen in an enriched learning experience.

2) Complex learning resources (CLR)

According to constructivist learning theories we actively create knowledge by building explanations of ourselves and our environments (see e.g. [4], for a review). To address the needs of an “active learner” who is actively involved in the learning process, an enriched learning experience is generated made up of complex learning resources (CLR). Those CLR are expected to add moments of collaboration, simulation, and storytelling to support the learners in achieving the learning objectives.

3) Assessment and Feedback

Assessment activities represent the third component of the enriched learning experience. There is a need for new forms of assessment which meet the high demands arising from the CLR. Innovative assessment activities are considered to base on the Bloom’s taxonomy of educational objectives (remember, understand, apply; [1]) and effective kinds of learning such as reflective learning and experiential learning [4] as well as socio-cognitive learning [6]. Besides traditional summative assessment in which the assessment is provided at the end of a learning activity, also formative assessment activities should be considered. Due to formative assessment, learners are assessed more or less regularly during the learning activity and are supported in reflecting their learning progress. New forms of assessment that are based on CLR also involve students in the assessment process. For instance, students can be asked to assess their own work (self assessment) and/or the work of their peers (peer assessment; see e.g., [7]). The involvement of students in assessment activities enables students to develop meta-cognitive skills and to find criteria that reflect the quality of their work or the work of their peers. Moreover, innovative forms of assessment should also consider emotional and motivational aspects of the learner in order to enhance their learning outcome. Finally, giving feedback is an important issue in context of assessment because learners become aware of their gaps in knowledge, skills or understanding of a topic [9], and can accordingly change their learning behaviour.

4) Evaluation and Validation

To ensure that learning and assessment activities have a high quality standard, these activities should be evaluated and validated regularly. Evaluation means that a method, procedure etc. are assessed, using predefined quality criteria. However, it is risky to confound results of successful assessment with successful assessment itself. For instance, even if all students have passed a course because they have completed a test successfully this does not mean that the assessment itself was reliable. Perhaps the test was simply too easy. Therefore, evaluation criteria should consider best practices and standards as well as the learning objectives.

Validation means that the measure provides a valid conclusion about the status of a learner. Thus, the underlying assessment activities (and also their underlying technologies) should be validated regularly in order to ensure that they are valid. Results from those evaluation and validation processes form important indicators for the quality of the enriched learning experience in order to adapt/enhance it.

Prepare Inputs to the enriched learning experience

An enriched learning experience is affected by several components such as psychological/pedagogical and/or technical aspects. Also motivational and emotional/affective aspects are expected to influence learning experiences. It has to be mentioned that there is some reciprocal relationship between these pedagogical and psychological components and use technologies (although not depicted in the graphic); psychological and pedagogical aspects should be considered in the development of technologies and the development of new technologies certainly affects psychological and pedagogical theories.

1) Psychological and pedagogical aspect

In order to describe and provide enriched learning experiences, learning theories (such as reflective learning, experiential learning, and socio-cognitive learning) and learning models have to be consulted. For instance, Blooms’ Taxonomy [1] [3] is a valuable framework in order to define learning goals as well as assessment activities (see sections before). Due to these theories, not only individual learning styles can be considered but also processes that affect types of learning (e.g. collaborative learning).

2) Motivational and emotional/affective aspects

Other important issues are motivational and emotional aspects during learning and assessment. Due to the measurement of the emotional/affective status of a learner he or she can be supported in a suitable and personalized manner in order to enhance his or her affective/emotional inclination and hence, to stimulate the learners’ attention and learning.
3) Technological aspects

From a technological viewpoint, learning and assessment activities can be supported in many ways. For instance, enhanced technologies cannot only generate CLR but also able to flexibly adapt the learning path with respect to the individuals needs and learning progress. One aim of ALICE is to develop innovative e-assessment tools that support assessment activities in the enriched learning experiences. These tools will not only consider the assessment of individual and self-regulated learning but also peer-assessment and group assessment. Furthermore, they will provide an adaptive learning path and consider emotional and motivational aspects based on the outcome of the assessment activities.

4) Standards and Specifications

Standards for e.g., learning content reusability and interoperability, learner’s information accessibility and share ability are essential for any learning management system (including e-assessment) and also for quality assurance. Different standards and best practices have been developed to design and develop e-learning content and components.

Outcomes from the enriched learning experience

1) Efficiency and Effectiveness

From an instructors’ viewpoint, efficiency and effectiveness of an enriched learning experience are important criteria. For instance, the theory of constructive alignment [9] describes the compatibility between instruction, learning, and assessment. According to this theory, teaching is more effective when there are alignments in between what teachers want to teach, how they teach, and how they assess students’ performance.

2) Quality Assurance

Learners profit from an enriched learning experience most when the standard of the quality is high for activities within the learning experience. Therefore, quality assurance is essential in order to guarantee that the learning experience meet the requirements. The quality can be assured when several aspects are considered. Learning and assessment activities should consider the state-of-the-art of best practices and standards in the field. It is also necessary to consider ethical aspects. Such ethical standards are not only addressed to issues like plagiarism or cheating but also the fact that personal information (emotional and/or motivational status, behaviour etc.) is used to adapt the learning and assessment activity – often without the explicit knowledge of the learner. Furthermore, results from regular evaluation and validation are also valuable indicators in order to measure and improve the quality of a learning experience.

Interaction with other models

In order to provide adaptive and personalized learning, IMA is interacting with three other models namely learning model, knowledge model, and didactic model. In cooperation with the learning model, the cognitive status of the learner in terms of knowledge and skills is updated, in cooperation with the knowledge model, the ontology of learning and in co-operation with the didactic model, eventual alternative models are recovered.

III. FRAMEWORK TO USE IMA

In order to use the IMA model in real learning scenarios a bottom-up framework has been proposed as a reference to facilitate IMA deployment. The framework is a continues process represented as layered components as depicted in Fig. 2. The framework provides a methodological approach where the following steps can be followed:

Define Application Domain: in this step required information about the application domain is collected. This step answers questions about IMA main components of didactical objectives, complex learning resources, assessment activities (including feedback), and indicators for these forms evaluation and validation. Moreover it investigates inputs to the IMA represented by psychological and pedagogical aspects, affective and emotional aspects, available technologies and specifications and standards. In more detail questions such as, what are the learning objectives? What is the learning style? What kind of learning? What are the available tools and software? What are the available specifications and standards? Are there any recommended guidelines? Moreover, questions about didactical objectives and suitable assessment forms can be answered. However, collecting all of these information can be a tedious task and requires experts to participate in this a step. Therefore, it is recommended to model application domains based on the relationships extracted from the aforementioned questions into ontology. An ontology is simply the collection of classes and relationships representing the domain. Having application domains ontologically modeled and represented on Semantic Web facilitates the extraction of answers and useful knowledge regarding the modeled application domain.

Identify Requirements: the information extracted from the first step is used to define the requirements. Common approach is to investigate requirements using Personas. Scenarios covering a variety of users represented as personas are built in this step.
**Build Use Cases**: the analysis of the requirements from previous step is used to build different use cases. Use cases cover the discussed personas and any other possible ones.

**Develop Tools and Services**: the information extracted from the first step regarding available software and technologies as well as specification and standards with the use cases and requirements from the other steps are used to develop and improve software and tools.

**Conduct experiments and Validate results**: the developed tools as well as the use case and scenarios are used to plan and conduct experiments. The analysis of the results is validated with the hypotheses extracted from the requirements definition step.

**Update IMA**: The overall output of this framework is represented by effectiveness of the suggested e-assessment of learning experiences enriched with complex learning resources. This output is allocated in top of the framework and is used to update IMA with the findings from the whole steps. This is depicted by the back - arrow which closes the cycle and represents the continuity of the process.

IV. **CASE STUDY**

This section explains a real case of how we have used IMA and the bottom-up framework to develop and evaluate a tool entitled “Co-Writing Wiki” for collaborative writing and peer-review as part of our contribution to ALICE project.

**Domain Definition**

1) **Personas**

Anna is a student in Computer Science Department and she has to participate in a collaborative learning activity within a group of peers as part of Software Engineering course. Anna may not have previous experience in online collaboration within a group. She has to participate within a group in a collaborative writing activity where her performance will be assessed.

Elena is a student in Computer Science and she has to participate in a small virtual group (4-5 members) to carry out a software development project at a distance. She has experience in computer programming, however the project sets high level requirements and needs that demand intensive collaboration during the whole quarter. Elena may not have previous experience in collaborating with other people, especially at a distance. She will certainly need guidance and support by her teacher who should be able to monitor individual and group work throughout the experience.

Eric is an assistant-professor in Computer Science Department. Eric is teaching Software Engineering for undergraduate students. Eric has been teaching the Software Development course for more than five years. Over the years he identified problems regarding a great variety of student’s knowledge and motivation; he also has somehow to deal with different types of students, from inexperienced fulltime students to experienced part time students. This year he is intended to offer blended learning activities and improve the course with collaborative writing activities. Moreover, he is interested to continuously evaluate student’s performance and knowledge competencies as part of theoretical and practical software development activities.

2) **Scenario**

An instructional designer has been asked to recommend possible tools to support Eric in his course. The instructional designer is following the bottom-up framework discussed before as a methodology to identify available tools, to define aspects related to learning and teaching styles, to define learning objectives and goals, possible strategies, and methods for assessment. The instructional designer started with the first step to define the application domain and reported the following aspects:

“…the course should be enriched with collaborative learning activity by which students can be grouped into small groups of (3-5) students. The learning activity should be applicable for both blended and distance learning where variety of students can participate and learn. Moreover, the learning activity should integrate self, peer-assessment activities by which students can reflect on them selves as well as evaluate the progress of their peers and provide feedback. The learning activity should reflect a continuous assessment where teachers/tutors can assess the progress of the collaboration, and the performance of individuals and groups. Therefore, software should be developed to deliver collaborative learning and provide a variety of learning styles (i.e. visual, verbal and non verbal) via a flexible way by which both students and teacher can receive valuable feedback regarding the group work and the learning progress represented by contribution and assessment. Moreover, I recommend a collaborative writing assignment by which students performs in groups and collaborate to provide solutions based on problems. Nevertheless, the outcome can be also a scientific report for specific topic in Software Engineering.

The tutors dispose of a variety of collaborative strategies, methods and tools to support and enhance collaboration, debate and information exchange among peers so as to lead them to complete the required project successfully. Each group should be able to choose an adequate subset of the given collaborative strategies and to build their own collaboration strategy that best suits the group's dynamics, interests, and goals. The tutor should provide a well-structured project with suitable learning activities, well defined tasks, as well as rules and procedures that group members have to follow in order to accomplish the project.”

**Use Cases**

From the discussed personas and the instructional designer recommendations, the software architect or system analyst has identified functional requirements and generalised the following use cases: assignment author, contributor, reviewer, and evaluator. The same user can take one or more use cases. As assignment author, user is allowed to author and schedule assignments, assign topics, configure groups, and create assessment rubric. The author has administrator role, and is responsible for organizational aspects. A contributor is allowed to create pages, to create links among pages, to add comments. A reviewer is allowed to view contributions and reviews of each participant and to
grade a page by using the rubric provided by the author. An evaluator is allowed to grade contributions and reviews.

Moreover, the developed tool should be enhanced to provide the recommendations form the instructional designer as well as to consider the use cases. Therefore the developed tool should achieve the following requirements: assignment management, group management, multiple roles, tools for integrated self, peer-assessment, assessment rubrics management, collaborative writing and contribution, web-based to support distance and blended learning, enhanced visualization tools to support different learning styles (i.e. visual, verbal and non verbal) and feedback provision, and interaction logging to evaluate performance.

Tools and Services

The generalized use cases and the functional requirements have been given to the developer in order to develop the tool. In this step services and tools that are suitable for the identified requirements and use cases are identified. An enhanced wiki system with the required functionalities has been developed as we could not find one tool to cover all the functionalities. Moreover, wikis have capabilities to manage groups and they are web-based applications. Nevertheless, they are suitable for collaborative writing assignments. Therefore, an enhanced wiki for collaborative writing and peer-review has been developed. The tool is entitled Co-writing Wiki and it provides integrated assessment of self, peer assessment as well as assessment rubrics for assignment grading and feedback [11].

Experimentation and Validation

In order to evaluate Co-writing Wiki prototype according the discussed requirements and goals, we have used the tool in a learning activity as part of the summer-term course at Graz University of Technology. The course is provided by computer science department for the subject “Human Computer Interaction” in the year 2011. “18” students participated in the learning activity of 15 males (83%), 3 females (17%), and an average age of 26 years old. For only 3 out of 18 participants the course was mandatory. The students were grouped into 6 groups of different group sizes. One of the groups had one participant where the grouping was performed based on the students’ interests on the groups’ topics.

1) Procedure

Students were asked to use the Co-writing wiki tool to communicate and collaborate in writing their scientific paper. They were asked to create a wiki page for each section, and to add in internal link to this section in the assignment “mainpage” which represents the cover page of the assignment and has been created automatically by the authoring phase. After that they were asked to use the “Homepage” of assignment to check the recent actions done by group members on the assignment sections. As disussed before this page is enhanced with an “Actions Feed” list by which group members can get information about the progress of the writing especially who did what and when. In order to edit a section (i.e. wiki page) one of the group members has to review the latest action on the page using the developed internal peer-review approach and may also provide comments that will be fed back to the assignment “Homepage”. After the internal peer-review the page is open to next edit and during the edit the student has to provide the intention of the edit as well as to rate his contribution with ability to provide comments. The self-reflection represented by the edit intentions as well as its rate and comments are fed back to the assignment “Homepage” to support students orienting their work with the group progress. After the group has finished their scientific paper groups were asked to peer-review other groups final product. In total each group member was asked to peer-review 5 other groups papers. The students have to use an assessment rubric developed as part of the group-assessment module to rate groups work based on three different criteria: paper style, literature, and paper content. Moreover, to provide comments based on the mastery levels of the three mentioned criteria. Groups’ peer-assessments are fed back to the assignment “Homepage” and comments and average rates were provided to students. After this step, groups may use the comments from other groups to enhance their papers before the tutor’s final assessment. Tutors were asked to assess the group’s final product using the same assessment rubric, and the results are fed back to assignment “Homepage”. The students and tutors were asked to fill in a questionnaire by which we investigate their perception about the learning activity in general, the tool usability, the support from the enhanced tool features, and their motivational and emotional aspects during the procedure.

2) First Findings

The provided questionnaire was divided into sections based on investigated aspect. Agreement scale of (I strongly disagree (1), I disagree (2), neither/nor (3), I agree (4), and I strongly agree (5)) has been used. For the sake of analysis a Median value (Md) with its Interquartile Range (IQR) are computed. The values are computed based on the scale and used to identify student’s agreement scale. The analysis of the student questionnaire has provided the following findings:

a) Self, Peer-assessment

The self-reflection on my contribution has supported me: to effectively reflect my work (Md = 3, IQR = 1.5), to indicate the importance of my contribution (Md = 3, IQR = 1.0), provide feedback about my contribution intentions (Md = 3, IQR = 0.75), to find the weaknesses of my work (Md = 3, IQR = 1.0), and to find the strengths of my work (Md = 3, IQR = 1.0) as well.

The internal peer-review supported me to effectively: rate the importance of my peer’s contribution (Md = 2.5, IQR = 1.25), comment on my peer’s contribution (Md = 3, IQR = 2), and track the latest changes in the paper (Md = 4, IQR = 1.0). This finding indicates that internal peer-review supports group members with information regarding the task progress which maintains group’s task awareness.

b) Group Assessment

According to the developed assessment rubric as part of the group-assessment, students stated that the assessment
rubric supported them to effectively review the product of other groups (Md = 4, IQR = 1.0), and to learn more about other groups’ topics (Md = 4, IQR = 1.0) as well, and they agreed that the rubric was easy to use (Md = 3, IQR = 1.25). However, in a question about what they did not like in the group-assessment in general, some students mentioned that they were not interested at all in reading other groups’ work. Moreover, the assessment rubric had many criteria to evaluate and was not clear. In the other hand, some students liked the group-assessment and argued that they learnt from reviewing other groups and supported them to compare their work and to enhance it. One participant commented that “comparing papers was motivational for me”.

**Enriched Learning Experience**

The enriched learning experience in our framework represents the outcomes from the evaluation of complex learning resources integrated with assessment forms to achieve pre-defined didactical objectives. As our framework represents a continuous process, findings from experimentation and validation step are used to update previous steps of the framework. For instance, in a question about what students did not like with using the Co-writing wiki, some students stated that the system was very slow when it comes to save an edited page, and that this drawback prevented them from working effectively. Moreover, they suggested to improve the tool by making the internal review optional. A participant proposed to include an option “minor-change” where no rating is required. Based on that, the performance of the tool should be enhanced where the slowness during the edit of the wiki pages which is coming from the update of the wiki-pages index should be fixed (tools and services step). A possible solution is to stop this update of the index during the edit of the pages and to update it manually from time to time. For procedural enhancements, the internal peer-review should be changed to have different options (requirements analysis step). For instance, to make it optional based on the student’s convenience, after a number of actions, or for specific actions.

**V. CONCLUSIONS AND OUTLOOK**

In this paper a model for integrated e-assessment (IMA) has been discussed. This model describes an enriched learning experience that is made up of the didactical objectives, different learning resources, and assessment activities. It also considers influences arising from the viewpoints of pedagogy and psychology as well as from the viewpoint of technology. Furthermore, the relationship to other models (didactic model, knowledge model and learner model) is emphasized. Finally, to assure a high quality standard of the model, efficiency and effectiveness as well as evaluation and validation processes are mentioned as indicators coming up from the model. In order to use IMA in real learning scenarios a bottom-up framework has been proposed as a reference to facilitate IMA deployment. Moreover, a case study from ALICE project has been presented to show how the framework can be used step-by-step in IMA deployment.

First results have shown the flexibility of using IMA to model the development of integrated e-assessment forms for learning experiences enriched with complex learning objects (C-LO). For future work, the bottom-up framework will be used to develop more scenarios and use cases within the context of ALICE project. Nevertheless, IMA will be more validated with experimentation and pilot testing of the developed tools and services.

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