ADAPTIVE E-ASSESSMENT APPLICATION SCENARIO
A Framework and Concept for the Integration of askme! in Higher Education

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Abstract: To provide the expertise to apply learned knowledge in practice is one main challenge of higher education. Especially, the engineering graduates need to solve complex problems in their profession and apply specific expertise in various contexts. These demands encompass less recalling of factual knowledge, but more comprehensive key competencies like problem-solving expertise. In this paper, the Adaptive Assessment System *askme!* is used to address this challenge. The authors discuss the general conditions of the education of a course in theoretical computer science offered for students of a Bachelor degree program. Furthermore, this paper provides an application scenario in which the applied learning platform Moodle will be extended by adaptive methods of assessment.

1 INTRODUCTION

For educational processes it is crucial to obtain evidence about knowledge and skills that were learned. Hence, the measurement of learning outcomes is an integral part of developing successful learning materials and a critical catalyst for student learning. This challenge is addressed through assessment.

The assessment in Higher Education (HE) has traditionally been focused on "[...] retention and application of knowledge in limited contexts as measured by paper and pencil tests and academic assignments [...]" (Reeves, 2000). But, as ICT-based applications become more prevalent in HE, assessment is going to be of increasing importance, because "[...] assessment drives learning [...]" (Reeves, 2006) and "[...] if something is not assessed in HE, then it is not learned [...]" (Bain, 2004). The majority of assessment strategies used in HE tend to focus on what is easy to measure rather than what is important. This is one of the "[...] strongest deficits of both traditional and recent course design and implementation in HE [...]" (Shipman et al., 2003). But, assessment is crucial to help students to learn and not just to rate and rank their efforts. Entering the world of employment makes new demands on today's graduates. These demands encompass less recalling of factual knowledge, but more comprehensive key competencies (Sippel, 2009).

Therefore, a main objective of HE is to empower students to discover findings and to develop knowledge by themselves – so called problem-solving expertise. This is reflected by a case study, which is developed in this paper. Specifically, the case study concerns the course "Theoretical Computer Science (THI)" at Erfurt University of Applied Sciences, which is composed of two sub-modules: THI 1 and THI 2. The lectures and seminars offered pursue the following three main objectives: (1) provide formal and algorithmic skills, (2) develope analytical skills, design expertise, construction expertise and project management skills, and (3) promote methodological competence, social competence and self-competence.

In this paper, the Adaptive Assessment System (AAS) *askme!*, which is being developed at the Fraunhofer Institute for Digital Media Technology (IDMT), is used to address the challenges currently posed by THI 1 and 2. E-assessment systems must evolve to further enter the field of HE for engineering sciences. What is needed are personalized assessment solutions, which are able to cover all levels of thinking skills. The AAS *askme!* addresses this challenge by taking into account students' individual context, prior knowledge and preferences in order to personalize the assessment. In order to face the challenge of didactical interactivity, *askme!* enables integrating Interactive Content Objects (ICOs).

2 ASSESSMENT IN MOODLE

Assessment can be defined as follows: *A systematic method comprising the process of identifying, gathering, analyzing and interpreting information about peoples knowledge, skills, attitudes and other characteristics aiming at drawing inferences about their achievements and progresses as well as improving their learning and development performance.*

Such methods are exams, tests, quizzes and surveys. Although the terms are often used interchangeably, they differ significantly in terms of the purpose of measurement and the scope of content covered.

2.1 Opportunities

Moodle[1] is an open source web-based and SCORM-compliant LCMS and LMS that can be used in many types of environments such as in education, training and development as well as in business settings. For creating assessments, Moodle provides several assessment options like set up a time limit, configure grading method or control the access. Two main forms of assessment namely *assignments* and *quizzes* can be used. Assignments allows teachers to collect work from students, review it and provide feedback including grades, whereas quizzes allows teachers to design and build assessments consisting of a set of questions. Furthermore, Moodle allows creating a variety of different question types to set up assessments. In general, it can be distinguished between *standard* (e.g., multiple choice, true/false, cloze, etc.) and *third-party question types* (e.g., drag and drop, opaque, regular expression short answers, etc.).

For interacting with the questions in the assessment, Moodle supports different question behavior modes (e.g., deferred feedback, manually graded, immediate feedback, etc.). Feedback can be displayed at different times during the assessment and can not only include text, but also images, multimedia files, equations, etc. Moodle distinguishes between *general*, *overall*, *specific* and *combined feedback*.

Questions created in Moodle can be exported according to the IMS QTI 2.0 specification - in addition to the export in a Moodle-specific text or XML format. For importing questions, Moodle has a variety of file formats that can be used. This includes some LCMS-specific question formats (e.g., the Blackboard V6+ format, the Examview format, the WebCT format, etc.) as well as the Moodle-specific text and XML format. At the moment of writing, importing questions in IMS QTI format is not possible.

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[1]http://www.moodle.org

2.2 Reality

In the everyday practice, it is not surprising that only a few of these features are used. LCMS such as Moodle are mostly used only to provide educational content, whereas the assessment possibilities of Moodle are sparsely used. Even the THI courses have only used basic possibilities of the assessments so far. Focussing the lectures, Moodle was only used to provide additional learning material. Thereby, Moodle resources like *labels*, *pages* or *files* were used to provide information or to download presentation slides. In addition, Moodle activities like *forums* were used to exchange experiences and problems.

For assessment purposes, both of the aforementioned methods (assignments and quizzes) were used. In terms of quizzes, tests were provided in addition to the exercises delivered during the presence seminars. The results of the students were included into the grading of the course, but they are also offered for self-studying purposes. But, the range of question types used were very limited. Mostly *multiple-choice*, *embedded answers (cloze)* and *true/false* questions were used to assess the students' knowledge. Missing question types were tried to cover by assignments. However, assignments are associated with an huge effort for correcting.

The use of e-learning systems in general and e-assessment in particular points to some deficiencies in practice.

2.3 Deficiencies and Problems

Especially theoretical computer science deals with some very complex issues, which can not be covered by the standard question types provided by Moodle. The problem is not asking the questions, but rather giving the answer and its automatic grading. As an example, let us consider a task in which a pushdown automaton is to be developed, which should recognize a given language $L(G) = \{a^{i+j}b^i a^j | i, j > 0\}$. If we want to combine different batched results and findings to create a complex scenario, the limits of the standard assessment features in Moodle are already far exceeded.

The learnability of theoretical computer science is generally not very easy. This is due to the mappability of many serious issues in a practical and complex relationship. In fact, these are not ideal conditions for the creation of scenarios in which learners fully can immerse and to experience it. But the authors of the present paper are convinced that this state must be changed.

3 FRAMEWORK

Increasing the effectiveness and efficiency of HE can not be guaranteed solely by the use of e-learning systems. In the following, several requirements are discussed, and matched against the *askme!* functionality.

3.1 Advanced Question Types

Theoretical computer science deals with very complex problems. In some rare cases, they can be covered by conventional question types. Questions such as (i) create a context-free grammar that generates the language $L(G)$ or (ii) create a pushdown automaton that recognizes the language $L(G)$ far exceeds the core functions of classical LCMS like Moodle.

Facing the challenge, *askme!* enables to create advanced question types by integrating ICOs like Webbles (Arnold et al., 2012), PATTI (Klein et al., 2010), RemoteLab (Wuttke and Henke, 2008) or WLABEL (Loureiro and Depover, 2005). Each of the ICOs allows setting input parameters, interacting with the tool, constructing hypotheses based on prior knowledge and their validation by observing the effect of changes.

3.2 Integrability of Third-party Tools

For some fundamental problems in theoretical computer science, tools have been developed, that offer very high potential as an illustration and for practical exercise. However, the offer is limited mostly to single special cases. The only option to integrate such tools into a learning resource is to insert a link to the external tool. A real integration into individual practice and teaching offer is desirable, but requires well-defined interfaces.

And again, *askme!* faces this challenge by integrating these tools as ICOs. It enables the assessment of the upper levels of Bloom's cognitive taxonomy (HOTS) by encouraging the students to apply their knowledge in new situations to solve unexpected problems, by that way creating new knowledge. This complements the system's ability to assess LOTS in a holistic adaptive assessment process addressing all levels of thinking skills.

3.3 Automation of the Grading

Direct feedback when editing tasks promotes the recognition of errors. However, this can rarely be implemented in a regular curriculum. The large number of students and the limited staff capacities play a considerable role in this case. A key objective is to give each student the opportunity to review the own knowledge and quickly comprehend errors in the context of problem solving. E-Learning systems do offer the potential to guarantee this, but for complex exercises, they quickly reach their limits.

askme! faces this challenge by taking sophisticated feedback techniques and methods into account, which results in providing feedback that is appropriate for the students' context, knowledge level, individual characteristics and preferences (Saul et al., 2010). Feedback can not only consists of textual information, but also graphics, audio and video. In addition, feedback is classified according to the levels of verification and elaboration incorporated. This results in five feedback categorizations, which supports their use in adaptation rules.

3.4 Practicability of the Authoring

For the acceptance and practical use of software systems, their practicability is of crucial importance. In general, the LMS and the e-assessment in particular, this concerns mainly the creation of content.

askme! faces this challenge by providing question and test authoring in an accurate way based on a well-designed user interface. It requires authorization and provides secure use according to user rights. Moreover, the sustainability of the questions created by *askme!* is guaranteed by the conformance to the IMS QTI v2.1 specification. The integration of *askme!* with established LCMS (e.g., EDMedia, Moodle, ILIAS) is realized through a generic interface (Saul et al., 2011).

3.5 Personalization of the Tests

Although online-assessments were the first implemented and are one of the most interactive components in LCMS (Brusilovsky and Miller, 1999), there are some problems to be addressed. This includes more technical ones such as user identity verification and security issues and more general ones such as personalization aspects (Vasilyeva et al., 2007). Personalization in online-assessments has to consider individual and social aspects to avoid treating all students in the same manner and to prevent the feeling of getting lost in the masses (Geister and Rastetter, 2009).

askme! faces this challenge by selecting questions dynamically. Based on rules and the last response of the student, appropriate questions are dynamically selected at runtime. This allows authors of tests expressing their didactical philosophy and methods through the creation of appropriate rules.

4 APPLICATION SCENARIO

Only the practical application shows the meaning of theoretical concepts. In order to realize this a application scenario for the complex course of theoretical computer science in the Bachelor program of applied computer science was developed.

4.1 Didactic Concept

The objectives of the course are (i) to provide formal, algorithmic skills, (ii) to develop analytical skills, design expertise, construction expertise and project management skills, and (iii) to promote methodological competence, social competence and self-competence.

The didactic concept of the whole event is based on the blended learning approach. Besides the basic content (taught in weekly lectures), accompanying exercises are offered. In addition to the face-to-face lectures, also additional digital content and learning opportunities (e.g., lecture slides, especially the lecture exercises, tests and additional interactive learning tools) are offered through Moodle.

The course concludes with a complex test where the content of the two sub-modules is tested. It is crucial that the knowledge imparted is not reproduced, but also comprehended and applied in this situations. However, it is important to design the learning process for students so that the training will promote the problem-solving skills optimally.

4.2 Didactic Implementation

An extension of e-Learning opportunities offered by the adaptive e-Assessment system *askme!* is intended to be a first step towards the improvement of teaching. In the current Moodle course the core features of Moodle are used. Moodle resources like labels, pages or files and Moodle activities like forums, assignments and quizzes are used.

There is no visually apparent difference. The objective of the present paper is to evaluate *askme!* in practice. To ensure this, only the core functionality of Moodle can be used.

On the one hand, the practicability of the authoring process and the resource management performance must be ensured. On the other hand, the comparison to e-learning using traditional assessments must be ensured. One obvious option is to leave the didactic structure of the previous course. Only the assessment elements are implemented internally by *askme!* and appear as Moodle assessment activities.

4.3 Adaptivity

The user-driven customisation of system-parameters is understood as *adaptability*, while an automatic, system-controlled adaptation to changing conditions is known as *adaptivity* (Leutner, 1995; Blank, 1996).

According to the remarks on the basic functionality of adaptive software systems the essentially three phases of the adaption must be considered in the implementation of *askme!* (Brusilovsky, 1996). Or, as Marcus Specht (1998) formulated it: "To increase the quality of technology anhanced learning it is important to distinguish what should be adapted, to what features should it be adapted and how should it be adapted".

The *objectives* of adaptation are: (i) avoid treating all students in the same manner, (ii) Identifying and rectifying individual shortcomings and deficits, and (iii) Encouraging students to actively thinking. The *means* of adaptation are: (i) Sequencing of Questions and (ii) Presentation of Feedback. The *information* for the adaptation are: (i) Performance of the student, and (iii) the Student Profile. The *process* of adaptation is (i) based on `IF <Condition> THEN <Action>` rules and (ii) Forward chaining.

4.4 Technical Implementation

The integration of the AAS *askme!* with the LCMS Moodle was done according to the approach proposed in (Saul et al., 2011) by using the OPAQUE (Open Protocol for Accessing QUestion Engines)[2] It is based on SOAP and allows LCMS to delegate the presentation of questions, the scoring of responses and the generation of feedback to a remote question engine.

In the following, an arbitrary testing procedure is described (see Figure 1): (1) Question is presented, (2) Student takes the questions and finally submits an answer, (3) *askme!* evaluates the answers, (4) *askme!* examines the condition for the rule, and (5) *askme!* updates the student profile with the results of the test.
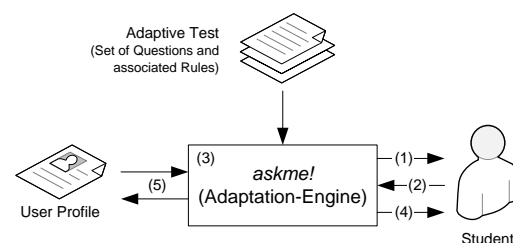

Figure 1: Technical Implementation.

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[2]https://github.com/timhunt/moodle-qtype_opaque

5 EVALUATION

Besides the practical realisability of a system, it is critical that the end users perceive the system as a supporting system and accept it. Based on a formative evaluation experiences for the further development as well as strengths and weaknesses of *askme!* will be determined.

The first deployment of *askme!* should take place within the framework of the application scenario described in Chapter 4. In the following discussion, the actual experimental conditions are described.

5.1 Objectives

The integration of *askme!* in a real teaching and learning scenario is the basis to obtain important experience of the technical feasibility and practicability of the system. In further considerations, the acceptance of teachers and students, the effort for teachers and the benefits for learners should be considered in detail. In this context they are regarded as long-term goals for the following evaluations, but should remain in mind.

The major objective of the evaluation is to estimate the benefits for learning. This essentially relates to the investigation of the efficiency and effectiveness of learning.

5.2 Definitions

The *efficiency* is generally defined as the ratio of effort to do something, and the benefits achieved. Following this understanding, the efficiency of learning describes the relationship between learning time and learning benefits. According to the authors view an intensive investigation of the benefits and success of learning isn't useful at this initial evaluation. Therefore, the present evaluation is limited merely to the investigation of the learning effort in terms of time needed for it. The learning benefits or learning success will in simplified form equated with the grading.

The *effectiveness* can generally defined as the value of the outcome of an action. In the considered action "learning", the grading or scoring can be seen simply as the value of the result.

5.3 Question, Hypotheses, and Criteria

The main problem of this evaluation can be summarised by the following research question:

> Is there an increasing of the efficiency and effectiveness of learning through personalised E-assessment?

Based on this research question, the following hypotheses can be form:

1. The more personalised e-assessments are deployed, the better the grades in the final test.

2. The more the assessments are adapted to the individual characteristics, the less time is needed for proper execution.

3. The more personalised e-assessments are used in the course, the more rapid decreases the frequency of errors.

Out of the question and the hypotheses three research criteria were extracted: (i) learning time, (ii) number of errors and (iii) grades.

5.4 Research Design

The key to successful evaluation with authentic and useful result is the choice of research methods. Essentially quantitative and qualitative research approaches can be distinguished (Flick, 2002; Lamnek, 1995). To evaluate the efficiency and effectiveness, quantitative methods are particularly suitable. But to get an impression of the usability, the practicality, and the didactic approaches using qualitative methods are reasonable, too. Therefore, a methodological mix of qualitative and quantitative research approaches is chosen.

The *population* of the study is represented by the participants and the tutors of the THI 2 course. A total of about 85 students in the second Semester of the Bachelor degree program AI participating in the lecture. The period of evaluation is limited to one full semester. The *sample* includes all students participating the course THI 2.

Regarding the large number of different *data collection* methods (Schnell et al., 2008) the authors chose especially the log-file analysis, in addition to the questionnaire methods - for economic reasons, and the handling. The non-reactively data collection by log files (log file analysis) is of high practicability. Moodle provides comprehensive data. Aspects for example the frequency of usage or the elapsed time for processing a task, and their evaluation are logged. In addition to that, a survey of quantitative data will be used. Besides general topics e.g., to the usability, special issues of *askme!* are requested.

The purely quantitative questionnaires provide only little information about which personal reasons have led to the statements. Qualitative aspects are requested to complement the quantitative question items. With the help of free text fields, the subjects should specify, inter alia, the reasons for their decisions.

6 CONCLUSIONS

Adaptive e-Assessments are able to support students to develop methodological competencies. That is one of the motivating hopes, which underlying the present paper.

Discussing motivational aspects of higher education and emphasizing the requirements of the case study shows that e-Assessments could be a solution. Focussing teaching of theoretical computer science showed the precise requirements could be fulfilled by *askme!*. The developed application scenario will now serve as the basis for new insights and cause debate potential in the field of educational research. The authors would like to share this work by the research community, to take part in this process.

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