Adaptive Navigation for Self-assessment Quizzes

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Abstract. Web-based parameterized quizzes provide teachers and students with several advantages as the technology for self-assessment. However, the effect of these advantages is strongly reduced, if a student does not receive enough support and cannot see her/his progress during the course. We have developed the system QuizGuide, which attempts to solve this problem by navigating students through the quiz material of the course in adaptive way. Architecture, interface and plans of future system development are described here. The paper also presents first results of system evaluation.

1 Web-Based Quizzes as the Technology for Self-assessment

Starting from the development of first Web-based educational systems, several successful technologies for online knowledge evaluation have been proposed [1, 2]. However, web-based quizzes have always played the leading role because of two main reasons. First, it is relatively easy to organize all three main stages of the question "life cycle" [2]: authorization, delivery/presentation, and assessment/feedback generation, in comparison to such classes of web-based systems as online simulation, collaboration support system or web-based ITS. Second, this technology inherits from traditional in-class quizzes; it is natural for both teacher and students to use it for knowledge assessment in the new conditions of web-based and web-enhanced education.

With the transfer of question material to the web such context of using quizzes as the self-assessment of student knowledge took on a special significance. Two trends in modern education increasing the teacher burden have appeared: the courses become more intensive, and the number of students grows (especially due to the distance and continuous education). This leads to the lack of traditional formative feedback that student can get in class. Web-based technologies for self-assessment, such as web-based quizzes, can help to solve this problem by providing students with meaningful information about their progress through the course and potential weaknesses [3].

Another strength of self-assessment technology is the self-motivation of students [4]. In our evaluation study [5] performed on QuizPACK we analyzed the subjective students evaluation of the systems. It was based on the questionnaires, filled by students after the term period of using system. More then 80% of students using QuizPACK reported positive attitude to it and high interest in taking online self-assessment quizzes.

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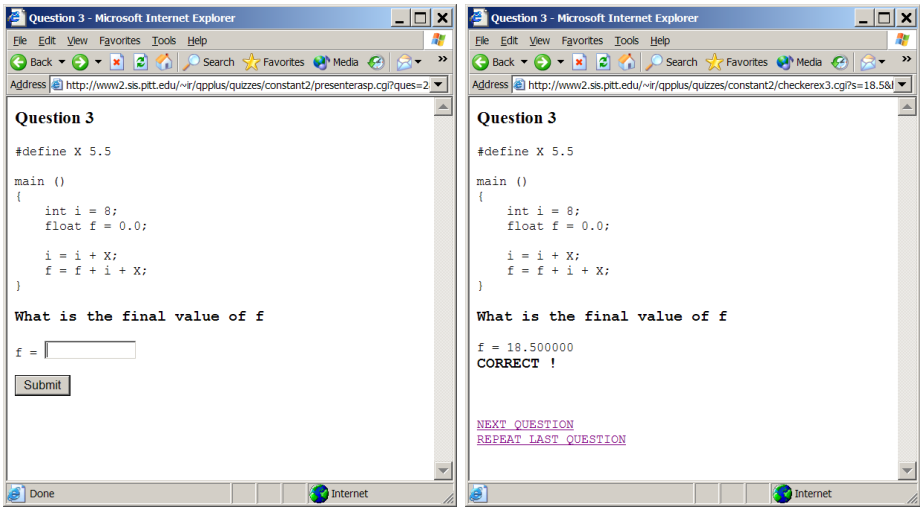
The pedagogical value of self-assessment quizzes has been confirmed by the number of papers. Regression analysis performed in [5] showed positive dependency between student performance in class and both the amount of students' work with self-assessment quizzes and their success (percentage of positive answers). Study reported in [6] showed statistically significant evidence of improvement in learning course material when students were using online self-assessment quizzes.

2 QuizPACK – Parameterized Quizzes

However, to possess all mentioned advantages in full degree, a system for self-assessment needs fairly large number of quizzes. Otherwise, students will hardly benefit from it, since familiar static question-answer pairs cannot reflect the real student's progress as well as initiate additional motivation.

The alternative to the large library of static question is the parameterized questions. This way has been used in our QuizPACK system (see Fig. 1). The architecture and interface of QuizPACK are described in details in [7]; the evaluation of the system is given in [5]. Below we provide the brief overview of the main features of QuizPACK.



a) b)

Fig. 1. Student interface of QuizPACK.

QuizPACK is the system for parameterized web-based quizzes authorization and delivery in the context of programming courses using C language. Each question in QuizPACK is actually a template containing a simple C program, one of the constants where is the generative parameter. When the question is delivered to a student parameter is instantiated with a randomly chosen value. Fig. 1 demonstrates the student interface of QuizPACK (the question sample – 1a, and the feedback on correct answer – 1b). After getting feedback students can proceed to the next question or go back and try previous question (with another value of the parameter) once again.

3 QuizGuide – Adaptive Quiz Navigation

QuizPACK evaluation study [5] and individual feedback, though positive, showed that students suffer from the lack of guidance. Indeed, as a self-assessment tool QuizPACK is supposed to help them in understanding their progress and finding knowledge gaps. However students could hardly estimate where their weakest topics are, and where they should feel confident without any support; they simply get lost. Even with the option of parameterizes quizzes and fairly large topics combining quizzes, we still needed to develop 46 quizzes to cover the whole course material. To assist students in getting valuable feedback that can help them to locate themselves in the course knowledge space we could apply the intelligent sequencing approach, which is used traditionally for the quiz adaptation. Instead we have developed the system QuizGuide, providing students with the adaptive navigation support by the means of such AH technique as adaptive link annotation (see for example [8]).

The student interface of QuizGuide (Fig. 2.) consists of two main parts: annotated list of hyperlinks to topics and quizzes and the frame for a question load and feedback generation.

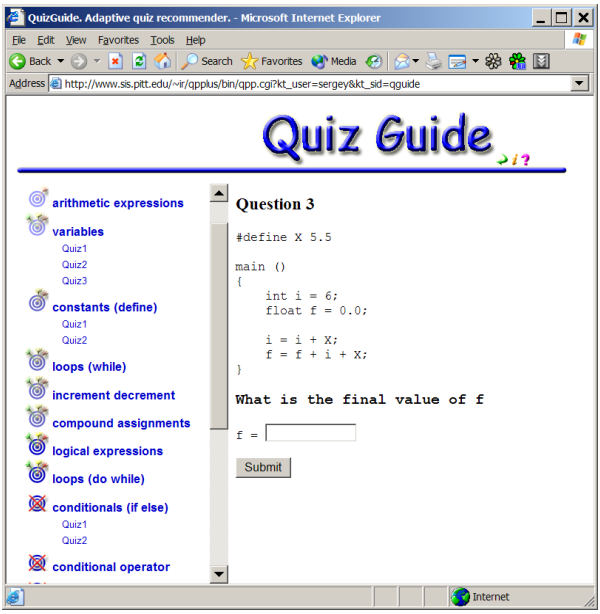


Fig. 2. Student interface of QuizGuide.

Adaptation in QuizGuide is performed on the basis of two traditional features of the user model: the knowledge level and the learning goal. Hyperlink to each topic is annotated with an icon reflecting the relevance of this topic in the terms of the current learning goal of the class and the level of knowledge that the individual student has for the specific topic. The annotation mechanism uses the "target-arrow" abstraction. Number of arrows in the target reflects the level of knowledge the student possesses for this topic: the more arrows the target has, the higher the level is. The target color

shows the relevance of the topic concerning the current learning goal: the more intensive color means that the topic is close to the current goal. Topics, which are not ready to be studied because of a non-reached learning goal, are annotated with the crossed target. Hence we have four levels of knowledge (from zero to three arrows) and four levels of topic actuality (not-ready, current, previous and non-important).

When a student clicks on the topic name, the list of quizzes available for this topic drops out. One more click on the topic name rolls this list back. Since the student works only with one quiz at one time links to other quizzes are not necessary and could be reduced. It does not mean however, that the student cannon drop out several topics (see Fig. 2). A click on the quiz link opens first question of this quiz. To navigate through the quiz students can use the links Next Question or Repeat Previous Question. As it is seen from the figures 1 and 2 quizzes for QuizPACK and QuizGuide are the same. These systems use the common question material; and the work of students with any of this system is reflected in the common user model.

As you can see from Fig. 2, QuizGuide does not forbid students to work with any of topics; it only recommends them by annotation. Students still can take any quiz belonging to "non-ready" learning goal, and when the time comes for this topic to become the current learning goal, previous students' work with it will be taken into account. The list of topics is fixed for students could not get lost in the material.

Brief help can be loaded in the main screen by clicking on the question mark icon. Also the icon for refreshing the application is available. Each time the student clicks it the new request is sent to the user model and the values for all topics are recalculated.

23 topics are determined in the course. They are connected to each other with prerequisite relations. These topics form 15 learning goals. Actually, learning goals acts as the lectures in the class, forming the flat sequence. Different topics have from 1 to 3 quizzes with 3 to 5 questions in these quizzes. Total number of quizzes is 46. Total number of questions is more then 150. Quizzes have assigned complexity value (from 1 to 3); quizzes with different complexity have different influence on the knowledge level calculation.

4 Preliminary Evaluation

Currently QuizGuide has been used for a half of the term in the context of real class environment for the undergraduate course *Introduction to Programming* taught in the School of Information Science at the University of Pittsburgh. For more then a month before working with QuizGuide students had been taking traditional QuizPACK quizzes without adaptive navigation support. However, the quizzes they took were the same that are used by QuizGuide. All data, obtained during the non-adaptive stage of taking quizzes have been stored in the user model and then used by QuizGuide. During the last month both adaptive and non-adaptive interfaces for quizzes have been available for students, i.e. data got from non-adaptive quizzes and the one from QuizGuide are equally considered for the user model updating.

Statistics that we got so far demonstrates the strong evidence that adaptive navigation support for self-assessment quizzes provides additional motivation for students to take quizzes. The average session length for non-adaptive quizzes is about 10 questions, when the average length of QuizGuide session is 26 questions, which means after starting work with self-assessment quizzes students take about 2.5 times more quizzes when adaptive navigation support exists. Only tierce of sessions for non-adap-

tive quizzes has a length more then 10 questions, while for QuizGuide this ration is more then twice bigger.

The analysis of students' paths through the questions showed that with adaptive interface they have got an additional motivation to use the parametric nature of QuizPACK questions. If in the past they often tried to solve the same question with different parameter values until they solve it correctly, now they also have new educational goal – to reach the maximum knowledge level, to get three arrows on the target. . It results in more then 10% higher performance of work with a tool. The percentage of correct answers for the students who mainly used QuizPACK is only 32%, when the students, who had switched to QuizGuide and used it regularly, have this ratio on the level of 43%.

At the same time we observe, that students are not persistent in using QuizGuide. Some of them switch to QuizPACK and back. Some students use primarily non-adaptive self-assessment quizzes. The numbers of active students for QuizGuide and traditional QuizPACK quizzes are approximately the same, when the total number of students using a tool is greater for non-adaptive quizzes. We are going to collect more consistent statistics in the next month, which is the last before the final exam, and traditionally is characterized by the increased students' activity.

5 Future Work

The system is currently developing in several directions. In the next versions of adaptation mechanism we are is going to compare different formulas for knowledge level calculation. We plan to recommend to the students the "best quiz" on every step. Better-grained concepts structure is going to be designed. For this purpose we plan to use the developed parsing component for automatic indexing of C programs, which have been applied already for domain description in NavEx system [9].

The current architecture of QuizGuide/QuizPACK, allows adaptive and non-adaptive components to use the same set of quizzes. This opens the exceptional opportunities for adaptive navigation mechanism evaluation. In the future we are going to perform more exhaustive comparative analysis of QuizPACK and QuizGuide to estimate the pedagogical value of using adaptive annotation technology in this class of systems.

Finally, web-based author interface is developing, which can provide us with new users: teachers and students; new questions; and new statistics and feedback.

6 Summary

We have developed QuizGuide, the adaptive navigation system for web-based self-assessment quizzes. This paper described the architecture and interface of QuizGuide as well as the initial motivation for its creation. QuizGuide is strongly interconnected with our old non-adaptive system QuizPACK and uses the same question material as QuizPACK does. Preliminary evaluation of the system showed that students spend much more time with adaptive self-assessment quizzes then with non-adaptive ones; additional motivation leads to more extensive usage of parameterized nature of QuizPACK questions. Future plans include further interface and architecture development as well as system evaluation studies.

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References

1. Hooper, M.: Assessment in WWW-Based Learning Systems: Opportunities and Challenges. Journal of Universal Computer Science, vol. 4 no. 4 (1998), 330-348.
2. Brusilovsky, P., Miller, P.: Course Delivery Systems for the Virtual University, In: T. Tschang and T. Della Senta (eds.): Access to Knowledge: New Information Technologies and the Emergence of the Virtual University. Amsterdam: Elsevier Science, 167-206.
3. Peat, M.: Online assessment: The use of web based self assessment materials to support self directed learning. In A. Herrmann and M.M. Kulski (eds.), Flexible Futures in Tertiary Teaching. Proceedings of the 9th Annual Teaching Learning Forum, 2-4 February 2000. Perth: Curtin University of Technology. http://lsn.curtin.edu.au/tlf/tlf2000/peat.html
4. AIMS website. Strategies for Assessing Student Knowledge and Performance. http://www.med.unc.edu/oed/testassess/assessment_strategies.htm
5. Sosnovsky S., Shcherbinina O., Brusilovsky P.: Web-based Parameterized Questions as a Tool for Learning. In: Allison Rossett (ed.), Proceedings of E-Learn'2003, Phoenix, Arizona, USA: AACE, 309-316.
6. Gayo-Avello, D., Fernández-Cuervo, H.: Online Self-Assessment as a Learning Method. In: Vladan Devedzic, J. Michael Spector, Demetrios G Sampson, Kinshuk (eds.), Proceedings of ICALT 2003, Athens, Greece: IEEE Computer Society, 254-255.
7. Pathak, S., Brusilovsky, P.: Assessing Student Programming Knowledge with Web-based Dynamic Parameterized Quizzes. In Proceedings of ED-MEDIA'2002 - World Conference on Educational Multimedia, Hypermedia and Telecommunications, Denver, Colorado, USA: AACE, 1548-1553.
8. De Bra, P.: Pros and Cons of Adaptive Hypermedia in Web-Based Education. Journal on CyberPsychology and Behavior, vol. 3, no. 1, (2000), Mary Ann Lievert Inc., 71-77.
9. Sosnovsky, S., Brusilovsky, P., Yudelson, M.: Supporting Adaptive Hypermedia Authors with Automated Content Indexing. In Proceedings of Workshop on Authoring Adaptive and Adaptable Educational Hypermedia at the AH-2004 Conference, Eindhoven, The Netherlands, August 23-26, 2004 (in Press).