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Development of a Multi-Device Data Structures Course Item Bank Practice System with Self-Regulated Learning Strategy on Bloom's Taxonomy of Educational Objectives

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Abstract: With the rapid development of information technology, traditional paper-and-pencil testing is lacked for immediate analysis and feedback. Thus, it has been replaced by computerized item bank practice systems. Because of the popularity of wireless networks and multi-devices, developing an item bank practice system which can support on multi-device has become a new trend gradually. This makes learning become more convenient. In this paper, we classify items by Bloom's taxonomy of educational objectives, and found the weaknesses of learners in the practice in order to improve the weaknesses. At the same time, we use self-regulated learning strategy in this system, so that learners can set their learning goals. In this system, it provides self-monitoring, standard setting, evaluative judgment, self-appraisal, and affective self-reaction, so that learners can learn in the best environment. In the future, we will combine this system with data structures course and hope to improve learners' learning motivation and effectiveness.

Keywords: Multi-device system, data structures, item bank practice system, self-regulated learning, Bloom's taxonomy of educational objectives

1. Introduction

The traditional practice method is a paper-and-pencil testing, and it is replaced by computers. When learners encounter problems, they need teachers help, otherwise students cannot get the correct information immediately. With the rapid development of information technology and internet, computer online practice has become the new trend gradually. Tu (2003) developed an on-line assessment system, which combined a natural sciences course. The system can be repeated practicing and provide the feedback immediately. In addition, Lee, Tseng and Tsai (2003) and Chen, Chang and

Wang (2008) mentioned, because of the popularity of wireless networks and multi-devices, learners can learn online via multi-device to improve their learning effectiveness. Therefore, multi-device item banks practice come into being. For example, Kung, Huang and Chung (2007) developed a multi-device learning assessment system which combined class b of computer software application technicians. The results of their study showed that the system improved learners' learning effectiveness. However, these papers only developed multi-device item bank practice systems, but did not enhance leaners' weaknesses. Therefore, we use the Bloom's taxonomy of educational objectives to analyze the weaknesses of learners.

Bloom, Engelahar, Frust, Hill and Krathwohl (1956) proposed the "Bloom's Taxonomy of Educational Objectives", which was used by many educators and updated to the new version (Anderson & Krathwohl, 2001). The Bloom's Taxonomy of Educational Objectives has good effectiveness on designing items and diagnosing learners' weakness (Crowe, Dirks, & Wenderoth, 2008; Hwang, Chen, Loe, & Huang, 2013). Therefore, we import the taxonomy and wish let learners can understand their weaknesses, so that they can adjust the learning goal by themselves and improve their learning motivation. However, initiative is a critical factor for learners' learning effectiveness (Govaere Jan, de Kruif, & Valcke, 2012). Thus, we also import the self-regulated learning strategy in this system to improve learners' initiative.

Learners can set a goal to carry on self-monitoring, standard setting, evaluative judgment, self-appraisal, and affective self-reaction, which is spirit of self-regulated learning (Bandura, 1991), i.e., learners can learn through setting and adjusting goals. We hope to improve learners' learning motivation and effectiveness via self-regulated learning. However, if learners only depend on the behavior of initiative investment and self-monitoring without the effective adjusting strategies, learners' learning effectiveness cannot be improved (Zimmerman & Kitsantas, 1997). Therefore, the effective adjusting strategy is a critical factor. Wang (2011) indicated that adding the self-adjust learning mechanism into formative assessment and using the Peer-Driven Assessment Module (PDA) strategy can lead to learners' learning motivation. The formative assessment can be learners' learning basis. Learners can adjust their goals repeatedly. The experimental results indicated that learners who use the PDA-WATA (Web-based Assessment and Test Analysis) system are better than learners who use the N (None)-WATA system on initiative and learning effectiveness. Therefore, we also provide all learners complete rate ranking, which can motivate learners via comparing.

In the past, about the self-regulated learning, many scholars found that learners can achieve good learning effectiveness via the self-regulated learning strategy in mathematics (Hackett & Betz, 1989; Malpass, O'Neil, & Hocevar, 1999; Pajares & Miller, 1994; Parker, Marsh, Ciarrochi, Marshall, & Abduljabbar, 2014) and natural sciences (Betz & Hackett, 1983; Britner & Pajares, 2006; Chen & Usher, 2013) domains.

Therefore, according to above mentions, we develop a multi-device data structures course item bank practice system with self-regulated learning strategy on Bloom's taxonomy of educational objectives. The Bloom's taxonomy of educational objectives and the self-regulated learning strategy can help learners understanding their weaknesses to practice and give the appropriate feedback. At the same time, learners can use multi-device learning tools to learn without any limitation of space and time. We expect that learners can improve their learning motivation and effectiveness via this system.

2. Literature

2.1 Item Bank Practice System

Bunderson, Inouye, and Olsen (1989) indicated that computerized testing includes four steps of development: (1) computerized testing: the traditional paper-and-pencil testing is replaced by using computer to practice; (2) computerized adaptive testing: item response theory (IRT) is applied to conduct the computerized adaptive test (CAT); (3) continuous measurement: history records are added; (4) intelligent measurement: expert systems with artificial intelligence provide learning suggestion to learners. The first three steps are lacked for immediate feedback to carry on effective improvement in traditional teaching. However, with the popularity of internet, item bank practice systems are changed from single-computer practice to computer-online practice (Hwang, Chen, Huang, & Loe, 2013; Tu, 2003; Yo, Jan, & Li, 2011). It is an issue how to improve learners' learning effectiveness by item bank practice systems. In this paper, the system combines the history records of the third step and the expert system of the fourth step, and assists learners to proceed to effective learning. On the other hand, multi-device learning tools make learners learn conveniently.

2.2 Multi-Device Learning

Gay, Stefanone, Grace-Martin and Hembrooke (2001) used laptops as learning tools on the communication course and the computer science course. Using of wireless Internet technology, learners can discuss course anywhere. Thus, learning by mobile device is feasible. Guerreroa, Ochoaa and Collazosb (2010) built a learning system. In this system, learners can use PDAs to carry on the grammar practice online. Learners are divided into some groups can discuss courses immediately. Teachers can see the learners' answers and comments and reduce the time of marking learners' homework. The experimental indicated that more than 70% of the learners who used the system can improve the language grammar ability, and more than 86% of the learners thought the system is operated easily. The system can not only improve learners' learning motivation and effectiveness, but also reduce the load for teachers. With the rapid development of multi-device learning tools (smart phones, tablets, notebooks, PDAs and computers), learners have more choices. In the empirical researches, Chen et al. (2008) and Hwang et al. (2013) had established two learning websites which allowing learners to use multi-device learning tools for learning without limitation all the time. At the same time, the learners' portfolios are recorded on the websites, so that teachers can see the learning situation of learners. The experimental results indicated that the webs can improve the performance of learners. As the above literatures mentioned, we can know that using multi-device learning tools will make learners learn conveniently. However, it is important to this paper how to recognize learners for items understanding. Thus, we use the Bloom's taxonomy of educational objectives to find the learners' weaknesses and improve them.

2.3 Bloom's Taxonomy of Educational Objectives

Bloom et al. (1956) propose cognitive domain taxonomy of educational objectives as "Bloom's taxonomy of educational objectives", which includes six classes. From easy to difficult, the six classes

included knowledge, comprehension, application, analysis, synthesis and evaluation. With the rapid development of educational psychology, Anderson and Krathwohl (2001) corrected the Bloom's taxonomy of educational objectives. This taxonomy includes knowledge dimension and cognitive process dimension. Knowledge dimension is subdivided into factual knowledge, conceptual knowledge, procedural knowledge and metacognitive knowledge. Cognitive process dimension is divided into six categories, i.e., remember, understand, apply, analyze, evaluate and create. Therefore, many scholars have used this taxonomy to classify items. Lan and Chern (2010) classified the university entrance exams in English reading questions by the Bloom's taxonomy of educational objectives, which can let teachers catch the emphasis to carry on teaching easily and let learners more understand the topic and the problem-solving elements. Therefore, in this paper, we use remember, understand, apply and analyze of cognitive process dimension to classify items of the data structures course. We hope to analyze learners' weaknesses effectively and let learners improve their learning motivation and effectiveness by the self-regulated learning strategy.

2.4 Self-Regulated Learning

Bandura (1977) indicated the self-regulated learning conception as self-efficacy includes the efficacy expectation and the outcome expectation. The efficacy expectation means to set goals and to do self-evaluation for these goals. The outcome expectation means that, if learners think that their ability can't reach their goals, they cannot keep their learning motivation. Therefore, we think that self-efficacy (self-regulated learning) is important to impact learners' learning motivation. Subsequently, Schunk and Zimmerman (1994) indicated that the self-regulated learning includes four steps, i.e., "self-evaluation and self-monitoring", "goal setting and strategy planning", "using and monitoring of strategies" and "monitoring of results of strategies". Learners can learn according to the learning pace by themselves via these four steps. In summary, all scholars think that setting goal and self-evaluation in self-regulated learning are very important. And Schunk and Zimmerman also proposed "using and monitoring of strategies" and "monitoring of results of strategies". In the self-regulated learning environment, learners can not only set goals and carry on self-evaluation, but also they can carry out self-adjustment via the learning results. In addition, Multon, Brown and Lent (1991) aim related 39 papers of self-regulated learning to carry on integrated analysis in the past. The results of their study showed that the self-regulated learning can improve learners learning effectiveness in different subject areas, and different assessment methods. Therefore, we develop a multi-device data structures course item bank practice system with self-regulated learning strategy on Bloom's taxonomy of educational objectives. We hope this system can improve learners' motivation and effectiveness of learning.

3. Development of Our System

3.1 System Architecture

In this paper, we use Windows Server 2008 to set up an Internet Information Services (IIS) web server and a Microsoft SQL database server, and develop all modules by Visual Studio 2010 ASP.NET C# language. This system is divided into two interfaces, i.e., the learner interface and the teacher interface.

The learner interface includes three modules, i.e., “goal management module”, “item bank practicing module” and “personal learning portfolio inquiry module”. Learners can carry on operating of three modules with multi-device learning tools, e.g., cellphones, tablets and computers. In order to implement the self-regulated learning strategy, “goal management module” can provide learners setting goals which include selecting range, Bloom's Taxonomy of Educational Objectives (remember, understand, apply and analyze), and passing score. “Item bank practicing module” can provide learners to carry on practice via selected range by learners, and it is based on the Bloom's taxonomy of educational objectives to display the weaknesses of learners. Learners can understand their weaknesses and adjust the goals in “goal management module”. “Personal learning portfolio inquiry module” can provide learners to inquiry the practice records in the past. On the other hand, the teacher interface includes three modules, i.e., “learners’ basic information management module”, “item bank management module” and “learning portfolio management module”. Teachers can operate these three modules by computers. “Learners’ basic information management module” can provide teachers to modify learners' basic information. “Item bank management module” can provide teachers to modify items and set the Bloom's Taxonomy of Educational Objectives (remember, understand, apply and analyze) of items. “Learning portfolio management module” can provide teachers to inquire the practice records of all learners’ learning situation. All modules can access “learners’ basic information database”, “item bank database” and “learning portfolio database”, as shown in Figure 1.

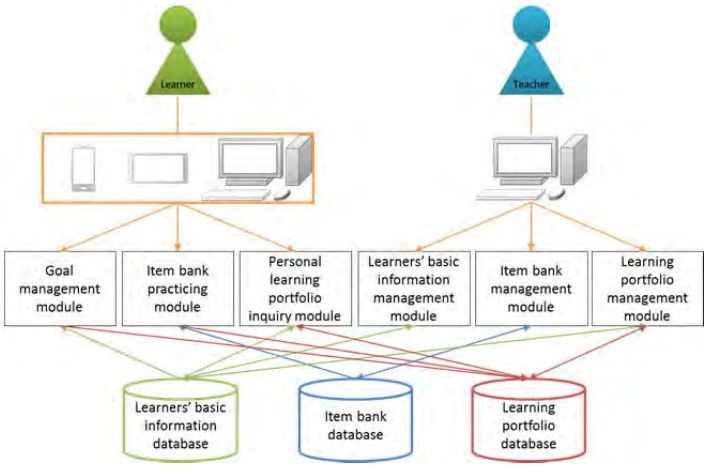

Figure 1. System architecture.

3.2 Operating interface

Learners can watch the currently complete rate ranking on the login snapshot of the system, as shown in Figure 2. After learners sign in the system, they can see the three buttons (“system homepage”, “goal management and item bank practicing” and “personal learning portfolio inquiry”) on left side, as shown in Figure 3.

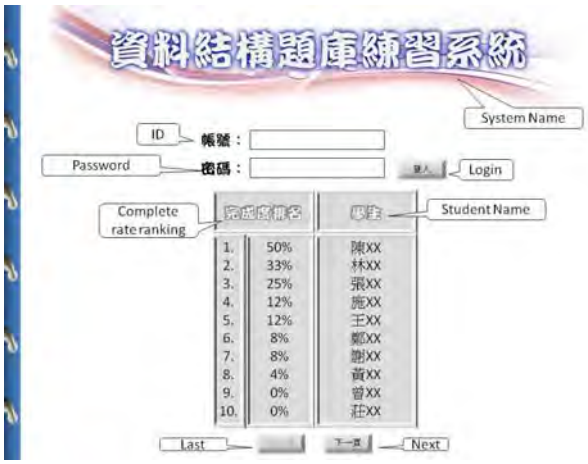

Figure 2. Login interface.

Figure 3. Multi-device of system homepage.

When learners click the “goal management and item bank practicing” button, and enter “goal management module”, they can select chapters to practice by themselves. The items of every chapter are classified according to Bloom's Taxonomy of Educational Objectives (remember, understand, apply and analyze), and learners can do practice for their selected types. In addition, the system also provides learners a setting goal function. Learners can set the passing score of the current practice, as shown in Figure 4. Subsequently, learners can carry on practice in “item bank practicing module”. The practice interface of learners is shown in Figure 5.

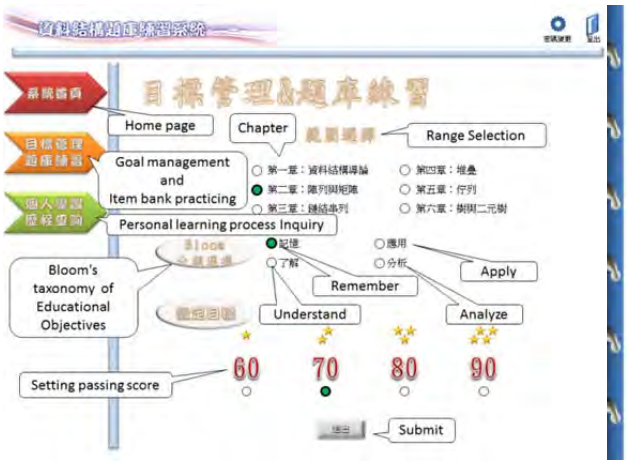

Figure 4. Item bank of setting goal snapshot.

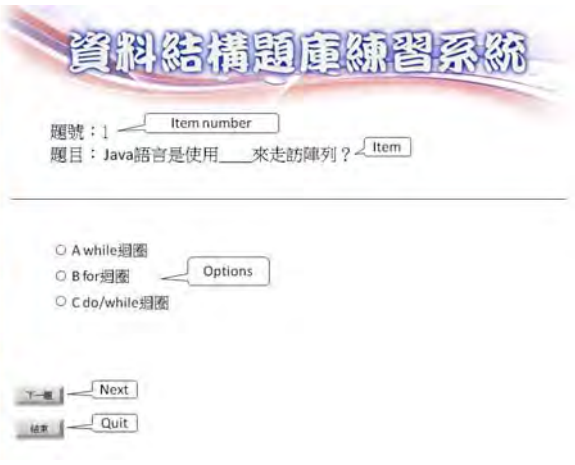

Figure 5. Practice snapshot.

End of the practice, the interface will change to the “goal management module”. Learners can see the correct rate, the courses complete rate and the feedback of practicing. There are two buttons at the bottom of “goal management module”, i.e., the “reset goal” button and the “practice again” button, are provided learners resetting goal to practice or practice again of the same goal, as shown in Figure 6, 7.

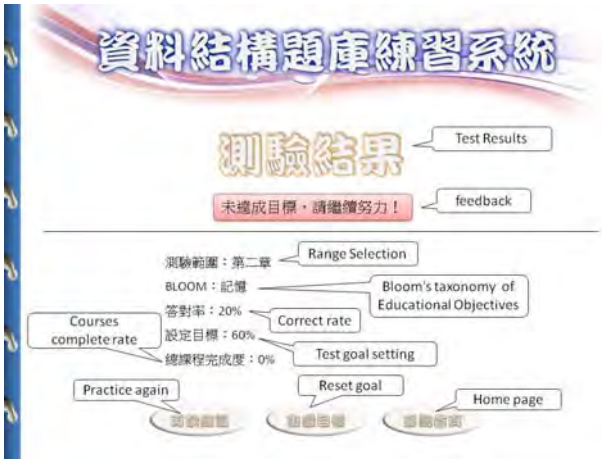

Figure 6. The snapshot of practice result without achievement.

Figure 7. The snapshot of practice result with achievement.

When learners click the “personal learning portfolio inquiry” button and enter the “personal learning portfolio inquiry module”, they can see the practice records quickly via the drop-down list above the interface. In the drop-down list, the red items mean that the practice is no-passed, and the black items mean passed, as shown in Figure 8. Learners can inquiry practice records after practicing, and they can watch all practice items or only wrong items, so that they can review and correct. Leaners can also watch items quickly via the drop-down list on the right hand of the interface. In the drop-down list, the red items mean that learners answer incorrectly, and the black items mean that leaners answer correctly right, as shown in Figure 9.

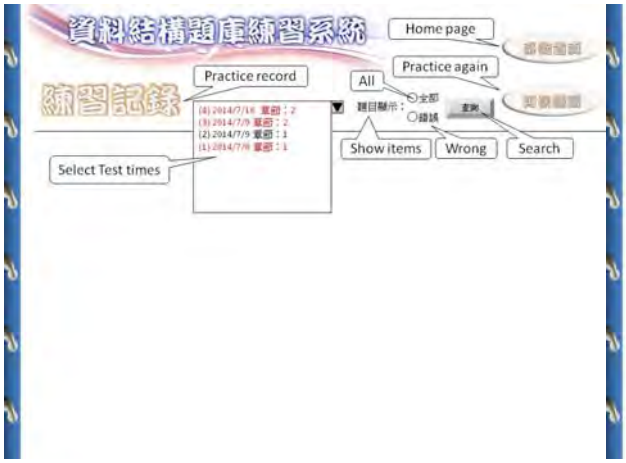

Figure 8. Practice records inquiry interface.

Figure 9. View practice items.

In the teacher interface of “learners’ basic information module”, which is provided teachers to inquiry the basic information of all learners. In “item bank management module”, teachers can click the

"item bank management" button and carry on the management of items, as shown in Figure 10. In "learning portfolio management module", teachers can watch all learners' portfolios.

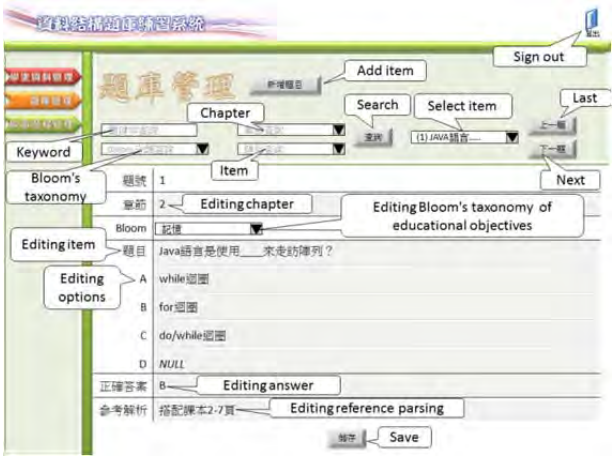

Figure 10. Item bank management.

4. Conclusion and future works

4.1 Conclusion

In this paper, we develop a multi-device data structures course item bank practice system with self-regulated learning strategy on Bloom's taxonomy of educational objectives. Learners can use multi-device to practice item bank. At the same time, they can set a goal to learn and budget time by themselves. In addition, every question in the item bank is set from a Data Structures teacher, and they are classified according to remember, understand, apply, and analyze. Therefore, this system can make learners clearly know what their weaknesses are. We expect learners can improve their motivation and effectiveness of learning via this system.

4.2 Future work

In the future, we will carry on an empirical research with two classes of attending data structure course which combine this system. The participants are about 99 learners in two classes. One class will be the experiment group which will use the self-regulated strategy. Learners of the experiment group can set a goal includes selecting range, Bloom's Taxonomy of Educational Objectives (remember, understand, apply and analyze), and passing score by themselves. The other class will be the control group which will use the non-self-regulated strategy. Learners of the control group will go by what the homework request of teacher to do practice. If they won't complete in time, they can't do practice. Their passing score will be set to 75. Two classes will proceed with pre-test, post-test and questionnaire (learning effectiveness, learning motivation, learning attitude, learning satisfaction and cognitive load). After the experiment, we will analyze to learners' learning motivation and learning effectiveness between the experimental group and the control group, as shown in Figure 11.

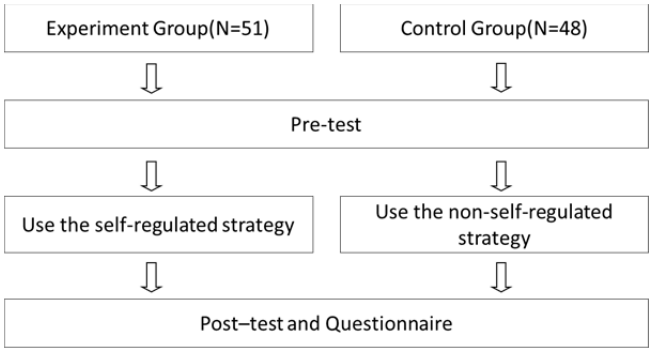

Figure 11. The flowchart of the experiment.

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