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Embedding ITS Concepts for Teaching Java with a Pair of a Pre-Quiz and a Quiz

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***Abstract*—This paper proposes a design of a learning management system based on three essential concepts of an intelligent tutoring system: knowledge domain, learning styles and navigation, and feedback. According to success of teaching by using a pair of a pre-quiz and a quiz, implemented by Moodle learning system in the previous research of the author, the teaching with a Pair of a Pre-quiz and a Quiz (PPQ) has been designed in order to improve the past learning system and take a step towards developing a practical intelligent tutoring system suitable for teaching Java.**

Keywords—intellegent tutoring system; teaching Java; quiz; pre-quiz

I. INTRODUCTION

Java is an object-oriented programming language widely used for decades. Learners are not only need to study the language syntax but also its characteristics designed by Sun Microsystems, now taken over by Oracle. In order to satisfy Java programming standard, Oracle provides a certificate called Sun Certified Java Programmer (SCJP). The content of this certificate is important for undergrads either for getting a certificate or not because it covers deep level of Java characteristics. As a lecturer of Java programming, the author therefore included the SCJP content in the course. Online exercises were implemented by Moodle so that students could get immediate feedback. Remarkably, the exercises were designed by a pair of a pre-quiz and a quiz for each question. It means that one particular question was duplicated into two similar questions. One question was used as a pre-quiz and the other was used as a quiz. Students were allowed to do pre-quiz exercise repeatedly as much as they wanted without getting points. Then they did a quiz for getting points. The overall result at the end of the course, according to questionnaire done by 38 students, was success. Students were enjoyed doing the quizzes and paid more attention on learning material. They also had enough time to learn on their own pace. [1]

However, the use of a pair of a pre-quiz and a quiz was built based on simple idea of the author and implemented on open-source learning management system. It lacked of novel educational intelligence that support difference of students' capability. On the contrary, some other universities implement intelligent tutoring system for teaching programming, for example, personalizing teaching material for particular students. In order to develop such system, the most important part is designing clearly what key issues should be considered.

This paper investigates an overview of intelligent tutoring system (ITS) in section II and recalls three important issues: (1) knowledge model, (2) learning styles and navigation, and (3) feedback, summarized in section III. A proposed design of a system is then represented in Section IV. Conclusion and future works are discussed in the last section.

II. AN OVERVIEW OF INTELLIGENT TUTORING SYSTEM

An Intelligent Tutoring System (ITS) usually composes of four important parts: domain model, learner model, pedagogy model, and user interface. H. Escudero and R. Fuentes [2] proposed ITS architecture composed of four modules: domain module, pedagogical module, student model, and dialog module. The domain module contains the content of the course. The pedagogy module contains teaching strategies and the student model represents knowledge student has acquired during instruction process. The dialog module defines the interface between the system and the users. Whereas, Henrique P. Maffon, et.al. [3] represented the architecture of the intelligent tutoring system consisted of four modules: Tutor module, Student module, Domain module, and Interface module. The system was for the teaching about breast anatomy and pathology.

Apart from the architecture of various ITSs which is mostly similar, functions of them are generally the same. Most of them aim to automatically support an individual student. Konstantina Chrysafiadi and Maria Virvou [4] surveyed a lot of quality papers about ITS searchable in Scopus and concluded that an adaptive system must be able to personalize learning paths, monitor students' activities, specify their needs, and exploit user knowledge and domain knowledge to dynamically facilitate students' learning process. Technology of student modeling should be adaptive and personalized. Chrysafiadi and Virvou described that student characteristics include knowledge and skills, errors and misconceptions, learning styles and preferences, affective and cognitive factors, and meta-cognitive factors. They pointed out that the trend of ITS research might focus on representing students' emotions in the system. Moreover, Kenneth R. Koedinger, et.al. [5] suggested that most online courses are lack of the following issues:

complex problem solving tasks, open-ended interfaces, and back-ends which can interpret students' step-by-step progress on complex tasks.

This paper focuses on three issues of ITS in order to improve teaching Java by using a pair of a pre-quiz and a quiz. The knowledge domain of other systems will be studied. How different students who have distinct styles of learning and navigating material will be also discovered. Students are usually have emotions in learning and should be in concern in designing feedback. In the next section, those three issues will be investigated.

III. THREE ISSUES OF INTELLIGENT TUTORING SYSTEM IN FOCUS

A. Knowledge Model

The ITSs have been implemented in different knowledge domain. COMET: METEOR, an intelligent system for medical students, has been improved by Hameedullah Kazi, et.al. [6]. Instead of using concept repository in a knowledge domain, the content distributed by the U.S. National Library of Medicine was deployed in the system. The U.S. knowledge domain was used in COMET as expert knowledge base embedded with relationship between concepts. Kazi, et.al. claimed that students had high learning gains and got more precise hint generation. In algebra domain, Miguel Arevalillo-HerráEz, et.al. [7] represented word problems in algebraic problem solving in a form of Fridman's trinomial graph and implemented it in XML. They aimed to encourage word problem solving by following a pure algebraic approach. They finally claimed that the system was able to improve student's competence.

Some researchers designed a set of knowledge as a graph both directed or undirected one. The graph can explicitly show various routes for moving from one node to others. Dinesha Weragama and Jim Reye [8] provided a set of knowledge nodes or facts in one programming code. If a student has visited nodes in whatever path to get through the final node, he/she has got the right answer. They suggested that intelligent tutoring system should be able to identify all solutions as semantically equivalent. Furthermore, Konstantina Chrysafiadi and Maria Virvou [9] commented that domain knowledge representation has to be combined with a well-designed student model. The most challenge is making the system able to support strategy freedom or let students seek for multiple solution strategies within a given problem as Maaike Waalkens, et.al. [10] claimed. The intelligent tutoring system should be able to support students in learning a complex problem-solving skill.

B. Learning Styles and Navigation

Students are not only different in capability but also learning style. Some researchers have developed new tutoring systems from scratch based on learning styles of learners. Hossein Movafegh Ghadirli and Maryam Rastgarpour [11] have established a Web-based learning management system by surveying learning styles before building the system. Learners were categorized into five learning styles: sensation seeking, goal-oriented achievers, emotionally intelligent achievers, conscientious achievers, deep learning achievers. Sensation seeking learners believe that experiences create learning while goal-oriented achievers set their certain target and have self-confidence to achieve them. Emotionally intelligent achievers are rational and goal-oriented. Conscientious achievers are responsible and insight creator. Deep learning achievers are interested in learning highly.

In teaching programming, Boban Vesin, et.al. [12] improved the Protus (Programming Tutoring System) for learning basic concepts of Java in order to enhance more personalization in the system. The personalization is based on learning styles of learners and mining the frequent sequencing. The new Protus consisted of four parts: Domain, Task, Learner model, and Teaching strategy. A learner was modeled as three components: performance, personal information, and learning style. Their learning styles could be considered in four dimensions: information processing, information perception, information reception, and information understanding.

Moushir M. El-Bishouty, et.al. [13] presented three approaches for automatically analyze learners' characteristics and courses in learning systems based on learners' cognitive abilities, learning styles, and context. Six behavior patterns were considered: linear navigation, constant reverse navigation, simultaneous tasks, recalling learned material, revisiting passed learning object, and learning style. All behaviors effect learning outcome, for example, the more revisiting passed learning object, the more problems student had in that learning object.

Not only providing learning style but also learning path should be considered. Z. Jeremić, et.al. [14] provided two kinds of navigation through their Web-based intelligent tutoring system for teaching design pattern. Direct guidance gives one option for students to go on browsing activity, for example, a next button leads to destination dynamically determined by the system. Link removal allows students to choose the concept to learn by selecting appropriate links from the content menu. However, providing too many possible paths is not good for students. Patricia A. Jaques, et.al. [15] developed the rule-based intelligent tutoring system for teaching Algebra in order to reduce a number of possible paths to explore when correcting a student's solution. The system could also demonstrate step-by-step of how to solve a problem.

C. Feedback

Giving students feedback is very important. Maria Knobelsdorf, et.al. [16] suggested that giving homework every week is compulsory and students need to stay motivated in learning theoretical computer science. Manolis Mavrikis, et.al. [17] suggested that design of intelligent learning environment has to consider three important requirements: rare interruption of interaction, feedback message should be co-located with object require students to act, and supporting towards specific goals which students are trying to accomplish. Then they formalized four priorities for designing of feedback: type of interruption, learner interactivity, system interactivity, and feedback message.

While Fernando Gutiérrez and John Atkinson [18] proposed a model of a sequence of feedback by using Hidden Markov Model in order to automatically select the best feedback strategy for students engaging in a foreign language learning context. Bram E. Vaessen, et.al. [19] studied three methods for measuring help seeking of students: counting a number of asking for help, model students' activities as Discrete Macov Model, grouping attempts on exercises with similar transition probabilities.

Emotion of students should be analyzed while students are learning. Neelu Jyothi Ahuja and Roohi Sille [20] have suggested. They did chronological review of development of ITSs in the past, the present, and the future. The past ITSs neglect the match between students' ability and difficulty level of courseware. It causes students disoriented during learning. Also the past works fail to provide encouragement at the time the student need and causes them to perceive negative emotions.

Everybody prefers welcome feedback. Anotonija Mitrovic, et.al. [21] claimed that positive feedback is nevertheless instrumental in producing the high gain scores obtained via tutoring. They agreed that an intelligent tutoring system that teaches primarily by addressing errors and misconceptions might become more helpful if extended with a positive feedback capability, for example, giving a guide for identifying problem states in which a student hesitates in a proper time. Susanne Narciss, et.al. [22] recommended that motivation is important for personalized feedback. They have studied that there were six types of feedback: performance, result, correct response, answer until correct, multiple try feedback, and elaborated feedback. There are two challenges in building ITSs , pointed out by Roger Nkambou, et.al. [23], Is the authoring bottleneck a natural border preserve variety of the systems?; Is the idea of one-sizes-fits-all possible?

IV. A DESIGN FOR TEACHING JAVA WITH A PAIR OF A PRE-QUIZ AND A QUIZ

The aim of teaching is engaging students with learning. After teaching with a pair of a pre-quiz and a quiz, the author has found that students paid more attention on teaching material while they had been trying pre-quiz exercises and had more responsibility to study on their own pace. Moreover, they studied in a group by discussing about the questions via social network. A pair of a pre-quiz and a quiz is demonstrated as below.

Pre-Quiz: Which is the wrong choice?

```
Kankrao is a Flower.
```

a. `Class Kankrao { Flower kankrao; }`
b. `Kankrao extends Flower`
c. `Flower kankrao = new Flower();`
d. `Kankrao implements Flower`

Quiz: Which is the wrong choice?

```
Isuzu is a Car.
```

a. `Class Isuzu { Car isuzu; }`
b. `Isuzu extends Car`
c. `Car isuzu = new Car();`
d. `Isuzu implements Car`

As the example, both questions have the same objective. And the four choices in one question are shuffled before giving to students. This kind of questions can be easily created and duplicated to another one by Moodle, an open-source learning management system.

This paper proposes a design of how three essential concepts in intelligent tutoring system can be implemented in teaching Java programming: knowledge domain, learning path and navigation, and positive feedback. The new proposed system is called "teaching with a Pair of a Pre-quiz and a Quiz", abbreviated PPQ. As Daniel Gooch, et.al. [24] indicated that design research in intelligent tutoring system served three important roles that support more specific design of user modeling. Design research could establish common ground by encapsulating domain knowledge in an accessible form, reveal a wide range of teaching and learning perspectives, and build new bridges between the design of the technology and the user model that supports it. Therefore, the PPQ should be finely designed.

A. Knowledge domain: basic of Java including SCJPcontent

The content of Java indicated in the Sun Certified Java Programmer (SCJP) is worth to learn although it does not focus on developing software in real life. But SCJP stresses on the language characteristics. Because learning object-oriented programming language must focus on PIE: Polymorphism-Inheritance-Encapsulation, all available in Java and concerned as a pure object-oriented language. However, students should be able to implement the language for building software in real life provided as Java basics. According to Java books in a market, general topics in basic Java are object-oriented programming, control structures, methods, arrays, strings and characters, GUI, exception handling, thread, multimedia, file and stream, networking, and utility packages. Whereas the SCJP are about declaration and access control, object orientation, assignments, operators, flow control, exception and assertion, string, IO, formatting, parsing, generics, collections, inner classes, and threads.

Some topics in both general books and in SCJP are similar but the objective may different. For example, declaration and access control, general books focus on how to define four types of access modifier: public, protected, default, private. On the other hand, SCJP focus on what is the effect of each modifier. Thus the knowledge domain of the PPQ should cover both objectives. By synchronizing topics of Java both in general books and SCJP, each topic can be considered as a piece of knowledge embedded with learning objectives that students must overcome. If one particular topic is a prerequisite of another one, both topics are related and students should begin at the prerequisite one. On the other hand, some topics may be independent of others. The alignment of all topics should provide easy traversal. Some researchers represent them as a graph of connected nodes of knowledge, as investigated in section III.

As Thushari Atapattu, Katrina Falkner, and Nickolas Falkner [25] presented an approach to utilize concept maps, instead of text-based answers, for the questions presented to educational question answering. The PPQ can also align topics as a graph and allow students to visit all nodes independently without concerning that there are prerequisite nodes or not because the directed lines are just for showing relationship of nodes. However, it is better to begin with the prerequisite one. The graph is demonstrated as below.

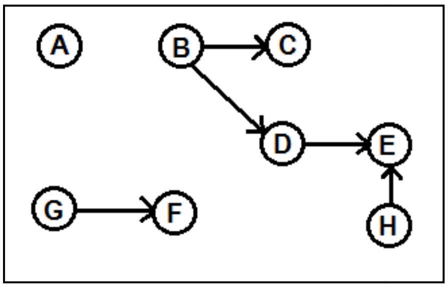

Fig. 1. The PPQ graph.

However, each node can be weighted with unequal scores according to its objectives specified by the teacher. Ideally, if students can overcome learning objectives of all nodes in the graph, they get 100 percent of scores of the course.

The real example of the PPQ graph can be demonstrated as below. Some topics of the Java course are selected for demonstration.

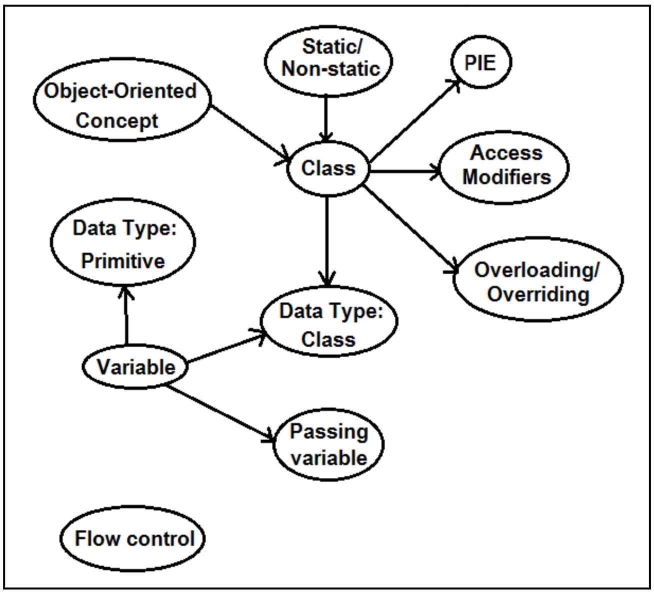

Fig. 2. The PPQ graph for some content of Java programming course.

As the graph above, a topic "Flow Control" is isolated from others whereas the rest of nodes are connected. There are a lot more topics of Java to be considered and included in a graph. Therefore the complete graph for Java is much bigger than the demonstrated one above. For example, a "Flow Control" can be attached with "If-Else", "Switch", and "Loop". Those topics mentioned are mostly located at the beginning section of the course. The rest sections could be graphic user interface (GUI), event handling, image and sound, collections, generic programming, I/O stream and file, threads, etc.

B. Learning path and Navigation

According to a graph of knowledge in the PPQ proposed in previous subsection, students are allowed to navigate over the graph freely and revisit each node repeatedly as much as they wish. The directed lines show relationships between some nodes in term of prerequisite topic of another. Therefore, the PPQ could represent the whole graph embedded with universal resource locator (URL) links to the content including exercises of each topic. Each exercise composes of a set of pre-quizzes and a set of quizzes.

In order to keep students stay motivated and have continuous learning, the system could apply following techniques suggested by researchers discussed in section III.

- Monitoring what an individual student has learning by keeping tracks of his/her traversal.
- Tracking how often a particular student revises teaching material.
- Allowing independent learning path or navigating route of learning freely with suggestion of what prerequisite nodes should be achieved.
- Providing material with suitable difficult level for individuals.
- Supporting goal-oriented achievers who set their certain targets and have self-confidence to achieve them by showing how far of their progress and how much of the rest in order to reach their goal.

Huong May Truong [26] investigated 51 papers, published in the last ten year available in Google Scholar, Scopus, and Science Direct, in order to find out how researchers have integrated learning styles with adaptive e-learning system. Integration learning styles with adaptive system is considered as two types: prediction and application. She found that the most popular learning theory which has been applied to adaptive systems is Felder-Silverman. Classification algorithms widely used are Bayesian Network, and Rules-based. Several applications have been found such as adaptive learning contents, teaching strategies, intelligent tutoring system, adaptive media, assessment, and educational games. Evaluation of the system can be done in two ways: satisfaction survey and statistical experiments. The first method is mostly used. Moreover, Jason Bernard, ting-Wen Change, Elvira Popescu, and Sabine Graf [27] introduced a new approach of using neural networks for identifying students' learning styles based on Felder-Silverman theory. The approach was evaluated by 75 students and concluded that it identified learning style more precisely and gave more accurate advice to students.

Consequently, the PPQ should categorize students' learning styles base on educational theory. The Felder-Silverman theory could be used.

C. Positive Feedback

According to literature surveyed in section III, the PPQ should handle feedback positively with concerning interaction between the system and students both interruption and interactivity. Some forms of feedback are suggested as following.

- Providing students homework weekly in order to keep them stay motivated.
- Addressing errors and misconceptions for individuals.
- Monitoring help seeking and automatically select proper positive feedback.
- Considering how to apply six types of feedback: performance, result, correct response, answer until correct, multiple try feedback, and elaborated feedback.

Kim Kelly and Neil Heffernan [28] reviewed three elements of self-regulated learning: motivational beliefs, help-seeking behavior, and meta-cognitive self-monitoring. They suggested that increasing task value could improve self-efficacy and could be done by asking students for promise. Instructional supports may not be useful for some students, so they advised a teacher to provide direct interventions to students. Moreover, they recommended that the teacher could guide students through encouraging message.

Therefore, the PPQ should provide not only positive feedback but also provide interventions to students directly.

V. CONCLUSION AND FUTHUR WORKS

The PPQ, as designed in section IV, is considered as an improved version of an online learning system using a pair of pre-quiz and a quiz. It is designed to be able to support difference of students along with formative assessment so that students can keep track of their progress continuously. The exercises should cover important misconceptions along with positive feedback. A set of knowledge in a particular course is represented as a graph. Each node in a graph, or a particular topic of a course, is embedded with a pair of pre-quiz and a quiz in order to evaluate students' performance and accumulate scores collected from the whole graph. By the way, the teacher, as human expert, is important for developing the intelligent system. As Sebastian Gross, et.al. [29] tried out their own ITS for supporting ill-defined knowledge domain so that the system can provide example automatically. They finally admitted that examples created by experts are more beneficial to support learning.

In order to evaluate the PPQ, a pre-test and a post-test are widely used. Kunyanuth Kularbphettong [30] developed an adaptive Web-based intelligent tutoring system for teaching Java programming. A pre-test is used for assessing prerequisite knowledge of students and a post-test is for evaluating the effectiveness of their knowledge. Both tests have two types of question: multiple-choice question, and subjective quiz. The subjective quiz is for testing programming skill and able to compile a Java program submitted by students. The system then checks scores based on rule-based approach. She claimed that the system satisfies learning management in three stages: pre-test, learning, and post-test according to student's performance. One more interesting concern for evaluation of an intelligent tutoring system is selection bias. Some students may more likely to volunteer than others and they may not representative of the target population according to Jim Greer and Mary Mark's suggestion. [31]

Furthermore, Clark N. Quinn [32] recommended that we should stop doing e-learning the old way such as rewriting PowerPoint or PDF files into online text, and multiple-choice knowledge tests. Making things more interesting can make them more effective. Teachers should start thinking not about creating content but about designing learner environments and architecting experiences. The PPQ could be integrated with theory of learning engagement.

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