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# Effects of concept map based cooperative peer assessment system on students' learning outcomes on programming

**Ya-Jing YU[a], Po-Han WU[a*] & Yu-Sheng SU[b]**

[a] *Department of Mathematics and Information Education, National Taipei University of Education, Taiwan*

[b] *Department of Computer Science and Information Engineering, Research Center for Advanced Science and Technology, National Central University, Taiwan*

*pohanwu.academic@gmail.com

**Abstract:** In past programming education, teachers could not offer students with learning assistance and feedback when students appeared misconception on the learning. This study integrates the real-time concept map based cooperative peer assessment system into programming course and applies the jigsaw cooperative learning strategy for the activity. The concept map drawn by students at each stage of the programming course is regarded as the auxiliary tool to diagnose the learning misconception. Students could clarify the misconception with the learning diagnosis feedback provided by the system and modify the concept map with experts' feedback. The research results reveal that students using the "real-time concept map based cooperative peer assessment system" present significantly better learning outcomes than other groups.

**Keywords:** concept map, peer assessment, programming

## 1. Introduction

Programming education aims to cultivate students' programming skills and capability to process data with computers. The US government regards programming education as an important indicator to enhance the global competitiveness and considers programming as the critical survival skill for the next generation. It is not the simple idea of programming education, but it stresses on cultivating students' problem-solving capability through the skills learned in classes, under messy situations (Robins, Rountree, & Rountree, 2003).

However, students, in the programming learning process, do not simply encounter difficulties on a single concept, but many problems, that it is necessary to divide difficulties into several questions for the solution (Bonar & Soloway, 1985; Robins et al., 2003). Besides, assessment strategies should be included in students' learning process so that teachers could understand students' learning conditions according to the assessment results, offer students with individual feedback according to the learning conditions, and adjust the teaching contents at any time to decide the necessity of review or material adjustment. Nonetheless, past research on programming learning focused on teachers requesting students to complete designated tasks and then evaluating such tasks completed by students. Under such a traditional learning environment, teachers had to precede individual assessment and give individual feedback to so many students that the learning outcomes could not reach the expectation (Wu, Hwang, Milrad, Ke, & Huang, 2012; Conklin, 1987).

Current research on programming courses mainly stresses on students implementing works through subject knowledge that the concept problems in the subject knowledge are likely ignored in students' learning process (Lahtinen, Ala-Mutka, & Järvinen, 2005). For this reason, it is important to cultivate students to actively construct knowledge before the implementation and assist students in learning meaningful programming concepts. Kinchin, Hay, and Adams (2000) considered that concept mapping could clearly present students' concept structure, teachers could find out which concepts students had understood or needed reinforcement from the concept mapping, and, more importantly, students could cultivate the habit to think with brains and operate with hands in such a learning process. When students comprehend the basic concepts of subjects, such basic concepts could be the basis for students' learning experience in the future and become the reference for solving problems in daily life.

Chu, Hwang, and Tsai (2010) indicated that the introduction of technology without suitable learning strategies would result in students' learning outcomes not achieving the expectation. A lot of researchers regarded the assistance of peer assessment in students' learning. Having students, from the aspect of teachers, assess peers' works would have them appear reflection behaviors (Yang, 2010).

## 2. Literature review

### *2.1. Importance of programming*

Programming is regarded as the key capability in the 21st century to solve daily problems (Chao, 2016; Grover & Pea, 2013). Susan Wojcicki, the vice president of Google, mentioned that programming had students feel powerful, creative, and confident. Sheryl Sandberg, the chief operating officer of Facebook, indicated that computer science was getting more important and national competitiveness relied on the education of children's capability of computer science. Besides, programming courses were emphasized by many scholars as programming could enhance students' computer awareness & literacy and logical reasoning ability as well as cultivate students to think of encountered problems and solve problems with present technology (Clement & Merriman, 1988). With the emerging programming issues, more and more scholars would cultivate students, with programming courses, to comprehend knowledge and skills for the flexible application to daily life problems.

### *2.2. Development and application of concept mapping in education*

In the cognitive learning and assimilation theory proposed by Ausubel (1968), learning was divided into rote learning and meaningful learning. The former referred to students not really comprehending knowledge, but simply remembering some knowledge. The latter, on the other hand, connected new knowledge with students' prior knowledge to generate meaningful learning. Teachers had to know students' prior knowledge in order to provide students with effective learning methods to enhance the generation of meaningful learning. Students would be enriched the mind after learning subject knowledge with meaningful learning, rather than rote learning. Ausubel (1968) pointed out three prerequisites for meaningful learning.

- Learning materials should present logical meaning, indicating that learning materials could be established non-artificial and real contact with the proper concepts in students' cognitive structure.
- Students had to present meaningful learning set, i.e. the intention to actively connect new knowledge with proper knowledge in students' cognitive structure.
- Students' cognitive structure had to present the proper concept of assimilating new knowledge.

### *2.3. Peer assessment model*

Topping (1998) regarded peer assessment as the assessment process in which students constructed personal knowledge and skills through the mutual assistance of other students with similar background, evaluated the number, degree, value, practicability, quality, and success of works or learning outcomes of each other through peer assessment, and changed from students into evaluators. The theory of peer assessment learning strategy is based on Distributed Constructionism proposed by Resnick (1996). In plural societies, the learning process of more than a person actively participating in discussion or constructing knowledge is particularly emphasized, and the elements of knowledge are indeed dispersed to different people or places for group interaction and crowd cooperation to more effectively acquire knowledge.

## 3. System design

### *3.1. Conceptual framework*

A system “integrating real-time concept map based cooperative peer assessment system into programming course” is constructed in this study. This system features to integrate class knowledge into life problems and allow students observing works among peers through the peer assessment model. In addition to peer assessment, this system also provides real-time concept assessment to enhance students’ problem-solving capability, learning motivation, and learning outcomes. This system contains five functions of “scientific problem comprehension”, “mathematical problem-solving”, “programming”, “programming work evaluation”, and “peer feedback”. The system architecture is shown in Figure 1

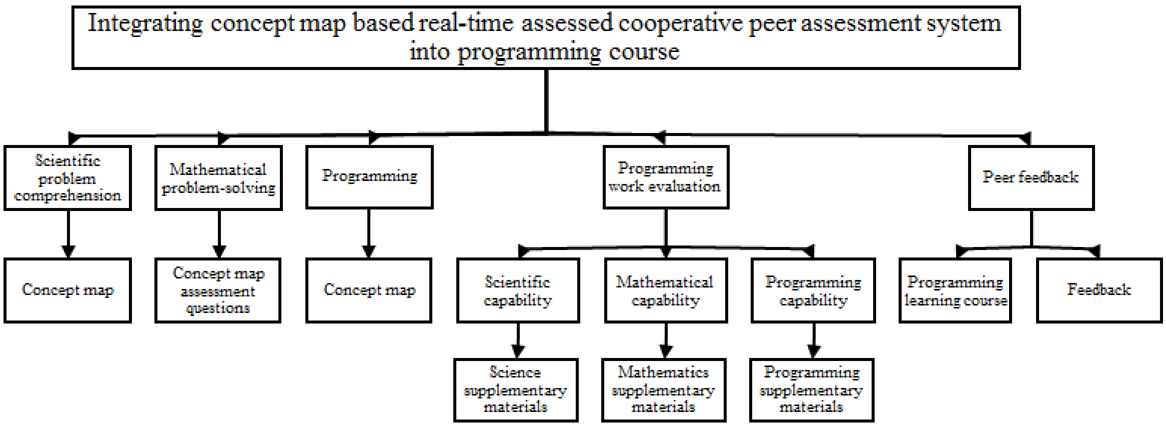


Figure 1 System architecture

The learning system contains five functions of “scientific problem comprehension”, “mathematical problem-solving”, “programming”, “programming work evaluation”, and “peer feedback”. Assuming that a student is at the stage of scientific problem comprehension, the scientific problem comprehension module would judge whether the student achieves 100%, and the system would automatically provide scientific supplementary materials for the student making corrections. The system would not open the supplementary materials before a student completes the sub-tasks (scientific problem comprehension, mathematical problem-solving, and programming). Furthermore, the “programming” module for equipping on desktop computers is also available that students could open MIT APP Inventor 2 (http://appinventor.mit.edu/explore/) for programming and then take pictures for uploading to the system.

### *3.2. Introduction of system function*

The system flowchart is shown in Figure 2. After a student logs in the original group, tasks are distributed among the student and the group members. The programming of free fall is taken as the example for the function introduction in this system. Assuming that a student is distributed the task of free fall, he/she has to learn the free fall sub-units in the expert group and then return the original group to teach other classmates the contents discussed in the expert group; meanwhile, the group members have to familiarize with the contents they learn from other expert groups. When all sub-tasks are completed, the system would evaluate and provide supplementary materials for students making corrections. The system then would judge whether the leader’s work has been assessed by peers; if not, a peer assessment button would appear. The evaluation includes giving scores and feedback for peers’ works and having the original group members read the feedback from peers for discussions and corrections. The system would then evaluate again to complete the programming of free fall.

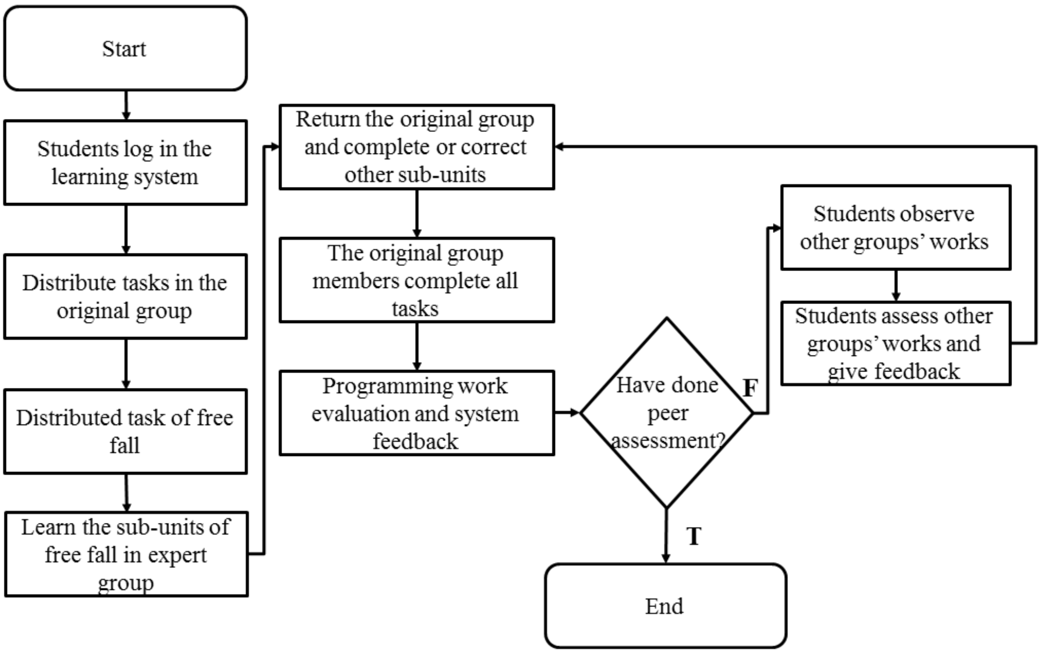


Figure 2 Student operation flowchart

The programming course in this study is referred to the jigsaw cooperative learning grouping model proposed by Jones and Steinbrink (1989). Four people are in a group; the jigsaw cooperative learning contains four stages. First, students, in the original group, would discuss with the group members to distribute tasks. The expert group is then established for learning the distributed tasks. Students would return the original group, after completing the distributed tasks, to share with the other three classmates. All learning sub-tasks are mastered from mutual teaching. Finally, teacher's feedback is given after the completion at each stage.

The system is demonstrated as following. The system, with a tutor, would inform the current stage, e.g. Please move to the expert group after selecting the task. Students, after see in the reminder of the system tutor, could discuss with the original group members for the task distribution. Students then tick the distributed sub-tasks, which contain free fall, vertical upcast, horizontal toss, and horizontal distance in this system. Finally, students move to the expert group according to the system grouping prompts

## 4. Experiment design

### *4.1. Research tool and object*

Total 87 students in a college in northern Taiwan are experimented in this study. The experiment is preceded for four months. With Quasi-Experimental Research, the students with the "concept map based real-time assessment programming evaluation system" and different system functions are compared the learning outcomes, learning motivation, problem-solving capability, and cognitive load. The learning content is free fall in physics for senior high schools, and the sub-tasks in the system are provided by experts, including free fall, vertical upcast, horizontal toss, and horizontal distance.

### *4.2. Experiment process*

Quasi-Experimental Research, as the major research design, is utilized in this study. The experimental research is preceded according to the research objective and discusses the relationship between dependent variables and independent variables. The teaching experiment is preceded for four hours, including the courses of system introduction and operation explanation. The experimental group and the control group apply different learning models and fill in three questionnaires (learning motivation, problem-solving capability, and cognitive load) and a learning test paper.

### *4.3. Experimental result and analysis*

Two-way Analysis of Covariance, with “learning outcome pretest” as the covariant and “learning outcome posttest” as the dependent variable, is used in this study. The Levene homogeneity of variance test results do not disobey the assumption of homogeneity of variance ($F=.517$, $p=.672>.05$), revealing the homogeneity of the between-group discrete case.

Regarding the between-group effect (Table 1), the interaction between concept map based real-time assessment and peer assessment achieves the significance ($F=7.30$, $p=.008<.05$, Partial $\eta 2=.082$) that the simple main effect test is preceded. In regard to the simple main effect analysis of learning outcomes, Table 2, the concept map based real-time assessment and peer assessment mutually interact with learning outcomes, but the effects appear under different conditions. The simple main effect of the concept map based real-time assessment “with introduction of concept map based real-time assessment” achieves the significance ($F=17.62$, $p=.000<.001$), showing that students using the “system integrating concept map based real-time peer assessment model into programming” (mean=52.90) present remarkably better performance on learning outcome posttest than those with the “system integrating concept map based real-time assessment into programming” (mean=32.43). In the concept map based real-time assessment “without introduction of concept map based real-time assessment”, the simple main effect also reaches the significance ($F=4.35$, $p=.045<.05$), revealing that students with “traditional teacher feedback model integrated programming” (mean=42.81) notably outperform those with “system integrating concept map based peer assessment model into programming” (mean=42.77) on learning outcome posttest.

Furthermore, researchers pointed out the simple main effect of peer assessment “with peer assessment” not achieving the significance ($F=1.26$, $p=.269>.05$), showing that students with the “system integrating concept map based real-time peer assessment model into programming” (mean=52.9) outperform those with the “system integrating concept map based peer assessment model into programming” (mean=42.77) on learning outcome posttest, but not showing significant differences. The simple main effect of students in peer assessment “without peer assessment” also reaches the significance ($F=.22$, $p=.639>.05$), presenting that students with “traditional teacher feedback model integrated programming” (mean=42.81) outperform those with the “system integrating concept map based real-time assessment into programming” on learning outcome posttest (mean=32.43), but not showing notable differences.

Regarding the concept map based real-time assessment, both “with introduction of concept map based real-time assessment” and “with peer assessment” receive high learning outcomes, while the learning outcome posttest does not appear large differences on both “without introduction of concept map based real-time assessment” and “with peer assessment”. In regard to peer assessment, “with peer assessment” and “with introduction of concept map based real-time assessment” receive high learning outcomes, while, both “without peer assessment” and “without introduction of concept map based real-time assessment” are better than “with introduction of concept map based real-time assessment”.

## 5. Conclusion and suggestion

The research results reveal the remarkable interaction between concept map based real-time assessment and peer assessment. The learning outcomes of students with peer assessment “with introduction of concept map based real-time assessment” are higher than those without peer assessment. On the contrary, the learning outcomes of students without peer assessment “without introduction of concept map based real-time assessment” are higher than those with peer assessment. Accordingly, the researcher consider that including concept map based real-time assessment in the group with peer assessment would enhance the learning outcomes on the programming subject, as a lot of researchers would design the programming courses and activities with groups, who would induce more ideas through group discussion among peers. When peer assessment is included in the complicated programming subject, the classmates could simultaneously be the evaluators as well as the evaluated. When evaluating others' works, the classmates would repeatedly compare with personal works to present reflection. Students could find out the advantages and drawbacks of the works through peer work and modify the work to enhance the quality. The evaluated would modify the work according to peers' evaluation and feedback. The result conforms to it of Lai and Hwang (2015). Apparently, the peer assessment model could largely enhance students' learning outcomes. However, it is better in the groups without concept map based real-time assessment, possibly because students' feedback, in the experiment process, is rather simple or irrelevant to the experiment so that students are distracted from the learning process for viewing peers' suggestions. Such a result conforms to it of Hsia, Huang, and Hwang (2016). The research result points out the best learning outcome on peer assessment. The researcher also indicates that the ineffective learning outcome might result from the students being lack of expression in traditional classes. In this case, peers' feedback show better meanings for students, after viewing experts' feedback.

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