

## INTEGRATING WORKED EXAMPLES INTO PROBLEM POSING IN A WEB-BASED LEARNING ENVIRONMENT

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### ABSTRACT

Most students always lack of experience and perceive difficult regarding problem posing. The study hypothesized that worked examples may have benefits for supporting students' problem posing activities. A quasi-experiment was conducted in the context of a business mathematics course for examining the effects of integrating worked examples into problem posing activities. A total of 107 undergraduate students at a technology university were invited to join this experiment for six weeks. The problem posing activities were carried out in a web-based learning system. The experimental condition receiving worked examples was compared with a control condition regarding the number, orientation and complexity for indicating problem posing performance. To evaluate students' problems as objectively as possible, a Problem-Level-Taxonomy was developed in this study. By the independent sample t-test analysis, the results showed that integrating worked examples into problem posing has a significant skills development effect on posing more orientated and complex problems, particularly for analytical problems referring to a learning concept or a formula. Besides, novice students with none experience in problem posing may benefit from the support of worked examples to improve their problem posing skills. The implications and limitations of this study were also discussed.

### INTRODUCTION

Good science education demands asking right questions and getting right answers, among that asking good questions is the important beginning (Orr, 1999; Woodward, 1992). However, the questions usually generate by the teacher and rarely by the students (Dillon, 1988). Dillon (1990) suggested that questions should come from both teachers and students. Recently, researchers emphasized the task of generating questions falls onto the shoulders of students (Chang, Wu, Weng, & Sung, 2012; Hofstien, Navon, Kipnis, & Mamlok-Naaman, 2005; Kaberman & Dori, 2009; Lan & Lin, 2011; Marbach-Ad & Sokolove, 2000; Vreman-de Olde & de Jong, 2004; Yu, 2009; Yu, Liu, & Chan, 2005), in which students shift from a passive role as information receiver to an active role, assuming the role of teachers as questioners to generate problems and also answer the problems. That is, students engage in self-questioning and self-answering activities during the problem posing process (King & Rosenshine, 1993). Mathematics education, without exception, has widely engaged in problem posing (Barlow & Gates, 2006; Crespo, 2003; Lavy & Shriki, 2010; Silver, 1994; Toluk-Ucar, 2009). While the positive influence of problem posing on content knowledge, comprehension, analytical skills, problem solving skills, and beliefs about subject matter has been evidenced (Barlow & Cates, 2006; Chang et al., 2012; Dori & Herscovitz, 1999; Kaberman & Dori, 2009; Lavy & Shriki, 2010; Toluk-Ucar, 2009), successful problem posing may be difficult for students. Particularly, students are accustomed to answering questions but still complete novices at problem posing (Dillon, 1990). The main challenge is a lack of experience (Vreman-de Olde & de Jong, 2004; Yu & Liu, 2009) and perceived difficulty regarding problem posing (Yu et al., 2005).

Under the premise that students should be provided real-time support with unrestricted time and space, a web-based learning environment used as a platform for problem posing would appear to be promising. Several

web-based learning systems, such as QSIA (Rafaeli, Barak, Dan-Gur, & Toch, 2004), QPPA (Yu et al., 2005), PeerWise (Denny, Hamer, Luxton-Reilly, & Purchase, 2008), Concerto II (Hazezama & Hirai, 2009), and QPIS (Lan & Lin, 2011) were therefore developed for supporting problem posing. Within these systems, having access to model problems was perceived as the most important support during problem posing (Yu, 2009). However, the model problems were generated by peer students, in which case the demonstrated problem states and solution procedures may contain errors (Braaksma, Rijlaarsdam, & Van den Bergh, 2002; Schunk & Hanson, 1985). In contrast, expert model problems, such as worked examples, that are presented in a didactical way are considered as an effective instructional strategy to demonstrate how to perform a task (Atkinson, Derry, Renkl, & Wortham, 2000; Braaksma et al., 2002; Sweller, Van Merriënboer, & Paas, 1998). Assisted by worked examples, that is, examples generated by teacher/expert generally provides complete problem states and correct didactical problem solving procedures (Atkinson et al., 2000; Crippen & Earl, 2007; Renkl, 2002; van Gog & Rummel, 2010; Ward & Sweller, 1990), it is hoped that students may view and imitate the worked examples and further reformulate or elaborate upon them in better conducting the problem posing task.

Nevertheless, the issue of considering the provision of expert model problems to support problem posing for students has attracted relatively little attention and is worth examining. A novel way of integrating worked examples into problem posing in a web-based learning environment was proposed in this study. The effects were investigated in the context of a business mathematics course focused on undergraduate students. The problem posing was conducted across three homework exercises in which students were required to generate at least one applied problem (i.e., like a real-life problem) respectively. The main assumption underlying this study was that studying worked examples could stimulate students' problem posing activities and develop problem posing skills. It was grounded in the literature documenting observational learning occurs when students are provided with model problems in problem posing activity (Yu, 2009) and studying worked examples is regarded as a kind of observational learning (Bandura, 1986; Sweller & Sweller, 2006; Sweller, 2004; van Gog & Rummel, 2010).

## THEORETICAL BACKGROUND

### Problem Posing

Problem posing refers to generating an original new problem or reformulating an existing problem (Silver, 1994). Marbach-Ad and Sokolove (2000) claimed that problem posing involves more than generating a problem, and also presenting a solution to the problem. From a cognitive perspective, Yu et al. (2005) referred to problem posing as an information-processing process that requires students to become actively immersed in the material, point out the important learning concepts, reason which parts are worth testing, clarify the relationships among the concepts and formulate or elaborate a problem. Through posing problems students expose their thoughts and reflect their level of understanding, skills and beliefs (Dori & Herscovitz, 1999; Toluk-Ucar, 2009). The posed problems provide opportunities for teachers to gain insights into the students' cognitive understanding (Woodward, 1992), and therefore, some studies used problem posing exercises as an assessment tool (Dori & Herscovitz, 1999; Hofstien et al., 2005; Kaberman & Dori, 2009). Moreover, Kaberman and Dori (2009) indicated that problem posing is a metacognitive function because students are trained to be self-questioners, enabling students to monitor their comprehension or identify the limits of their knowledge and better self-regulate their progress (King & Rosenshine, 1993; Palinscar & Brown, 1984; Wong, 1985).

Considering that problem posing is an important strategy for cognitive comprehension and metacognitive regulation (Aldridge, 1989; Dori & Herscovitz, 1999; Hartman, 1994; Heady, 1993; Kaberman & Dori, 2009; Paris & Myers, 1981; Yu et al., 2005), several researchers have focused on teaching/learning environmental designs such as cooperative learning, or inquiry-based learning, in which students were provided with opportunities to formulate more and higher level problems (Hofstien et al., 2005; Lan & Lin, 2011; Marbach-Ad & Sokolove, 2000). Although Kaberman and Dori (2009) presented evidence that question classification taxonomy served as scaffolding that effectively stimulated students to generate questions, the question of ways to guide or instruct students in posing better problems, particularly in upgrading the cognitive level of problems, remains unanswered and there is a need to be investigated. Yu et al., (2005, 2009) also indicated that the question of how to improve students' problem posing ability and performance is emerging as an important issue. Therefore, this study aimed to fill this gap in the literature.

### Worked Examples

Worked examples usually provide students with example problems and worked-out solution steps for final answers (Renkel, Stark, Gruber, & Mandl, 1998; Sweller et al., 1998). Research has shown that studying worked

examples in contrast to conventional problem solving is an effective way to enhance understanding why solution steps are effective, how the operators should be applied and the rationale underlying solution procedures (Sweller, 1988, 2004; Sweller & Cooper, 1985), which allows students to build cognitive schemas (van Gog & Rummel, 2010). The effectiveness of learning from worked examples for novice students in well-structured domains such as physics, programming and mathematics (Kalyuga, 2007; Kalyuga, Chandler, Tuovinen, & Sweller, 2001; Sweller et al., 1998; van Gog & Rummel, 2010; VanLehn, 1996) is promising, but validation of the strategy in the problem posing activity is needed and noticeably missing from the literature.

### **Integrating Worked Examples into Problem Posing**

Most students always lack the experience of problem posing (Vreman-de Olde & de Jong, 2004; Yu & Liu, 2009). Even though students were drawn into problem posing activities, a significant percentage of students felt that problem posing was a difficult task (Yu et al., 2005). These problems demonstrate the necessity of searching for further support in the effort to promote problem posing activity. Yu (2009) researched students' perceived usefulness of each scaffolding techniques, among which model problems generated by peers was viewed as the top most support for problem posing. The researchers employed the exemplary problems generated by students as models for being viewed and observed by other students. In this case, observing model problems were considered as observational learning (Yu, 2009). Furthermore, researchers claimed that the words or images included in worked examples are symbolic models that can be observable for the students (Bandura, 1986; Sweller & Sweller, 2006; Sweller, 2004). Therefore, studying worked examples is also regarded as a kind of observational learning (van Gog & Rummel, 2010) in which students may observe symbolic models in words or images with written accounts of what the problems state and how the solution steps evolve. The present study hypothesized that observational learning may occur when integrating worked examples into a problem posing activity.

Summarizing the above, the study presumed that worked examples may contribute to problem posing activities. Worked examples, expert model problems, could be viewed as an analogy (Reed, Willis, & Guarino, 1994) for generating new problems and solving such problems during problem posing. Studies showed that the availability of models for reference is one of the factors that influence student performance in problem posing activities (Yu et al., 2005). The main research question in the study was: Can providing worked examples stimulate more problem posing activities and develop better problem posing skills?

## **METHODOLOGY**

### **Participants**

A total of 107 undergraduate students taking business mathematics course, with an average age of 21 from department of business administration at a technology university in Taiwan, were invited to join the experiment. The participants of this study were taught by the same teacher. A quasi-experiment was conducted in two classes. Each class was randomly assigned to one of two conditions, worked examples condition ( $n=54$ ) and control condition ( $n=53$ ). Students' consent was obtained. The two conditions differed in whether worked examples provided along with each problem posing homework. The control condition only received the notification of homework without any worked examples, whereas in the worked examples condition, two worked examples were additionally provided. A control condition was included in this study, thus, the effects of integrating worked examples into problem posing could be observed in the absence of confounding factors. Before the experiment, none of the participants was ever equipped with problem posing skills and experience in such activities.

### **Learning Materials and Objectives**

Business mathematics, a 2-credit, two-semester required class, was specifically selected for leaning materials in this study because the course is a well-structured domain and emphasizes introductory mathematics skills that are prior knowledge for required courses such as consumer finance and investments. The learning objective was to enable students to become acquainted with five units: "Simple Interest", "Compounded Interest", "Future Value of Annuities", "Bonds and Sinking Funds", and "Present Value of Annuities". The experimental materials addressed latter three learning units and the "Simple Interest" and "Compounded Interest" learning materials were instructed before the experiment.

### **The Learning Environment**

A web-based learning management system, a commercially system called iLMS, developed by FormosaSoft Corp. in Taiwan, was used in this study for managing students' assignments and sharing information. The reasons of using the learning system were as follows. First, the problem posing homework could be assigned in

an assignment function and the requirements of the homework could be specified herein, especially including the delivering of the worked examples for worked examples condition. Furthermore, the notification of homework information could be sent by the system. Second, the period of submitting homework could be set to ascertain that the students submit their problem posing homework to the system during the valid period. The function of submitting-assignment would be disabled automatically once the period is expired.

During the valid period, students could modify the problems they posed at any time. Finally, the system could be act as a platform for demonstrating the problems that the students posed; that is all problems were shown in the system until after the valid period of submitting homework. In the light of Brandura's (1986) social modeling, previous researchers suggested that engaging in the process of observing their peers' problems may be conducive to their knowledge levels and modeling may be occurred (Yu et al., 2005; 2009). The effects of the peer model problems were not relevant in this study though.

#### **A Problem-Level-Taxonomy for categorizing students' problems**

Bloom taxonomy (Bloom, 1984) is the most common hierarchy for evaluating questions based on the cognitive level required to answer it. The hierarchy consists of six levels: knowledge, comprehension, application, analysis, synthesis and evaluation from lower to higher levels respectively. However, Bloom taxonomy is not fully appropriate for this study due to the following reasons. One is that the classification is mainly used to categorize teachers' questions rather than students' questions posed in problems posing activity (Marbach-Ad & Sokolove, 2000). A second is that problem posing can be regarded as a component of high level thinking skills (Barak & Rafaeli, 2004) rather than low level skills such as information recalling or knowledge understanding, and the problems posed in this study were all applied problems. A third is that problems should be evaluated based on the required learning concepts concerned with the objectives of the lesson for completing the task (Barden, 1995; Shepardson, 1993). Bloom's taxonomy and other methods that have been used to classify students' problems (Barak & Rafaeli, 2004; Dori & Herscovitz, 1999; Marbach-Ad & Sokolove, 2000) were completely inadequate for this study.

**Table 1:** Rubric for Problem-Level-Taxonomy

Level	Description	Score
Digression	Problems that do not make sense regarding the learning unit or digressed from the subject.	0
Application	Problems to which the answer is figured out by matching the elements of problems with the formula elements referring to a learning concept or a formula.	1
Analysis	Problems to which the answer is an analytical or comparative evaluation for reaching a particular goal referring to a learning concept or a formula.	2
Synthesis	Problems resulting from a synthesis of prior knowledge and the newly acquired learning concepts.	3

Consequently, in order to match with the objectives of the lesson, a Problem-Level-Taxonomy was developed in this study for ranking students' problems as objectively as possible, as specified in Table 1. The problem was categorized as one of four levels: digression, application, analysis, and synthesis under the number of above-mentioned learning concepts required to answer the problem for demonstrating students' mastery.

A digression-level problem referred to a problem that did not contain a certain formula or orientated toward a certain learning unit. An application-level problem caused students to vary the knowns or givens, reversing knowns and unknowns from an original problems. The answers were figured out by matching the elements of problems with the formula elements referring to a formula. An analysis-level problem required students to generate a new problem including several similar cases with different conditions. The answers were obtained by utilizing a certain formula to analyze or evaluate these cases for reaching an optimal goal. Lastly, a synthesis-level problem engaged students in drawing relationships among prior knowledge and the newly acquired learning concepts. More than one learning concept or formula was synthesized for solving this kind of problems. Both the analysis- and synthesis-level problems were viewed as complex problems resulting from analyzing different cases or from synthesizing different learning concepts (Marbach-Ad & Sokolove, 2000). An example of "Future Value of Annuity" was given, for each level each example problem posed by students was illustrated and the comments for each one were also exemplified respectively in Table 2.

**Table 2:** Examples for each level regarding “Future Value of Annuity”

Level	Examples	Comments
Digression	For an 8.5% simple interest 4-year \$20,000 loan, what is the total interest?	The problem is a digressive problem, since it is not orientated towards the concept of “Future Value of Annuity”.
Application	You deposit \$100 per month into an account that earns 1.2% interest per year compounded monthly. After 10 years, how much should the account be?	The answer to the problem can be solved with a concept of “Future Value of Annuity” only.
Analysis	You deposit \$100 per month into an account that earns 1.2% interest per year compounded monthly. And, Mary deposit \$350 per quarter into an account that earns 1.5% interest per year compounded quarterly. After 10 years, how much should the difference between your and Mary’s account be?	For answer the difference between the two accounts, the concept of “Future Value of Annuity” is utilized for both accounts and the difference can be calculated accordingly.
Synthesis	You deposit \$100 per month into an account that now contains \$10,000 and earns 1.2% interest per year compounded monthly. After 10 years, how much should the account be?	The problem contains two learning concepts, “Compounded Interest” and “Future Value of Annuity”.

### Procedures

Before the experiment, to assure equivalent student achievement across conditions, a prior knowledge test on “Simple Interest” and “Compounded Interest” was administered in a traditional paper and pencil form. The test consisted of five applied problems with a total possible score of 100. No significant differences in prior knowledge scores existed between the two conditions. Besides, all participants were provided with a Problem-Level-Taxonomy that instructed what the evaluation criteria were, what complex problems were, and what the instructor expected for problems posing to self-evaluate the problems they posed. Related research showed that students instructed in problem classification taxonomy significantly improved their problem posing skill and advanced on the complexities of the problems they posed (Kaberman & Dori, 2009).

The total duration of the experiment was six weeks. For matching with three experimental units, that is, “Future Value of Annuities”, “Bonds and Sinking Funds”, “Present Value of Annuities”, the experiment procedures were conducted in three rounds of learning activities. Each round lasted two weeks and concentrated on one of the three units. Students were instructed in traditional classes for 2 hours each week. In the first week of each round, the foundational concepts related to the corresponding unit were instructed. After class, the students were assigned a problem posing homework of a week. The homework required students to generate at least one applied problem and the subject of the problems should be matched with the learning unit. Two worked examples corresponding to the learning unit were additionally provided only for worked examples condition. These two worked examples were application-level problems with the same underlying concepts but changed known or unknown features. The impetus for students was that all posed problems were graded and counted towards one fifth of the overall semester grade. The following week of each round, in order to maximize students’ mastery of the learning units, the teacher illustrated some problems posed by the students in the class and took them as exercises by discussing any existed misunderstanding, aiming to remedy students’ comprehension. The problems illustrated in both conditions were exactly the same.

Summing up, the following steps provide an overview of the process for problem posing activities: (1) to inform students the grading of posed problems counted towards semester grade, (2) to provide the Problem-Level-Taxonomy for students, (3) to delivery 2-hour lecture in class, (4) to assign a problem posing homework in iLMS and provide two worked examples only for worked examples condition, (5) to require students complete problem posing in iLMS within a week, and (6) to discuss posed problems for 2 hours in next class. Each round of learning activities repeated from step (3) to (6).

### DATA ANALYSIS

Over the experiment period, students were assigned three problem posing homework exercises. The results over three homework exercises were aggregated for analyzing in terms of the number, orientation and complexity for indicating problem posing performance (Dori & Herscovitz, 1999).

Firstly, with regard to the number, for each student the quantity of posed problems across three homework

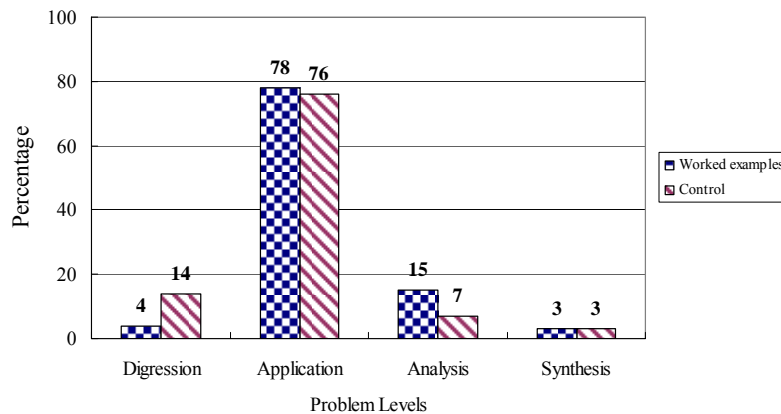
exercises was counted in Total Problems (future called TP). Next, with regard to the orientation, the content of each problem was analyzed for determining whether the problem digressed, i.e., judging whether the problem that did not orientated towards the learning unit. Digressive Problems (DP) was used to indicate the number of non-orientated problems that fell into the digression level. Conversely, a non-digression problem was implemented only if the problem oriented towards the learning unit, that is, the answer to it contained the learning concepts for solving it.

Thirdly, with regard to the complexity, the content of each non-digression problem was further analyzed for determining what level into which the problem fell in the Problem-Level-Taxonomy. Complex Problems (CP) was used for representing the quantity of complex problems including analysis- and synthesis-level problems. Besides the quantity, it is also valuable to understand the obtained scores associated with the quantity of complex problems. Therefore, for scoring students' problems, one, two, three points were given respectively for application-, analysis- and synthesis-level problems. No credit was given for digression-level problems. The Average Complexity (AC) was defined as the ratio of the obtained points to the quantity of complex problems.

After the experiment two experts were invited to grade the problems over three homework exercises according to the Problem-Level-Taxonomy, i.e., to categorize problems as digression-, application-, analysis- or synthesis-level problems. The two independent raters fully agreed on the problems categorized as digression level. The inter-rater reliability between the two raters on was 0.938 (Spearman's Rho). The problems on which disagreement occurred were re-categorized and an agreement was reached. This indicated that the two experts graded very consistently. This also implied that the Problem-Level-Taxonomy was appropriate for problem posing evaluation matching with the objectives of the lesson.

## RESULTS

The number of problem posed by students for worked examples condition (below called WE) and control condition was 405, and 370 respectively. Figure 1 presented the percent distribution with respect to problem levels in two conditions, sorting by cognitive level. The distribution of the percentage of digression-, application-, analysis-, and synthesis-level problems in WE was 4, 78, 15, and 3 compared with 14, 76, 7, and 3 in the control condition, respectively. With the exception of digression-level problems, the percentage points for the WE were almost above the control condition. Both conditions posed mainly application-level problems. Even though both condition performed equal percentage of synthesis-level problems, the WE outperformed the control condition for posing over two times of analysis-level problems, suggesting worked examples effects for WE.



**Figure 1:** Distribution of problem levels in two conditions.

Table 3 presented a comparison of problem posing performance in terms of the number, orientation and complexity of problems between two conditions. The mean scores for the WE were higher than that for the control condition regarding to TP, CP, and AC. However, DP was a negative item that is reversely related to problem posing skills, the mean score for the WE was below that for the control. The greater DP one received the more digressive problems one posed, and the poorer problem posing skills one had.

**Table 3:** A comparison of each measure by two conditions

Aspect	Measure		WE (n=54)		Control (n=53)		t-value	p-value
			M	SD	M	SD		
Stimulation	Quantity	TP	7.50	3.61	6.98	4.12	0.69	.25
	Orientation	DP	0.26	0.52	0.98	1.10	-4.35	.00**
Skills Development	Complexity	CP	1.37	1.32	0.72	0.99	2.90	.00**
		AC	1.24	0.27	1.19	0.34	0.83	.41

Notes: WE = worked example condition, Control = control condition.

\*\*  $p < 0.01$ , one-tailed testing.

The study aimed at examining the effects of worked examples on problem posing activity stimulation and problem posing skills development. The results of data analysis focused on two aspects: activity stimulation and skills development. As to activity stimulation, the two conditions were compared with regard to the quantity of problems. On the other hand, the quantity of digressive problems and the complexity of problems were considered for skills development.

#### **Problem posing activity stimulation**

For examining the worked examples effect on problem posing activity stimulation, the difference in the quantity of problems, TP, posed by the two conditions was tested. The independent sample t-test showed that the WE condition did not significantly outperform the control condition in TP, as shown in Table 3. The worked examples effect on problem posing activity stimulation was not confirmed, yet the direction of the results was as expected.

#### **Problem posing skills development**

Regarding worked examples effect on problem posing skills development, the differences in sub-skills (orientation and complexity) for the two conditions were examined respectively.

##### ***Problem orientation***

With regard to problem orientation, the quantity of problems classified as digression level, DP, was examined. The independent sample t-test revealed that there was a significant difference between the WE condition and the control condition. However, the result also showed a significant trend in the contrary direction, as mentioned before, DP is a negative item. As expected, the mean of DP for the WE condition ( $M = 0.26$ ) was significantly below the control condition ( $M = 0.98$ ;  $p = 0.00$ ). In other words, the students in the WE condition supported by worked examples posed more orientated problems compared to those in the control condition, suggesting that worked examples had a positive effect on problem orientation.

##### ***Problem complexity***

The complexity of the problems was examined by utilizing AC and CP respectively. The independent sample t-test showed that the WE condition did not produce significantly more AC ( $M = 1.24$ ) than the control condition ( $M = 1.19$ ,  $p = 0.41$ ). However, more CP ( $M = 1.37$ ) were posed by the WE condition compared to the control condition ( $M = 0.72$ ,  $p = 0.00$ ), suggesting that the WE condition supported by worked examples exhibited a positive effect on posing more complex problems but not on average complexity of problems.

## **DISCUSSION**

The results indicated that worked examples had an inconclusive effect, particularly in ‘stimulation’ case in which the hypothesis of stimulating more problem posing activities was not confirmed. The results suggested that worked examples did not elicit more problem posing activities. Additionally, with respect to the problem posing skills development, the following discussion focused on the effects of worked examples on (1) orientated problems posing, and (2) complex problems posing.

#### **Effects of worked examples on orientated problems posing**

The worked examples effect was detected on orientated problem posing. The control condition produced significantly more digressive problems than the worked examples condition. This can be attributed to the fact that worked examples provided students with the problem states and worked-out solution steps (Atkinson et al.,

2000; Crippen & Earl, 2007; Renkl, 2002; van Gog & Rummel, 2010; Ward & Sweller, 1990). The problems states clearly describing the tasks in particular situations for reaching particular goals orientating towards the particular learning unit can be viewed as models for worked examples condition to observe and imitate. Therefore, observation learning could take place in the worked examples condition, leading to producing fewer digressive problems.

#### **Effects of worked examples on complex problems posing**

The effects of worked examples on complex problems posing were discussed regarding the quantity of complex problems and average complexity respectively. Worked examples effects were partially detected on complex problem posing. The quantity of complex problems posed by the worked examples condition was almost twice the quantity posed by their counter peers. However, there was not a differentiating effect on the average complexity between two conditions.

A possible explanation for the lack of a significant difference in the average complexity might be that students posed mainly application-level problems that were not categorized as complex problems whatever condition they were in. The average complexity was a measure of an average score relative to the quantity of orientated problems. Even though the worked examples condition produced significantly more complex problems compared with their counter peers, they still posed relatively more application-level problems. Therefore, the points given for complex problems did not significantly contribute to the average complexity, resulting that the average complexity of problems for the worked examples condition were not noticeably higher than that for the control condition.

Although worked examples produced a significant positive effect on the quantity of complex problems, the percentage of synthesis-level problems across conditions were identical. In other words, the result showed that the significant effect on the quantity of complex problems was resulting from the quantity of analysis-level problems. The effect found in this study suggested that worked examples may promote complex problem posing for only specific type problems and not for others. Previous research indicated that the effectiveness of problem posing depends on the amount and type of training and practice that students received (Dori & Herscovitz, 1999; 2005). We believed that the superior outcomes of the quantity of analysis-level problems were most likely due to the worked examples that students received mainly referring to a learning concept. Furthermore, the finding was similar to those of Butler and Winne (1995) who claimed that students with more explicit teacher modeling of cognitive and metacognitive skills were more likely to develop cognitive and metacognitive skills.

#### **CONCLUSION**

Problem posing is an active learning strategy in which students generate problems and present the answers to those problems. Research has shown that students have difficulties with problem posing due to a lack of experience or support. For guiding the students into problem posing activities, the Problem-Level-Taxonomy developed in the study was exposed to them before the experiment for demonstrating what the instructor expected. Moreover, for fostering students with mastery of related learning concepts, the notion of developing Problem-Level-Taxonomy was based on the number of learning concepts required to answer the problem. Regarding the issue of how to instruct problem posing, worked examples were used as expert model problems for supporting problem posing in this study to stimulate problem posing activities and develop problem posing skills. A quasi experiment was conducted to examine the effects of worked examples provided in an experimental condition compared to a control condition in terms of problem posing activity stimulation and skills development.

Based on the inconclusive results, several important findings were obtained. First, worked examples did not have a significant impact on stimulating students' motivation for posing more problems. Secondly, integrating worked examples into problem posing partially exerts a significant effect on skills development. Considering the results of orientation problems posing, students in the worked examples condition may produce fewer digressive problems. Thirdly, considering the results of complex problems posing, students in the worked examples condition may work best only for analysis-level problems. Combining with the results of orientation problem posing, this study manifested that studying worked examples improves problem posing skills development regarding posing orientated and analytical problems to which the answer is an analytical or comparative evaluation by referring to a learning concept or a formula for reaching a particular goal.

Although the web-based learning management system, iLMS, used in this study is a general system for learning management rather than a customized system for problem posing, it appeared to be an alternative suggestion for



supporting innovative instructional activity, especially when the specialized systems were inadequate. For example, for integrating worked examples into problem posing in the context of mathematics, the developed systems specialized for problem posing were deficient for integrating worked examples into them and were deficient for editing graphical representation and devising mathematical equations or symbols. For addressing usability issues, the integration of instructional design with human-computer interface, particularly in creating multimedia learning environment, is an important consideration to promote learning interest and willingness of the students for success of web-based instruction (Dalacosta, Kamariotaki-Paparrigopoulou, Palyvos, & Spyrellis, 2009; Kuzu, Akbulut, & Şahin, 2007; Lan, Hung, & Hsu, 2011; Özdilek & Özkan, 2009).

### IMPLICATIONS FOR PEDAGOGIES AND FUTURE RESEARCH

The results from this study might imply several pedagogies for problem posing activities. The study suggested that teachers try as much as possible to encourage students to conduct problem posing, such as relating the problem posing performance to the final semester grade. For novice students with none experience in problem posing, the support of worked examples may benefit students in posing orientated and complex problems. In addition to worked examples, providing students with an adequate problem classification taxonomy matching the objective of a lesson is also needed.

Although the findings are encouraging and useful, there are some questions that remain in this study. First, this study focused mainly on examining problem posing performance. It is not clear whether the problem posing performance also directly fosters positive learning achievements. Moreover, prior-knowledge (Yeh, Chen, Hung, & Hwang, 2010) or leaning styles (Özgen & Bindak, 2012) are important learner characteristic that should be considered when choosing the most appropriate instructional formats for students. Third, only providing worked examples did not contribute to posing synthesis-level problems that synthesize prior knowledge and the newly acquired learning concepts. The meaningful relationship of learning concepts may be beneficial for students in synthesizing the relationships of learning concepts. A concept map expressing the hierarchal structure to knowledge (Gaines & Shaw, 1995; Gordon, 2000) may be promising. These issues should be addressed in future studies. Finally, Moreno (2006) indicated that students are often under the illusion of understanding when studying worked examples. Bearing in mind that problem posing is recognized as both a cognitive and a metacognitive function, it is therefore may be considered as an important strategy in the comprehension of worked examples. Thus, further research should also address whether problem posing enhances learning performance when studying worked examples. The topic regarding whether problem posing and worked examples are mutually beneficial deserves to be studied.

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