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Can students develop self-regulated learning through worked examples?

S. Nurhayati
SMPN 5 Depok Sleman Yogyakarta, Yogyakarta, Indonesia

E. Retnowati & Y.A. Alzuhdy
Universitas Negeri Yogyakarta, Yogyakarta, Indonesia

ABSTRACT: This study aimed at comparing the effectiveness of learning through worked example pairs and problem-solving strategies in solving word problems using Linear Equation System with Two Variables (SPLDV) with regard to Self-Regulated Learning (SRL). Fifty junior high school students who had learned word problems about two-variable linear equation systems using graph, substitution, and elimination methods participated in the study. There were 24 students in a worked example pairs group and 26 students in a problem-solving group. To measure the self-regulated learning level, a questionnaire for Measured Strategies for Learning Questionnaire (MSLQ) was adapted. Analysis used independent sample t-test, and the result showed that there was no significant difference of self-regulated learning level between the worked example pairs strategy and the problem-solving strategy. It may be said that both strategies could facilitate the development of self-regulated learning.

1 INTRODUCTION

One character which is important for students to possess and that is closely related to the assessment of learning outcomes is namely *Self-Regulated Learning* (SRL). SRL is very closely related to the way a person regulates himself toward his learning environment so that it will make him an expert (master) in learning (Zimmerman, 1989). According to a study by Alsa (2005), there is a positive correlation between learning based on *self-regulated learning* and the achievement of assessment results in learning mathematics.

SRL is an active and constructive process of a learner in determining the learning goals, monitoring, regulating, controlling all the cognition, motivation, and their behavior guided by learning objectives as well as the context of the environment (Pintrich, 2000). The main key to the success of SRL is in setting the goals to be achieved. When someone learns mathematical symbols, he will organize the knowledge he has so that he can write the correct symbols, because he has the confidence and sense of responsibility in what he is doing. This suggests that the SRL greatly affects the attainment of assessment of the learning being carried out.

Learning occurs because of an experience (Schunk, 2012). This implies that learning through the process is not solely results-oriented. There might be varied activities designated to learning mathematics, but the main activity of learning mathematics is widely agreed as being problem-solving (Retnowati et al., 2010). A problem-solving activity essentially takes place when the students perform a systematic procedural operation step-by-step with actions in sequence to solve a problem (Wena, 2009).

Below is an example of a math problem-solving:

> '*Hilda has two buckets with no indicated scale, each measuring 7 liters and 4 liters. What can Hilda do to get exactly 6 liters of water from a reservoir just by using the two buckets?*'

The example above shows that the problem presented cannot be solved in a straightforward manner or in only one step. It needs some understanding of mathematical concepts underlying the problem. Such problems, like the example above, cannot be solved through a familiar (routine) procedure, and may become a challenge for students. According to Kilpatrick (1985) this kind of problem is called a non-routine problem.

In learning mathematics, the problem is often presented in a realistic way, such as by a story problem (or is also called a *word problem*). According to Killen (2009), learning word problems will be appropriate if carried out through *problem-solving*. Intuitively, a word problem that is contextual is easier to solve because it provides some information that may be used to comprehend the required knowledge to solve the problem. However, Cummins et al. (1988) stated that the word problems will be more difficult to solve than the problems presented in the form of symbols since they do not always provide clear hints of what the problem is. Converting the meaning and interpretation of sentences into symbols (mathematical model) is the main key to solving the word problem (Mahmudi, 2010).

Turning to the self-regulated learning, according to Schraw et al. (2006) the main components of SRL are (1) motivation (beliefs and attitudes that affect the use and development of cognitive and metacognitive abilities); (2) cognition (the ability needed in coding, remembering, and recalling information); and, (3) metacognition (the ability to understand and monitor their cognitive processes).

Learning by problem-solving is assumed to be useful to develop SRL. Through problem-solving strategy teachers can: (1) improve student's learning motivation; (2) improve metacognition ability; (3) take an approach to learning; (4) improve the ability to analyze situation; (5) apply prior knowledge to new situations; (6) organize the differences of facts and opinions to make a goal-oriented decision; and, (7) direct students to be more responsive to learning instruction (Killen, 2009). Problem-solving strategy is a learning strategy that lets students solve problems in their own way. This seems more suitable for students with some prerequisite knowledge, in order to successfully solve and learn the problem solution (Kalyuga, 2007).

Novice students (i.e. students with minimum or no prior knowledge) will likely face learning difficulties, particularly when solving complex problems. They are unable to construct new knowledge effectively because they have to use their working memory load (where cognitive process occurs in our mind) to achieve the solution of the problem-solving without necessarily learning it. It may cause students to have a lack of confidence in their own ability to solve the problems because of the failure they may experience when solving the problem using random knowledge (Killen, 2009).

Worked example pairs, on the other hand, have been empirically proven to be effective in assisting novice students by providing sufficient guidance that directs the working memory load to construct new knowledge based on the problem solution; hence they are able to build relevant knowledge structure in their long-term memory (Paas & Van Gog, 2006). Worked example pairs is a learning strategy that presents a problem statement with a detailed step-by-step example and complete problem-solving procedure from the beginning to the end (Sweller et al., 2011).

Previous studies indicate several designs of worked examples. The design of worked example pairs is shown to be more effective than block design (i.e. a design that presents a set of new samples and then follows with a set of similar problems to solve) (Trafton & Reisser, 1993). Worked example pairs provides learning material that is presented sequentially where a problem with the example of the solution is given first, followed by a similar problem without an example (Sweller & Cooper, 1985). It should be noted here that the pairs of example-problems are identical or isomorphic. There may be several pairs to be learned by students; however, it is suggested that variation of contexts and procedures are in accordance with the student's level of expertise.

In this study, the worked example pairs strategy was tested with regard to the level of SRL after the study period. In the *introduction phase*, the students first activated the *prior knowledge* they already had, by recalling prerequisite material relevant to the learning material being studied and by completing problem-solving. It was then followed by the *acquisition* *phase*, which is the learning phase itself. In this phase, the formation of acquisition capability is formed through three phases: *declarative knowledge* (phase 1), *compilation knowledge* (phase 2), and *procedural knowledge* (phase 3) (Kanfer & Ackerman, 1989). *Declarative knowledge* is the earliest phase of the formation of skill acquisition, which involves the process in order to obtain an understanding of the task. *Compilation knowledge* is the phase in which students integrate the sequence of cognitive processes and monitor what is required to complete the task. *Procedural knowledge* is the ability of how to perform various cognitive activities as a result of the compilation knowledge by rehearsing the constructed knowledge. It should be noted that when learning worked example in the *acquisition phase,* students are given an identical (isomorphic) problem to be solved, simply by using their newly acquired understanding without looking at the learning resource (Retnowati & Marissa, 2018). It was predicted that following this worked example strategy, students may develop *self-regulated learning* because they have to internalize independently and monitor their own understanding toward the knowledge presented by the worked example, and then apply it into the isomorphic problem-solving.

The material of Linear Equation System with Two Variables (SPLDV) is a material that is taught to eighth graders, and has never been given in the previous grades. SPLDV presented in the form of word problems is a difficult and complex material (Cummins et al., 1988), because it requires some basic concepts that become the prerequisite materials (*prior knowledge*) (i.e. the linear equation with one variable and mathematical model on the system of two linear equations).

2 RESEARCH METHOD

An experimental research with a *post-test non-equivalent control group* design was used (Cohen et al., 2007; Creswell, 2012). The participants of this research were junior high school students who had never learned about word problems on SPLDV material. Fifty students of class VIII participated in this study, divided into two experimental groups, namely *working example pairs* consisting of 24 participants and *problem-solving* consisting of 26 participants. Random grouping was used; nevertheless, all students had the same learning resources, teacher, as well as the same number of learning hours.

The research was conducted from March 1 to April 27, 2017 in Grade VIII of Junior High School in Sleman Yogyakarta.

2.1 *Procedure*

The study was conducted in eight lesson meetings: two initial meetings were held for classical prerequisite learning, three meetings were held for material learning (graph, substitution and elimination), and three meetings for the test phase. The allocated learning time was divided as follows: Meeting-1 (3×40 minutes); Meeting-2 (2×40 minutes); Meeting-3 (3×40 minutes); Meeting-4 (2×40 minutes); Meeting-5 (3×40 minutes); Meeting-6 (2×40 minutes); Meeting-7 (3×40 minutes); and Meeting-8 (2×40 minutes). At the 8th meeting (the last meeting), the learning ended 15 minutes earlier, as the time was used for a Measured Strategies for Learning Questionnaire (MSLQ).

Procedures undertaken in this study were: (1) selection of experimental groups conducted randomly and equally; (2) learning prerequisite material 1 (solving Linear Equations with Two Variables) classically through direct learning; (3) learning prerequisite material 2 (mathematical model) classically through worked example pairs; (4) implementing learning with worked example pairs strategy for experimental group 1 and learning with problem-solving strategy for experimental group 2 with graph material; (5) giving post-test classically for graph material; (6) conducting learning with worked example pairs strategy for experimental group 1 and learning problem-solving strategy for experimental group 2 with substitution material; (7) giving post-test classically for substitution material; (8) implementing learning with worked example pairs strategy for experimental group 1 and learning with problem-solving strategy for experimental group 2 for elimination material; (9) giving post-test classically for elimination material; and, (10) giving post-test classically to measure the SRL variable and MSLQ.

This study involved two independent variables: learning strategies (worked example pairs and problem-solving) and materials (graphs, substitutions, and elimination), and one dependent variable: SRL. *Problem-solving* strategy is a learning strategy used to solve new problems for students by linking the prior knowledge to new situations through problem identification, problem-solving strategy planning, implementing the planned strategy, and checking results. Worked example pairs strategy is a problem-solving learning strategy, with an example of a step-by-step problem-solving designed in pairs between *example* and *problem,* which is given as soon as the student studies the example. *SRL* is a process of managing and activating the cognitive aspects and students' learning behavior, systematically oriented to the achievement of learning objectives through the management of metacognition, motivation, and behavior conducted by students to achieve the objectives of learning mathematics.

There are two main components of SRL, namely motivation (consisting of three aspects) and learning strategy (consisting of two aspects). These five aspects are spelled out in 13 indicators (sub-aspects), developed according to the theory of SRL (Zimmerman, 1989). The complete aspects of SRL are presented in Table 1. Using the MSLQ (Pintrich & DeGroot, 1990), there were 44 statements divided into two main components, i.e. motivation (22 items) and learning strategy (22 items).

The MSLQ instrument was validated using construct validity, by factor analysis and content validity by expert judgment. The result of factor analysis on each aspect of SRL was obtained using Kaiser-Meyer-Olkin (KMO) value, as shown in Table 2. The coefficients of Cronbach's alpha on graph, substitution and elimination materials, and SRL were 0.769; 0.775; 0.888; and 0.886 with SEM 3, 65; 3.63; 3.18; and 8.25.

Table 1. SRL aspects and indicators.

No	Aspect	Indicator	Item
1	Self-efficacy	a. Self-efficacy for learning b. Self-efficacy for performance c. Control of learning	a. I believe I will receive a good grade in this class. b. I am certain I can understand the ideas taught. c. I am sure that I can do an excellent job on the problems and task assigned for this class.
2	Intrinsic value	a. Intrinsic interest b. Important of course work c. Challenge and mastery goal	a. I think what we are learning in this mathematics class is interesting. b. It is important for me to learn what is being taught in mathematical class. c. I prefer class work that is challenging so I can learn new things.
3	Test anxiety	a. Anxiety in having a mathematics test b. Anxiety related to the result of test	a. I am so nervous during a test that I cannot remember facts I have learned. b. When I take a test I think about how poorly I am doing.
4	Cognitive strategy use	a. Rehearsal b. Elaboration c. Organizing d. Critical thinking	a. I say the word over and over to myself to help me remember. b. I put important ideas in to my own words. c. I outline the chapters in my book to help me study. d. When I read I try to connect the things I am reading about with what I already know.
5	Self-regulation	a. Metacognition b. Management effort	a. I find that when the teacher is talking I think of other things and don't really listen to what is being said. b. When the work is hard I either give up or study only the easy part.

Table 2. KMO of SRL aspects.

No	Aspect	*KMO value*	Number of indicators
1	Self-efficacy	0.517	3
2	Intrinsic value	0.561	3
3	Test anxiety	0.504	2
4	Cognitive strategy use	0.716	4
5	Self-regulation	5.65	2

Table 3. Qualitative to quantitative data conversion.

Interval score (X)	Category
$242 < X \leq 308$	Very high
$198 < X \leq 242$	High
$154 < X \leq 198$	Medium
$110 < X \leq 154$	Low
$44 < X \leq 110$	Very low

The obtained SRL scores were then categorized, based on the converted standardized intervals. The categorization of SRL score was done by referring to the ideal average classification score and ideal standard deviation according to Azwar (2005 p. 108), as presented in Table 3.

The inferential analysis was carried out using *t-test independent sample*. Prior to hypothesis testing, the assumption test was done first. The assumption test consisted of the normality test (*K-S test*) and homogeneity test of variance (*F test*). The assumption test showed that the obtained SRL data in this study was normally and homogeneously distributed.

3 RESULT AND DISCUSSION

Data descriptions of the worked example pairs and problem-solving group on SRL are presented in Table 4, while the description of percentage data of the students' category in both groups is presented in Table 5.

Table 4 shows that the SRL mean of worked example pairs group is higher than that of the problem-solving group. However, the highest questionnaire score was achieved in the problem-solving group. Standard deviation in problem-solving group is also larger than in the worked example pairs group. From Table 5 it is found that the percentage of SRL in the worked example pairs group is high, while that in the problem-solving group is medium. From the description of the data it is also found that both groups have the same category of the average score (i.e. medium).

The hypothesis to be tested in this study is that there is no significant difference of SRL level after studying by worked example pairs strategy or problem-solving strategy. The analysis shows that $t(48) = 0.489$; p value $= 0.627$; Cohen's $d = 0.139239$; and $f = 0.06962$.

Because p value > 0.05 and *effect size* $= 0.06962 < 0.1$, it can be said that there is no significant difference between each strategy group and SRL. In other words, we can say that worked example pairs and problem-solving strategies have the same effectiveness toward SRL.

Retnowati et al. (2010) explain that worked example is problem-solving with additional examples. The worksheet given to students differs only in whether or not there is explicit guidance. So, in the affective aspect it is assumed that both strategies have the same effect on SRL. In addition, there may be many factors affecting the SRL, while the different used

Table 4. Description of *SRL data score*.

Description	WE	PS
Average	194.42	190.75
Max	240.00	261.00
Min	136.00	128.00
SD	25.73	34.75

Table 5. SRL percentage category (%).

Description	WE (%)	PS (%)
Very High	0	3.85
High	37.5	26.92
Medium	50	61.54
Low	12.5	7.69
Very Low	0	0
Average	Medium	Medium

learning strategies is only one factor in SRL development, which both includes metacognition and effort management.

Motivation is one of the main components of SRL (Pintrich et al., 1991). The isomorphic problems with the example given in worked example pairs will motivate students, who feel guided and satisfied to develop SRL because they are able to solve similar problems with the examples. According to Killen (2009), problem-solving makes students more responsive to learning forms and instructions. This element is also strongly suspected as one of the causes of both strategies having the same effectiveness with regard to SRL. Students who are knowledgeable (*expert*) indeed have a higher SRL. They tend to be able to manage the time, environment, and emotion in learning (Sweller & Kalyuga, 2011), so they will always be motivated to overcome obstacles they face (Ruliyanti, 2014). Students with good SRL will always be positive and have the confidence that they can solve the problems through their analysis, equipped with the experience they already have in problem-solving (Foshay & Kirkley, 2003).

From metacognitive viewpoints, the knowledge and experience obtained by students (their prior knowledge) becomes the basis for them to develop appropriate steps and strategies in solving the problems they are facing (Kalyuga, 2007) so that problems will be easily solved. Worked example pairs strategy gives examples in an effort to provide prior knowledge for students. In problem-solving strategy, the adequacy of prior knowledge of students is also a key to the success of learning (Sweller et al., 2011). Students become experts, not only because they have strong confidence, but also a good SRL skill in mastering the learning materials. This is very important to achieve success in learning (Ruliyanti, 2014, Wangid, 2004). Students who have low confidence in learning will tend to choose easy tasks and avoid difficult and challenging tasks. The element of confidence is an indicator of self-efficacy, and one of the benefits of problem-solving learning strategy (Killen, 2009).

Through problem-solving, students who are able to complete tasks and discover new knowledge by themselves will have great satisfaction (Killen, 2009), so that students will have a high self-confidence (self-efficacy). With the many examples that they have learned through the learning process, students will have many strategic viewpoints to solve the problem. They will have the confidence that they are capable of solving the given problem (self-efficacy). Pintrich and DeGroot (1990) say that the skills students achieve in the classroom are strongly influenced by students' cognition and learning behaviors in the learning process. Both of these are important components in forming SRL. In mathematics learning, a student will learn well if he has enough prior knowledge relevant to the material being studied (Sweller & Kalyuga, 2011).

4 CONCLUSION

Basically, a worked example pairs strategy is similar to a problem-solving strategy but with a different level of guidance. Both has focus on assisting students to acquire problem-solving skill. Although they have different characteristics, both strategies have the same advantages in developing *self-regulated learning*.

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