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# How Can SEAMEO QITEP in Mathematics Help Indonesian Mathematics Teachers to Help Their Students to be Independent Learners in the Case of Disaster Risk Reduction (DRR)?

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There are a number of disasters threats in Indonesia, such as earthquakes, tsunamis, volcanic eruptions, fires, landslides and floods. When a natural hazard strikes, children are among the most vulnerable population group, especially those attending school in the times of disaster. What people know is more important than what they have when it comes to saving lives and reducing loss. It implies that students should also learn DRR during the teaching and learning of mathematics. This paper reports on a number of studies conducted by SEAMEO QITEP across the years 2012 – 2015 that attempted to improve both teachers and students learning outcomes.

**Keywords:** Disaster awareness, meaningful learning, independent learners, problem solving approach, Lesson Study.

## Introduction

On one side, there are a number of disasters threats in Indonesia, such as earthquakes, tsunamis, volcanic eruptions, fires, landslides, typhoons, and floods. Those disasters could be natural or as a result of man-made action. UNESCO (2010) has already differentiated between 'hazards' and 'disasters'. Hazards are natural while disasters are not. Hazards such as floods, earthquakes, and tsunamis become disasters only when society lacks the ability to cope with them. The most important thing is how to educate people in such a way that the hazards which are natural things do not become disasters. When a natural hazard strikes, children are among the most vulnerable population group, especially those attending school in times of disaster. UNESCO ISDR (2007) states that disasters such as the October 2005 earthquake in Pakistan, where over 16,000 children died in schools that collapsed, or the recent mudslide on Leyte Island in the Philippines, where more than 200 school children were buried alive, are just a few tragic examples of why more needs to be done to protect our children before disasters strikes. In Indonesia and in other countries, the lack of knowledge on disaster especially the tsunami phenomena leads to a tremendous number of victims. People living along the coastline failed to recognize that the receding of water quickly and unexpectedly from the coast may be the sign of tsunami will be coming. People followed it instead of running toward higher ground and inland. Many lost their lives because they did not know the meaning of receding water.

On another side, the ability to think and to reason is very important to everyone. Mathematics could be seen as the language that describes patterns (De Lange, 2004; NCTM, 1999). During the mathematics teaching and learning process, students can learn to think, to solve problem, to reason, and to communicate. Therefore, Marquis de Condorcet as quoted by Fitzgerald and James (2007, p. ix) stated: "Mathematics … is the best training for our abilities, as it develops both the power and the precision of our thinking." In addition, the National Research Council from USA (NRC, 1989, p. 1), reminds us 24 years ago that: "Communication has created a world economy in which working smarter is more important than merely working harder. … We need workers who can absorb new ideas, to adapt to change, to cope with ambiguity, to perceive patterns, and to solve unconventional problems." These two statements show the importance and relevancy of mathematics to enhance the ability of our students thinking.

In addition, Isoda and Katagiri (2012, p. 31) stated that the aim of education as follows:

> " … To develop qualifications and competencies in each individual school child, including the ability to find issues by oneself, to learn by oneself, to think by oneself, to make decisions independently and to act. So that each child or student can solve problems more skilfully, regardless of how society might change in the future."

However, many mathematics educators focus on skills and offer mostly procedural practice. This form of instruction focuses on a lot of memorization and skill-and-drill practice. Teachers offer lecture type instruction and then students complete the pages in the texts during class time. The conclusions of the Indonesian research conducted by the writer (Shadiq, 2010, pp. 56-57) stated that most teachers of mathematics in their schools use or implement the traditional ways during the learning and teaching process of mathematics. They still use the paradigm of transferring knowledge from teachers' brain to students' brain.

An alternative type of mathematics program leans more toward exploration of mathematical concepts through conceptual investigation. Students use concrete materials, such as manipulatives both concrete and virtual, and participate in experiments and kinaesthetic demonstrations that exhibit mathematical concepts. This type of mathematics program matches constructivism, the current issue in mathematics education. Therefore Haylock and Thangata (2007, p. 35), stated that constructivism focuses attention on the pupil's learning rather than on the teacher's teaching. In Japan, Isoda and Katagiri (2012) stated that a Problem Solving Approach (PSA) can be implemented to help learner to develop mathematical thinking.

In Indonesia, the objectives of the compulsory mathematics program are to help and facilitate learners' positive attitudes and personal qualities needed to succeed in life, and develop the knowledge and basic mathematics skills in communicating, arguing, and problem solving through using mathematics needed in their daily life and further education. However the results of TIMSS 2007 (Kemdikbud, 2012b, p.14) shows that only 5% of Indonesian students could work on the problems in the high category and advance level [requires reasoning], while 71% of Korean students could. In addition to Indonesia, only 78% of students could work on the problems in the lower categories that require only rote learning, so it is necessary to develop a curriculum that requires the effort to strengthen the reasoning ability. Kemdikbud: (2012a, p. 11) also stated the need for change in the process of learning from teacher-centred to process-centred to learner-centred. It requires a change of the textbook which contains only the subject matter to the textbook that includes the learning materials, assessment systems and competencies expected. At the elementary level, the Government also asks teachers to implement an integrative thematic approach to all subjects in Grade 1 to Grade 6 within 30% of chosen elementary schools in Indonesia.

However, to change and to improve the quality of teaching and learning processes from a "typical" mathematics classroom to the new one that is more innovative is not easy. The factors that should be taken into account are teachers' views and beliefs. In other words, the process of teaching and learning of mathematics in the classroom will be largely determined by teachers' view and beliefs about mathematics and mathematics education. Frei (2008, p. 8), for example, stated that often teachers feel comfortable teaching the way they were taught. It is what they remember and what they know, so it becomes the way they teach, regardless of whether they believe it is the correct way to teach.

To change and improve the quality of teaching and learning process from a "typical" or "traditional" mathematics classroom to the new one that is more innovative is not easy. Teachers need to experience mathematics in ways that they will be expected to teach it. Mathematics teachers need concrete examples that can be used and implemented in mathematics classes. Teachers are more likely to implement the new approaches in their own classes if they have experienced it in their own learning experiences. Therefore the questions that can arise:

In the case of DRR, what should be done and to find the 'best way' in helping and facilitating students to learn mathematics meaningfully and joyfully, to learn to think and to find issues by oneself, to learn by oneself, to think by oneself, to make decisions independently and to act. So that each child or student can solve problems more skilfully, regardless of how society might change in the future?

In the case of DRR, what should be done and to find the 'best way' in helping and facilitating mathematics teachers in such a way that they can change their teaching and learning processes such that they can help the learners to learn mathematics meaningfully, to learn to think and be independent learners?

## Literature Review

This literature review will briefly discuss several terms which will be implemented in this study regarding meaningful learning, independent learners, problem solving approach (PSA) and Lesson Study (LS).

### Meaningful Learning

If learners are given three numbers: (1) 37.131.512, (2) 31.117.532, and (3) 23.571.113. The questions that arise are: (a) Which number is the easiest to repeat? Number (1), number (2) or number (3)? Why? (b) Based on the results, what does it mean for how to help our children to learn mathematics easily?

The third number (23.571.113) is the easiest to learn only if the learner is successfully able to relate to the first six prime numbers (2, 3, 5, 7, 11, 13) which has been learnt by and known to them. In other words, a student has to learn successfully the first six prime numbers (2, 3, 5, 7, 11, 13) before s/he can repeat the third number (23.571.113). So the task of the teacher is to facilitate his/her student regarding the relation between the first six prime numbers (2, 3, 5, 7, 11, 13) and the third number (23.571.113). The second number (31.117.532) is the second easiest to learn only if the learner successfully relates it to the third number (23.571.113) in which the second number can be found from the third number (31.117.532) in reverse order. Otherwise, the learner must memorize or implement a rote strategy which is difficult for the learner. In addition students will be faced with the difficulty to memorise the third and the second numbers if they do not have the pre-existing or prior knowledge. The first number is the most difficult number to memorise because students do not have the pre-existing knowledge to be related. The conclusion is, that new knowledge can be easily understood if it can be related to the pre-existing knowledge and has been learnt by the student. The learning principle stated by NCTM (1999) is that students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge. Therefore Ausubel (Orton, 1987, p.34) states “If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly.” The question that arises is: How to help and facilitate students to learn mathematics meaningfully and with understanding?

**Joyful Learning**

Based on brain theory, Pranoto (2011) stated that every brain consists of three main parts: cortex, mid brain, and lower brain. The cortex always searches for novelty, the mid brain always searches for pleasure, and the lower brain will always search for safe or non-threatening situations. This theory implies that we have to design the activities using varied rules and contents. Students must always find the activities new. One may also include the possibility for the students themselves to create the newer rules. This will increase the feeling of ownership of the students. Based on the second brain part, as our brain naturally always searches for challenge, however, the challenge we like to do is not the one that is too high. We like to do challenges that have a probability of success. Our brain will not like to do tasks that are too hard and that we will feel a failure. Therefore, based on this principle, the differentiation based on readiness makes sense. It is parallel to brain theory. Based on the brain theory, this primitive part of our brain mostly regulates our routine tasks. Our lower brain always would like to make sure that we do tasks that will not embarrass us. This part of the brain will urge us not to do some tasks if they show some threats. This means that if we want to satisfy the lower brain, the activities must always involve some kind of surprise, luck, joy, and celebration. Every student should also be able to contribute. Some traditional games like bingo or snake-ladder are appropriate and easy to modify for various mathematics contents. Activities that involve problem solving are also good. Our brains naturally are designed for solving problems. However, we have to apply the same three principles. They must satisfy our three brain parts. Thus, they must consist of novelty, generate pleasure, and provide safe environment. The question that arises is: What should be done to help students to learn joyfully?

**Thinking Skills**

Bastow, Hughes, Kissane, and Mortlock (1986, p.1) stated: “Among many mathematics educators there is a growing recognition of the need in school mathematics to increase the emphasis placed on process objectives.” Regarding the process objectives, as an example, Gauss (1777-1855) is known widely as one of the five best mathematicians around the world.

When he was 10 years old, his teacher asked him and his friends to find the result of: 1 + 2 + 3 + 4 + … + 98 + 99 + 100. Gauss found the structure in his method as shown in this diagram.

$$\underbrace{1 + \overbrace{2 + \underbrace{3 + 4 + \ldots + 97 + 98}_{101} + 99}^{101} + 100}_{101}$$

Gauss found that: 1 + 100 = 101, 2 + 99 = 101, 3 + 98 = 101, . . . .

Based on the data above, little Gauss concluded that:

a) Every number has a pair with the sum of every pair was 101.

b) There were 100 numbers to be added, so this implies that there were 50 pairs altogether.

c) So, the result of addition was 50 × 101 = 5050.

Learn from the little Gauss, the conclusion can be raised as follow.

a. The beautifulness of pattern and thinking that Gauss discovered and performed.

b. The importance of finding the structure.

c. The importance of thinking and reasoning.

d. Learning mathematics means to help anyone to think of the best way of counting (better and easier).

Therefore, Marquis de Condorcet (in Fitzgerald and James, 2007, p. ix) stated: "Mathematics … is the best training for our abilities, as it develops both the power and the precision of our thinking." Students should be facilitated to achieve their potential through the teaching and learning of mathematics. In the information technology era, the ability to think logically, creatively and critically is very important. Regarding the importance of thinking abilities during the teaching and learning process, the National Research Council from USA (NRC, 1989, p.1) states "[the economy] requires workers who are mentally fit – workers who are prepared to absorb new ideas, to adapt to change, to cope with ambiguity, to perceive patterns, and to solve unconventional problems." The question that arises is: What should be done and how to help and facilitate students to learn to think?

## Independent Learners

The ultimate goal of schooling is to help and facilitate children to be independent in their real life situation. In the introduction, the importance of helping learners to be independent in Japan was highlighted (Isoda & Katagiri, 2012). Again, the question that arises is: "What should be done and how to help and facilitate students to be independent after finishing their study? "

## Problem Solving Approach (PSA)

Isoda and Nakamura (2011, p. 10) proposed a Problem Solving Approach which consists of 5 steps as follow: (1) posing problem, (2) estimating the ways of solutions (planning and predicting the solution), (3) independent solving, (4) explanation and comparison and (5) integration and application. The problems or activity on the first step can help and facilitate students to think, enabling them to apply and extend what they have learned to new problem situations. Make sure that the problem on the first step can be solved by previous knowledge to ensure that the problem will help students to learn meaningfully and the teacher must accept any ideas from the children and allow them to talk on their ideas if it has originated from what they have already learned. On the second and third steps, students learn to formulate problems on their own, estimating the ways of finding solutions and then solving it, finally they check the results. Once again problems become the heart of the lesson. Therefore, those tasks, activities, or problems should be well prepared. Based on the outline above, the PSA can facilitate students to find issues by oneself, to learn by oneself, to think by oneself, to make decisions independently and to act by oneself. It is clear that those tasks, activities, or problems become important to facilitate students to be independent learners.

As stated in the introduction, traditional mathematics educators focus on skills and offer mostly procedural practice while instead mathematics programs should have more exploration of mathematical concepts through conceptual investigation, where the teacher focuses attention on the pupil's learning. The task of change is not easy. The PSA can help the learner to learn mathematics: (1) meaningfully and with understanding, (2) joyfully, (3) to think and (4) to be independent learners.

**Lesson Study**

Stacey, Tall, Isoda and Imprasitha (2012, p. v) stated that Lesson Study (LS) is a system of planning and delivering teaching and learning that is designed to challenge teachers to innovate their teaching approaches. It operates when teachers develop a sequence of lessons together: to plan, to do, and to see (reflect) to improve the lesson for future presentation on a wider scale. Lewis (2011) also stated that part of the LS process is ‘kyouzaikenkyuu’, careful study of the teaching materials focused on both the mathematics and the pedagogy. Lewis (2011) stated that normally, there are 3 steps of Lesson Study which are: Plan → Do → See. However, Catherine Lewis proposed four steps of Lesson Study which are as follows.

1. STUDY. Teachers consider long term goals for student learning and development or study the curriculum and the standards.
2. PLAN. Teachers select or revise research lesson, do task, anticipate student responses, plan data collection and lesson
3. DO RESEARCH LESSON. Teachers conduct research lesson, collect data
4. REFLECT. Teachers share data, ask and answer this question: What was learned about student learning, lesson design, this content? What are implications for this lesson and instruction more broadly?

The relationship among Lesson Study, the problem solving approach and mathematical thinking in Japanese culture are very solid. Therefore the implementation of Lesson Study was used to change or to innovate the teaching and learning mathematics in Japan to be more students centred and in touch with the newest issues and current trends in the teaching and learning of mathematics. The focus of Lesson Study in Japan was the students as learners, and how to help them to learn mathematics meaningfully, how to help students to learn to think and how to help students to learn mathematics by/for themselves and to be independent learners. The Lesson Study in Japan was supported by an expert from a university and also from mathematics teachers, such as Mr. T. Seiyama from an Elementary School attached to the University of Tsukuba who was videotaped by JICA (Japan International Cooperation Agency). This video gives a good and clear example of problem solving approach.

## Methodology

This section will discuss the methodology that was implemented in the number of studies. Since 2012 SEAMEO QITEP in Mathematics conducted studies related to Disaster Risk Reduction (DRR). In 2012 the study related to earthquakes and tsunamis (Ponidi, Setyaningrum, Dwinugrahaningsih, Shadiq, Wahyudi and Subanar, 2012), in 2013 it related to floods (Setyaningrum, Hidayah, Dwinugrahaningsih, Wismono, Shadiq, Pujiati, Sahid, Wahyudi, Widodo and Subanar, 2013), in 2014 it related to volcanic eruptions (Rahayu, Anindito, Darto, Wismono, Shadiq, Pujiati, Sahid, Wahyudi, Kirbani and Subanar, 2014), and in 2015 it related to landslides (Vikrama, Windarti, Margono, Dwinugrahaningsih, Shadiq, Yunianto, Fina, Sahid, Wahyudi and Subanar, 2015). Every year, SEAMEO QITEP in Mathematics conducted a workshop to develop a proposal and instruments for the study. The workshops were attended by practitioner mathematics teachers and specialists from SEAMEO QITEP in Mathematics as teams. For example, in 2012 the DRR topic was earthquake and tsunami. The team then decided that the Mathematics topics were statistics data for Primary Schools, Logarithm for Senior Secondary Schools and no topic suitable for Junior Secondary Schools. In Table 1 this information is summarised for 2012 to 2015.

Table 1

*The Data of Mathematics Topic Related to DRR Topic in SEAMEO QITEP in Mathematics*

| Year | DRR Topic | Mathematics Topic |
|---|---|---|
| 2012 | Earthquake s | Statistics Data (PS), Logarithm (SSS) |
| 2013 | Floods | Analyzing Data (SSS) and Differentiation (SSS) |
| 2014 | Volcanic Eruptions | Collecting Data (PS), Surface Area (JSS) and Differentiation (SSS) |
| 2015 | Landslides | Data Statistics (PS), Gradient (JSS), Integration (SSS) |

PS: Primary School, JSS: Junior Secondary School, SSS: Senior Secondary School

As mentioned earlier, the problem solving approach and Lesson Study were implemented. Data were collected from observations of students work, student interviews, photos of blackboard presentations, videotape of the teaching and learning processes, and teacher interviews and records. An example of the observation sheet is shown in Table 2 below.

Table 2

*The observation sheets for real teaching.*

The Teacher Name :
Topics :
Class/School :

| No | Indicators | Yes /No/NA | Score 4/3/2/1 | No-tes |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| 1. | Motivating students at the beginning of the lesson | | | |
| 2. | Revising or checking the prerequisite of the students | | | |
| 3. | Starting lesson with activity, contextual, realistic, or mathematical problems | | | |
| 4. | Facilitating students to observe | | | |
| 5. | Facilitating students to raise question by themselves | | | |
| 6. | Facilitating students to learn to reason (inductive and deductive) | | | |
| 7. | Facilitating students to learn to communicate | | | |
| 8. | Facilitating students to learn to experiment | | | |
| 9. | Facilitating students to learn mathematics joyfully | | | |
| 10. | Using blackboard, OHP, or LCD effectively | | | |
| 11. | Facilitating students to reflect on the lesson that has been learnt | | | |
| 12. | Facilitating students to take note of the lesson | | | |
| 13. | Taking into account students' differences | | | |
| 14. | Assessing students authentically | | | |
| 15. | Closing the lesson | | | |
| Total Score | | ...... out of 60 = ....... (Max Score = 60) | | |

Note: 4/3/2/1 = Very Good/Good/Fair/Poor (For observer who tick 'Yes' on the third column)
Date: ..................Observer Name:..................................... Signature: ..............................

| |
|---|
| What are the interesting parts of the lesson? |
| What specific suggestion would you make to improve the lesson? |

Note: Observer can write the teaching and learning process on the next plain pages.

The data were collected and analysed by a team to ensure reliability and to reduce bias and the results are discussed in the next section. Readers wishing further details are directed to the earlier listed publications (Ponidi, et al, 2012; Setyaningrum, et al, 2013; Rahayu, et al, 2014; and Vikrama, 2015).

## Results and Discussion

This section summarizes the specific outcomes of the research and discusses the implication and recommendations for both the practice of teaching and learning of mathematics in class and for further research.

If we will consider the importance of the first step of PSA in supporting the SA. In Japan, the PSA (Isoda & Katagiri, 2012) consist of 5 steps, while in In Indonesia, the Scientific Approach (SA) was planned to be implemented in Indonesia under the 2013 New Curriculum. The five steps of Scientific Approach are: (1) observing, (2) questioning, (3) experimenting, (4) reasoning and (5) communicating, and so it is clear that the Problem-Solving Approach (PSA) from Japan can support the Scientific Approach from Indonesia. The PSA and SA can be compared in table 3.

Based on the table, it can be observed that the teaching and learning process should be started with a contextual, realistic or mathematical problem which is in line with the first step of PSA to ensure that the SA can be implemented during the teaching and learning of mathematics.

For example, the starting problem was: How much more intense is an earthquake of magnitude 6.5 as compared to one of magnitude 4.5? On 11 January 2012, Meulaboh Nangroe Aceh Darussalam experienced an earthquake of Richter magnitude 7.3. Calculate the energy associated with this earthquake!

Table 3

*A comparison of the Japanese Problem Solving Approach and the Indonesian Scientific Approach*

| No | The PSA (Japanese) | No | The SA (Indonesian) |
|---|---|---|---|
| 1. | Problem posing | | |
| 2. | Estimating the ways of solutions (planning and predicting the solution), | 1. | Observing |
| | | 2. | Questioning |
| | | 3. | Experimenting |
| 3. | Independent solving | 4. | Reasoning |
| 4. | Comparison and discussion | 5. | Communicating |
| 5. | Summary and integration | | |

To change and improve the quality of the teaching and learning process from a “typical” or “traditional” mathematics classroom to a more innovative one is not easy. Goos and Vale (2007, p. 4) stated: "Whether we are aware of it or not, all of us have our own beliefs about what mathematics is and why it is important." Furthermore, Goos and Vale (2007, p. 4) quoted Barkatsas and Malone (2005, p.71) who stated, “Mathematics teachers’ beliefs have an impact on their classroom practice, on the ways they perceive teaching, learning, and assessment, and on the ways they perceive students’ potential, abilities, dispositions, and capabilities.” The results of this study were consistent with the conclusions of the research conducted earlier by the author (Shadiq, 2010, pp.56-57) in that most teachers of mathematics in their schools still use or implement the traditional ways during the learning and teaching process of mathematics. This remained even after some experience with Lesson Study, which further points to how strong are these beliefs. The teachers still believed in the paradigm of transferring knowledge from teachers’ brain to students’ brain because they believed this was the best way based on their own learning experiences. Thus, the result of this research study indicated a failure to change the teachers’ attitudes. However, giving teachers further experience with Lesson Study and PSA provides greater opportunities for the teachers to develop different beliefs about teaching and learning.

The data suggests that the integration of DRR can promote students having a more positive attitude toward mathematics.

## Conclusion and Recommendations

While the author makes no claims that the findings can be generalized to all teachers in Indonesia, nevertheless the following recommendations are made a guide for educators to consider.

1. It is recommended that every mathematics teacher and educator be encouraged and motivated to improve his/her competency in order to produce such high quality of teaching and learning resource materials for teachers (including designing lesson plans that start with activities or contextual/ realistic/ mathematical problems) as real examples for mathematics teachers.
2. While the initial use of Lesson Study was a failure, it is recommended that teachers still need to experience mathematics in ways they will be expected to use in teaching. Mathematics teachers need the experience of concrete examples that can be used and

implemented in mathematics classes. Teachers are more likely to implement the new approaches in their own classes if they have experienced it in their own learning.

In Japan, the Lesson Study process was supported by university experts. Following this model, it is recommended that every pre-service and in-service institution could work with and help elementary and secondary school teachers and could focus on helping and facilitating learners. The main focus of pre-service institution could be on how to produce mathematics teachers who can help their students to learn mathematics meaningfully, learn to think, and to learn mathematics by and for themselves.

It is recommended the main focus of in-service institution be upon how to maintain and improve the quality of mathematics teachers in order to help their students to learn mathematics meaningfully, learn to think, and to learn mathematics by and for them to anticipate the change in technology and in society.

It is recommended that further research could be designed to find ways to influence the Indonesian mathematics teachers' beliefs about their classroom practice, their perceptions of teaching, learning and assessment, and their perceptions of students' potential abilities, dispositions, and capabilities.

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