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The Impact of the Use of Active Learning Strategies in the Development of Mathematical Thinking among Students and the Trend Towards Mathematics

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Abstract
The lecture format is the most commonly used approach in teaching mathematics theoretically, and this approach reveals isolation between students. This paper tries to review the problems and challenges of the traditional teaching methods used in mathematics learning, and it advocates the possibility of the implementation of particular alternative teaching methods such as active learning and cooperative learning. The proposed approach emphasizes the participation of students to extend their views and to be interactive more.
Keywords: mathematics learning, active learning, teaching methods.

1. Introduction

The modern instructional techniques are not effective enough to immediately implemented, but rather we need to start with small sample and continuously develop the size and implement the required changes and provide feedbacks (Braun et al., 2017). Some factors can negatively affect the education process and harm the outcomes of education (Davidson, 2016).

The movement from passive learning to active learning implies the drive from passive teacher to active teacher or learner (Katsap, 2009). The most important factors affecting the students' attitudes to learning mathematics are: the textbook and teaching methods. This is strongly proved by many researchers in their research reports and discussions of the mathematics learning (Röj-Lindberg, 2001).

Traditional teaching methods involving ineffective teaching methods impact on the students' knowledge and subsequently revel poor academic performance. Teaching is not just a transmission of information for teacher to student, but rather it is a process of bringing desirable changes to the content and the way that the content is presented to get particular outcomes (Ganyaupfu, 2013).

Traditional learning approach, passive learning, focuses on resolving and answering the problems in the mathematics textbook. Indeed, many students fail to answer due to the improper or poor explanations presented by the teacher, or might due to the inherent lack of mathematical intelligence of the learner. In details, the successful experience of the student in mathematics learning relies on the teacher skills in presenting and explaining algorithms, models, and rules, as well as the talent of the student. Furthermore, the teachers of mathematics determine on-going goals for doing activities and require students to love mathematics for better understanding and learning (Röj-Lindberg, 2001).

Active learning is a concept that indicates to the use of several learning activities that provide the students a degree of control of these activities. In active learning, the learning experience is converted from tightly pre-determined to open-ended learning process, whereas students are able to actively and freely participate in how the shape of the learning experience will look like. Moreover, active learning is similar to a problem or project, and it can be called teacher-facilitated teaching approach or student driven learning approach (Davidson, 2016).

Active learning demands participants to have the skills needed to adapt the diversity of knowledge and information sources mainly internet sources (however, internet sources are difficult to cop since they are mostly in English). Active learning also demands placing great effort by teachers and students including physical, emotional, and mental resources (Katsap, 2009).

Teaching does not imply learning; learning is self-evident. The difference between individual or single activity and collaborative activity appears in the way of listening or doing, watching and discussing (Swan, 2005). Learning in nature is a process that leads to change (Millis, 2012).

The effective teaching behavior leads to develop and improve the achievement of students. The involvement of students in active participation in the class demands the teacher to provide students with clear introduction that involves stated lesson objectives, and to ask questions during the lesson. The teacher should ensure of assessment of student's behavior, keep student actively involved, define the thinking process, clarifying how solve problems, and make sure that student is ready to raise his/her cognitive level (Charlotte Rappe Zales,).

Active learning enforces the involvement of students in thinking and doing things. The core component of active learning is the student (Millis, 2012). The teacher is the manager of the learning process including learning resources, time, and many others to guide and support inclusive, communicative, and non-minatory learning environment (Röj-Lindberg, 2001).

1. Teaching mathematics

In teaching mathematics, active learning asks the teacher to be equipped with the novel strategies used to convey and enrich the mathematical knowledge to effectively participate in the course (Katsap, 2009).

Mathematics in nature requires active learning to emerge discussions, problem-solving, and group work. Mathematics learning has a structure of tasks the enables lower possibility to modify the content for the same subject. For this reason, the following proposals are helpful for constructive learning for rigid courses (Entonado & García, 2003):

- The teacher should start from the level of his/her students.
- The teacher should ensure of the concept construction in significant learning.
- The teacher should ensure that students can develop their learning by themselves.
- The teacher can allow the students to structure their knowledge they have.
- The teacher might favor to intense activities for more student interactivity.

The learning, thinking, and reasoning through mathematics are very important because it enables students to identify and pose problems, select and apply proper strategies to resolve problems (The State of Queensland (Queensland Studies Authority), 2005).

Students need to improve their attitudes towards mathematics and the participation in resolving mathematical problems. Thus, thinking, reasoning, and working mathematically implies active learning partnership between the teacher and student (The State of Queensland (Queensland Studies Authority), 2005).

2. Background

In many decades, the strategy of active learning gives the educators and teachers the opportunity to improve the proficiency of their students (Davidson, 2016). Active teaching is helpful and useful to the student with low achievement. Likewise, adopting interactive teaching approaches allows for explicit mathematics focus to assist low-achievement of students (Sullivan, 2011).

A little research has been published on the teaching methods of mathematics (Anderson-Pence, 2017). Many related works have confirmed that the student-centered approach can produce higher-level of learning results and provide more efficient skills (Ganyaupfu, 2013). The resources on student active educational strategies vary from journals to websites and they still scarce (Froyd, 2007).

Many studies have confirmed the increasing achievement of students who learn in active learning environment (Millis, 2012). The great interest received by mathematics learning primarily raised due to the desires of students to actively participate in the development of ideas and attitudes. Moreover, the student that feels more tolerant and has high academic performance can be more interactive and helpful to play role in the process of active learning (Entonado & García, 2003).

Active learning has received considerable attention in the last decades because of its importance in presenting radical change from traditional teaching approaches to active learning strategies (Springer et al., 1999). There is evidence showing that the implementation of active learning and putting it as a regular basis in the education environment could make the results better in terms of student learning and understanding (Davidson, 2016).

Most of literatures have focused on showing the role of teachers to adopt in-depth approaches that can reveal in-depth students learning. Further, these researches provide a set of findings that described the main factors of the in-depth learning of mathematics, including time constraints, the discipline, and lower expose to the recent educational approaches. In addition, these findings support the teachers in terms of educational preparation to help in outperforming the main difficulties and challenges facing in-depth learning of mathematics (Ramli et al., 2013).

The importance of active learning comes from the heavy attention retained in the research community. Further, the amount of information given to the students in traditional teaching approaches might drops after a few minutes. Subsequently, the measure of retention of information after the finish of course will be short. Other measures like attitude change, problem-solving, further learning, and motivation could show different but relatively low results (Bonwell, & Eison, 1991).

The major characteristics of the active learning strategies are (Bonwell, & Eison, 1991):

- Engaging students in active activities such and writing, discussing, reading, etc.
- Placing great emphasis on the development of students' skills and the exploration of values, attitudes, and talents of students.
- Placing low emphasis on transmitting information to students and increasing the motivation of students.
- Involving students in higher level of thinking such as synthesizing, analyzing, and evaluating.
- Receiving immediate feedback on the behavior of students.
- Letting students to do things, thinking about thing they are doing, and evaluating the things they done.

Some kinds of active learning are: fun learning, real-life application, effective communication,

constructivism approach, problem-based instruction, student-centered learning, and technology integrated learning (Ramli et al., 2013).

The emergence of mathematical reasoning and mathematical thinking became a simulated and influenced process due to the internal and external conditions and factors that affect the teacher control in the classrooms (Ramli et al., 2013).

Active learning strategies in mathematics show the process of learning as changeable way or process that can be entailed to anything such as the conversion of teaching methods and educational approaches to actively constructing knowledge base that guide the change smoothly. Traditionally, the teachers focused on how to teach mathematics by explaining the sequence of procedural steps described in the textbooks without competence of the performance and understanding (Röj-Lindberg, 2001).

Active learning strategies are continuously moving from simple and easy tasks to complex ones. We mean of simple tasks as the short unstructured tasks, while complex tasks mean the long-time, planned and structured tasks (Bonwell, & Eison, 1991).

The role of teacher in active learning is to (Swan, 2005):

- Make constructive use of prior knowledge.
- Expose challenges to the students to mitigate.
- Explain and clarify the purpose of activities.
- Allow students to work together in profitable way.
- Motivate students to exchange reflective ideas.
- Motivate students to discuss their understanding.
- Eliminate the phenomenon of fear from failure.
- Allow students to evaluate their performance.
- Draw out the significant taught ideas and concepts.

Based on (The State of Queensland (Queensland Studies Authority), 2005), the role of teacher is represented by the following:

- Create investigation about the problem being resolved to show the requirements.
- Guide students in mathematical conversations to develop required knowledge, procedures, and strategies.
- Ask questions to motivate and utilize thinking and reasoning.
- Allow students to provide opportunity to self-assessment and self-monitoring.

Based on (The State of Queensland (Queensland Studies Authority), 2005), the role of student is represented by the following:

- The student should be active and self-directed.
- The student should connect knowledge with experience.
- The student should identify what the needs to do.
- The student should evaluate alternative solutions to choose.
- The students should share information with collagenous.

3. Literature review

The study (Prince, 2004) (Springer et al., 1999) examined the evidence of the effectiveness of active learning by defining the common forms of active learning, collaborative learning, cooperative learning, and problem-based learning. The study defined the active learning types, provided an overview of the effectiveness of active learning from the literature, and assisted to summarize the relevant issues in the field of active learning.

The paper (Anderson-Pence, 2017) contained a proposed framework called Techno-Mathematical Discourse (TMD) that indicates of the analysis and interpretation of learning aspects using technology for mathematics teaching. It is focused on technology tools, mathematical tasks, and classroom discourse. The proposed framework can be applied by teachers and researchers to show how the technology positively contributes in mathematics teaching.

The aim of the study (Afzal et al., 2014) was to prompt the impact of the instructional teaching methods on mathematics teaching. The three instructional teaching methods were teacher-facilitated learning, traditional instructional method, and computer assisted instruction. The experiment was conducted in two urban and rural male and female schools. The results were measured and analyzed and revealed that the active involvement of students in mathematics teaching produced better results.

In study (Tandogan & Orhan, 2007), the effect of problem-solving active learning on the concept learning and the academic achievement of students was determined. The study was both qualitative and quantitative. The experiment was conducted on one of the school's students in Istanbul. The result showed that the implementation of problem-solving active learning approach provides positive effect to the academic achievement of students including science course and attitudes as well as the conceptual development.

The paper (Entonado & García, 2003) included a designed and experimented proposed approach to be implemented in classrooms to teach mathematics. The factors influencing the development of academic performance and the improvement of task structuring like many other researches were illustrated in tutoring case. The results presented the role of cooperative learning in improving class environment for more motivation, socialization, and effective problem-solving. Further, the students showed big improvement in reasoning, generating new ideas, resolving problems, and transferring what they learnt.

The study (Bullard, 2008) involved a comparison between two lectures taught in both traditional lecture-based approach and extensive active learning approach. The experiment encompassed teaching student in groups for every class session. The implementation of student-centered approach described active, inductive, and cooperative learning strategies. Whereas teacher-centered approach described individually doing of home works. The results showed that the use of student-centered approach was adopted simply and it was more effective to teach the material.

Based on (Davidson, 2016), the results showed an improved performance of the students with the reference to the pre and post assessments achieved over time (Davidson, 2016). A qualitative study was achieved in (Ramli et al., 2013) and applied on the teachers of mathematics in one of the secondary schools in Malaysia.

The research (Rosenthal, 1995) described the implementation of cooperative learning in the university of Minnesota by analyzing the data collected from questionnaires. The research argued to reform many teaching techniques and it is not necessarily to require much effort. The shortcomings of the current lecture approaches in teaching mathematics are many. Most participants of the questionnaire agreed with learning mathematics by actively doing, synthesizing, and discussing is better. A positive experience was provided in practice as a cause of believe in presenting teaching strategies simply to give students better retention and deeper understanding of knowledge.

The study (Freeman et al., 2014) involved an analysis of 225 researches to create a report of the performance (success or failure) of students under traditional learning versus active learning in science, mathematics, engineering, and technology courses. Major studies, 158, indicated of the increased performance of students with 6% improved scores, whereas 67 studies showed failing. Moreover, the report showed the increasing scores in active learning across the four courses with all class sizes. The report is considered as the most comprehensive meta-analysis of studies about the four courses education published up to 2014.

The study (Ramli et al., 2013) exposed the main requirements for active learning implementation in schools including the need for effort by ministry of education, schools, and teachers to promote and motivate in-depth learning environment conducted in mathematics. The study has used an initial qualitative approach to examine in-depth learning in mathematics and the nature of common challenges faced by students in everyday school environment especially the learning of mathematics. Further, the study tried to help teachers in proposing the instantaneous educational preparations to outperform these difficulties faced by students.

4. Definition of terminologies

Active learning is an instructional method used to engage students in the process of learning, and it requires students to work on classroom's activities that reflect what is being done (Prince, 2004).

Collaborative learning is an instructional method used to let students work together in a group to achieve a specific goal. Collaborative learning focuses on the interaction between students (Prince, 2004) (Springer et al., 1999).

Cooperative learning is a structured form of group work that allows students to individually follow and assess common goals (Prince, 2004) (Springer et al., 1999).

Problem-based learning is an instructional learning methods used to introduce problems to the students and ask them to resolve in active way. It involves self-directed learning (Prince, 2004) (Springer et al., 1999).

We should distinguish between teacher-centered approach, student-centered approach, and teacher-student interactive approach. The former, teacher-centered approach involves the transmission of information from teacher to student with any participation of student in the content he/she receive. Teacher-centered approach is not practical, and it focuses more on memorizing and theorizing rather than applying activity-based learning. In teacher-centered approach, the teacher controls the process (minimize time, maximize content, etc.) so the student misses the understanding and interest (Ganyaupfu, 2013).

Student-centered approach promotes interest, enjoyment of students, analytical research, and critical thinking. Student-centered approach has more effective tasks and goal-oriented behavior, so it can effectively improve the achievement of students. Whereas teacher-student interactive approach combines the above two approaches into one approach. In this approach, the information presented by a student to the other students can be remembered better than that information presented by the teacher. This approach stimulates the students to search for related information and hence improves his/her academic performance (Ganyaupfu, 2013).

Active learning strategy refers to the methods used in the classroom and can lead and guide the tasks and activities. To deal with the learning activities, active learning strategy carries out two sides: changing the

experience of the teacher and promoting his empowerment (Katsap, 2009).

5. Results and discussion

Typically, the implementation of active learning strategy requires changing the perception of teaching, good experience, much experimentation, and adapting the proficiency of the educational environment (Katsap, 2009). Teaching mathematics might be very suitable to divide students into groups because of the variety of mathematical skills among students; some students love mathematics lessons while other have other skills that help in resolving mathematical problems in such way (Röj-Lindberg, 2001).

The participants, both student and teacher, should preserve the following properties regarding the reflections on the teaching methods (Katsap, 2009):

- The learning is cooperative.
- The decision of adopting the topic and method is influenced by the colleagues.
- Teacher takes responsibility of preparing course book units to be taught.
- The organization of class into groups is based on the division of labor.

Some guidelines that could facilitate active learning in classrooms concern the behavior of the students and teacher with respect to the used methods for teaching and assessment. These guidelines are stated below (Katsap, 2009):

- The teacher should direct students.
- The students should participate in setting goals.
- The environment of class should be shared, supportive, problem-centered, and student-driven.
- The assessments should be continuous and supportive.
- Teaching focus should be on the improvement rather than setting many expectations and varied outcomes.

The effect of active learning on the process of education can be measured by the description of the experience, called self-descriptions, introduced by the students and teachers. The teacher has to manage the class to find the sources of information and knowledge and educate students to find them by themselves, and subsequently they create effective knowledge the need for teaching. The teacher and students through examining the knowledge can write, edit, delete, and present the knowledge units (Katsap, 2009).

Students will not get the total benefit of learning when they sit in class, listen to the teacher, memorize information, and answer questions. Instead, they need to talk with others, explain what they are learning, write about what they are learning, connect ideas, and connect between past and current experiences (Bonwell, & Eison, 1991).

The purpose of the mathematics teaching should be established based on the intelligent learning culture and the deep knowledge in mathematical concepts, so mathematics learning requires the knowledge of mathematical concepts or conceptual knowledge. Thus, the intelligent learning generates relational understanding and conceptual knowledge when the teacher creates rich content structures based on the mathematical concepts connections and teaching procedures (Röj-Lindberg, 2001).

Active learning strategies in mathematics should provide interpersonal relations and teaching procedures in mathematics to enhance the culture of active and creative learning. In active learning approach, the students can construct how to understand the mathematical concepts in refined manner, meaning that the content and structure can simultaneously enhance procedural knowledge (which steps to follow up) and conceptual knowledge (why the step is followed). The mind of the student is developed with more sophisticated relationships and cognitive information among multiple elements of mathematical knowledge. In other words, the knowledge of concepts and procedures is connected to provide good feeling of the perception of mathematics in terms of enhancing answering capacity and problem-solving (Röj-Lindberg, 2001).

Cognitive goals for students are (Braun et al., 2017):

- To recognize mathematical arguments.
- To discuss mathematical ideas coherently.
- To work self-sufficiently and creatively.
- To assess alternative solutions to the problem.
- To create and explore examples as well as experiments.

The main barriers and obstacles faced the interests in the implementation of active learning strategies in mathematics can be overcome through (Bonwell, & Eison, 1991):

- The teacher can reduce the amount of available time to cover the content by ensuring that the student is given the enough time to learn the content.
- The teacher can reduce time needed for preparation by creating thoughtful and thorough novel courses and recycling old ones.
- The teacher can overcome the problem of large sizes of classes by dividing large groups of students into

smaller ones.

- The teacher should take reasoning to change because teaching is not like learning so the teacher should pay attention to the difference between what is presented to the student and what is effectively taught.
- The need for equipment and material to implement active learning is not always true; the teacher can ask students to summarize what they learnt from the class.
- The resistance of students to non-lecturing approaches can be resolved by providing familiar passive listening with explicit instruction and showing how students can actively participate and learn in less traditional mode.

The teachers should have and enforce motivation, curiosity, willingness to participate and success the task, take an experience, and reflect their impressions on the experiences (Katsap, 2009).

6. Conclusion

The goal of this study is to set a foundation for the implementation active learning strategies in mathematics. We review the definitions of active learning, types of active learning examples of active learning, and the techniques used in active learning.

We can conclude the following obstacles and limitations of the implementation of active learning strategies in mathematics (Eison, 2010):

- The muchness of pre-class preparation to devise active learning strategies in mathematics.
- The huge number of students and large size of classes limit the implementation of active learning strategies in mathematics.
- The wrong thought of the teachers that they are good lecturers to implement active learning strategies in mathematics.
- The lack of equipment and materials required to implement active learning strategies in mathematics.
- Time constraint that prevent teacher from fully covering the course content at time.
- The resistance of students to no-lecture approaches rather than implementing active learning strategies in mathematics.

The choice of active learning strategy is influenced by a set of factors including the degree of objective, the capacities of students, the teaching skills and preferences, and the class size.

Learning outcomes of active learning are:

- Improved academic achievement.
- Improved quality of interpersonal interactions.
- Improved self-esteem.
- Improved perception of greater social support.
- Improved student attitudes.
- Improved retention in academic programs.

The findings that can be drawn out from this study are:

- The benefits of student engagement in active learning cannot are many to both students and teachers.
- Active learning is not the magic solution to be employed for all educational problems

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