PREPARING TO TEACH MATHEMATICS WITH TECHNOLOGY: REVIEW OF AN INTEGRATED APPROACH TO DEVELOP STUDENT’S METACOGNITIVE SKILLS

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Abstract

Metacognitive skills are the driving force behind mathematical learning. It is an element that supports the learning process and improves mathematics problem-solving skills. Metacognitive skills developments will ensure students manage their learning well. However, due to technological advancements and the need for expertise and skillful, transformations of teaching are essential to address the industrial needs. The creating and development of metacognitive skills are seen to be more significant through integrated technology teaching. This review paper will discuss teaching practices based on metacognitive strategies that can integrate with technology as an element of intervention and injection in enhancing students' understanding, mastery and achievement. Studies around 2000 and up to date have been explored based on approaches, methods, techniques, and practices of metacognitive strategies implemented. A total of 15 articles were selected through a search of databases such as Google Scholar, Eric, Science direct, Elsevier, Springer Link and more. Snowball methods are also implemented to improve article search. It can be concluded that technology elements will be excellent mediators for improving metacognitive skills while also producing meaningful learning. Thus, stakeholders should ensure that in developing a quality teaching and learning approach, metacognitive strategies cannot be overlooked and significantly integrated with technology that will further enhance student learning and achievement especially in critical subjects like mathematics.

Keywords : Metacognitive Skill, Integrated Technology, Metacognitive Strategies, Student’s Mastery, Mathematic Learning

I. Introduction

The definition of metacognition is "cognition about cognition" or "thinking about thinking" as stated by experts in this science, including Schraw & Moshman.
In Flavell's Classical Model (1976) the metacognitive has several components including metacognitive knowledge, metacognitive experience, the objective of task and action (strategies) [XII][XIII]. Later, Nelson & Narens' [XXXV] introduced the Alternative Model of Metacognition by adding aspects of the control and monitoring process as subcomponents. Recently, the components of metacognition according to Papaleontiou-Louca [X] can be summarized as metacognitive knowledge (awareness), metacognitive experience and metacognitive regulation that will always be trained and enhanced as metacognitive skills throughout the learning process. Each of these components has subcomponents that support and have specific clusters and hierarchy [XXVI]. The subcomponents of knowledge are declarative knowledge, procedural knowledge, and conditional knowledge while metacognitive regulation also has three subcomponents namely, planning, monitoring and evaluating [XXXV][XII].

Metacognitive skills are the awareness and action of the individual about self and others' thinking [XVII]. Suriyon, Inprasitha & Sangaroon [V] conclude that this is a knowledge and skill acquired through cognitive connection and action through trust and experience stored in memory. The effectiveness of mathematical learning is influenced by metacognitive skills. According to Moos & Ringdal [VIII], these metacognitive skills will work as soon as they are facing the tasks based on specific phrases. The first phase is to understand math problems. At this point, metacognitive knowledge will play a role. Next, the metacognitive regulation skills will continue this cognitive process with actions such as setting goals, planning, selecting strategies, synthesizing strategies and ending with a reflection phase and evaluating them for the task to be completed accurately. It can be concluded that metacognitive skills are significant and can influence students’ perfection and accuracy in solving mathematics problems or tasks. Su, Ricci & Mnatsakanian [XV] suggest that mathematics teachers should constantly train students' metacognitive skills so that they can think and manage their cognitive processes refer to respective stages in improving mathematical achievement. Learning activities that stimulate students' cognitive and metacognitive aspects are important during the learning process. According to Hasbullah [XIII], Moos & Ringdal [VIII] and Smith & Mancy [XVII], during mathematics learning, students need to be aware of how they learn, be aware of appropriate procedures and strategies and also be able to act on cognitive conditions to be more effective in improving their understanding.

Technology has a profound effect on every aspect of modern life [XXVIII]. By integrating technology, teaching and learning processes can be merged with more interactive multimedia programs to increase meaningful learning support [XVI]. Smith, Shin, Kim & Zawodniak [XXX] state that technology integration has become increasingly important for learning to be more meaningful in today's classroom. According to Bonwell & Eison [VII], learning is meaningful when students are actively involved in the learning process. This involvement is both metacognitive and motivational [XII]. According to Gurbin [XXXIV], if the application of technology in learning is successful, it can influence the development of metacognitive skills. This is because one of the reasons why technology is integrated into learning is based on
the importance of metacognitive skills. Clarebout et al [XI] suggest that integration should focus on the relationship between knowledge and metacognitive strategies, such as the use of support devices in computer-based learning environments (CBEs). Technology-integrated learning will enhance students' readiness to act, ensuring students see the need for learning, organizing, monitoring their learning. This has been reported in the studies of Panaoura, Gagatsis & Demetriou [IV], Hasbullah [XIII] and Menz& Cindy Xin [XXIV], which prove that technology integration can enhance metacognitive skills and assist students in learning management. Digital game-based learning, for example, has been developed to enhance students’ knowledge and skills [XXII]. Gordon [XVI] provides an example of technology integration in learning through interactive multimedia programs, one of the ways to support metacognition based on the influence and impulse of processes and promoting problem-solving skills. One of these is the genre of templates built into the interactive multimedia program package.

Metacognitive skills can be enhanced when students are allowed to discuss, organize and present their ideas depending on the task assigned, assisting students in thinking, processing information and monitoring their learning process [XVI]. Sherman [XXI] points out that instructional models using technology have been developed by forming video presentations, which can be done outside of the classroom or outside of the timetable, while for classroom time only focus or engage students in problem-solving, project management or conduct discussions in small or large groups.

Technology will also act as a mediator or tool for obtaining information resources and requirements, evaluating and acting in the right way. These tools are widely discussed and proven through the implementation of Vygotsky's Social Development Theory based on the concept of a mediator [XXXI] [XVIII]. Gurbin [XXXIV] also discussed the concept of this mediator from the perspective of metacognitive skills and reported about technology is important as a metacognitive tool. This tool will provide support for metacognitive skills. Gordon [XVI] said that instructional technology can provide students with metacognitive support tools and cognitive tools that implement the constructivist theory. It is in line with the belief of constructivism that states, learning is the process of how we build meaning and knowledge as a result of conscious processes during minds-on and hands-on [XXXVII]. Accordingly, technology can also be used as an inventory or assessment tool to view students' skills and abilities more generally or more specifically in their assignments [XXXIV]. Technology is also used as a tool for measuring student achievement, which is to see how understanding in the classroom can be represented to develop and enrich knowledge [XXX]. Mathematical learning is also seen as having to integrate technology. According to Borba et al [XIX], studies of the effectiveness of using technology such as mobile devices such as smartphones or tablets in mathematics teaching and learning are increasingly being reported in research journals and educational practitioners. A study conducted by Eyyam&Yaratan [XXVIII] showed that post-mathematical tests of students taught using technology were significantly higher than the posttest results of groups taught without technology. These results indicate that students have a positive attitude towards the use of technology. According to Sherman [XXI], technology can
influence or target students' focus and thinking in mathematical activities. In this regard, Borba et al [XIX] have listed several advantages of technology integration in mathematics learning, including:

A. Mobile technology creates a student-mathematical relationship without going through the teacher and this slightly distorts traditional learning processes that see teacher authority as a source of knowledge.

B. The potential of MOOCs in allowing students to access resources or courses without prerequisites and no cost.

C. The production of mathematics learning resources online or as a digital library and learning targets can be used without reference to the source of textbooks or teachers. However, this access should be developed based on an appropriate pedagogical approach to ensure conceptual understanding is the main objective of the presentation.

D. Online exploration and discussion is gaining ground and leveraging on the blended learning model and the flip classroom to expand and enhance classroom learning functions and networks.

Teachers need to integrate technology into mathematical learning. This is because mathematical skills and competencies can be enhanced with the development of metacognitive skills that can be trained and enhanced with the use of technology in teaching delivery. Technology will also produce students who are motivated and can develop good metacognitive management [XI]. Helping students to regulate their knowledge, learning strategies, and responses, the executive function process of metacognition involves the ability to understand, control, monitor, and adjust one's cognitive processes to facilitate learning [XXXIV]. MatSina, Talib & Norishaha [XXII] report that a lot of research has shown that technology applications are used to provide a learning environment that can encourage students to be motivated and closer, this is because most students have their gadgets. The application of technology has created contextual learning and experience. Mistretta [XXIX] argues that teachers who receive training in the field of teaching by technology are more interested and motivated than those who do not integrate technology into learning. Teachers are more likely to use computers in effective ways such as simulation learning, learning applications, and math learning games. However, some teachers use technology only as their social interaction tool [XXX]. The ability, knowledge, and skills of teaching with a technology need to be emphasized especially to new teachers as a way to prepare teachers so that they can integrate specific technologies and use them for specific teaching purposes or as an intervention for mathematical learning problems [XXIX].

Hasbullah [XIII] points out that the nature of mathematics itself is very limited learning of mathematics. Chris [XXIII] argues that one of the contributing factors to mathematics learning problems is the weakness of teacher presentation techniques. Therefore, the preparation of teachers to respond to the challenge of transforming quality teaching is through technology integration. The need for teacher preparation programs to act as a catalyst for technology integration into classroom teaching is important and needs attention from those involved in educational development [XXIX]. Based on these suggestions, researchers look at the need for a
study that can propose some more specific teaching approaches and techniques for integrating technology. Choosing the best teaching practices should be done so that it can be injected with the elements of technology to contribute to improving the quality of mathematical learning. To prepare students to immerse themselves in a more global future and the need for today's teachers is to see how technology integration can help students learn, think, and build skills to see a different perspective [XXVIII].

II. Methodology

This research is aimed at reviewing the integrated technology approach in support of metacognitive learning strategies in mathematics learning. Review is based on the impact of the approach on students' metacognitive skills. The research question was developed to achieve the objectives of this systematic review. The research questions are:

a. what’s teaching practices based on metacognitive strategies that can be integrated with technology

b. what’s the impact of technology-integrated metacognitive skills as a mediator on student’s learning and achievement

Through databases like Google Scholar, ScienceDirect, ERIC, Springer Link, Elsevier, and several other databases, search articles and journals are started using keywords such as metacognitive learning strategies, learning activities in mathematics, metacognitive skills, and mathematics and integrated metacognitive and technology in learning mathematics. Articles within the year between 2009 and up to date are selected. Journals or articles related to the area of study are selected by first looking at the abstract and if confirmed, the content will be viewed more specifically. Selected articles will go through a specific research process and the method used in the learning approach as a treatment will be fully referenced. The following table shows the analysis of the effect of instructional practices based on the implementation of metacognitive strategies and what is the relation to the metacognitive components and subcomponents.

Table 1. Analysis of Effect of the Teaching Practices Based on Metacognitive Components and Subcomponents

| Author(s) / Title | Objective(s) / Teaching and Learning Method(s) | Component and Subcomponent of metacognitive | Description |
|------------------|-----------------------------------------------|---------------------------------------------|-------------|
| [1] Petra Menz& Cindy Xin (2016) | Objective(s) | Experience | Help students to form a new habit of thinking |
| Making Students’ Metacognitive Knowledge Visible through Reflective Writing in a Mathematics-for-Teachers Course |
|---|
| To describes the rationale, implementation, and assessment of a weekly online reflection activity based on instructor prompts designed for post-secondary students who aspire to be elementary school teacher. |
| Regulation |
| Implement metacognitive skills for the learning of mathematics, such as planning learning tasks, monitoring comprehension, and evaluating progress. |
| Online Reflection Activity |
| Teaching and Learning Method(s) |
| Declarative knowledge |
| Accessing self-possessed knowledge |
| Condition knowledge |
| Dealing with the feelings of the self specifically during mathematical learning. |

| [2] | Cera, Mancini & Antonietti (2013) |
| Relationship Between Metacognition, Self-Efficacy And Self-Regulation In Learning |
| Objective(s) |
| To Study the relationship between metacognition, self-efficacy and self-regulation in learning |
| Declarative knowledge |
| May identify relevant information as necessary |
| Procedural knowledge |
| i. Higher skill to choose strategies |
| ii. Students can manage time more effectively |
| Monitoring of regulation |
| Monitoring |

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| Problem Based Learning Activity | and Learning Method(s) | Objective(s) |
|---------------------------------|------------------------|--------------|
| Condition al knowledge          | i. Can improve sensitivity to feedback content |
| Evaluating of regulation        | ii. Self-assessment by linking the previous knowledge to the learning process |
| Experience                      | iii. Can connect existing knowledge with new ones |

[3] Julie M. Smith & Rebecca Mancy (2018)

Exploring The Relationship Between Metacognitive And Collaborative Talk During Group Mathematical Problem-Solving – What Do We Mean By Collaborative Metacognition?

*Journal of Research in Mathematics Education, 20:1, 14-36*
| Mathematical problem solving | Monitoring of regulation |
|-----------------------------|--------------------------|
| ii. To identify the metacognitive content during the interaction of students | i. Using the metacognitive skill of monitoring during the interactions of another student |
| ii. Calculating the answer out loud | |
| iii. Trying to work out the solution to the problem | |
| iv. Student is questionin another student’s thinking | |
| v. Inviting peers to justify their answer | |

**Teaching and Learning Method(s)**

| Metacognitive And Collaborative Talk (Discussion ) Activity | Evaluating of regulation |
|----------------------------------------------------------|--------------------------|
| | i. Students are trying to determine the differential ideas |
| | ii. Seeking clarification through peer questions |

**Objective(s) Declarative knowledge**

| Planning is being more effective during learning |
|------------------------------------------------|

[4] Mary Jarratt Smith (2013) An exploration of metacognition and its

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| **Objective(s)** | Declarative knowledge | Making sense of the task |
|------------------|-----------------------|--------------------------|
| **Planning of regulation** | Procedure knowledge | i. Extracting the given information |
|                   |                       | ii. Seeking any examples used in the past |
| **Monitorin g of regulation** | Procedure knowledge | iii. Thinking aloud protocol transcripts |
|                   |                       | i. Being aware of the goal |
|                   |                       | ii. Mapping a solution. |
|                   |                       | iii. Thinking aloud protocol transcripts |
| **Problem Based Learning Activity** | Procedure knowledge | i. Screenin g |
| Evaluating of regulation | Two levels of evaluation: intuition and make a reason |
|-------------------------|-----------------------------------------------|

| [6] Adnan & ArsadBahri (2018) | Objective(s) | Metacognitive regulation | Will train skill of student on how plan, manage, and evaluate their learning |
|-------------------------------|--------------|--------------------------|---------------------------------------------------------------------|
| Beyond effective teaching: Enhancing students’ metacognitive skill through guided inquiry | To compare metacognitive skill of students between thought by guided inquiry and traditional teaching. | Declarative knowledge | |

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| Teaching and Learning Method(s) | Procedural knowledge |
|---------------------------------|----------------------|
| Guided Inquiry Activity | i. The students explore their thoughts to find out what previous knowledge they have |

| Planning of regulation |
|------------------------|
| i. Identify the resource that will help them to complete the task |
| ii. The students know what needs to be done first in order to help in completing the task |
| iii. The students |
|                |                                                    |
|----------------|---------------------------------------------------|
| **Procedural knowledge** |                                                    |
| i. Students take action to solve the problems |                                                    |
| ii. Remember important information |                                                    |
| **Monitoring of regulation** |                                                    |
| i. Check whether it is on the right track |                                                    |
| ii. The student will ask himself or herself what related information is important to remember and what to do to solve the problem |                                                    |
| **Evaluating of regulation** | Students can ask themselves how well they have solved |
[7] Sd Du Toit & Gf Du Toit (2013)

Learner metacognition and mathematics achievement during problem-solving in a mathematics classroom

*TD The Journal for Transdisciplinary Research in Southern Africa, 9(3), Special edition, December 2013, pp. 505-518.*

| Objective(s) | Declarative knowledge | Procedural knowledge | Conditional knowledge |
|--------------|-----------------------|----------------------|----------------------|
| To investigate the level of learner metacognition as well as the level of mathematics achievement during problem-solving in a mathematics classroom | Knowledge about the correct formulas to use in present solution | Know how to implement problem-solving strategies |

| Teaching and Learning Method(s) |
|---------------------------------|
| Problem Based Learning Activity |

| Planning of regulation |
|-------------------------|
| i. Planning the solution |
| ii. Makes a goal-setting |
| iii. Students allocated of resources prior to a learning activity |

| Monitoring of regulation |
|--------------------------|
| i. Students considered different |

The problem
| Ways of solving the problem | Evaluating of regulation |
|---------------------------|-------------------------|
| ii. Students can finding alternative solutions for the problem | Reflecting on the validity and correctness of solution. |

[8] Hasbullah (2015)  
The Effect Of Ideal Metacognitive Strategy on Achievement In Mathematic  
*International Journal of Educational Research and Technology* 6[4] 2015; 42-45

| Objective(s) | Metacognitive knowledge |
|--------------|-------------------------|
| i. Emphasize the provision of project or task |
| ii. Know aspects to be focused on the learning materials |
| iii. Students will be considered important information and source |
| iv. Stimulate students’ sense of responsibility in carrying out the project |

| Teaching and Learning Method(s) | Metacognitive regulation |
|-------------------------------|--------------------------|
| Ideal Metacognitive Strategy | i. Stimulate the students to understand |
the situational problem by using a specific form of representation

ii. Discuss the finding and solution with peer

iii. Evaluate the problem solving and accuracy

[9] Areti Panaoura, Athanasios Gagatsis & Andreas Demetriou (2009)

An Intervention To The Metacognitive Performance: Self-Regulation In Mathematics And Mathematical Modeling

*Acta Didactica Universitatis Comenianae Mathematics, Issue 9, 2009, pp. 63–79*

| Objective(s) | Declarative knowledge | Understanding the phenomenon under investigation |
|--------------|-----------------------|-----------------------------------------------|
| To investigate the improvement of students’ self-representations about their self-regulatory performance on mathematics by developing an intervention program depended on the mathematical model proposed | Procedural knowledge | Students need to rely on another part of their knowledge base, it is mathematical concepts, formulas, techniques and heuristics |

i. Students have to consider and decide what elements are essential

ii. Finding the elements
| Teaching and Learning Method(s) | Monitorin of regulation | Evaluating of regulation |
|--------------------------------|-------------------------|--------------------------|
| Web(comp)uter based Activity (Mathemati cal Modelling) | i. Working through the mathemati cal model | i. Evaluating the model by checking if the interpreted mathematic al outcome is appropriate and reasonable for the original problem situation |
|                                 | ii. Students derive some mathematic al results | ii. Communicating the solution of |
|                                 | iii. Interpreting the outcome of the computati onal work to arrive at a solution | |

are less important to include in the situation model.
| Objective(s) | Declarative knowledge | Students thinking how to find ways or strategies to finish the task |
|--------------|-----------------------|------------------------------------------------------------------|
| To investigate the influence of self and peer-assessment in active learning to metacognitive awareness; cognitive knowledge, cognitive regulation, and the combination between them | Procedural knowledge | Students know how to perform in carrying out the steps in a solution |
| Teaching and Learning Method(s) | Condition al knowledge | i. Knowing of when a procedure, skill or strategy is used and when it is not used |
| | Planning of regulation | ii. Known for what conditions a procedure can be used, and why a procedure is better than other procedures. |
| | Monitoring and evaluating | i. Students use various means to |
Based on the analysis of Table 1 above, the study found that metacognitive components have the greatest potential to influence student learning. These components guide learning efforts and actions and ultimately determine the meaning and effectiveness of learning. As a result of the analysis of Table 1, the researcher can identify the components and subcomponents in the following Table 2.

**Table 2. Students’ Skills and Behaviour Based on the Metacognitive Components and Subcomponents**

| Metacognitive Components | Subcomponents | Behaviour/Students Skills |
|--------------------------|---------------|----------------------------|
| **Metacognitive Knowledge** | Declarative knowledge | 1. Identifying what is the phenomenon or problem and what is the relevant information as necessary  
2. Students thinking how to find ways or strategies to finish the task  
3. Knowing about the correct strategies and formulas to use in present solution |
| | Procedural knowledge | 1. Know how to perform, implement in carrying out the steps or strategies in a solution  
2. Students take action to solve the problems  
3. Remember and extracting important information  
4. Seeking any examples or previous knowledge used in the past |
| | Conditional knowledge | 1. Knowledge of when a procedure, formulas, skill or strategy is used and when it is not used  
2. Students have to consider and decide what elements are essential  
3. Finding the elements are less important to include in the situation, problems or task |
| **Metacognitive Regulation** | Planning | 1. Knowing the purpose of learning is about  
2. Set up the goals and objectives  
3. Know aspects to be focused on the learning materials  
4. Know the source and how to find the information  
5. Students know what needs to be done first in order |
| Monitoring | 1. Managing time to understand information  
2. Manage the time to find new information  
3. Take time to implement strategies  
4. Implement selected strategies, skills or formulas  
5. Make some revisions and allocate some time to check  
6. Students use various means to accomplish these tasks and vary in each  
7. Students considered different ways of solving the problem  
8. Implement an alternative way if the previous way is ineffective  
9. Interpreting the outcome of the computational work to arrive at a solution  
10. Student will ask himself or herself what related information is important to remember and what to do to solve the problem |
| Metacognitive Experience | 1. Creating new experiences  
2. Can connect existing knowledge with new ones  
3. Develop a new habit of learning and thinking  
4. Represent the learning in to real life |

Therefore, it can be concluded that almost all teaching methods will involve metacognitive components but may impact learning in different forms, as according to Tarricone [XXVI] these components have different taxonomies and different activities and effective times. Furthermore, to see whether all learning activities can develop these metacognitive components, researchers look for and select articles that report on teaching and learning activities that discuss the effectiveness of these
activities on student mathematics learning. A total of 5 articles were selected and analyzed. The results are presented in Table 3 below.

**Table 3. Analysis of Implementation of Metacognitive Components in Learning Activities and Their Impacts to Mathematics Learning**

| Author(s) | Activities | Implementation Of Metacognitive Components | The Impacts To Mathematical Learning |
|-----------|------------|-------------------------------------------|-------------------------------------|
| [1] David S. Benders (2016) | 1. Cooperative work (game) | Knowledge / Regulation / Experience | 1. Increase conceptual understanding |
| | 2. Independent work (practice workbook pages-math journal challenge) | / / / | 2. Improve critical thinking skill |
| | 3. Cooperative work (computer review skills) | / / | |
| [2] HalilCoskunCelik (2018) | 1. Problem solving activity | / / / | 1. Increase mathematics achievement |
| | 2. Project work | / / | |
| | 3. Practical investigation | / / / | |
| Author(s)                                                                 | Year | Methodologies                                                                 | Benefits                                                                                           |
|--------------------------------------------------------------------------|------|------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| Peter Rillero                                                            | 2016 | Deep Conceptual Learning in Science and Mathematics: Perspectives of Teachers and Administrators | 1. Become more effective thinker and decision maker                                               |
|                                                                          |      |                                                                               | 2. Used to apply their knowledge                                                                    |
|                                                                          |      |                                                                               | 3. More Engaged                                                                                    |
|                                                                          |      |                                                                               | 4. More Motivated                                                                                  |
| AzukaBenard Festus                                                       | 2013 | 1. Observations activities                                                    | 1. Being active learner                                                                            |
|                                                                          |      |                                                                               | 2. Discovering things for themselves                                                                |
|                                                                          |      |                                                                               | 3. Increasing mathematical achievement                                                               |
|                                                                          |      |                                                                               | 4. Long-term retention of information                                                                |
|                                                                          |      |                                                                               | 5. Motivated towards further learning                                                                 |
|                                                                          |      |                                                                               | 6. Can apply information in new settings                                                              |
|                                                                          |      |                                                                               | 7. Increase thinking skills                                                                          |
| AjiWibowo                                                                | 2017 | 1. Realistic and Scientific Mathematics                                       | 1. Increase reasoning ability                                                                      |
|                                                                          |      |                                                                               | 2. Motivated and interested to                                                                         |

1. PBL / / / / 2. Discovery Learning / / / 3. Project Learning / / 4. Observation activities / / / 5. Practical work / / / 6. Using teaching aids / / / 7. Cooperative activity or small group activity / / 8. Group discussion / / 9. Realistic and Scientific Mathematics / / /
III. Finding and Discussion

The integration of technology in the metacognitive learning strategy will have an impact on students' mathematical learning. Technology has the potential to increase motivation and drive openness of cognitive and metacognitive functions. Attractions of technology will shape deep learning, exploring and discovery [XXV].

Based on the findings obtained through this review, several mathematics teaching techniques are seen to have the potential to train and enhance students' metacognitive skills. What's even better is that the approach is very well-formulated and integrated with the technology. Elements of technology can act as a synergy and a dye to such an approach that students' mathematical competencies can be afforded. The impact of this integration on students' mathematical learning is based on the original effects of the approach and added after the integration process.

RQ1: what's teaching practices based on metacognitive strategies that can be integrated with technology.

Table 4 below shows some examples of learning practices that can be integrated with technology elements. This integration is based on the appropriateness of the metacognitive learning strategy and the effectiveness demonstrated through the reports of selected studies. Besides, the main focus is to look at and evaluate the impact of mathematical learning.

Table 4. A Learning Practices That Can Be Integrate with Technology and Their Impact on Students.

| Elements of Technologies | Learning Practices Based on Metacognitive Learning Strategies | Impacts on Students | References |
|--------------------------|---------------------------------------------------------------|---------------------|------------|
| Integrating ICT / ICT    | Transformed Learning                                          | 1. Excitement, being active | Menz & Cindy Xin [XXIV]; Rillero [XXV]; Benders [IX]; |
| Internet                                                                 | e.g Web application, online based, presentations, reciprocal teaching, folios, innovation competition, discovery | 2. Greater reduction of misconception                                                                 |
|------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| Problem Based Learning                                                 | e.g problems solving activity, problems situation, experiment/investigation activity                | 3. Being active, interacting with others                                                                    |
|                                                                         |                                                                                                 | 4. Higher transfer knowledge / concept to the new experiences                                           |
|                                                                         |                                                                                                 |                                                                                                         |
| Interactive teaching materials / tools                                  | Cooperative Learning e.g class discussion, group work, group project                                | 1. Influence on classroom climate and students behaviour                                                  |
|                                                                         |                                                                                                 | 2. Increase in creativity, excitement, stimulation, learning skills                                     |
|                                                                         |                                                                                                 |                                                                                                         |
| Competition / Challenge Based Learning                                 | e.g individual/group competitions, school competitions or higher level competitions, problems challenge, project challenge |
|                                                                         |                                                                                                 |                                                                                                         |
| Educational software / application                                     | Game Based Learning e.g played game, technology game                                              | 1. Excitement, interactivity,                                                                             |
|                                                                         |                                                                                                 | Benders [IX]; Tony Karnain et al [XXXVI]; Hasbullah [XIII]; Panaoura,                                    |
Project/Activity Based Learning
e.g Ideal, Geogebra, Modelling, Sketchpad

emotion

2. Gain in self-care behaviour and self-efficacy

Gagatsis & Demetriou [IV]

By choosing the right teaching practices will ensure the learning ability and potential of students. In line with technological developments, the need for innovation and modification of the teaching delivery method is compulsory [XXIX]. Chris [XXIII] and Radovic, Marie & Passey [XXXIII] state that the transformation of the curriculum will certainly change the learning environment of mathematics not only by "telling" but also by shaping the medium of knowledge development, finding and determining resources, comparing resources, discuss, build new knowledge and make enrichment directions or apply new knowledge based on needs. Traditional practices can be refined and re-colored with technology. For example, the search for learning resources is not confined to books, but with the presence of web, e-book, online journal, online video, encyclopedia, wikipedia and more, various resources can be utilized [XXI][XXIV][IV].

In addition, social applications such as facebook, twitter, instagram, whatapps and so on, discussion are not limited to face-to-face, but even more open-ended, can gather more members and most important is, the discussions are recorded, stored and can even be printed [XVI][XXX]. Also, the sophistication of technology can produce tools, kits, and materials that support positive learning. The interactive and engineering aspects of this instrument ensure enhanced student competence [XXXIV][XXV]. For example, geometric tools, measurement, inactive games, and more flexible learning aids are available in today's market. This material is more specific, simple, attractive and even in very compatible sizes [XXVIII].

RQ2: what’s the impact of technology-integrated metacognitive skills as a mediator on student’s learning and achievement

The impact of the implement of metacognitive skills approaches with technology-integrated as a mediator of learning can be seen from several aspects, such as mastery of mathematical concepts, creating learning environments and developing thinking skills. Reviewed articles show that the implementation of activities such as Problem-Based Learning, Project Work, Discussion, Games, and so on, largely affects the students' understanding (e.g. [IX][XIV][II]). Student learning can be enhanced when students' existing knowledge can restructure and even improve. This process has the potential to provide students with the opportunity to correct misconceptions. Students also synthesize prior knowledge and develop new understanding schemes based on a topic being studied [XXXII]. According to Celik [XIV], Festus [I]; Du Toit & Du Toit [XXXII] and Adnan & ArsadBahri [III] learning outcomes are optimized when the enrichment of concept can be implemented from previous knowledge. Technology is opening the ways to the impetus for actionable metacognitive skills to deeper learning occur [XVI][XXV]. Technology also creates
self-regulatory skills where students are better directed to manage their learning. Interactions between students-students, students-materials and students-teachers can also be optimized by the presence of technology as a mediator [XVI][XXXIV][XXI]. The following interactions are to train and develop students' metacognitive skills. Accordingly, technology implementation enhances student collaboration too [XVII].

Students are more focused on discussion, sharing and tutoring. This collaborative learning is significant because it enhances student achievement [XVII][XXV][I].

Besides, the use of technology-integrated metacognitive learning strategies also has the potential to enhance critical thinking and other skills such as questioning, reasoning, as reported by Rillero [XXV], Wibowo [VI], Benders [IX], Festus [I]. This critical thinking enables students to process information logically, analytically and motivating them in preparation for learning. They can identify errors logically, and this situation helps students solve more complex math problems. If students can think systematically, manageably, critically, creatively, then solving mathematical problems is easier and can be implemented independently. Students can make their own choices and if successful in making decisions, understanding choices and developing knowledge for everyday life, then this experience will remain preserved as their metacognitive history [XXXII]. This concept is what should be translated into upcoming learning.

IV. Conclusion and Recommendation

In conclusion, it can be summarized that this study can uphold approaches that have the potential to increase mastery of students' mathematical concepts. Understanding the concepts is crucial to ensuring that students master the knowledge and skills in each of the mathematics subject areas. Not only can it be re-translated in the exam but it can also be applied in daily life. Active learning experiences can also foster scientific and technological culture. In this context, a positive perception of mathematics can be formed. This, in turn, can spark interest and fun in exploring mathematics subjects. Thus, this review can also provide insights into the development of mathematics curriculum that should aim to produce students who can think mathematically and apply mathematical knowledge in daily life.

Accordingly, the findings of this review will certainly give the mathematics teacher the idea that transforming the teaching presentation is necessary. Teaching should emphasize mathematical ideas and concepts rather than through the organization of operations, or provide a solution procedure that teachers consider to be good practice. Therefore, teachers' confidence in using technology in any form needs to be improved. If teachers use certain hardware or software, this will help them to develop their level of expertise, especially in mathematics teaching which is seen as a complex subject. Also, if teachers can provide more than one type of technology in the classroom, this is a great way to turn to technology teaching that can serve as a good practice guide. Another good practice of using technology is to not only make calculations and presentations faster or more efficient but because it allows students to reflect more on mathematical results than producing answers.
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