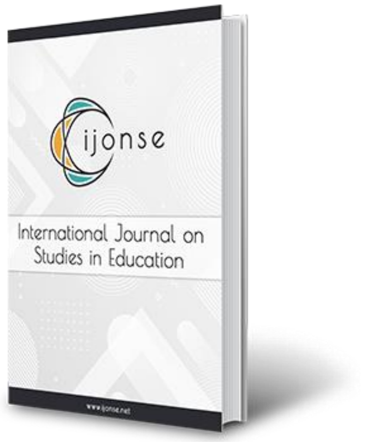


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# Effectiveness of Metacognitive Instruction on Students' Science Learning Achievement: A Meta-Analysis

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## Abstract

This study examined the effectiveness of metacognitive instruction on science learning achievement using a meta-analytic procedure. Statistical analyses were performed using the software Comprehensive Meta-Analysis (CMA) Version 3 developed by Biostat, Inc. Based on the findings, the overall effect size (ES=0.808) revealed that the use and integration of metacognition in science instruction has a significantly large and positive effect on student learning achievement. Moderator analysis showed that there was a significant difference in the effect sizes of the individual studies when grouped according to the student's level of education and the scientific disciplines being studied. However, the obtained positive and large effect sizes suggested that the use and integration of metacognition can be effectively implemented whether students are in the elementary, secondary or tertiary level, be it Biological or Physical Science. Moreover, the metacognitive strategies employed by individual studies are mostly found to be integrated with ICT mainly metacognitive prompts; other practices were student-led metacognitive discussions, concept mapping, metacognitive writing, and metacognitive practice and training. This result establishes the effectiveness of the use and integration of different metacognitive strategies to improve student learning. Thus, science teachers must be equipped with pedagogical knowledge on the implementation and integration of metacognition in classroom instruction.

## Introduction

Learning how to learn is one of the lifelong skills that students in the 21$^{st}$ century must possess. This skill entails the use of metacognition, which is regarded to be essential to effective and successful learning. Metacognition refers to the awareness of one's learning in utilizing information to achieve a goal and evaluating the cognitive demands of a particular task (Flavell, as cited in Dori & Kabermann, 2009). It is the process of reflecting on and directing one's thinking (National Research Council, as cited in Seraphin, Philippoff, Kaupp & Vallin, 2012), thus considered as the highest level of thinking, which involves active control of one's cognitive processes (Livingston, 1997).

Flavell (1987) argues that metacognition consists of two primary components: knowledge of cognition or metacognitive knowledge, and monitoring of cognition or metacognitive regulation. Metacognitive knowledge refers to what a person knows about his strategies, his own thought processes, and people in general as cognitive beings (Pintrich, 2002). Meanwhile, metacognitive regulation serves as the "active side" of metacognition which involves the use of metacognitive strategies that one uses to control cognitive activities. These processes help regulate and oversee learning, and consist of planning and monitoring cognitive activities, as well as checking or evaluating the outcomes of those activities (Schraw, 1998; Veenman & Spaans, 2005; Peteranetz, 2016).

Moreover, metacognitive knowledge consists of person variable, task variable, and strategy variable. Person variable refers to the general knowledge about how an individual learns and processes information, as well as knowledge of his own learning processes. This involves the awareness of one's strengths and weaknesses in learning and processing information. On the other hand, the task variable includes knowledge about the nature and context of the task as well as the type of processing demands that it will place upon the individual. Meanwhile, the strategy variable consists of one's knowledge about both cognitive and metacognitive strategies to be used to successfully accomplish a task (Flavell, 1978).

Other researches on metacognition presented another framework for categorizing metacognitive knowledge. The concepts of declarative and procedural knowledge were used to distinguish types of metacognitive knowledge (Cross & Paris, Kuhn, Schraw, Crippen, & Hartley, Schraw & Moshman, as cited in Lai, 2011). Declarative knowledge is described as epistemological understanding or student's understanding of thinking and knowing in general (Kuhn & Dean, as cited in Lai, 2011). It is the knowledge of oneself as a learner and the factors that can affect one's performance (Schraw, Crippen, & Hartley, as cited in Lai, 2011) and it answers the question: "*Do I know this?*" (Paris & Winograd, as cited in Lai, 2011). Procedural knowledge includes awareness and management of cognition and knowledge of strategies (Cross & Paris, Kuhn & Dean, & Schraw, Crippen, & Hartley, as cited in Lai, 2011).

Since metacognitive regulation serves as the "active side" of metacognition, it includes activities such as planning, monitoring, and evaluating. Schraw, as cited in Lai (2011), discusses that planning involves goal setting, activating background knowledge, budgeting time, selecting appropriate strategies and allocating resources. Monitoring or regulating involves awareness of comprehension and task performance and can include self-testing. Evaluation includes appraising the products and a regulatory process of one's learning and involves revisiting and revising one's goals. In other words, metacognitive regulation is the regulation of cognition and learning experiences through a set of activities that help people control their learning. In the context of learning, students become metacognitive when they plan how to approach learning tasks, monitor comprehension and evaluate their progress toward completion of these tasks. Thus, students become successful learners (Schraw, 1998; Livingston, 1997).

The integration of metacognition in classroom instruction is designed to enhance students' metacognitive knowledge, develop their metacognitive skills, and help them acquire a habit of using metacognition in learning (Peteranetz, 2016). In the past decades, several studies have emerged rapidly signifying the role of metacognition in science education. In fact, in the systematic review analysis of Zohar and Barzilai (2013), a total of 178 studies were reviewed which only indicates that metacognition is in the state of growth and expansion in the field of science education. For instance, in the study of Zhao, Wardeska, McGuire, and Cook (2014), a case study was conducted in which metacognition was explicitly introduced to undergraduate Chemistry students. The intervention was intentionally designed to help students gauge and improve their learning strategies through metacognition. Significantly, results showed that students have acquired the learning strategies introduced to them and have agreed that the strategies had helped them become more effective learners. Furthermore, Zohar and Barzilai (2013) found out there was a wide range of instructional strategies to foster metacognition in the classroom. However, there is a lack of empirical studies that looked into the effectiveness of metacognitive instructional practices in science learning. Little is known about effective metacognitive strategies as employed in science instruction. Aside from this, there exists a gap between theory and practice as many teachers do not have enough pedagogical knowledge about metacognition (Veenman, van Hout-Wolters & Afflerbach, 2006; Wilson, 2010).

Considering the positive impacts of metacognition on student learning, this meta-analysis was carried out in order to shed light on the effectiveness of metacognitive instruction, particularly on student learning achievement in science. Since there was no meta-analysis conducted before that only focused on student achievement, this meta-analysis provides teachers empirical and valuable information about its effects on student learning achievement, as well as information on integration and implementation of metacognitive strategies in science instruction. More specifically, this meta-analysis was designed to answer the following questions:

1. What is the effectiveness of metacognitive instruction in maximizing student learning achievement in science?
2. Is there a significant difference between the effect sizes of the studies according to the education level of the students exposed to metacognitive instruction?
3. Is there a significant difference between the effect sizes of the studies according to the scientific disciplines studied?
4. What were the metacognitive strategies that have been investigated?

## Methodology

### Research Design

This study employed meta-analysis as the main research design to examine the effects of metacognitive instruction on student learning achievement in science. As described, meta-analysis refers to the systematic synthesis of quantitative results from a collection of studies on a given topic (Borenstein, Hedges, Higgins, & Rothstein, 2009).

### Study Search Procedure

Research articles included in this study were obtained from several meta-search engines. Specifically, searches were conducted by searching the (1) electronic databases, such as ERIC, Elsevier, EBSCO host, and JSTOR (2) web using standard search engines, such as Google and Google Scholar. The researcher purposely chose to start the search in the year 2013 until 2018. Descriptors entered into the search engines were: *metacognition, self-regulation, metacognitive instruction, metacognitive learning,* and *metacognitive strategy.*

### Inclusion and Exclusion Criteria

Quantitative studies published between 2013-2018 regarding metacognition were examined in the context of this study. Inclusion criteria were as follows: (a) must be a research article published from 2013 to 2018; (b) may not include an explicit reference to metacognition or self-regulation in its title or abstract; (c) must use student academic/learning achievement as the dependent (outcome) variable; (d) must have a quasi-experimental research design; (e) must focus on any scientific discipline: Earth Science, Biology, Chemistry, and Physics;  (e) must provide sufficient statistical or quantitative information to allow calculation of the effect size. After rigorous screening, only ten articles qualified to the aforementioned criteria. The major reason for the small number of included studies was that most studies did not meet the criteria and required information is lacking.

### Coding Procedures

Relevant information from the articles were analyzed and coded in a coding sheet with the following: (a) authors (b) students' level of education (c) scientific discipline studied (d) control/comparison condition, (e) duration/frequency of intervention (f) instruments used and (g) results.

### Effect Size Calculation

Effect size (Hedge's *g)* was mainly used to detect the magnitude and strength of the effectiveness of the metacognitive strategy employed. Hedges *g* is the standardized mean difference equal to the difference between the mean values of experimental and control groups divided by the standard deviation. It is a more accurate version of Cohen's *d* which corrects bias in small sample studies without affecting larger samples (Hedges & Olkin, 1985). The magnitude of the effect size was decided according to Cohen's (1988) criteria: 0.80 and above (large); 0.50 to 0.80 (medium); 0.20 to 0.50 (small); less than 0.20 (no effect). Statistical analyses were performed using the software Comprehensive Meta-Analysis (CMA) Version 3 developed by Biostat, Inc. Moderator analysis was also utilized to determine whether the effects of metacognitive instruction on student achievement showed a significant difference in terms of the level of education of students and the field of science studied.

## Results

Based on the ten (10) empirical studies included in the meta-analysis, there was a total sample size of 1,079 students from various levels of education. Descriptive features such as the students' level of education and the scientific discipline studied are presented in Table 1.

Table 1. Frequencies and Percentages of Students' Level of Education and Scientific Disciplines Studied

| **Level** | **Frequency** | **Percentage** |
|---|---|---|
| **Elementary** | 1 | 10% |
| **Secondary** | 8 | 80% |
| **Tertiary** | 1 | 10% |
| **Scientific Discipline** | | |
| **Earth Science** | 0 | 0 |
| **Biology** | 2 | 20% |
| **Chemistry** | 3 | 30% |
| **Physics** | 5 | 50% |
| **Total** | **10** | **100%** |

As shown in Table 1, it can be noted that metacognition was studied in specific scientific disciplines in different levels of education. As observed, most of the research articles were conducted at the secondary level (N=8) and mainly involved Physics (N=5), followed by Chemistry (N=3) and Biology (N=2). There was no empirical study found in Earth Science. In order to statistically determine the effectiveness of metacognitive instruction in maximizing student learning achievement, the overall effect size was calculated by combining the effect sizes of individual studies as revealed in Table 2. This table presents the values for the number of studies (*k*), overall effect size (*ES*), standard error (*SE*), variance, confidence intervals, *z* value, and *p*-value.

Table 2. Over-all Effect Size

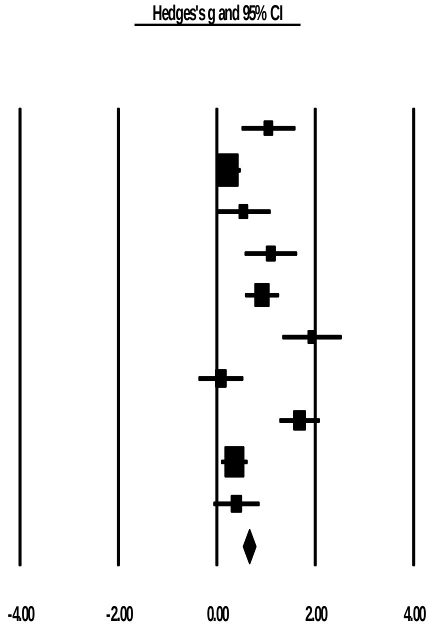
| | ***k*** | ***ES*** | ***SE*** | ***Variance*** | ***95% CI*** | | ***Z*** | ***p*** | ***Heterogeneity*** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **Lower** | **Upper** | | | **Q** | **df (Q)** | **P** |
| **Fixed** | 10 | 0.652 | 0.064 | 0.004 | 0.527 | 0.776 | 10.263 | 0.000 | 69.674 | 9 | 0.000 |
| **Random** | 10 | 0.808 | 0.184 | 0.034 | 0.446 | 1.169 | 4.384 | 0.000 | | | |

From this analysis, it was found out that the overall weighted effect size is 0.808 indicating that metacognitive instruction has a significantly large and positive effect on student learning achievement. However, the heterogeneity test result was found to be significant ($p<0.05$) which suggests that studies included in the meta-analysis do not have a common effect size. Thus, the distribution of effect sizes among the studies was significantly heterogeneous (Borenstein *et al.*, 2009). Table 3 reflects a detailed analysis including the forest plot that shows the distribution of effect sizes of the included studies.

Table 3 presents a detailed analysis of each study. Overall, the forest plot distribution showed that all studies favored the experimental (metacognitive) over the control (non-metacognitive) group. With regards to effect size, the decreasing magnitude is that of Bajar-Sales, Avilla and Camacho (2015), Lozada (2015), Olakanmi and Gumbo (2017), Lai, Hwang, and Tu (2018), Huang, Ge and Eseryel (2017), Moser, Zumbach and Deibl (2017), Marée, van Bruggen and Jochems (2013), Fouche (2013), Dike (2013), and Chen, Huang, and Chou (2016).

Table 3. Forest Plot of the Meta-analysis Results of the Ten (10) Included Studies

| Model | Study name | Hedges's g | Standard error | Variance | Lower limit | Upper limit | Z-Value | p-Value |
|---|---|---|---|---|---|---|---|---|
| | Lai et al. (2018) | 1.049 | 0.282 | 0.079 | 0.497 | 1.601 | 3.724 | 0.000 |
| | Dilke et al. (2017) | 0.231 | 0.131 | 0.017 | -0.025 | 0.488 | 1.766 | 0.077 |
| | Moser et al. (2017) | 0.541 | 0.284 | 0.081 | -0.015 | 1.097 | 1.906 | 0.057 |
| | Olakanmi & Gumbo (2017) | 1.098 | 0.274 | 0.075 | 0.562 | 1.635 | 4.010 | 0.000 |
| | Huang et al. (2016) | 0.919 | 0.178 | 0.032 | 0.569 | 1.269 | 5.151 | 0.000 |
| | Bajar-Sales et al. (2015) | 1.935 | 0.310 | 0.096 | 1.327 | 2.542 | 6.240 | 0.000 |
| | Chen et al (2015) | 0.083 | 0.235 | 0.055 | -0.377 | 0.543 | 0.353 | 0.724 |
| | Lozada (2015) | 1.683 | 0.211 | 0.045 | 1.268 | 2.097 | 7.958 | 0.000 |
| | Fouche (2013) | 0.358 | 0.139 | 0.019 | 0.085 | 0.631 | 2.575 | 0.010 |
| | Marée et al. (2013) | 0.399 | 0.241 | 0.058 | -0.074 | 0.871 | 1.653 | 0.098 |
| Fixed | | 0.652 | 0.064 | 0.004 | 0.527 | 0.776 | 10.263 | 0.000 |




To find out if there exists a significant difference between the effect sizes of the studies according to the education level of the students exposed to metacognitive instruction as well as scientific discipline studied, a moderator analysis was employed as reflected in Table 4.

Table 4. Moderator Analysis on the Level of Education and Scientific Discipline Studied

| **Moderator Variables** | ***k*** | ***ES*** | ***SE*** | ***Variance*** | ***95% CI*** | | ***Z*** | ***p*** | ***Heterogeneity*** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **Lower** | **Upper** | | | **Q** | **df (Q)** | **P** |
| **Level of Education** | 10 | 0.739 | 0.140 | 0.020 | 0.464 | 1.014 | 5.267 | 0.000 | 69.674 | 9 | 0.000 |
| Elementary | 1 | 1.049 | 0.282 | 0.079 | 0.497 | 1.601 | 3.724 | 0.000 | 0.000 | 0 | 1.000 |
| Secondary | 8 | 0.649 | 0.068 | 0.005 | 0.516 | 0.782 | 9.582 | 0.000 | 66.580 | 7 | 0.000 |
| Tertiary | 1 | 0.399 | 0.241 | 0.058 | -0.074 | 0.871 | 1.653 | 0.098 | 0.000 | 0 | 1.000 |
| **Scientific Discipline** | 10 | 0.794 | 0.181 | 0.033 | 0.439 | 1.149 | 4.379 | 0.000 | 69.674 | 9 | 0.000 |
| Biological Science | 2 | 0.707 | 0.325 | 0.106 | 0.071 | 1.344 | 2.178 | 0.029 | 3.078 | 1 | 0.079 |
| Physical Science | 8 | 0.833 | 0.218 | 0.048 | 0.405 | 1.261 | 3.813 | 0.000 | 69.674 | 9 | 0.000 |

Evidently, there is a significant difference in the effect size of the individual studies if grouped according to the students' level of education and the scientific discipline studied ($p<0.05$). With regards to the students' level of education, it was revealed that metacognitive instruction had a larger effect to elementary level (ES=1.049) than that of the secondary (ES=0.649) and tertiary level (ES=0.399). Meanwhile, it was found out that metacognitive instruction had a larger effect in Physical Science (ES=0.833) than in Biological Science (ES=0.707). These results can be attributed to the heterogeneity of studies conducted at the secondary level ($p<0.05$) and in physical science ($p<0.05$). To shed light on different metacognitive strategies employed in each study, individual studies were analyzed according to which specific metacognitive strategy was used. This analysis was based on the previous analysis of metacognitive instruction by Zohar and Barzilai (2013).

As shown in Table 5, there were various metacognitive strategies employed by the individual studies included in the meta-analysis. It can be noted that 40% of the studies have integrated the use of ICT with metacognitive instruction and metacognitive prompts. A small percentage of the studies have used student-led metacognitive discussions, concept mapping, metacognitive writing, and practice and training.

Table 5. Metacognitive Strategies Employed by Individual Studies

| Metacognitive interventions and/or strategies | Frequency | Percentage |
|---|---|---|
| **ICT use for metacognitive instruction** | 4 | 40% |
| **Metacognitive prompts** | 4 | 40% |
| **Student-led metacognitive discussions** | 2 | 20% |
| **Concept mapping** | 2 | 20% |
| **Metacognitive writing** | 1 | 10% |
| **Practice and training** | 1 | 10% |

Note*: Studies could appear in more than one category.*

## Discussion

The results of this meta-analysis involving 1,079 students from different levels of education and scientific disciplines indicated the effectiveness of metacognitive science instruction in maximizing student learning achievement. This result was statistically determined by analyzing ten (10) empirical studies from the year 2013 to 2018. Based on the analysis, the overall effect size 0.808 is interpreted as having a "large and positive effect." Since there was no meta-analysis conducted before that only focused on student achievement in learning science, this result initially establishes metacognitive instruction as an effective pedagogy in science education in terms of improving student achievement.

Though the overall weighted effect size is 0.808 has been found out to have a large and positive effect to student learning achievement, the heterogeneity test analysis resulted to be significant ($p<0.05$) which suggests that studies included in the meta-analysis did not share a common effect size. More specifically, those studies that had large and positive effects were that of Bajar-Sales *et al.* (2015), Lozada (2015), Olakanmi and Gumbo (2017), Lai *et al.* (2018), and Huang *et al.* (2016) with ES of 1.935, 1.683, 1.098, 1.049 and 0.919, respectively.

Moser *et al.* (2017) got a medium effect of 0.541. Meanwhile, studies of Marée *et al.* (2013), Fouche (2013) and Dike *et al.* (2017) obtained ES of 0.399, 0.358 and 0.231, respectively, had small effects.

Another result of this meta-analysis revealed that metacognitive science instruction had positive effects on learning achievement whichever level of education the students are in. In detail, the combined effect sizes of the studies conducted at the elementary, secondary and tertiary level were 1.049 (large), 0.649 (large) and 0.399 (medium), respectively. This suggests that metacognitive instruction can be effectively utilized and implemented whether students are at the elementary, secondary or tertiary level. Though a medium effect was calculated at the tertiary level, it is not enough to generalize this effect since there was only one study conducted herein (Marée *et al*., 2013).

Similarly, moderator analysis showed that metacognitive science instruction had positive effects on student learning achievement when grouped according to the scientific discipline studied. In fact, it had large effects on both disciplines, Biological Science and Physical Science, with effect sizes of 0.707 and 0.833, respectively. This only means that metacognitive science instruction can be effectively used in teaching scientific concepts, be it in Physical Science or Biological Science. From the findings, it was observed that were more studies that involved learning Physical Science concepts (N=8) than Biological Science concepts. It was also found out that no study examined metacognitive instruction in learning Earth Science concepts. This result is in contrary to the meta-analytic review of Zohar and Barzilai (2013) wherein the most studied scientific discipline then was Biology, followed by Physics, Chemistry, and Earth Science.

As described by Zohar and Barzilai (2013), metacognitive instruction refers to the use and integration of specific and explicit metacognitive activities in classroom instruction. Based on the analysis, there were various metacognitive strategies employed by individual studies. Specifically, it can be noted that 4 out of 10 studies integrated metacognition with the use of ICT (Lai *et al.,* 2018; Moser *et al.,* 2017; Huang *et al.,* 2016; Marée *et al.,* 2013). For instance, in the study of Lai *et al. (*2018) with ES=1.049, a learning management system was developed consisting of inquiry learning system, a self-regulated learning system, a teacher management system, and a database. In here, metacognition is found to be integrated into the self-regulated learning system where students set their goals for learning and evaluate their learning performance before and after their courses. In the teacher management system, the teacher gives comments corresponding to a student's inquiry performance and self-regulation. Subsequently, students make reflections after reading the comments and prepare the next goal setting for the succeeding science inquiry. From these studies that integrated metacognition with the use of ICT, Moser *et al.* (2017) and Huang *et al.* (2016) specifically utilized computer simulations in learning Physics. Apart from the use of computer simulations, Huang *et al.* (2016) also infused metacognitive prompts to better improve simulation-based Physics learning. Metacognitive prompts are questions, cues, or probes that are introduced in writing, by the teacher, by student peers, or in an ICT environment (Zohar and Barzilai, 2013). Other than Huang *et al.* (2016), there were several studies that utilized the use of metacognitive prompts to foster metacognitive thinking among students (Moser *et al*., 2017; Bajar-Sales *et al.* (2015); Chen *et al.*, 2015).

Having the largest effect size of 1.935, the study of Bajar-Sales *et al.* (2015) did not only utilize metacognitive prompts in teaching Chemistry concepts but also integrated metacognitive writing and concept mapping in the Predict-Explain-Observe-Explain (PEOE)-based learning tasks they developed. These learning tasks are actually experiments that contained preliminary questions or prompts that required students to predict prior to doing the experiments and write their answers or explanations by assessing their prior knowledge. Following this, students carry out the procedures of the experiment and do their observations. Then, they compare their predictions with the data they have gathered. Students are also tasked to share their ideas based on the experiment with the other students. Afterward, they are asked to summarize their acquired ideas through concept mapping and writing reflective journals. Results showed that these students achieved more meaningful and better learning in chemistry. Moreover, the calculated large effect size of Bajar-Sales *et al.* (2015) can be attributed to the different strategies utilized by the students in approaching learning tasks which include cooperation, background knowledge, communication, and focus on goals. Recent studies have shown that metacognitive regulation observed at the individual level can be further enhanced through collaborative problem-solving activities (Mathabathe & Potgieter, 2017). This notion can be drawn from Vygotsky's theory of proximal development that an individual's ability to complete a task can be enhanced with peer collaboration. Similarly, Moser *et al.* (ES=0.550) also employed metacognitive scaffoldings in the form of training and prompts in simulation-based Physics learning. Their analyses indicated that metacognitive prompting, in particular, has a positive effect on learning with simulations, provided that learners use prompts in an appropriate manner.

Other than metacognitive prompts, there were several studies that relied on student-led metacognitive discussions which were led and managed by the students, themselves (Lai *et al.*, 2018; Dike *et al*., 2017; Fouche, 2013). These activities were usually done in planned structured or semi-structured ways that were intended to facilitate metacognitive thinking. Particularly, their study employed the thinking aloud metacognitive strategy which helped students in organizing and enhancing their thoughts while working especially during problem-solving. In here, students need to think critically and verbalize and describe their thinking as well as examine their current thinking by asking the following questions *e.g.* What do I already know about this topic? Is there any relationship between this topic and my knowledge of other subjects? How do I tackle this problem if it appears in my test or final examination? (Dike et al., 2017).

Another study which integrated the use of concept mapping and other visual representations with metacognition was that of Maree *et al.* (2015). With an effect size of 0.403, they tested the effectiveness of self-regulated science learning through multimedia-enriched skeleton concept maps. In doing the concept maps, students were guided with collaboration scripts which guide them critically analyzing, elaborating, and explaining the meaning of the concept to foster meaningful science learning and retention. Result showed a statistically significant, meaningful understanding and retention of concepts in a biomolecule unit in Chemistry.

Finally, Olakanmi and Gumbo (2017) incorporated a self-regulation learning (SRL) model in learning chemistry. In here, students underwent SRL training particularly on forethought (goal setting), performance (self-monitoring) and self-reflection. With this said, students with SRL training had significantly higher achievement and higher metacognitive self-regulation than those students who did not receive any SRL training

(ES=1.113).

However, out of the ten (10) studies, the study of Chen *et al.* (2015) got "no effect" (ES= 0.084) where goal setting and planning was integrated into a microcomputer-based laboratory (MBL). Both groups were exposed to MBL but the experimental group was exposed to metacognitive scaffolding to promote goal setting and planning. Based on the results of the study, both groups improved significantly, thus, no larger effect size was calculated which could also be linked to the short duration time of the implementation of such intervention.

**Limitations of the Study**

The number of studies included in this meta-analysis can be considered small. However, the result can be considered valid since the researcher had difficulty looking for empirical studies involving the effectiveness of metacognitive instruction. This is why a small number of studies were included in the meta-analysis. Aside from this, the variables that might have influences on the effects of metacognitive instruction on student learning achievement must also be studied. These include the duration of the implementation of the metacognitive strategy and the students' various backgrounds. These variables were not included in the analysis because some studies were not able to report them explicitly.

## Conclusion and Recommendations

A total of ten (10) empirical studies on metacognitive science instruction and its effects on student learning achievement were meta-analyzed. The total number of sample both in the control and experimental group was 1,079 students from various levels of education. Based on the meta-analysis result, the overall effect size of 0.808 revealed that metacognitive science instruction has a significantly large and positive effect on student learning achievement. This result establishes the effectiveness of the use and integration of different metacognitive strategies to improve student learning. Although moderator analysis showed that there was a significant difference in the effect sizes of the individual studies when grouped according to the student's level of education and the scientific disciplines studied, the obtained positive and large effect sizes suggest that metacognitive instruction can be effectively utilized and implemented whether students are at the elementary, secondary or tertiary level, be it Biological or Physical Science. Further, the metacognitive strategies employed by individual studies are mostly found to be integrated with the use of ICT mainly metacognitive prompts; other practices were student-led metacognitive discussions, concept mapping, metacognitive writing, and metacognitive practice and training.

Since metacognitive science instruction has a positive impact on student learning achievement in science, teachers should continuously integrate and implement the use of metacognition in their teaching practices. Teachers should be provided with professional development training programs about metacognition and its impact on student learning. Most importantly, teachers must be well adept at effective implementation and integration of metacognition in classroom instruction with the aim of improving student learning.

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