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Metacognition Skill Exploration in Six Developing Countries: A Systematic Literature Review Towards Advancing Learning Quality

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Abstract

This study was conducted to analyze the literature related to the role of metacognition in science learning in six developing countries in an effort to improve the quality of learning. The objectives of this study include: 1) to explore the role of metacognition as a learning strategy applied to science learning; 2) to explore the role of students' metacognition skills in science learning. 3) knowing the role of metacognition in science learning to improve the quality of science learning. The benefit of this research is to facilitate researchers in obtaining literature that is suitable for analysis related to the research title to be carried out by researchers. The method of this research is to use the Systematic Literature Review (SLR) method, which consists of 4 steps, including identification, screening, eligibility, and inclusion. The results of this study are obtained from as much as six pieces of literature that are suitable for analysis. The results of the analysis of this article include: 1) Some parts of the country applying metacognition strategies in science learning are proven to be able to improve 21st century skills and also concept understanding. 2) Some parts of the country apply several innovative learning models that are able to improve students' metacognition skills. The level of education that is widely used in the research studies reviewed is 40% at the junior and senior high school level and 20% at the university level. It is expected that this research will emphasize common patterns, challenges, and opportunities in using metacognitions skills in various science education contexts by gathering information from various relevant studies.

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INTRODUCTION

Enhancing learning standards requires the development of metacognitive skills. This entails introducing metacognitive instruction into the curriculum to guarantee its applicability, teaching students the advantages of these exercises to motivate them to work harder right away, and offering continual training to guarantee the seamless and continuous application of metacognitive exercises (Azevedo, 2020). An overview of the significance of enhancing teachers' preparedness for future learning can be obtained from the literature review on the subject of metacognition abilities. However, teachers must also comprehend and encourage metacognitive training for themselves.

In developing countries, science education plays an important role in steering the progress of science and technology amidst the various hurdles that exist around the world (Triana et al., 2020). In this study, several regions from 5 developing countries and 1 country in total were studied for the role of metacognition applied in the learning process, namely 4 regions of Capricorn, Phoenix, Tongaat, and KwaZulu-Natal in South Africa, 2 regions of Malang and Klaten in Indonesia, 1 region of Jiangsu in China, 1 region of Delta in Nigeria, 1 region of Addis Adaba in Ethiopia, and all high school students in Malaysia.

In this process, metacognition skills have been recognized as an essential component of effective science learning. The aforementioned competencies, including self-awareness, self-control, and capacity for introspection, serve as a very important foundation for students' scientific progress. Metacognition skills play a role in regulating and controlling students' cognitive processes in learning and thinking, and can improve students' critical thinking skills and learning outcomes in science learning (Gunmah, 2020). Metacognition skills involve awareness and control of one's thinking process, which has a significant effect on learning outcomes in science education (Willison et al., 2023)

The development of effective strategies for students is also influenced by metacognition skills to acquire, understand, and apply scientific concepts and skills in science learning. (Durukan et al., 2020). Research on metacognitive skills has the potential to influence how science curriculum and learning practices are created in developing countries. Curriculum developers can create learning materials and strategies that teach metacognitive skills by understanding how students learn and the methods they use to organize their learning (Osturk et al., 2020).

This can help students become more independent and improve their academic performance. In addition, research on metacognition can inform teacher training programs and help teachers incorporate metacognitive approaches into their teaching methods. Ultimately, this can lead to more efficient science learning methods in developing countries, which will overall improve student learning outcomes. Therefore, in order to enhance the caliber of learning, more study on the mapping of metacognitive techniques and metacognitive skills is required (Zohar & Lustov, 2018). In order to manage complicated demands and prepare for the future, students must develop metacognitive skills, according to the Organization for Economic Co-operation and Development (OECD).

Emphasizing the role of metacognitive skills in science learning in developing countries, the main objective of this study was to conduct a systematic and thorough review of the literature. The main objective of this step was to collect and synthesize information from various sources of scientific literature. One of the main benefits of this research is to provide an in-depth understanding of how metacognition skills can play an important role in improving the quality of science learning in developing countries. It is expected that this research will emphasize common patterns, challenges, and opportunities in using metacognition skills in various science education contexts by gathering information from various relevant studies. This research not only provides comprehensive information, but also allows people to understand and direct attention to important elements and helps in the creation of more efficient educational approaches in developing countries. Therefore, this research is expected to be an important foundation for education stakeholders to make evidence-based decisions and policies. It can bring about major

changes and make a significant contribution to improving science education in developing countries.

METHODS

The research method used in this study is a systematic review using the Preferred Reporting Items for Systematic Reviews and Meta-analyses method (Kitchenham, 2004). Therefore, conducting a systematic literature review will facilitate researchers by systematically identifying journals in accordance with predetermined procedures. The stages of this research method are:

Determining literature with inclusion criteria and exclusion criteria

A crucial stage in conducting research or creating a literature review is choosing the appropriate literature, which can guarantee that the analysis that is produced has a high level of relevance, credibility, and informativeness. The process of screening literature involves using inclusion and exclusion criteria, which aid in locating relevant literature for the research question or objective of the literature review. Setting inclusion criteria is crucial for managing the deluge of available material as well as ensuring the validity and quality of the analysis's conclusions in some cases. By using inclusion criteria, the researcher can narrow the scope of the search to only include literature that is directly relevant to the research question, the methodologies employed, and a given time period. Consequently, it might be seen as a crucial first step. The following table provides an explanation of the exclusion and inclusion criteria indicators.

Table 1. Inclusion and exclusion criteria

Inclusion criteria	1. Searchable articles published in 2019-2023 2. Research topics around metacognitive skills applied at secondary school to diploma and undergraduate levels. 3. The method of the article to be searched is quantitative
Exclusion criteria	1. Literature from research articles 2. Literature from publish or perish and smantic scholar 3. The research studies come from research conducted in developing countries 4. The research study was conducted in 2019-2023

After the inclusion and exclusion criteria are determined, the next step is the selection of articles to be reviewed.

Literature screening

This stage of literature screening ensures that the studies included in the analysis are of the relevance and quality required to answer the research questions or achieve the objectives of the literature review. This helps to produce a more accurate and meaningful analysis. Literature screening is divided into four stages: identification, screening, eligibility, and included. At the identification stage, the literature articles related to metacognition in learning were searched through PoP and Smantic Scholar. Then, at the screening stage, articles were selected based on relevant studies discussing metacognition skills in science learning, and the selection process was based on predetermined exclusion criteria. Then, at the eligibility stage, this stage ensures the eligibility of the article study after screening based on the inclusion criteria; the eligible literature is relevant literature and in accordance with the research objectives. And the last stage is included; the included articles meet the predetermined quality and validity criteria of the research and are

considered relevant and in accordance with the objectives of the research or literature review. The act of designating literature as "included" indicates that it adds significantly to our understanding of the subject and promotes the development of a body of knowledge that is in line with the research objectives. All these processes are depicted in the following diagram:

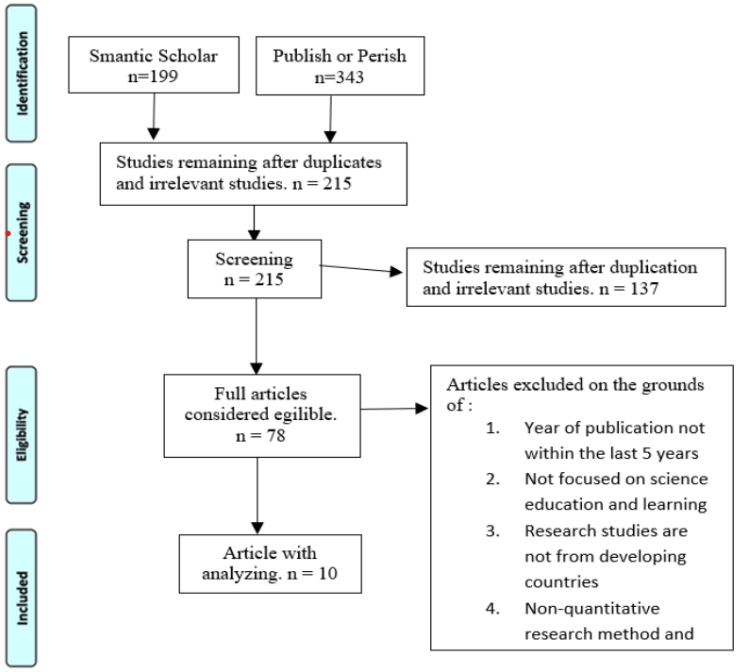

Figure 1. Diagram of The Article Selection Process

RESULTS AND DISCUSSION

Based on the research method using the PRISMA diagram, 199 articles were identified from Smantic Scholar and 343 from Publish or Perish, then 215 journals were obtained from the screening process, and 78 journals were found after the eligibility process. The analysis met the inclusion and exclusion criteria, so ten articles were found to be eligible for analysis regarding the study of the Role of Metacognition Skills in Science Learning in Developing Countries.

Table 2. Analysis of 10 Research Articles on Metacognition Skills in Science Learning

No	Researcher and Year of Research	Title	Research Subject
1	Tsamago, H., & Bayaga, A. 2023	Self-organized learning environments (SOLEs) pedagogy as a conduit to learners' metacognitive skills and conceptual understanding of "S" in STEM: The South African study.	Grade 10 and 11 students in 4 Capricorn District High Schools in South Africa.
2	Retno Wilis, Baskoro Adi Prayitno, Widha Sunarno, Suwanida Anjirawaroj. 2023	Improving students' metacognitive abilities and creative thinking skills through STEM-based in online learning	9th grade students of Ceper State of Junior High School, Klaten Regency (Indonesia)
3	Nagalaxmy Markandan, Kamisah Osman and Lilia Halim. 2022.	Integrating Computational Thinking and Empowering Metacognitive Awareness in Stem Education	Students of Junior High School in Malaysia

4	S. Chee Choy, JoanneSau-Ching Yim,Poh Leong Tan. 2020	A Metacognitive Knowledge, Metacognitive Experience, and Its Effects on Learning Outcomes for Stem and Non-Stem Malaysian	958 STEM students and 1256 non-STEM students in Diploma and undergraduate programs
5	Yating Zeng, Shaohui Chi, Zuhao Wang, Xiaosong Zhuang.2023	Developing And Validating An Instrument to Assess Ninth-Grade Students' Online Metacognitive Skills In Solving Chemistry Problems	Ninth grade students from 2 Junior High Schools in Jiangsu, China.
6	Ronesh Rajcoomar, Olebogeng Nico Morabe, and Betty Breed. 2022.	Effectiveness in Fostering Metacognition: Analysis into the State of Metacognition within South African Physical Science Classrooms with the Aim of Improving Attainment	Grade 11 students and high school science teachers from seven schools in the central districts of Phoenix and Tongaat, KwaZulu-Natal, South Africa.
7	Ozoji, B. Ebele, Iliya, Godiya B., Garba, Saad A. and Isuwa, S. Damjik. 2022	Achieving Gender Equity in Nigerian Basic Science and Technology Classrooms with Metacognitive Skills Package	High school students from 3 schools; city public school, outermost public school, middle public school, Nigeria.
8	Okafor, Sabina Nwakaego, Ajaja, O. P, Agbohgo Roma, T. E. (Ph.D.). 2023	Effect of Metacognitive Instructional Strategy Using PEEDA on Biology Students Achievement in Delta State	high school students from three senatorial districts in Delta State.
9	Habtamu Wodaj, Solomon Belay. 2021	Effects of 7E Instructional Model with Metacognitive Scaffolding on Students' Conceptual Understanding in Biology	Ninth grade junior high school students from 4 schools in Addis Ababa, Ethiopia.
10.	Parlan & Sri Rahayu. 2021	Students Higher Order Thinking Skills in Metacognotive Learning Strategy	2 1st semester Chemistry Education classes, University of Malang, Indonesia

The research results in the article above show that a total of 5 studies focused on metacognition skills as a learning approach and strategy, and 5 other studies focused on the achievement of students' metacognition skills. The percentage of the application of metacognition skills in science learning is as follows.

Figure 2. Application of Metacognition Skills

The Figure 2 shows that metacognition can be used as an approach and strategy in science education and learning. In science learning, strategies are ways to create an engaging, informative and interactive learning environment to achieve 21st century skills.

Metacognitive-based learning strategies have been effectively proven to improve student learning achievement in both urban and rural schools in Nigeria. It is therefore expected that basic science and technology teachers use metacognitive-based teaching strategies to improve students' learning achievement (Ozoji et al., 2022).

Metacognitive learning strategies are also able to facilitate students to develop problem solving skills so that the realm of students' critical thinking skills also increases (Parlan & Rahayu, 2021). Critical thinking abilities can be improved by metacognitive techniques. For instance, metacognitive techniques like planning, observing, and assessing can assist students in recognizing and fixing faults in their reasoning as well as in making better decisions. Analysing and evaluating information helps students reflect on their own thought processes and pinpoint areas for growth, which is another way that critical thinking skills can support metacognitive abilities (Azevedo, 2020).

Another innovative strategy developed is the PEEDA (Prior knowledge, Exploration, Discussion, Dissatisfaction, and Application) metacognitive instructional strategy can significantly improve student achievement in biology lessons. The PEEDA metacognitive instructional strategy emphasizes the active participation of students in constructing their own knowledge and understanding. By incorporating components such as prior knowledge, exploration, discussion, dissatisfaction, and application, the PEEDA approach aims to engage students in their own metacognitive processes, thereby enhancing their cognitive strategies for knowledge acquisition. This student-centered approach aligns with the principles of metacognition and has the potential to positively impact student achievement in biology lessons (Okafor et al., 2023).

The implementation of the 7E learning model with metacognitive scaffolding, which includes metacognitive strategies of planning, monitoring, and evaluating, can help students improve conceptual understanding and minimize misconceptions. This approach can also help students become independent learners who can monitor and use their own knowledge. This model can be very useful for schools that have inadequate facilities (Wodaj et al., 2023).

Aside from being an approach and strategy, a lot of research is done to measure metacognition skills in students. In science learning, students' metacognition skills are very important because it can help them become independent and effective learners. In STEM-based learning studied in Indonesia and Malaysia, the results showed that students' metacognition skills improved after STEM-based learning was implemented. Students' metacognitive skills and conceptual understanding in STEM fields were enhanced by SOLEs pedagogy. STEM-based online learning tools applied to diploma and undergraduate students are able to improve creative thinking and metacognition skills because STEM courses focus on theory and application. Non-STEM courses focus on creative concept development. Malaysian students may face difficulties with teacher-centered learning. Learning outcomes in STEM fields improve if students are more involved in active and collaborative learning.

Given the importance of measuring students' metacognition skills, the need for an assessment instrument to measure students' online metacognitive skills in chemistry problem solving, highlights the need for better educational interventions and future research to explore the relationship between these skills (Zeng et al., 2023). A more thorough understanding of how students apply and grow their metacognition skills online can be obtained through accurate and pertinent evaluation tools, especially when it comes to chemistry problem solving. Better educational interventions that support the development of metacognitive features can be devised with a better understanding of the metacognition skills of students.

From the research methods that have been carried out, it can be reviewed from the research subject to see the effectiveness of the role of metacognition skills at each level of education. The percentage of the application of metacognition skills based on the level of education can be seen as follows:

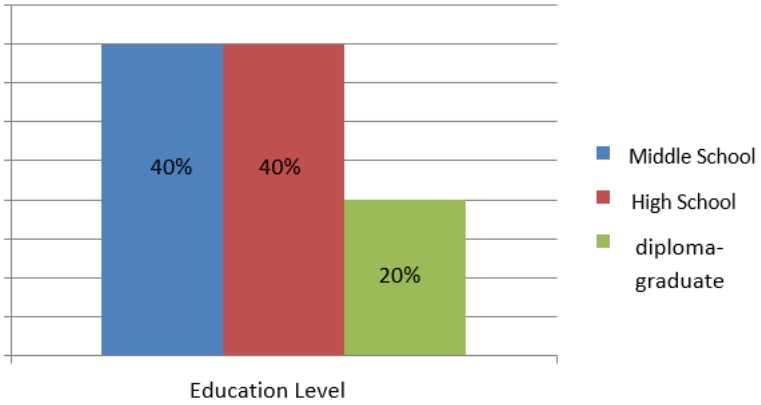

Figure 3. Percentage Chart of Research Subjects

At the junior high school level, metacognition skills are needed to build and improve higher order thinking skills (HOTS). Metacognition skills, the ability to think about thinking, allow junior high school students in their early teens to consider how they come to conclusions and make decisions that will help them develop both now and in the future. Therefore, it becomes an urgency to develop metacognition skills in junior high school science learning.

At the high school level, the urgency of implementing metacognition skills in science learning is related to learning achievement and gender-friendly education. Learning independence and conceptual understanding of science learning in urban and rural areas are significantly improved through metacognition approaches applied to STEM-based learning.

Meanwhile, in Nigeria, there is an issue of gender equality in education in Nigeria, especially at the secondary education level. Although Nigeria's national education system policy states that there are no gender differences in education and that all students have equal opportunities for education, traditional rules and traditions prevailing in Nigeria lead to higher dropout rates for female students. Improving metacognition skills or learning with metacognition strategies can significantly prove that there is no significant difference in learning achievement between male and female students. This can be used as a strong reason to organize gender-friendly education and erode the issue of gender equality in education (Enyioko, 2021)

Metacognitive skills are very important for college students because it helps them become more effective students. Metacognition is the ability to think about one's own thinking and learning processes, which can help students in critical thinking, problem solving, and decision making (Anthonysamy, 2023). In addition, research has shown that students with strong metacognitive abilities are more likely to achieve better academic results and improve their mental resilience.

Furthermore, metacognitive ability can help students become self-aware problem solvers and take control of their learning. By using metacognition while learning, students can be strategic in their approach, considering what they already know, what they need to work on, and how best to learn new material. Therefore, developing metacognitive skills is essential for students at university.

CONCLUSION

Systematic literature review research using the PRISMA method provides a strong methodological foundation to ensure validity, transparency, and accountability in literature synthesis. This method helps researchers analyse that science education and learning can benefit from the application of metacognition as a method and strategy. In numerous developing countries, a variety of metacognition-based tactics have been shown to be successful in raising student learning achievement. Furthermore, new approaches that have the potential to enhance students' conceptual

understanding and lessen misconceptions include the PEEDA metacognitive instructional technique and the 7E learning model with metacognitive assistance. Metacognition research is crucial for measuring students' metacognition skills, in addition to learning methodologies and strategies. According to the study's findings, using online resources and implementing STEM-based instruction helped students' metacognition abilities. In response to the need for comprehensive research, improved educational interventions, and evaluation of students' metacognition abilities in online chemistry problem solving

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