Fostering Disciplinary Literacy: *Mathematics Teaching Strategies in Early Childhood Education*

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***Abstract*— Fostering disciplinary literacy skills from an early age is essential to prepare young children for educational success in the future. This study explores teaching strategies to develop disciplinary literacy, particularly in mathematics within early childhood education (ECE). Drawing on a literature review approach, this paper integrates three key frameworks: the Developmentally Appropriate Practice (DAP) by the National Association for the Education of Young Children (NAEYC), the 4Es heuristic model by Moje (2015), and the eight mathematical practices outlined in the Common Core State Standards (CCSS). The findings highlight three main strategies that considered effective in promoting disciplinary literacy in mathematics: (1) involving children with their social rich learning environment; (2) implementing play-based learning to foster cognitive, linguistic, and social development; and (3) facilitating conversation-rich instruction to encourage problem solving and mathematical reasoning. These strategies are essential in scaffolding children's abilities to read, write, and comprehend mathematical concepts within disciplinary contexts. Additionally, introducing these practices in early education contributes to build a strong academic foundation for children and promotes critical engagement with disciplinary knowledge in later years.**

Keywords: disciplinary literacy, early childhood education, mathematic.

I. INTRODUCTION

Fostering disciplinary literacy skills from an early age is important to prepare young children for educational success in the future. This is because disciplinary literacy emphasizes the special abilities, knowledge, and practices used by experts in a particular disciplinary field that focuses on how to think, read, write and solve problems in a particular subject of study (Shanahan & Shanahan, 2012). It involves advanced literacy instruction within content areas like science, mathematics, and social studies (Shanahan & Shanahan, 2012). In the Mathematics discipline, children sometimes find it difficult to understand some vocabulary or do problem-solving. In the Indonesian context, studies have revealed various challenges encountered by student in Jambi, where the students faced some difficulties in mathematics, including challenges in comprehending and using basic mathematical principles, and also difficulties in accomplishing activities using direct mathematics (Maryati et al., 2023).

Similarly, Sidik et al (2021) also shows that many students aged 6-8 years at State Elementary Schools in Parungponteng District, Tasikmalaya, have difficulty understanding addition and subtraction operations. Apart from that, in his previous research, Sidik (2016) also found that many students had difficulty understanding questions regarding solving contextual problems related to integers. This is due to a lack of instilling specific literacy disciplines that enable children to fully understand and explain mathematics since early childhood education (ECE).

ECE is an ideal environment for introducing disciplinary literacy early through a simple classroom learning approach as a basis for children's understanding (Mongillo, 2017). This skill is really needed in children's literacy development, their successful education, and more than that, it is very necessary

in their economic success and social participation in this modern society. Therefore, the role of teachers is very much needed to build these literacy skills. Teachers must understand what teaching strategies are needed to foster disciplinary literacy, especially in the field of mathematics. With this strategy, teachers can effectively scaffold and equip children with skills and competencies to understand texts as well as develop their critical thinking, particularly in the discipline of mathematics.

This paper will elaborate more deeply on teaching strategies that can be used by teachers to foster disciplinary literacy in mathematics in early childhood education. By delving into this strategy, this research will guide teachers with knowledge and prepare them for effective teaching and learning. It also will help teachers to engage students in mathematical activities in literacy disciplines, particularly in early childhood education.

1. Disciplinary Literacy and Its Important

Literacy experts have discussed a lot regarding disciplinary literacy and its importance in literacy development. Shanahan and Shanahan (2012) explained that disciplinary literacy is an emphasis on the knowledge, abilities, and practices used by experts in a particular disciplinary field. It focuses on how to think, read, write, and solve problems in a particular subject of study. Disciplinary literacy involves advanced literacy instruction within content areas like science, math, and social studies. This opinion is similar to Moje (2015) that disciplinary literacy refers to a particular disciplinary field, such as history, mathematics, or arts. He explained that the scope of disciplinary literacy to encompass thought processes unique to their fields. It focuses on the specific ability to engage students' cognitive, semiotic, and social practices within content areas (Fang & Coatoam, 2013).

Furthermore, Gardner (2008) argues that developing disciplinary literacy is essential to becoming an educated person. To properly absorb, analyse, and interpret information, the reader or listener must be aware of the perspective that was used to collect, evaluate, and disseminate the material. It can foster critical thinking and analytical skills for students in receiving, understanding, and evaluating information (Shanahan & Shanahan, 2012). Discipline-specific literacy aims to identify all relevant differences in reading and writing between disciplines and provide strategies for assisting students in effectively navigating these literacy elements of their studies (Shanahan & Shanahan, 2012). In another research, Moje (2015) also said that disciplinary literacy will provide all students the opportunity to gain an understanding of how disciplines work and to evaluate the reliability of disciplinary knowledge. He explained that disciplinary literacy practices can foster students' basic understanding and knowledge.

Disciplinary literacy practices might also contribute to what Erickson (2014) refers to as "rational dependence" or the reasoned reliance of knowledge. Moreover, Fang and Coatoam (2013) also explained that the aim is to create critical thinkers who can understand and analyse knowledge, preparing students to be more than simply subject matter specialists but also people who can evaluate and engage with complicated concepts. In addition, Moje (2015) also explains that by using disciplinary language and literacy tools to explore important issues, it will enhance students' curiosity and their interest in learning from a fully developed disciplinary literacy practice. It provides a strong emphasis on inquiry within a community of practice and motivates students to involve themselves in disciplinary practices with a passion and curiosity.

2. *Disciplinary Literacy in Mathematics*

One of the subject areas in disciplinary literacy is mathematics. Several studies have been found the topic that focus on disciplinary literacy in mathematics. For instance, research by Hilman (2014), said that diciplinary literacy in mathematics refers to the specific communication techniques and customs that are unique to a field. This includes comprehending and efficiently using mathematical texts, symbols, and language. The communication is not only in solving problems but also communicating arguments, reasoning, and solutions clearly and precisely. It emphasises the particular ways mathematicians utilise language and solve problems, as well as how they think, speak, and comprehend their subject (Mongillo, 2017).

Furthermore, Shanahan and Shanahan (2008), in their research focuses on two of their most important techniques during think-alouds that the mathematicians highlighted, namely rereading and close reading. Mathematicians explained that, in their vocabulary, Mathematics is very specific, unlike other fields. Even "function" words were important. For example, "'*The*' has a very different meaning than '*a*'. However, students frequently try to skim math texts in order to get the main concept or substance, yet close reading is necessary in order to understand this type of material. Reading math texts demands precision in meaning, with each word required to be comprehended in relation to its specific meaning (Shanahan and Shanahan, 2008).

In depth, Hilman (2014) in his research highlights eight mathematical practices based on The Common Core State Standards (CCSS) that represent the standards and ideals of the mathematical community, such as *problem solving,* by engaging with complex problems presistently and creatively, *abstract reasoning*, by employing quantitative reasoning and abstract thinking to communicate mathematically, *constructive arguments*, by developing and evaluating thinking through dialogue, *modeling*, by connecting mathematics to real-world problems and other dicipline, *strategic tools*, by effectively applying mathematical techniques and comprehending data representation, *precision*, by utilising mathematical language to communicate with precision and clarity, *structure use*, by understanding and implementing numbers' inherent properties in rule-based systems, and *pattern recognition*, by identifying and utilising recurrent patterns in reasoning.

3. *Disciplinary Literacy Teaching*

Studies have provided methods or strategies that teachers can use in implementing disciplinary literacy teaching. According to Moje (2015) there are four frameworks designed to support disciplinary literacy teaching. These four frameworks are called the 4Es Teaching Heuristic, namely *Engage Elicit/Engineer, Examine,* and *Evaluate*. *Engage*, where teaching involves students in scientific discipline practices, such as discussions and inquiries, to learn more deeply about the scientific discipline. *Elicit/Engineer*, by extracting and cultivating students' knowledge, abilities, and practice, required to participate meaningfully in disciplinary procedures. *Examine*, by promoting in-depth examination of terms, expressions, and symbols used in the field as well as the discipline's unique language usage. *Evaluate*, which asks students to determine whether and how disciplinary language is beneficial, with a focus on the navigational aspect of disciplinary literacy.

In the context of early childhood education (ECE), one approach that teachers can take to support disciplinary literacy is developmentally appropriate practice (DAP) (National Association for the Education of Young Children (NAEYC), 2009). Research by Mongillo (2017) highlights that DAP integrates theories of learning and child development with knowledge of children's social and cultural environments and individual needs, interests, and talents.

It encompasses a set of 12 guiding principles that directs the work of early childhood teachers and impacts their methods for instructing and learning with children from birth through age 8 (p.2). According to the NAEYC, the 12 principles of child development and learning, are:

1. "All areas of development and learning are important,
2. Learning and development follow sequences,
3. Development and learning proceed at varying rates,
4. Development and learning result from an interaction of maturation and experience,
5. Early experiences have profound effects on development and learning,
6. Development proceeds towards greater complexity, self-regulation, and symbolic or representational capacities,
7. Children develop best when they have secure relationships,
8. Development and learning occur in and are influenced by multiple social and cultural contexts,
9. Children learn in a variety of ways,
10. Play is an important vehicle for developing self-regulation and promoting language, cognition, and social competence,
11. Development and learning advance when children are challenged,
12. Children's experiences shape their motivation and approaches to learning"

(Mongillo, 2017).

Based on previous research related to disciplinary literacy and its importance, disciplinary literacy in mathematics, and disciplinary literacy teaching in general and in early childhood education, the author believes that discussions related to disciplinary literacy in mathematics, particularly in ECE is very important. Furthermore, discussions related to mathematics in disciplinary literacy are usually only discussed at the elementary, middle or high school student level. In fact, it is very important to introduce disciplinary literacy in mathematics from an early age. Therefore, this research will discuss in more depth what teaching strategies teachers can use to foster disciplinary literacy in mathematics, particularly in early childhood education.

II. METHODS

This research uses a qualitative literature review approach to explore the teaching strategies for fostering disciplinary literacy in mathematics by collecting and synthesizing the existing literature and theoretical research focusing on teaching strategies for fostering disciplinary literacy in mathematics, particularly in ECE. The literature search was conducted through the Scopus database as a database recognized for its high-quality and comprehensive coverage of peer-reviewed academic publications. The researcher chose to focus solely on Scopus to ensure the credibility and reliability of the review findings. To ensure the relevance of the source, the following keywords were used in various combinations, such as ("disciplinary literacy" OR "mathematics") AND ("early childhood" OR "preschool") AND ("teaching strategies" OR "instructional practices"). The inclusion and exclusion criteria in the selection of literature are described in the following table.

Table 1. Inclusion and Exclusion Criteria in Selecting Literature

Criteria	Inclusion	Exclusion
Database	Scopus indexed articles	Non-Scopus database articles
Publication Year	2013-2024	Article published before 2013
Article Type	Empirical or theoretical research discussing teaching strategies or instructional practices	Editorials, opionon, or articles with no significant data or analysis
Study Focus	Disciplinary literacy in mathematics in the context of early childhood or preschool education	Studies that focus not on early childhood education
Availability	Open access article	Non open access article

After the sorting process based on the criteria above, a total of 18 articles met the criteria and were fully analyzed. In analyzing teaching strategies for fostering disciplinary literacy in mathematics in ECE, researcher use a thematic approach by integrating several theoretical frameworks such as the Developmentally Appropriate Practice (DAP) approach by the National Association for the Education of Young Children (NAEYC) and the 12 principles, 4 frameworks by Moje (2015) in disciplinary literacy teaching, and 8 mathematical practices based on The Common Core State Standards (CCSS). By synthesizing these frameworks, the study reveals repeatable and evidence-based strategies that align with child development theory and disciplinary literacy goals in early mathematics education.

III. RESULT AND DISCUSSION

There are several teaching strategies for fostering disciplinary literacy in mathematics in early childhood education, such as:

3.1 Engaging Children with Social Environment

One foundational teaching strategy for fostering disciplinary literacy in mathematics in ECE is actively engaging children with their social environment. Social interaction plays an essential role in fostering cognitive and linguistic development, particularly in supporting children's abilities to reasoning, communicating, and do a problem solving. By involving children with the surrounding environment, it will help children to use their skills in interacting and practicing their responsibilities, both with teachers and their friends. These interactions can take the form of conversations, discussions, or questions that can develop children's communication skills and critical thinking. This strategy aligns closely with the first principle in the 4Es Teaching Heuristic by Moje (2015), namely *Engage*, which emphasizes the importance of engaging and involving students with inquiries or discussions related to scientific discipline. For instance, involving students in question-and-answer sessions, group conversations, and collaborative problem-solving activities to helps them to build the foundational language and reasoning skills needed for mathematical literacy. Furthermore, Shanahan and Shanahan (2014) also emphasize that many disciplines, particularly in mathematics require teamwork and the capacity to communicate effectively both in orall or written forms. Therefore, fostering children's social engagement and their surrounding environment can supports their understanding regarding a scientific discipline.

Moreover, this strategy also grounded in the Developmentally Appropriate Practice (DAP) principles, established by the National Association for the Education of Young Children (NAEYC), specifically in the first principle, namely *"All areas of development and learning are important"* and the eighth principle, namely *"Development and learning occur in and are influenced by multiple*

social and cultural contexts" (NAEYC, 2009). The first principle emphasize that all areas of children's development and learning are important. It shows the interconnectedness of cognitive, social, and emotional development, indicating that mathematics learning is not isolated from these domains, but is shaped by them. The eighth principle shows that social contexts, such as children's family, friends, and classroom, can shape their experiences, understanding, and perceptions of scientific disciplines, including mathematics. In the Indonesian context, studies have found that children's approaches to mathematical problem-solving are often shaped by their surrounding environments and their cultural practices.

Children's familiarity with numerical concepts, patterns, spatial understanding, and problem solving often emerges from their routine experiences with their environment, such as helping parents with housework, shopping at traditional markets with parents, and participating in religious or cultural ceremonies (Rahmawati & Widodo, 2023; Wulandari et al., 2024). Apart from that, teachers and early childhood classrooms also contribute to shaping children's literacy development. Teachers can leverage this environment by designing activities that support cooperative learning, dialogue, and inquiry-based exploration, all of which contribute to the development of disciplinary literacy in mathematics. By fostering a socially responsive and communicative classroom culture, teachers can help children to connect their language and mathematical reasoning to real-world interactions to support students' deeper conceptual understanding.

3.2 Learning Through Play

Play is widely recognized as one of the important element in early childhood education and serves as a strong method for engaging young children in meaningful learning experiences. According to the tenth principle of Developmentally Appropriate Practice (DAP) by the National Association for the Education of Young Children (NAEYC, 2009), *"Play is recognized as a vital vehicle for developing self-regulation and promoting language, cognition, and social competence"*. This is because play can help students to foster cognitive and verbal abilities, which is consistent with the idea of learning through play (Mongillo, 2017). Play allows children to explore and develop their language skills through role-playing or interactive games with their friends, which can enhance their reasoning and communications. Furthermore, play also contributes students to develop the concentration and creativity needed for literacy and numeracy skills. As study by Segal (2004) that shows, play can fostering childrens' internal mental processes and communication abilities.

In mathematical practice, teachers can create game scenarios that can improve students' thinking and problem solving abilities. As research by Clerkin and Gilligan (2018), teachers can create games by implementing Early Numeracy Activity (ENA), such as counting games, numbers, arranging blocks or construction, card games, or singing counting songs to strengthen children's ability in numerical understanding and recognizing mathematical patterns. Their research shows that through this numeracy activities in ECE has a positive correlation with children's afterward mathematics achievement. Integrating play into mathematics learning aligns with disciplinary literacy goals. It will encourage children to use their mathematical language, symbols, and their reasoning ability in familiar and fun contexts. By engaging children in fun problem-solving scenarios, they begin to think and communicate like mathematicians, laying the foundation for discipline-specific literacy. These activities can enhance key mathematical skills such as pattern recognition, abstract reasoning, and the development of strategic thinking, which are emphasized in the frameworks such as the Common Core State Standards (Hillman, 2014).

3.3 Facilitating Conversation-Rich Instruction

Another strategy that is considered effective in fostering disciplinary literacy in mathematics is creating a classroom environment that involve students in rich and meaningful conversations around disciplinary content (Mongillo, 2017). According to Mongillo (2017), engaging students in dialogue, whether in pairs, small, or big group conversations, can exchange ideas and strengthen their understanding regarding scientific disciplines. In this case, teachers should provide opportunities for students to have conversations related to discipline practices, by giving open-ended questions or creating space for student to reflect on their thought. Students can discuss their learning and ways of thinking with their teachers. In addition to the mathematical material, the teacher may emphasize questions on mathematical practices including identifying patterns, paying attention to the intricacies of problem solution, or promoting persistence in problem solving.

Moje (2015) also provides an overview of conversation-rich environments as the core of disciplinary literacy. He describes a conversation-rich environment as the ability to engage students with content that reflects the construction and communication of knowledge within a discipline. In mathematics subject specifically, this means understanding symbolic representations, using precise terminology, and collaboratively evaluating problem-solving strategies. Through this sustained dialogues, students will begin to adopt the mental habits of mathematicians, such as using their logical reasoning, paying attention to details, and presenting evidence-based argumentation. Furthermore, discussions about mathematical content can enhance the interconnectedness of early childhood development because it fosters not only cognitive development but also linguistic and social competence. Teachers can create classroom environment that promotes both a thorough comprehension of mathematics and the disciplinary literacy skills needed for children's continued success by integrating structured conversations into mathematics learning and instruction.

However, the implementation of strategies to foster disciplinary literacy in mathematics within the context of Early Childhood Education cannot be separated from the contextual challenges faced by teachers in their everyday learning practices. One of the challenges that often occurs is teachers' efforts to create play-based learning or interactive dialogue. In practice, many teachers feel less confident in implementing play-based learning. This hesitation usually occurs because of the limited resources, such as learning materials or teaching aids available that can support fun learning in the classroom (Sidik et al., 2021; Maryati et al., 2023). Furthermore, learning in the curriculum in Indonesia tends to emphasize formal cognitive achievements. This hinders teachers in integrating play-based learning or interactive dialogue in learning. Teachers will more often prioritize curriculum targets so that opportunities to explore creative and meaningful learning are limited (Sidik et al., 2021). Therefore, it is important to provide support in the form of providing adequate learning resources and aligning curriculum standards with learning approaches that are appropriate to child development. (Rahmawati & Widodo, 2023). The aim is that the development of disciplinary literacy in mathematics in early childhood can be implemented effectively, especially in the context of PAUD in Indonesia.

IV. CONCLUSION AND RECOMMENDATION

Fostering disciplinary literacy, particularly in mathematics, is an essential step in supporting children's academic development and lifelong learning. This study highlights that early childhood education (ECE) offers a critical window of opportunity and an ideal environment for introducing early disciplinary literacy, through a simple classroom learning approach as a basis for children's understanding. By integrating theoretical frameworks such as the 12 principles of Developmentally Appropriate Practice (DAP), the 4Es Teaching Heuristic, and the eight mathematical practices from the Common Core State Standards (CCSS), this study revealed three effective strategies to foster

disciplinary literacy in mathematics, such as: fostering learning through social environments, incorporating play-based mathematical learning experiences, and facilitating conversation-rich instruction. These strategies provide young learners opportunities to engage in mathematical thinking and enhance students' abilities and skills in reading, writing and comprehending specific texts, particularly in mathematics. More than that, these approaches not only enhance students' abilities to read, write, and comprehend mathematical texts but also set the foundation for academic confidence and curiosity in future learning stages.

Furthermore, based on these findings, teachers are recommended to implement these strategies in their daily learning from an early age to foster children's disciplinary literacy from an early age. Teachers are also expected to receive training or professional development programs so that they can easily integrate their knowledge of disciplinary literacy and contextualize it in mathematics. In addition, policymakers should design and ensure early childhood curricula that provide space for play, social interaction, and dialogic learning. Future studies could further explore how these strategies are implemented in diverse educational settings and how their effects on long-term learning outcomes in mathematics and other subjects. However, this study is limited to a literature review and does not provide empirical data. This makes the findings of this study conceptual and have not yet been validated through practical implementation, especially in the context of early childhood education in Indonesia. Therefore, further research is expected to continue research that focuses on empirical studies that can ensure that the development of disciplinary literacy in mathematics truly provides benefits in diverse learning environments.

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