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## A Semiotic Project-Based Module to Enhance Early Childhood Numeracy Literacy

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### ABSTRACT

The semiotic-based project module is a learning module that integrates a project-based approach with semiotic theory, focusing on the analysis and understanding of signs, symbols, and meanings within real-world contexts through well-planned projects. The objective of this study is to develop a semiotic-based project module for early childhood education, aiming to utilize signs and symbols through activities that are aligned with children's developmental stages. This study employed a Research and Development (R&D) methodology, adapted from the Thiagarajan model. The stages implemented in this study included: (a) needs analysis, (b) diagnostic assessment, (c) development of the semiotic-based project module, (d) expert validation by a team of experts, (e) implementation of the teaching module through product trials, and (f) evaluation to determine the impact on student learning outcomes and the quality of instruction. The results from the expert validation showed an average validity percentage of 85%, categorized as "very valid." The average percentage of responses from teachers at TK ABA 3 Summersari Jember was 98.46%, indicating a "very effective" category. Observations of children's engagement in semiotic-based project learning activities showed a participation rate of 98%, categorized as "very practical." Based on these findings, it can be concluded that the semiotic-based project module for enhancing early childhood numeracy literacy meets the three product quality criteria—validity, effectiveness, and practicality—and can be considered successful and suitable for implementation.

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## 1. INTRODUCTION

Instructional modules within the Merdeka Curriculum are essential tools that play a critical role in facilitating the implementation of learning activities based on a new educational paradigm (Sari, M, & Febriani, 2024). These modules serve as instructional designs rooted in the Merdeka Curriculum, intended to help achieve learning objectives that align with established competency standards. In this context, instructional modules encompass a variety of components, including materials, media, methods, and guidelines, all of which are systematically and attractively designed to meet the needs and characteristics of learners. The development of instructional modules must take into account the Learning Outcomes (Nugraha, Aziz, & Ibrahim, 2021), which serve as a foundation for formulating specific learning objectives. These objectives are then implemented through the Learning Objective Pathway to support the achievement of the Pancasila Student Profile (Ali & Susilawati, 2024). Furthermore, the development of instructional modules should be aligned with children's developmental stages, aiming to support lifelong learning and generate long-term developmental impacts. By designing instructional modules that reflect these considerations, teachers can create more engaging and meaningful learning experiences that are well-suited to children's developmental levels and individual characteristics (Alfiansyah & Hakiky, 2021).

Semiotics, also known as semiology, originates from the Greek word *sēmeion*, meaning sign (Peirce, 1958). In mathematics education, signs and representations are essential, as abstract mathematical concepts become more tangible when represented through signs. Semiotics, defined as the study of signs, essentially explores the use and interpretation of both visual and verbal symbols (Godzich, Eco, & Nattiez, 1978; Gravells, 2017). These signs can be perceived through various human senses when they form a system of codes that systematically convey information within human activity. Mathematics learning involves the interpretation and transformation of signs to develop mathematical knowledge (Presmeg, Radford, Schubring, & Kadunz, 2016; Christine Wulandari Suryaningrum, Misyana, & Jatmikowati, 2021). On one hand, signs help learners think about the relationship between mathematical concepts and real-world objects; on the other, signs are also products of thought that generate new representations. In the context of early childhood, semiotics refers to the understanding of signs, symbols, and the interpretation of meanings found in everyday life. These signs can take the form of images, words, sounds, gestures, and other sensory cues that carry specific meanings. Each child may interpret these symbols differently, depending on their individual perspectives and experiences (Christine Wulandari Suryaningrum, Munandar, Nurul Imamah, & Khaulida, 2023).

Literacy is broadly defined as the ability to listen, speak, read, and write to communicate effectively (Muttaqin & Rizkiyah, 2022; Robiah, Hermawan, & Hidayat, 2023). Among the six foundational literacies—reading, science, digital, financial, civic, and numeracy—numeracy is essential as it relates to applying numbers in solving real-life mathematical problems (Napfiah, Yazidah, Pebrianti, Budi, & Malang, 2023; Nursyifa & Masyitoh, 2023). Numeracy fosters creative thinking by enabling learners to interpret ideas and understand mathematical concepts in practical contexts. Teachers play a crucial role in guiding students through contextual mathematical problems (Maulida, 2022; Yunanti & Amanda, 2022).

Early childhood education institutions (PAUD) are expected to be accessible resources for literacy development, particularly in addressing learning loss due to the pandemic. These institutions play a vital role in fostering early language and character development while also supporting regional educational initiatives (Direktorat PAUD, 2021). Teachers can stimulate mathematical thinking and critical problem-solving through numeracy-based activities.

A semiotic project-based module is a learning module that integrates project-based learning with semiotic theory, focusing on the analysis and interpretation of signs, symbols, and meanings within real-world contexts through carefully designed projects. In semiotic-based project learning, students do not merely acquire conceptual understanding—they also construct meaning by using and interpreting signs and symbols to solve everyday problems through creative project activities. The semiotic project-based module for early childhood education aims to utilize signs and symbols through activities that are

developmentally appropriate. At an early age, children learn best through observation, direct experience, and creative physical activities. Therefore, teachers must design instructional modules that actively engage children in ways that are both enjoyable and suited to their level of understanding. This module offers young children opportunities to explore the world through signs and symbols and to interpret them in ways that foster the development of communication skills, critical thinking, creativity, and collaboration with peers. Activities involving semiotic exploration lay a strong foundation for children to build long-term visual, numeracy, and communication literacy skills.

Based on a preliminary study conducted at TK ABA III Jember, it was found that teachers primarily implemented paper-based learning activities. Although various play activities were provided for children to choose from, many of these activities still relied heavily on worksheets and printed materials. According to the principal of TK ABA III Jember, this paper-based approach was considered wasteful and costly, as it required frequent purchases of paper and ink for daily learning tasks. This issue was attributed to a lack of creativity among teachers in developing engaging and innovative learning media. At the time of the study, no semiotic project-based learning modules had been developed or implemented. In light of this problem, the research question formulated for this study is: How can a semiotic project-based module be developed to enhance early childhood numeracy literacy?

## 2. METHODS

This study employed a Research and Development (R&D) approach, which is a research methodology aimed at producing educational products and evaluating their effectiveness in the field of education. The development of the module was based on the Thiagarajan model, commonly known as the 4D model, which includes four stages: Define, Design, Develop, and Disseminate (Feriyanti, Hidayat, & Asmawati, 2019; Christine Wulandari Suryaningrum, Rhomdani, & Jatmikowati, 2023).

The research adopted and adapted these stages into the following steps:

1. Needs Analysis: Conducted by examining real classroom conditions to identify the need for mathematics teaching materials to be developed.
2. Diagnostic Assessment: Carried out to assess the numeracy literacy needs of early childhood learners.
3. Module Development: Involved the selection of appropriate media, determination of the module format, planning of learning stages, selection of developmentally appropriate play activities, and the overall product development.
4. Expert Validation: Conducted with a panel consisting of a language expert, an assessment expert, and an early childhood education specialist to ensure the module's academic and practical validity.
5. Implementation: The developed instructional module was tested in two stages—a small-scale trial involving 6 children and a large-scale trial involving 12 children—to assess its practical applicability.
6. Evaluation: Conducted to measure the module's impact on students' learning outcomes and the quality of the learning process.

The data collection instruments used in this study included: (1) Needs Analysis and Diagnostic Assessment Instruments: These were employed to analyze the necessity for semiotic-based teaching materials and to identify the characteristics of early childhood learners. (2) Expert Validation Sheets: Used to collect data on the module's validity, assessed by a panel of three experts: a language expert, an assessment and instructional expert, and an early childhood education specialist. (3) Questionnaires: Distributed to respondents—specifically, teachers at TK ABA 3 Summersari Jember—to gather and record feedback on the developed product. The aim of the questionnaire was to determine the practicality level of the instructional module.

The data analysis technique utilized a Likert scale to assess and ensure that the developed instructional module met the criteria of validity, practicality, and effectiveness (Milenia, Suryaningrum, & Rhomdani, 2022). The following guidelines were used to evaluate the product's validity.

Table 1. Product Validity Categories

Validity Criteria	Validity Level
85,01% - 100%	Very Valid
70,01% - 85%	Valid
50,01% - 70%	Not Valid
1% - 50%	Very Not Valid

The practicality analysis was based on the results of teacher response questionnaires. The following is the guideline for analyzing product practicality using a Likert scale:

Table 2. Product Practicality Categories

Practicality Criteria	Level of Practicality
81% - 100%	Very Practical
61% - 80%	Practical
41% - 60%	Not Practical
1% - 40%	Very Not Practical

The effectiveness analysis of the teaching material was based on observations of early childhood behavior during participation in project-based learning. The following is the guideline for analyzing learning completeness using a Likert scale:

Table 3. Categories of module effectiveness

Effectiveness Criteria	Category
81% - 100%	Very Effective
61% - 80%	Effective
41% - 60%	Not Effective
1% - 40%	Very Not Effective

Based on the effectiveness analysis above, the developed teaching material is considered effective if the students' learning outcomes meet at least the "Effective" category of mastery.

### 3. FINDINGS AND DISCUSSION

The development of the semiotic project-based module was carried out through six main stages: (1) needs analysis, (2) diagnostic assessment, (3) product development, (4) expert validation, (5) implementation, and (6) evaluation. Each stage is described in detail below

#### 3.1. Needs Analysis

This stage was conducted by examining field conditions to identify the necessity for developing mathematics teaching materials. The goal was to determine to what extent semiotic-based learning could stimulate early childhood learners to understand mathematical concepts more meaningfully. The needs analysis revealed the following findings:

- Young children require concrete and contextual learning media, which is consistent with Piaget's theory stating that children in early childhood are still in the preoperational stage (Retnaningrum & Umam, 2021).
- Children need various forms of representation, including visual, concrete, verbal, and symbolic. This aligns with (Gunarsa, 2004), who emphasizes that these representations are interconnected with children's everyday activities. To support symbolic representation, semiotics—through signs such as icons (images), indices (clues), and symbols (numbers or abstract signs)—can meet the developmental needs of early learners.
- Semiotic-based learning helps children grasp mathematical concepts through contextual approaches, making abstract ideas more accessible (Hidayat, 2023).
- Teaching materials integrated with semiotics can transform abstract mathematics into concrete or visual concepts, thereby helping children relate mathematics to their real-life experiences (C. W. Suryaningrum & Ningtyas, 2019).

### 3.2. Diagnostic Assessment

This stage was conducted to examine the numeracy literacy needs of early childhood learners. The diagnostic assessment produced the following findings:

- a. Young children exhibit varying levels of understanding, influenced by experiences gained through parental stimulation at home, play activities, and interactions with their environment.
- b. Children develop at different rates—some are still in the stage of recognizing basic shapes and numbers, while others are already capable of counting, understanding patterns, quantities, measurement, and comparison.
- c. Children grasp mathematical concepts more easily through comparative vocabulary, such as "more or less," "bigger or smaller," and "farther or closer." This suggests that early learners benefit from play-based activities that integrate numeracy with language development and games that stimulate logic and mathematical thinking (Miftahurrohmah & Hisbuan, 2024).
- d. Mathematics learning for early childhood requires a holistic approach, offering concrete, contextual, interactive, and enjoyable numeracy experiences tailored to their developmental stage. In mathematics learning, literacy plays a key role due to the need for children to understand terms, symbols, and signs used to communicate mathematical ideas and to solve problems (Wardhani, B., Adi, E., Rengganis, N., Chitra, W., & Pratiwi, 2021).

### 3.3. Development of the Semiotic Project-Based Module

The development of the semiotic project-based module involved several key steps: (a) selection of media and module format, (b) planning of learning stages, (c) selection of play activities, and (d) product development. Each of these steps is described in detail below:

#### a. Media Selection and module format,

The media were selected based on the developmental level and interests of early childhood learners. The chosen media included images of traditional foods from the city of Jember. To make the learning experience more enjoyable and to capture children's attention and motivation, the researchers incorporated short videos exploring various traditional foods from Jember. These videos also demonstrated how the foods are prepared (Gusliati, Eliza, & Hartati, 2019; Kurniasih, 2022). The semiotic elements used in the module included images of these traditional dishes, which serve as icons representing the cultural identity of the city.

#### b. Planning the Learning Stages

The learning activities were designed in three stages: Introduction: Children were introduced to traditional foods from Jember. Development: Children participated in making the traditional foods. Conclusion: Children shared their experiences and showcased their culinary creations in a mini-exhibition.

#### c. Selection of Play Activities

The play activities were carefully chosen to suit the age and characteristics of the children. The researchers designed four main food-making activities: suwarsuwir (a traditional sweet), prol tape (cassava cake), edamame milk, and edamame pudding.

#### d. Product Development

The learning objectives within the semiotic project-based module were aligned with three dimensions of the Pancasila Student Profile: Global Diversity: The goal at this stage is for children to recognize their identity and cultural practices within the family. Collaboration (Gotong Royong): The expected outcome is for children to become accustomed to working cooperatively in group settings. Creativity: Children are encouraged to explore and express their thoughts and/or feelings through simple creative works and actions, and to appreciate the works and efforts of others.

The semiotic project-based module was designed with activities that actively engage children in the process of making traditional foods from the city of Jember. The learning process was structured into three phases: Introduction, Development, and Conclusion. In the Introduction phase, children

were invited to watch a video showcasing various traditional foods from Jember. Following that, they watched another video demonstrating the process of preparing these foods. The video included information on the ingredients, utensils, measurements, preparation steps, and packaging methods. After watching the videos, the children visited a local food production site to observe the process firsthand.

During the Development phase, children were grouped based on their interests. They then went to the market to purchase the ingredients needed for food preparation. Next, they prepared the necessary utensils, measured the ingredients, and selected packaging materials. Once everything was ready, the children, together with their teacher, made the traditional foods and packaged them. In the Conclusion phase, children shared their experiences about the cooking process. The project culminated in a "Market Day" event, where children exhibited and shared their food products with their parents.

In addition, the semiotic project-based module included assessment instruments developed for teachers to evaluate student participation and engagement. The module also featured teacher reflection sections and suggested follow-up activities for continuous improvement.

An overview of the semiotic project-based module development is presented in Figure 1 below.

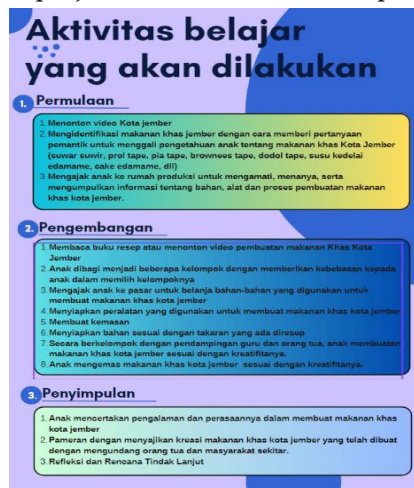


Figure 1. Initial product of the semiotic-based Project Module

### 3.4. Expert Validation

Expert validation was conducted by a panel consisting of a language expert, an assessment expert, and an early childhood education expert. The validation team members were selected based on their expertise relevant to the research and development objectives of this study. The validation was carried out by three validators: two faculty members from Universitas Muhammadiyah Jember, who served as experts in instructional design and assessment, and one early childhood education expert, a teacher from TK ABA 1 Kaliwates Jember. The results of the expert validation are presented in Table 4 below:

Table 4. Expert Validation Results

No	Component	Total Scor	Percentage	Criteria
1.	Profile and Objectives	38	95%	Very Valid
2.	Assessment Rubric	32	80%	Valid
3.	Learning Activities	40	100%	Very Valid
4.	Assessment	36	90%	Very Valid
5.	Language	32	80%	Valid

Based on Table 4, the results indicate that the developed product is highly valid in terms of profile and objectives, learning activities, and assessment, with percentages equal to or exceeding 90%. It is also considered valid in terms of the assessment rubric and language, each with a percentage of 80%. Based on the evaluations provided by the three experts, it can be concluded that the semiotic project-

based module developed in this study is feasible for use in early childhood education. Additionally, feedback from the assessment and language experts emphasized that the module should further highlight its semiotic components, as it is designed and positioned as a semiotic-based project module.

### Product Improvement

The product improvement was made based on feedback from assessment and learning experts. Based on the feedback, the following improvements were implemented: (1) the semiotic-based project module was enhanced by adding images of typical dishes from Jember, with embedded links to videos showing their preparation process, (2) images of the tools and measuring instruments required for preparing these dishes were included, (3) several examples of packaging that can be used were added, (4) a depiction of the market day event to be conducted was included. The revised version of the semiotic-based project module can be seen in Figure 2.



Figure 2. Final Product of the Semiotic-Based Project Module

### 3.5. The implementation

The implementation of the designed and developed teaching module, in accordance with the standards, will undergo product trials in two stages: small-scale trials and large-scale trials. The small-scale trial will involve 6 children, while the large-scale trial will involve 12 children. In the small-scale trial, the overall project-based learning activity will take place indoors, which includes watching videos about typical dishes from Jember, watching videos on how to prepare those dishes, cooking the dishes, packaging the food, and showcasing the results. The practicality analysis is based on the teacher's questionnaire responses after the small-scale trial. The data shows that 88.69% of teachers stated that the semiotic-based project module is very practical to use in enhancing early childhood numeracy literacy.

After the small-scale trial, the research team and teachers conducted a reflection. The results of the reflection revealed that the children did not choose the ingredients to be used, cooking indoors resulted in mixed smells, limited visibility, and smoke that could not escape the room. Based on this reflection, the research team and teachers made a follow-up plan: before preparing the typical Jember dishes, children would select the ingredients to be used. The cooking would take place outdoors, so that the smells wouldn't mix, the view would be wide, and the smoke could dissipate easily. This is in line with the opinion of (Herlinda, 2018; Muhammad Akhlis Rizza, Ratna Monasari, Etik Puspitasari, & Kris Witono, 2021) who stated that outdoor activities can develop children's abilities as they engage in physical activities, explore challenges, and have fun. From the large-scale trial, the data showed that 98.46% of teachers stated that the semiotic-based project module is very practical for improving early childhood numeracy literacy. From the results of both small and large-scale trials, it can be concluded that the semiotic-based project module is a highly practical product.

### 3.6. Evaluation

An evaluation was conducted to determine the impact on students' learning outcomes and the quality of teaching. From the observation of project-based learning using the semiotic module, an analysis of the effectiveness of the teaching materials was conducted, based on observations of the behavior of early childhood students. It was found that 98% of the children participated enthusiastically in the project-based learning. The children followed the project learning sequence, starting with watching videos about typical dishes from Jember, discussing what they had seen in the video, selecting ingredients for making the Jember dishes, measuring the ingredients according to the video instructions, collaborating with friends to prepare the dishes, and packaging the food. This demonstrates that the semiotic-based project module is highly effective for use in early childhood education.

## 4. CONCLUSION

After undergoing several stages of research and development, the following conclusions can be drawn:

1. The semiotic-based project module developed is considered highly valid and is therefore suitable for use in early childhood education.
2. The semiotic-based project module is highly practical, as the learning stages align with the characteristics and age of the children.
3. The semiotic-based project module is highly effective in enhancing early childhood numeracy literacy.

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