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The Efficacy of the "Pojok Ceria" Interactive Bulletin Board in Enhancing Early Number Sense and Self-Directed Learning among First-Grade Students

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Abstract

This study aims to develop and examine the efficacy of the "Pojok Ceria" (Joyful Corner) interactive bulletin board in addressing the ongoing problems of low student engagement, weak development of early number sense, and limited self-directed learning in primary-level mathematics classes. This study employed a strong R&D framework that combines the development stages model proposed by Sukmadinata with principles of systematic instructional design from the ASSURE model. This study employed a qualitative approach that spanned over two months among the first-grade students of a public school in Indonesia. Through triangulation of observations in the classroom, analysis of student work, and video recordings, combined with Focus Group Discussions (FGDs) for more in-depth insight into a specific issue. This study indicated that the "Pojok Ceria", designed with interactive activities, manipulatives, and interesting visuals, had a high intervention and practical value and was well accepted by the teachers in terms of usability. Additionally, the Interactive Bulletin Board has proven to be highly effective in promoting student involvement and fostering independent learning. At the same time, it is also effective in exploring number sense concepts among first-graders. These findings provide informative guideposts for effectively developing and implementing engaging learning environments that function well, especially in low-resource educational environments. Although the small sample size limits this study, it suggests a conclusive possibility of interactive media being produced locally. Hence, more longitudinal studies with larger and more diverse samples are needed to confirm and fully generalize the positive consequences.

INTRODUCTION

The early years of schooling are crucial for developing foundational mathematical understanding and laying the groundwork for future academic success (Clements & Sarama, 2020). Early identification and intervention can significantly enhance children's mathematical learning and mitigate their potential difficulties (Marcelino et al., 2017). In the first to third grades, more formal math skills begin to develop, such as mastery of number competencies, including number recognition, number comparisons, and understanding of number magnitudes (Little et al., 2021). However, research highlights the diverse learning needs of children in public schools in Salatiga, where access to resources and specialized support may be limited. This study examines the learning experiences of first-grade students in a public Indonesian school during their initial introduction to subtraction concepts, with a focus on the effectiveness of various teaching strategies and resources in this context.

Observations and interviews revealed a wide range of abilities and challenges among the students, highlighting the need for differentiated instruction and support tailored to their individual needs. For instance, while student initial A demonstrated proficiency in both reading and basic mathematical concepts, others faced specific difficulties. This finding, supported by a longitudinal study involving over 355,000 students, revealed a statistically significant positive correlation between reading and mathematics achievements. Higher prior reading scores are associated with better subsequent performance in mathematics (Hübner & Bloch, 2022).

Student initial D1, despite strong number recognition, struggled with performing addition and subtraction with numerals, although she excelled when presented with visual aids. This suggests a potential disconnect between her conceptual understanding of numbers and her ability to apply these concepts to their symbolic representations. Bruner's theory of cognitive development posits that mathematical understanding progresses through three representational stages: enactive, iconic, and symbolic (Bruner, 1997; Bruner & Kenney, 1965; Schwartz, 1968). In the enactive stage, learning occurs through hands-on experiences and the manipulation of concrete objects within the child's context. The iconic stage is characterized by the ability to visualize and mentally represent concrete experiences. Finally, the symbolic stage marks the ability to utilize abstract symbols, such as numerals and operational signs, to represent and manipulate mathematical concepts. This progression suggests that effective mathematics instruction should incorporate activities that cater to each of these representational stages.

Other students had different needs. The student initially demonstrated proficiency in addition, but also exhibited challenges with numeral orientation, potentially indicating a need for targeted interventions to solidify foundational number skills. Despite demonstrating mathematical ability, Student G struggled

with self-confidence and shyness, emphasizing the importance of creating positive learning environments that foster self-assurance and risk-taking. However, another student demonstrated advanced mathematical abilities, highlighting the importance of acknowledging individual strengths and providing opportunities for advanced learning. These observations underscore the diversity of learning needs in a single classroom. Clear classroom rules and expectations foster a safe and supportive learning environment, encouraging student participation (Nagizade, 2024). Creating an inclusive classroom where individual needs are understood helps build a sense of belonging, especially among shy students (Ramsey, 2024). Therefore, a supportive atmosphere is crucial for effective learning and engagement in the classroom.

These observations highlight the diverse learning needs present even within a single first-grade classroom. This research aims to contribute to a deeper understanding of how early math skills are developed in public Indonesian schools, inform educators about effective pedagogical approaches, and provide insights for curriculum development. The findings are expected to inform the design and implementation of more effective teaching strategies and resources tailored to address the specific challenges faced by first-graders in public settings, ultimately promoting greater mathematical understanding and achievement.

By highlighting the diverse learning needs and challenges encountered in this public Indonesian classroom, this study sheds light on the importance of individualization and adaptation in early math education. The use of manipulatives, such as math link cubes, proved to be a valuable tool for some students, enabling them to visualize and manipulate numbers. Others found the number line to be a more effective visual aid. The study also found that students with slower processing speeds and weaker writing skills often relied heavily on fingers for counting, highlighting the importance of providing alternative strategies and accommodations to cater to diverse learning styles.

Early numeracy encompasses a foundation of mathematical skills crucial for later mathematical development (Chang, 2023). These skills include the ability to count verbally, recognize number sequences, compare the size of numbers, manipulate groups of objects, and perform basic addition and subtraction with concrete objects. The development of number sense, which includes understanding patterns, such as groups of patterned dots, and recognizing concepts like more than, less than, and equal to, is critical for young learners (Van de Walle et al., 2022). It is crucial for students to establish this foundational understanding of number sense in their early years, as it facilitates the development of more advanced mathematical concepts later on. Number sense involves understanding the relationships between numbers 1-10, using ten frames or five frames, comprehending part-part-whole relationships, engaging in missing part activities, developing pre-place value concepts, and recognizing the application of number sense in everyday situations.

To create an engaging and relatable learning environment based on the observation and interview findings, especially for math concepts, the Pojok Ceria utilized a Realistic Mathematics Education (RME) approach, incorporating enactive and iconic phases to connect numbers to students' everyday lives. RME, a teaching theory originating in the Netherlands, emphasizes the use of real-world scenarios to engage students in mathematical learning (Van den Heuvel-Panhuizen & Drijvers, 2020). Freudenthal (2006) argued that mathematics is better understood as a creative art form, emphasizing its practical application and skill-based nature rather than viewing it solely as a body of knowledge. He believes mathematics is a tool to be used, not a goal to be achieved, and its relevance lies in its usefulness rather than its absolute certainty. De Lange (1996) further supports this perspective by emphasizing the importance of "Conceptual Mathematization" - starting with real-world experiences to introduce and develop mathematical concepts. He explained that children find it challenging to grasp abstract concepts from symbols alone, making a grounded approach with real-world connections crucial for meaningful learning.

Media plays a crucial role in early math learning by bridging the gap between abstract concepts and concrete experiences. By providing engaging and interactive opportunities for exploration, media fosters deeper understanding, promotes verbal interaction, and enhances problem-solving skills during both play and structured activities. This active engagement with mathematical concepts through media contributes to an improved number sense, a skill essential for everyday life and future academic success (Syarfina, 2022). The "Pojok Ceria" (Cinta Edukasi, Ragam Inspirasi Anak) bulletin board was developed as a solution to the challenges of managing diverse learning needs and interests within a classroom, drawing upon the principles of a mathematics realistic approach and the established concept of bulletin boards. This innovative learning center was developed in response to teachers' requests for engaging and effective classroom wall settings that support a dynamic learning environment for all students.

Based on the data collected using Y-Chart, it was coded into three main categories: Aesthetics, Function, and Influence. Aesthetics refers to the visual appeal of classroom walls, encompassing elements such as color, neatness, and attractiveness. Function describes the purpose and role of classroom walls in learning, such as displaying student work and fostering interest in learning. Influence refers to the impact of the classroom walls on students and the learning atmosphere, such as creating a sense of comfort, enjoyment, or positivity. The coding system uses the following codes: E1: Unattractive; E2: Colorful, lively, and full; E3: Lively, full, messy but beautiful; E4: Adequately filled, with sufficient color; E5: A tangible representation of student creativity; E6: Leftover decorations from previous classes; F1: A board for displaying student assignments; F2: Cultivating student interest in learning; F3: Making students happy; P1: Creating a comfortable

and calm learning environment; P2: Preventing boredom; P3: Making sad students happy.

Teachers' responses to the question about their classroom walls displayed a range of perspectives; a common theme emerged: the importance of creating visually stimulating, functional, and positive classroom environments. Some teachers found their walls lacking in visual appeal (E1), while others described them as colorful, lively, and full (E2), even acknowledging a "messy but beautiful" aesthetic (E3). Several teachers emphasized the functional aspects of their walls, highlighting their use for displaying student work (F1) and fostering student engagement and positive emotions (F2, F3, and P3). Others noted a sense of comfort and tranquility created by their wall arrangements (P1, P2), while some expressed that their current walls were simply remnants from previous classes (E6). However, the Y Chart data did not explicitly reveal any direct insights into student engagement with classroom walls. This suggests the need for further exploration to understand the impact of classroom wall design on student motivation and learning from the students' perspective.

A good bulletin board should incorporate visually appealing graphics, relevant and diverse content, and active student engagement (Smaldino et al., 2014). It should also adhere to three main principles: decoration, motivation, and instruction. Furthermore, bulletin boards should be easily accessible and understandable for students to use. The "Pojok Ceria" embodies these principles while emphasizing hands-on, enjoyable learning. Its main focus is to engage students in math activities that align with their individual interests, extend learning beyond the textbook, and foster a more interactive and engaging classroom experience.

Classroom bulletin boards, particularly when considering the interplay of information, interaction, and aesthetics, have a significant impact on student engagement and learning. Research has consistently demonstrated that interactive learning environments lead to greater student engagement, satisfaction, and improved learning outcomes (Oluwajana et al., 2019; Sharma et al., 2020; Zimmermann et al., 2018). Well-designed, aesthetically pleasing spaces that incorporate visual elements and interactive displays further encourage positive emotional responses, facilitating comprehension and knowledge retention (Gauci, 2015). These findings highlight the importance of visually engaging and interactive bulletin boards in fostering collaborative learning and achieving higher learning outcomes.

Bulletin boards have been investigated as a tool for improving educational quality, such as in a study that explored the enhancement of Social Studies learning outcomes for fifth-grade students on the topic of the Proclamation of Independence at SDN Sambungrejo Sidoarjo (Pahlawani & Siradjuddin, 2018). Additionally, bulletin boards have been shown to improve the understanding of multiplication

concepts in fourth-grade students at SDN 65 Kota Bengkulu (Oktarina et al., 2024). These bulletin boards can be creatively named, as exemplified in the research "PAGORO-QR: Collaborative Bulletin Board Material Integrating QR-Code Based on Character Education for Fourth-Grade Elementary School Students" (Solihin et al, 2024). The ability to develop interactive, informative, and aesthetically pleasing bulletin boards is crucial for teachers to create a positive and supportive learning environment in the classroom.

METHODS

This study employed a Research and Development (R&D) methodology based on Sukmadinata's (2019) model, incorporating the ASSURE model (Smaldino, 2014) for product development (see Figure 1). Sukmadinata's R&D process involved three main stages: Preliminary, Product Development, and Product Testing. The Preliminary stage involved identifying needs and problems in the field, reviewing the literature to find suitable solutions, and drafting the initial "Pojok Ceria" design. The Product Development stage comprised planning and developing the initial "Pojok Ceria" product, expert validation, limited trials, and wider field testing. The Product Testing stage involved observing student responses and conducting interviews with both teachers and students.

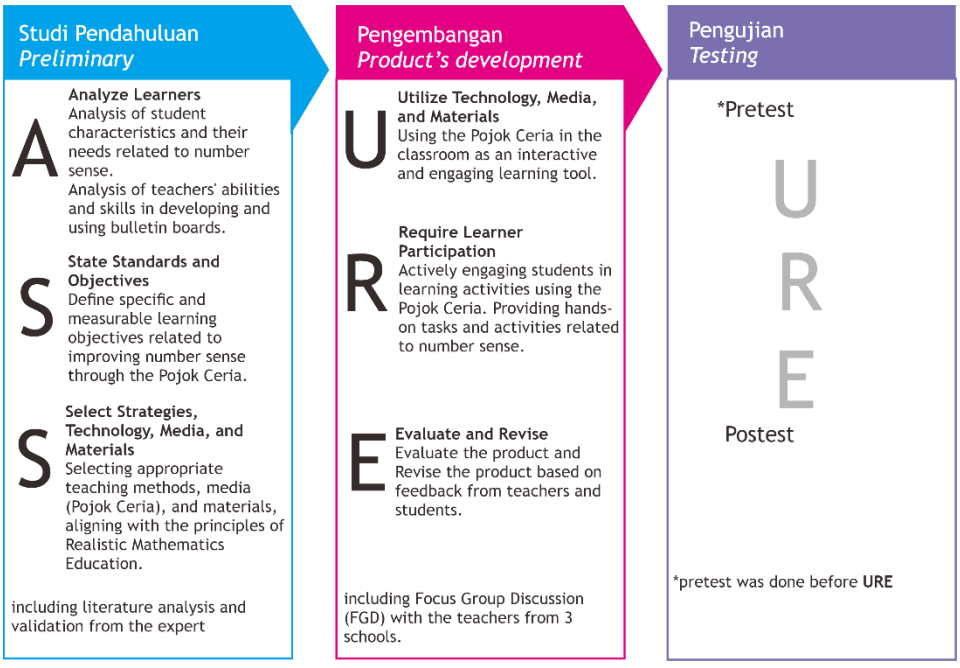

Figure 1. The framework for developing Pojok Ceria

The ASSURE model comprises six steps: **A**nalyze Learners, State Standards and Objectives, Select Strategies, Technology, Media, and Materials, Utilize Technology, Media, and Materials, Require Learner Participation, and **E**valuate and Revise. The ASSURE model guided the development process, beginning with

analyzing learner characteristics and needs related to number sense, as well as teachers' abilities to develop and use bulletin boards. This was followed by stating specific, measurable learning objectives for improving number sense through "Pojok Ceria," and selecting appropriate learning methods, media (including "Pojok Ceria"), and materials aligned with realistic mathematics principles. The following stages involved utilizing the "Pojok Ceria" in the classroom as an interactive learning tool, requiring active learner participation through hands-on activities related to number sense. Finally, the effectiveness of "Pojok Ceria" was evaluated and revised based on feedback from both teachers and students.

This study employed a descriptive qualitative approach to investigate the learning experiences and challenges faced by first-grade students in a public Indonesian school during their initial exposure to addition and subtraction concepts. The research design employed a combination of participant observation and document analysis, utilizing field notes and student work samples to gather rich, contextualized data. The participants were eleven first-grade students from a single classroom in a public Indonesian school, selected to provide in-depth insights into their individual learning processes. The "Pojok Ceria" (Joyful Corner) bulletin board, a learning center designed to foster independent learning and enhance number sense, was a key element of this study. Observations of student interactions with the bulletin board were documented through field notes and video recordings.

Data analysis involved a thematic analysis (Braun & Clarke, 2006), which identified key themes and patterns emerging from the field notes, student work samples, and video recordings. Triangulation was used to ensure the validity of the data, cross-referencing observations, student work, and video recordings to confirm emerging patterns. The "Pojok Ceria" was specifically designed to integrate various visual aids and activities that cater to diverse learning styles, promoting hands-on engagement and self-directed exploration. The effectiveness of this approach was evaluated through ongoing observation and analysis of student interactions with the bulletin board, focusing on their engagement levels, problem-solving strategies, and the development of their number sense.

Three indicators were used for validation by experts: information, interaction, and aesthetics (Oluwajana et al., 2019; Sharma et al., 2020; Zimmermann et al., 2018). Moreover, three aspects were observed and measured through pretest and posttest: students' engagement, number sense, and independent learning. Student engagement is a multifaceted concept that includes behavioral, cognitive, and emotional dimensions, all of which are essential for fostering a positive and productive learning environment (Tam et al., 2023). Number sense was observed and demonstrated through students' involvement in a combination of efficient problem-solving strategies, mathematical reasoning, and the ability to make connections between numbers (Witherspoon, 2023). Independent learning involves

students actively engaging in their learning with the support of a well-structured curriculum and effective teaching strategies (Safitri & Rokhimawan, 2024).

RESULTS

1. Preliminary Phase

a. Analyze Learners

Observations and interviews revealed a diverse range of student abilities and challenges. Student D1, for example, demonstrated strong number recognition but struggled with symbolic representation in addition and subtraction, excelling only with visual aids. This disparity underscores the need for interventions that bridge the gap between conceptual understanding and procedural skills, particularly when working with abstract mathematical symbols. Student A's difficulties with both mathematical symbols and language underscore the interconnected nature of these skills and the necessity of comprehensive support. Other students, such as D2 and I, encountered challenges with numeral orientation, while G's lack of self-confidence also indicated a need for a supportive learning environment.

Teachers' perspectives on their classroom wall displays reflected a shared emphasis on creating visually engaging, functional, and positive learning spaces. While some teachers felt their current displays lacked visual appeal, others appreciated the vibrant and potentially eclectic nature of their arrangements. The practical function of the displays, particularly for showcasing student work, and their potential to boost student engagement and emotional well-being were also recognized. Crucially, however, teacher feedback did not directly address student responses to the displays themselves.

This gap in the data highlights the need for further investigation into how students interact with the classroom environment, specifically their engagement, number sense development, and independent learning. To truly understand the impact of classroom design, a deeper exploration of student perspectives on the displays' effectiveness is essential. Student input is necessary to determine if the visually engaging displays, as perceived by teachers, are fostering active engagement, supporting the development of number sense through practical application, and encouraging independent learning, where students can use the environment as a springboard for exploring mathematical concepts on their own.

b. State Standards and Objectives

This study focused on number sense in Phase A, aligning with the Merdeka Curriculum's general learning outcomes for Mathematics in Phase A. The learning outcome was “at the end of Phase A, students should demonstrate understanding and number sense for whole numbers up to 100” (Indonesia, 2022).

The prototype of Pojok Ceria was designed to foster student engagement and a positive learning environment. Its activities, rooted in a Realistic Mathematics

Education (RME) approach, aimed to develop number sense through hands-on problem-solving, mathematical reasoning, and connecting numbers to real-world contexts. The design also supported independent learning by providing engaging activities within the learning center.

c. Select Strategies, Technology, Media, and Materials

The Pojok Ceria, as depicted in Figures 2 and 3, provides a stimulating environment for hands-on exploration. Figure 1 shows the overall design, while Figure 3 highlights the manipulatives that support learning. These tools enable students to participate in activities that promote counting skills, comparisons, and an understanding of quantity, thereby fostering a deeper comprehension of number concepts. The student also probably learns about the insects around them.

The "Pojok Ceria" incorporates ten-frames, building upon McGuire et al.'s (2012) research on the use of five-frames as an instructional tool in early mathematics. While ten-frames broaden the numerical representation from zero to ten, the "Pojok Ceria" adapts this concept by also including representations up to five, similar to McGuire's five-frames, to support pre-K children in developing fundamental counting principles and number sense with smaller sets.

The "Misi hari ini" (Figure 4) employs durable, laminated activity cards, designed for repeated use with non-permanent markers, to promote student engagement with practical math applications. This design, based on a mathematically realistic approach, enables students to actively explore the use of numbers and practice addition and subtraction through the creation of drawings that represent numbers and mathematical operations. This study examined the effectiveness of a "Pojok Ceria" (Joyful Corner) bulletin board as an interactive learning center designed to promote independent learning and enhance number sense in a first-grade classroom of a public Indonesian school.

A focus group discussion (FGD) with two mathematics lecturers from Satya Wacana Christian University, who teach at the Bachelor of Elementary Education program, identified three key aspects of effective bulletin boards: information, interaction, and aesthetics.

The validator highlighted the clarity of the information presented in the "Pojok Ceria," noting that the number lines could be used interactively with cars, insects, or other manipulatives due to their play-based nature. Regarding aesthetics, the validator emphasized the importance of the bold red color, which effectively draws attention and helps the bulletin board stand out within the learning space. Moving forward, it is crucial to ensure that color choices align with the overall design goals and promote exploration of the bulletin board. Additionally, the validator recommended incorporating color into the "Bilangan Hari Ini" (Today's Number) section to further enhance its visual appeal and importance within the bulletin board's design.

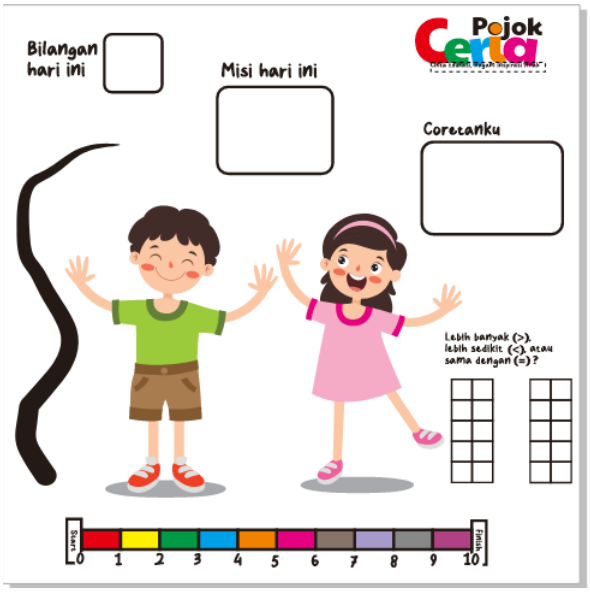

Figure 2. Pojok Ceria Design

The expert validator provided valuable feedback on the design, suggesting an enhancement to the hands-on activities. They recommended making the hands movable to increase student engagement and enjoyment. This could be achieved by constructing the hands from flannel fabric, filled with bendable wire and covered in soft, fuzzy chenille stems, allowing the fingers to be flexed and manipulated.

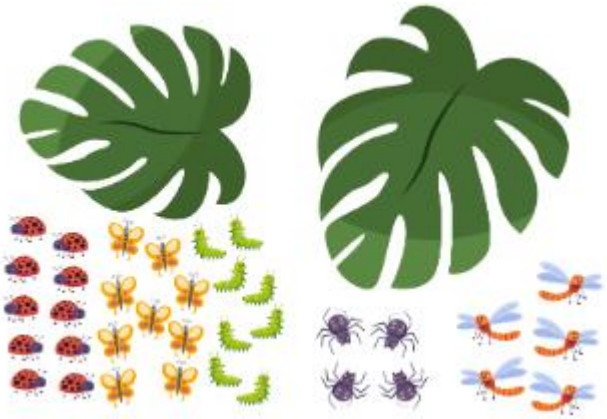

Figure 3. Pojok Ceria's Manipulatives

The validator also praised the "Pojok Ceria's" mission section, commending its interactive nature and student-centered approach. Students can independently choose activities, learn based on their interests, and discover the relationship between numbers and their real-world applications. This "learning by doing" approach fosters a dynamic and engaging learning experience for young learners.

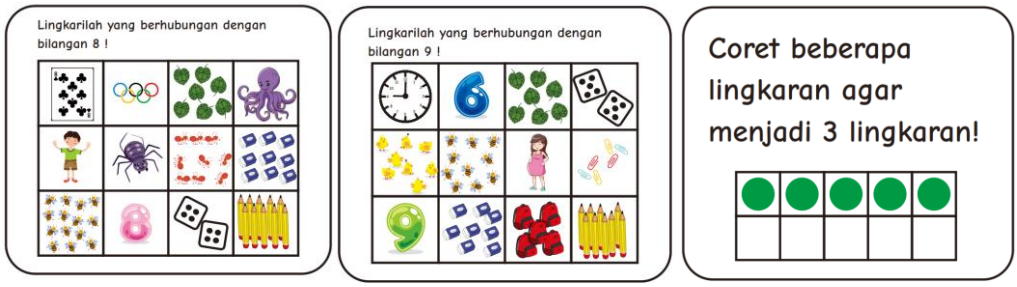

Figure 4. Sample of Missions

2. Product's Development Phase

a. Utilize Technology, Media, and Materials

Teachers' involvement in the Pojok Ceria design was crucial to its success. Three schools piloted the prototype, providing teachers with firsthand experience in creating engaging learning spaces. This hands-on experience offered teachers new knowledge and skills, expanding their understanding of bulletin board construction, including using banners to create designated zones within the classroom without damaging the walls. Teachers also gained valuable experience integrating math concepts with other subjects, like social studies, as well as incorporating creativity and easily-removable materials like tack-it, markers, and manipulatives for hands-on engagement further enriched the design process.

Figure 5. Researchers' collaboration in preparing Pojok Ceria

This practical application allowed teachers to merge theoretical concepts into tangible classroom resources. They learned to create interactive bulletin boards capable of hosting dynamic scenarios for student exploration. Teachers gained valuable experience in crafting a "mission" based bulletin board, transforming static displays into spaces for active learning. This process enhanced their understanding of RME (Realistic Mathematics Education) principles, promoting student-centered activities. The positive feedback suggested the feasibility and value of this approach to enriching learning experiences in the classroom.

b. Require Learner Participation

The teacher introduced the "Pojok Ceria" to students by having them form a line and explore the bulletin board individually. Students were encouraged to choose their own "mission" activities from the available cards. The teacher also incorporated the "Bilangan Hari Ini" (Number of the Day) activity, where students

could manipulate the provided manipulatives. While the teacher noted that the "Coretanku" (My Scribbles) section did not seem to generate much interest among students, the overall experience was deemed positive.

The "Pojok Ceria" proved popular with students, particularly the mission section which allowed for drawing and writing. Students A and D explicitly expressed their enjoyment of finishing the mission, while Student B appreciated the opportunity for free expression, mentioning both doodling and writing their name. These observations indicate that the interactive and creative elements of the "Pojok Ceria" fostered student engagement and enjoyment. Student initial A and D said “suka bagian misi, karena bisa menulis, menggambar”. Student initial “B” said, “suka coretanku, bisa coret-coret, menulis nama.”

c. Evaluate and Revise

Student enthusiasm for the Pojok Ceria, their desire to take home the manipulatives, necessitates a designated space or clear class rules for the use of Pojok Ceria. This level of engagement highlights the importance of the center's appeal and its potential for fostering a deeper connection with mathematical concepts. The initial design proves effective, but a formal structure for material management is crucial to prevent loss and maintain Pojok Ceria's functionality.

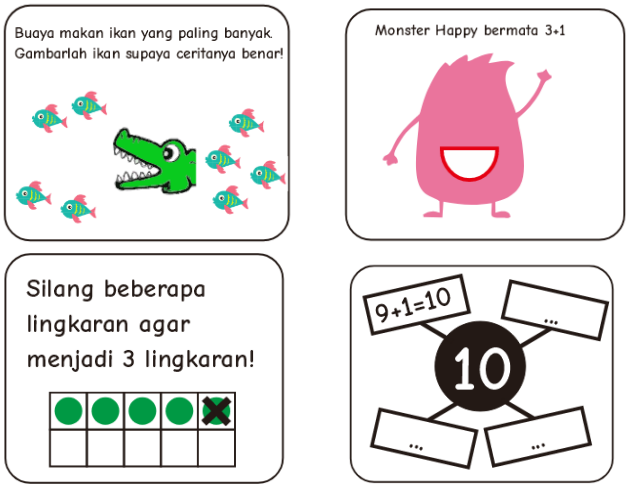

Figure 6. Additional Missions

Maintaining consistent engagement requires ongoing teacher input to develop new and challenging "missions." The initial activities were successful, but creating diverse problem-solving tasks, particularly those focused on comparing quantities (e.g., more/less within a 10-frame), is vital. The need to regularly introduce new "missions" ensures ongoing student interest and prevents Pojok Ceria from becoming stagnant.

Student responsibility for the care of the Pojok Ceria, particularly the "Coretanku" (My Scribbles) section, needs to be addressed. Damage to materials

indicates a need for clear guidelines and expectations regarding responsible use. Reinforcing proper handling and care practices, along with regularly updating and replenishing materials, will be essential to ensure the longevity and effectiveness of the learning center. Developing a system for consistent maintenance will be key for the long-term sustainability of the Pojok Ceria.

3. Testing

a. Effectiveness of the "Pojok Ceria" Bulletin Board

Observations conducted over two months period revealed that the "Pojok Ceria" bulletin board had a positive impact on student learning, particularly for those who demonstrated strong foundational number sense and a desire for independent exploration.

Table 1. The Observation Result before Pojok Ceria was applied

Aspect's Observed	Result
Engagement	Students engagement are varied. Two students (initial A1, B) demonstrated active participation and interaction with peers and the teacher, others (F, A2, D1, F2) exhibited less engagement, often working independently with minimal interaction. Two students (I, G) displayed disruptive behaviors, interfering with both their own learning and that of their peers. The limited engagement of some students suggests a need for differentiated instruction to increase their interest and motivation in learning activities
Number Sense	The limited opportunity to develop number sense is evident. The focus on textbook problems ("soal") which were often symbolic, rather than contextual or problem-solving-based, likely hindered some students' ability to connect numbers to real-world situations and develop a deeper understanding. Specific difficulties with symbolic representation, numeral orientation (D1, I), and operational understanding (D2) further highlight the need for more varied and contextualized learning experiences to promote stronger number sense.
Independent Learning	Independent learning was mixed. While some students (A1, A2) demonstrated strong independent work habits and high proficiency with assigned tasks, others (F, D1, D2, I) required significant teacher support to complete assigned work. The reliance on teacher-directed tasks ("soal") suggests that students' independent learning skills require development, likely including instruction and practice in independent problem-solving approaches. The observations also highlighted the importance of providing differentiated support to ensure that each student can independently progress in their learning, aligning with individual needs and challenges.

The observations reveal a need for a more comprehensive approach to fostering student engagement, developing number sense, and promoting independent learning in the classroom. While some students displayed strong independent work habits and mathematical proficiency, others struggled with engagement and displayed difficulties with symbolic representation and procedural

fluency. This highlights the need for differentiated instruction and learning activities that connect mathematical concepts to real-world contexts and cater to various learning styles. The limited engagement from some students, coupled with their difficulties in independent problem-solving and the reliance on teacher-led exercises, suggests the need for interactive and more varied instructional strategies that encourage collaboration, exploration, and active participation to promote a deeper understanding of mathematical concepts and foster stronger independent learning skills.

Table 2. Pojok Ceria's Effectiveness

Aspect	Observation and Interview result
Increased Engagement	Students showed increased engagement and motivation during self-directed learning activities, with a particular interest in the interactive elements of the bulletin board.
Enhanced Number Sense	The bulletin board facilitated the exploration of various number sense concepts, including counting, number recognition, and problem-solving, which contributed to the overall development of students' mathematical understanding.
Independent Learning	Students were able to engage in independent learning, demonstrating self-directed learning skills and confidence in their abilities.

Following two weeks of implementation, the Pojok Ceria demonstrated students engagement. Teachers noted a significant increase in student interest, with children actively seeking out the Pojok Ceria even outside math class session. This enthusiasm was evident during break times, as students revisited activities and continued work independently. The discussions becoming more collaborative and problem-solving-oriented, engaging both students and teachers in joint exploration. This demonstrates the Pojok Ceria's effectiveness in capturing students' interest and motivating their independent learning efforts.

The collaborative and interactive nature of the Pojok Ceria fostered positive student-student and student-teacher interactions. Students were observed sharing tasks and engaging in peer-to-peer consultations. The ability to repeatedly engage with activities—and the satisfaction of being able to erase or reposition items—was a driving force behind this engagement. This freedom to explore, manipulate, and revisit tasks highlights the importance of offering hands-on, adaptable learning experiences.

The Pojok Ceria's design facilitated both play and learning, supporting flexible and independent exploration. Students readily participated in a variety of tasks and expressed enjoyment in sharing and exchanging their findings. This positive feedback suggests the need for additional development of such interactive learning spaces to create a dynamic environment fostering a love for learning that

extends beyond the typical classroom structure, encouraging not only engagement but also an internal motivation to engage with mathematical concepts.

Teacher feedback indicated that the "Pojok Ceria" bulletin board was especially beneficial for students who were considered "fast learners" within the class. These students were able to work independently at their own pace, enriching their understanding of mathematical concepts and challenging themselves with more advanced activities. The bulletin board really helped the fast learners stay engaged and motivated. They were able to work ahead at their own pace, and it was great to see them exploring different concepts on their own.

The "Missions" aimed to make learning relatable to children's lives by connecting numbers to everyday experiences. For example, the number one was linked to the number of one nose, one mouth, and the concept of "me" as a unique individual. Similarly, number two was connected to pairs, while number three was explored through shapes (triangle's side), Roman numerals (III = three sticks), and stories like "The Three Little Pigs." However, observations revealed that students tended to avoid "missions" with extensive text, such as "Please guess what is more than one but less than three?" (Figure 7). This suggests that, while the teacher was willing to assist with reading, the students' limited reading skills hampered their engagement with text-heavy missions.

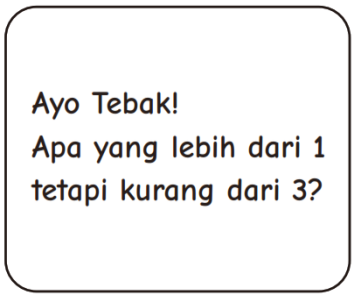

Figure 7. Mission with text

Based on students' interview, they like to use Pojok Ceria, especially the mission section, they said "I can draw and write there".

DISCUSSION

Effective elementary math instruction emphasizes contextual learning, exploration, and student-constructed understanding. This approach focuses on developing a deep understanding of number meanings, operations, relationships, and magnitudes, ultimately promoting flexible thinking and problem-solving skills through engaging, student-centered activities (Yuniawatika, 2018). The findings of this study provide valuable insights into the effectiveness of a "Pojok Ceria" (Joyful Corner) bulletin board as an interactive learning center for fostering independent learning and enhancing number sense in a first-grade classroom in a public Indonesian school. The results demonstrate the positive impact of this approach on

student engagement, number sense development, and independent learning, particularly for students who were considered "fast learners" within the classroom.

Student engagement is a multifaceted concept encompassing behavioral, emotional, and cognitive dimensions. Teachers play a crucial role in fostering meaningful engagement (Pedler et al., 2020). Research suggests that autonomy-supportive and structured teaching approaches significantly impact student engagement in primary schools (Näkk & Timoštšuk, 2019). Studies have shown that students in classrooms led by highly autonomy-supportive teachers demonstrate greater engagement across all dimensions compared to those in classrooms led by low-autonomy-supportive teachers. This difference is attributed to the use of more social constructivist methods, emphasizing group work and individual/small group discussions, which empower students to take more responsibility for their learning.

Self-directed learning argues that students should be empowered to take control of their learning process, including choosing what to learn, how to learn it, and how to evaluate their own progress. This type of learning is fostered in environments that encourage collaboration and support from teachers, adults, and peers (Della-Dora & Blanchard,1979). Self-directed learning enhances student autonomy by fostering proactivity, self-efficacy, and cognitive competence. It positively impacts motivation by creating supportive learning environments, promoting collaboration, and enabling learners to take charge of their educational journeys, ultimately leading to improved attainments (Vaičiūnienė & Kazlauskienė, 2023). In this context, Pojok Ceria offers an alternative approach that empowers students to learn at their own pace and in their own way. Whether they choose to engage with the assigned tasks, freely express themselves through drawing or doodling, or explore the manipulatives provided, students have the freedom to learn based on their individual interests and preferences. Furthermore, the interactive nature of Pojok Ceria fosters more intensive and meaningful interactions between teachers and students.

Figure 8. Student Engagement with "Pojok Ceria" Bulletin Board

Source: Keterina Marwa (2024)

Furthermore, the findings support the importance of differentiated instruction in meeting diverse student learning needs (Tomlinson, 2017). The "Pojok Ceria" bulletin board allowed students to work independently at their own pace, accessing activities tailored to their individual levels of understanding and skill development. This aligns with the principle of providing appropriate challenges and support to maximize individual learning potential (Kim et al., 2019).

The qualitative nature of this study, employing in-depth observations within a single public Indonesian first-grade classroom, allowed for a nuanced understanding of how the "Pojok Ceria" bulletin board impacted student learning. The rich data collected provides valuable insights into the specific challenges and successes experienced within this context. However, the small sample size and the inherent limitations of the design itself (such as the limited number of missions and the potential for physical damage) restrict the generalizability of these findings. Future research, employing larger sample sizes and diverse settings, is needed to further explore the effectiveness and broader application of the "Pojok Ceria" model.

Additionally, while the "Pojok Ceria" bulletin board demonstrated effectiveness for students who were considered "fast learners," further investigation is needed to understand its impact on students with slower processing speeds and those who require more direct instruction. The study did not include specific interventions or strategies for addressing the learning needs of these students.

Despite these limitations, this study offers a promising approach to enhancing early mathematics learning, particularly in resource-constrained settings like public Indonesian schools. The "Pojok Ceria" bulletin board provides a cost-effective and engaging way to promote independent learning and number sense development, contributing to a more inclusive and effective learning environment for all students.

Future research should focus on further exploring the effectiveness of the "Pojok Ceria" bulletin board for students with diverse learning needs, developing specific interventions and strategies to cater to those who require more support, and investigating the long-term impact of the bulletin board on student achievement in mathematics. By addressing these areas of inquiry, researchers can contribute to a more comprehensive understanding of the role of interactive learning centers in early mathematics education and enhance the educational outcomes for all students.

CONCLUSION

This research and development project investigated the merit of a "Pojok Ceria" (Joyful Corner) bulletin board in fostering student engagement, developing number sense, and promoting independent learning in a first-grade Indonesian classroom. Using a qualitative approach, observations and interviews over two months revealed a positive impact of the Pojok Ceria, particularly in engaging "high-achieving" students and fostering self-directed learning. The interactive nature of

the center, featuring engaging activities and manipulatives, stimulated student interest and contributed to their active exploration of mathematical concepts. However, limitations exist due to the small sample size and short duration of the study, limiting the ability to generalize findings.

Further research with larger samples and longitudinal data collection are necessary to confirm and generalize the positive impact of the "Pojok Ceria" and inform the development of targeted interventions. This research offers valuable insights for designing engaging learning environments in resource-constrained settings, particularly by showing the potential of interactive learning centers to enhance early mathematical development. However, to fully leverage this potential, focused strategies are needed to support all learners, addressing individual differences and needs.

Policy implications for schools include the development of guidelines and resources for teachers to implement interactive learning environments such as "Pojok Ceria." Curriculum makers should also consider integrating hands-on, inquiry-based activities that connect mathematical concepts to real-world situations to strengthen students' number sense and develop 21st-century skills. Schools could develop training programs for teachers, emphasizing the design and implementation of engaging and inclusive learning centers.

Further research should focus on a long-term study investigating the impact of the "Pojok Ceria" on the development of 21st-century skills, such as critical thinking, problem-solving, and collaboration. A study examining the long-term effects of such interactive learning spaces on student academic outcomes and broader developmental growth, including social-emotional learning, would also provide valuable data. Expanding the study to include diverse learners and settings would offer a more comprehensive understanding of the Pojok Ceria's impact and applicability across various contexts.

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REFERENCES

Braun, Virginia; Clarke, Victoria. (2006). *Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101.* https://doi.org/10.1191/1478088706qp063oa

Bruner, J. S. & Kenney, H. J. (1965). Mathematical Learning: Report of a Conference Sponsored by the Committee on Intellective Processes Research of the Social Science Research Council || Representation and Mathematics Learning. *Monographs of the Society for Research in Child Development, 30(1), 50–59.* https://doi.org/10.2307/1165708

Bruner, J. S. (1977). *The process of education*. Harvard University Press.

Chang, I. (2023). Early numeracy and literacy skills and their influences on fourth-grade mathematics achievement: a moderated mediation model. *Large-scale Assessments in Education*, *11*(1), 18. https://doi.org/10.1186/s40536-023-00168-6

Clements, D. H., & Sarama, J. (2020). *Learning and teaching early math: The learning trajectories approach*. Routledge.

De Lange, J. (1996). Using and applying mathematics in education. In *International Handbook of Mathematics Education: Part 1* (pp. 49-97). Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-94-009-1465-0_3

Della-Dora, D., & Blanchard, L. J. (1979). Moving Toward Self-Directed Learning. Highlights of Relevant Research and of Promising Practice.

Freudenthal, H. (2006). Revisiting Mathematics Education: China Lectures. Kluwer: Dordrecht/Boston/London.

Gauci, J. (2015). Designing Learning Environments through Inspiration, Innovation and Creativity. In *INTED2015 Proceedings* (pp. 802-806). IATED. https://library.iated.org/view/GAUCI2015DES

Hübner, N., & Bloch, W. M. (2022). Reading to learn? The co-development of mathematics and reading during primary school. *Child Development*, *93*(6), 1760–1776. https://doi.org/10.1111/cdev.13817

Indonesia, R. (2022). *CP & ATP Fase A Matematika SD*. CP & ATP - Matematika Fase A. https://guru.kemdikbud.go.id/kurikulum/referensi-penerapan/capaian-pembelajaran/sd-sma/matematika/fase-a/

Kim, N. , Belland, B. R. , & Axelrod, D. (2019). Scaffolding for Optimal Challenge in K–12 Problem-Based Learning. *Interdisciplinary Journal of Problem-Based Learning, 13*(1). https://doi.org/10.7771/1541-5015.1712

Little, C. W., Lonigan, C. J., & Phillips, B. M. (2021). Differential patterns of growth in reading and math skills during elementary school. *Journal of educational psychology*, *113*(3), 462. DOI: https://dx.doi.org/10.1037/edu0000635

Marcelino, L., de Sousa, Ó., & Lopes, A. (2017). Predictive relation between early numerical competencies and mathematics achievement in first grade Portuguese children. Frontiers in Psychology, 8, 1103. https://doi.org/10.3389/fpsyg.2017.01103

McGuire, P., Kinzie, M. B., & Berch, D. B. (2012). Developing number sense in pre-k

with five-frames. *Early Childhood Education Journal*, *40*, 213-222. https://doi.org/10.1007/s10643-011-0479-4

Nagizade, P. (2024). Strategies for creating a positive supportive environment at school. *Deleted Journal*, *91*(1), 251–254. https://doi.org/10.69682/azrt.2024.91(1).251-254

Näkk, A. M., & Timoštšuk, I. (2019). The dynamics of learning engagement and its relationship with teachers' classroom practices in primary school. *Education 3-13*, *47*(1), 89-100. https://doi.org/10.1080/03004279.2017.1404620

Oktarina, K., Ariani, N. M., & Riwayati, S. (2024). Meningkatkan Pemahaman Konsep Perkalian Matematika Dengan Papan Pintar Pada Siswa Kelas 4 SDN 65 Bengkulu. *Community Development Journal: Jurnal Pengabdian Masyarakat*, *5*(3), 5503-5507. DOI: https://doi.org/10.31004/cdj.v5i3.30265

Oluwajana, D., Nat, M., & Fadiya, S. O. (2019). An Investigation of Students' Interactivity in the Classroom and within Learning Management System to Improve Learning Outcomes / Istraživanje o interaktivnosti studenata u učionici i interaktivnosti studenata u sustavu za upravljanje učenjem s ciljem pob. *Croatian Journal of Education-Hrvatski Casopis Za Odgoj i Obrazovanje*, *21*(1), 77–102. https://doi.org/10.15516/CJE.V21I1.3085

Pahlawani, G., & Siradjuddin, S. (2018). Penggunaan Media Papan Buletin Untuk Meningkatkan Hasil Belajar Ips Materi Proklamasi Kemerdekaan Kelas V. *Jurnal Penelitian Pendidikan Guru Sekolah Dasar*. 6(12), 2256-2266. https://ejournal.unesa.ac.id/index.php/jurnal-penelitian-pgsd/article/view/25703

Pedler, M., Hudson, S., & Yeigh, T. (2020). The teachers' role in student engagement: A review. *Australian Journal of Teacher Education (Online)*, *45*(3), 48-62. https://doi.org/10.14221/ajte.2020v45n3.4

Ramsey, H. (2024). *Fostering an inclusive and socially responsive classroom environment using 5-minute self-regulation strategies*. https://doi.org/10.18260/1-2--46043

Safitri, R., & Rokhimawan, M. A. (2024). Assessing the Impact of the Independent Learning Curriculum: A Case Study in Elementary Schools. *Al-Ishlah*, *16*(4), 4931–4944. https://doi.org/10.35445/alishlah.v16i4.5606

Schwartz, R. (1968). Studies in Cognitive Growthby Jerome S. Bruner; Rose R. Olver; Patricia M. Greenfield. *The Journal of Philosophy, 65(6), 172–179.* https://doi.org/10.2307/2024205

Sharma, K., Leftheriotis, I., & Giannakos, M. N. (2020). Utilizing Interactive Surfaces to Enhance Learning, Collaboration and Engagement: Insights from Learners' Gaze and Speech. *Sensors*, *20*(7), 1964. https://doi.org/10.3390/S20071964

Smaldino, S. E., Lowther, D. L., Russell, J. D., & Mims, C. (2014). *Instructional technology and media for learning*.

Solihin, A., Pujiyati, L., Syanis, P. F. H. A., Lestari, S., & Puspita, A. M. I. (2024). PAGORO-QR: Bahan Ajar Papan Gotong Royong Integrasi QR-Code Berbasis Pendidikan Karakter Siswa Kelas IV Sekolah Dasar. *Jurnal Basicedu*, *8*(3), 2125-2140. DOI: https://doi.org/10.31004/basicedu.v8i3.7623

Sukmadinata, N. S. (2019). *Metode penelitian pendidikan*.

Syarfina, S., Basri, B., Hasibuan, R. H., Abidin, Z., Ulya, K., Tursina, A., ... & Fadli, M. (2022, October). Developing mathematics learning media to introduce the concept of numbers to early childhood. In *AIP Conference Proceedings* (Vol. 2524, No. 1). AIP Publishing. https://doi.org/10.1063/5.0112389

Tam, K. I., Philpott-Robinson, K., Johnson, T., & Lane, A. E. (2023). Measurement of School Engagement in Elementary School Students: A Scoping Review. *American Journal of Occupational Therapy*, *77*(3). https://doi.org/10.5014/ajot.2023.050036

Tomlinson, C. A. (2017). Differentiated instruction. In *Fundamentals of gifted education* (pp. 279-292). Routledge. https://doi.org/10.4324/9781315639987-26

Vaičiūnienė, A., & Kazlauskienė, A. (2023). Liberating and Oppressive Factors for Self-Directed Learning: A Systematic Literature Review. *Education Sciences*, *13*(10), 1020. https://doi.org/10.3390/educsci13101020

Van de Walle, J. A., Karp, K. S., & Bay-Williams, J. M. (2022). *Elementary and middle school mathematics: Teaching developmentally*. Pearson. One Lake Street, Upper Saddle River, New Jersey 07458.

Van den Heuvel-Panhuizen, M., & Drijvers, P. (2020). Realistic mathematics education. *Encyclopedia of mathematics education*, 713-717. https://doi.org/10.1007/978-3-030-15789-0_170

Witherspoon, T. (2023). Developing Number Sense with Number Talks. *Journal of Mathematics Education at Teachers College*. https://doi.org/10.52214/jmetc.v14i2.11709

Yuniawatika, Y. (2018, September). Improving the number sense ability of elementary school students in mathematics learning. In *1st International Conference on Early Childhood and Primary Education (ECPE 2018)* (pp. 241-245). Atlantis Press. https://doi.org/10.2991/ecpe-18.2018.53

Zimmermann, P. A., Stallings, L., Pierce, R. L., & Largent, D. L. (2018). *Classroom Interaction Redefined: Multidisciplinary Perspectives on Moving Beyond Traditional Classroom Spaces to Promote Student Engagement*. *7*(1), 45–61. https://files.eric.ed.gov/fulltext/EJ1195242.pdf