

Examining the Role of the School Environment to Enhance Indonesian Middle School Students' Numeracy

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ABSTRACT

Numeracy is one of the fundamental skills that individuals of all ages need to function effectively in modern society. Yet in many Indonesian schools, opportunities to develop numeracy remain limited, especially through the school environment. This study investigated how the school environment, both physical and non-physical, can support the development of middle school students' numeracy in Indonesia. The study used a mixed methods approach in two junior high schools in North Sulawesi during the *Kampus Mengajar 7* program. Environmental interventions included numeracy-themed visual displays, games, and integration of numeracy across subjects and projects. A total of 48 grade 8 students from two classes since they were prepared to participate in the Minimum Criteria Assessment soon. The data were collected from pre-tests, post-test, interviews, and observations. Quantitative data showed there is an increase in the mean scores from the pre-test to the post-test for each school. Public School A recorded a gain of 17.95, while Private School B showed a gain of 12.29. A Wilcoxon signed-rank test showed significant improvements in both schools. For Public School A ($V = 0$, $p = 5.723e-05$) and Private School B ($V = 0$, $p = 5.866e-05$) indicating statistically significant gains after the intervention. The interventions received positive responses from students, teachers, and principals. Moreover, both schools faced challenges, including repurposing existing spaces and encouraging teacher collaboration (especially non-science and non-mathematics subjects). In conclusion, the findings suggest that designing a numeracy-rich school environment, both physical and non-physical, can help to improve students' numeracy.

KEYWORDS

numeracy, mathematical literacy, school environment, Indonesian students, middle school

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A. Introduction

Numeracy is one of the fundamental skills that individuals of all ages, from children to adults, need to function effectively in modern society (Jonas, 2018). It helps us to navigate everyday life situations, such as making informed decisions or solving problems in various aspects of our daily life (O'Donoghue, 2021). In many developed countries, this ability is assessed regularly and systematically nurtured as part of national education priorities. For instance, in countries like Australia and the United Kingdom, they have National Numeracy Day and participate in the Program for the International Assessment of Adult Competencies (PIAAC) to assess and monitor the adult population's numeracy (Mallows et al., 2017; PIAAC Numeracy Expert Group, 2009). Ireland launched a large-scale assessment known as the National Literacy and Numeracy Strategy 2011-2020 as a basis for developing educational policy, aiming to improve literacy and numeracy among children

and young people at all levels of the education system (Karakolidis et al., 2021). Singapore implemented a policy for children from disadvantaged backgrounds to ensure the development of numeracy concepts and skills, known as the Early Years Development Framework (EYDF) and the Nurturing Early Learners (NEL) curriculum (Muñez & Cheung, 2024). Moreover, in higher education, numeracy becomes one of the core subjects in teachers' training programs and a mandatory requirement for teacher certification (Bennison, 2019; Department of Education, 2023; Forgasz & Hall, 2019; Hall & Forgasz, 2020). Due to its significance, numeracy (commonly alongside literacy) is considered a key indicator of a country's education quality. One of the global assessments that measures this competency is the Programme for International Student Assessment (PISA).

The latest results in the 2022 PISA assessment indicate Indonesia continued to perform lower than the global average, especially in mathematical literacy. Indonesia's average score is only 366, significantly under the OECD average of 472. This score marks a 13-point decline from the previous 2018 PISA assessment. In addition, from the mathematical proficiency level, over 80% of the students performed below level 2 (the minimum competency level of the OECD) (OECD, 2023). These PISA results indicate that Indonesian students demonstrate limited foundational mathematics skills. If this continues, our young generation might struggle to participate effectively in modern life in the future, such as making decisions for personal finance, performing workplace tasks, or interpreting basic data. These results highlight a need for improvement in our education system, particularly in efforts to enhance mathematical literacy (numeracy).

While PISA results provide us with a broad picture of Indonesian students' mathematics proficiency, the previous studies' findings show challenges faced at the ground level. Several studies were conducted to analyze Junior High School students' mathematical reasoning levels in solving numeracy problems. They found that above 40% of the subjects performed low mathematical reasoning or fell in the below-basic or very poor categories (Ate & Lede, 2022; Jazilah et al., 2024; Nurhaliza & Ni'mah, 2023; Sari et al., 2021). It was assessed using mathematical reasoning or mathematical literacy indicators, such as making a hypothesis, performing necessary manipulations, drawing conclusions, and identifying patterns or properties within mathematical phenomena. Moreover, our teachers are not yet proficient in supporting students' numeracy development, particularly middle school and high school teachers. Many studies have been conducted concentrating only on primary school teachers, for they have *tematik* approach (integrates multiple subjects into thematic instruction) in teaching. In interviews with teachers in the school in which we conducted the study, some teachers still struggle with integrating numeracy into cross-curricular teaching. The same issue is observed among our pre-service teachers or teacher education students. Most of the students face a challenge in comprehending some mathematical concepts and how to apply them to solve problems, particularly those resembling the Minimum Criteria Assessment (*Assesmen Kriteria Minimum*) problems. They still view mathematics as something whose formulas need to be memorized rather than perceive it as a tool for reasoning and solving problems in daily life (Ermita et al., 2023).

In addition, observations and interviews with teachers in the schools where we conduct the study reveal that teachers and students still face challenges in improving numeracy. Based on the *Assesmen Kriteria Minimum* (AKM) result of both schools, the average student is not yet proficient in mathematical literacy. Alarming, some students in grade 7 have not mastered basic arithmetic, and some other fundamental skills, such as writing and reading the alphabet. The majority of the teachers

were not fully familiar with the concept of numeracy beyond arithmetic, particularly integrating numeracy in subjects other than mathematics. There were found some posters and wall displays that promote numeracy. However, the teachers had not used it effectively in their interaction with students. The schools in general had not provided a conducive learning environment to nurture students' numeracy development. There were no activities in the classroom or outside the classroom that supported students in applying their numeracy skills.

The environment plays a crucial role in developing and nurturing students' numeracy (Dewayani et al., 2021; Sari et al., 2023). A well-designed physical environment, positive social-affective environment, and numeracy integration across the curriculum can stimulate and nurture students' numeracy development in meaningful ways (Dewayani et al., 2021). For instance, we provide interactive displays or makerspaces that could promote exploration and problem-solving (Doorman et al., 2019). Schools should implement comprehensive and targeted programs, such as collaboration among teachers to design learning activities that support the application of numeracy in solving daily life problems. A study suggests that students' perceptions of numeracy are shaped by how often teachers integrate mathematics across subjects, even though the evidence remains inconclusive. The study proposes that this may reflect either the learning environment or students' own numeracy skills (Federici et al., 2016). National Council for Curriculum and Assessment in (Goos & O'Sullivan, 2022) describes how students in the junior secondary responded positively when two teachers, one specializing in mathematics and the other in a different subject area such as science, business, art, geography, or design and graphics, collaboratively developed numeracy tasks that connected learning objectives from both subjects. This could help students see its relevance in a variety of subjects and real-life contexts. These findings highlight that Indonesian students might need to have a better learning environment to develop strong numeracy skills.

While studies about students' numeracy at K-12 levels are relatively common, there are still limited studies investigated how the school environment affects students' development of numeracy. This gap underlines the need how intentional improvements in the learning environment (physical and non-physical) can enhance students' numeracy. Therefore, the aim of this study is to examine the role of the school environment, both physical and non-physical, in enhancing numeracy among Indonesian middle school students.

B. Research Methods

The current study employed mixed methods to examine the role of the environment in enhancing middle school students' numeracy. Mixed methods were selected to get more comprehensive and well-supported results (Creswell & Clark, 2017). The study was conducted during the *Kampus Mengajar* program. The *Kampus Mengajar* program is under the Merdeka Belajar – Kampus Merdeka (MBKM) framework initiated by the Ministry of Education to provide university students from all study programs with the opportunity to contribute to the improvement of literacy and numeracy, particularly in underdeveloped, frontier, and remote (3T) areas (Shabrina, 2022). Therefore, the interventions in the study were part of *Kampus Mengajar*'s work programs, designed by university students and the research team as field advisors. It was conducted simultaneously in two Junior High Schools in Tomposo Subdistrict, Minahasa Regency, North Sulawesi, Indonesia. To achieve richer data, one of the schools is a public school, and another is a private school. Both schools received similar interventions in their environment to improve the students' numeracy development.

The interventions were implemented for the entire school's community for four months. They were documented and reviewed monthly. Participants in this study were teachers, both mathematics and non-mathematics, headmasters, curriculum coordinators, and students. Participants were selected using purposive sampling. However, for pre-test and post-test, we only involved 48 students in grade 8 since they were prepared to participate in the Minimum Criteria Assessment soon.

1. Quantitative Methods

To assess how the change in the environment impacts the students' numeracy, we administered a pre-test before the intervention. Around 4 months of intervention, a post-test was conducted. The test instruments were prepared by the Ministry of Education, and the researchers only received the raw test score data. The test items were adapted from AKM's framework and had a similar type to AKM items.

The data from the pre-test and post-test were analyzed by using descriptive statistics and the Wilcoxon signed-rank test for each school to check whether there is an improvement in students' numeracy after the intervention. The Wilcoxon signed-rank test was chosen since we have a small sample size and non-normal distribution (Sheskin, 2020). After analyzing the data from both schools, we performed the Mann-Whitney U test on gain scores to compare the effectiveness of the intervention between schools. The Mann-Whitney U test was chosen for the same reason we chose the Wilcoxon signed-rank test (Sheskin, 2020).

2. Qualitative Methods

In the qualitative methods, we focused on documenting the type of changes made in the environment, the scope of the changes, and the teachers' and students' perceptions of those changes. The intervention was conducted collaboratively by university students and school personnel.

Furthermore, the implementation of the interventions was carried out in both physical and non-physical environments. For the physical environment, we designed some visual numeracy aids, such as wall displays and makerspace materials (some numeracy games). While for non-physical environment, we integrated numeracy into non-math subjects (Prakarya and Teknologi Informatika), the use of real-life problems in mathematics lessons, and cross-curricular lesson planning for Project to Strengthen the Pancasila Student Profile (Proyek Penguatan Profil Pelajar Pancasila). Project to Strengthen the Pancasila Student Profile is a program in the Merdeka Curriculum aimed at developing the Pancasila Student Profile through project-based learning, in which various school subjects are integrated within the project (Satria et al., 2022). The whole process of intervention was documented through observations, field notes, and photos. In addition to gathering data about teachers' and students' perspectives, we interviewed the headmasters, curriculum coordinators, teachers, and students to explore their opinions and challenges, and strategies applied during the intervention. The interviews were audio-recorded, transcribed, and thematically analysed.

C. Results and Discussion

The findings of this study will be categorized into two sections: quantitative and qualitative findings.

1. Quantitative Findings

Table 1 shows the descriptive statistics of the pre-test and post-test of the two schools where the study was conducted. There were 23 subjects from the Public-School A and 25 students from the Private School B.

Table 1. Pre-tests and Post-tests of the Two Schools

Schools	Test	N	Mean	Median	Standard Deviation	Min	Max
Public School A	Pre-test	23	28.64	27.5	9.66	15	40
	Post-test	23	46.59	45	4.73	50	55
Private School B	Pre-test	25	17,50	15	10	5	15
	Post-test	25	29,79	30	7.87	40	45

As shown in Table 1, there is an increase in the mean scores from the pre-test to the post-test for each school. For Public School A, there is a gain of 17.95. While for Private School B, the gain is 12.29. The same trend is evident in the minimum and maximum scores. It suggested that after the interventions, both schools showed an improvement from the lowest and the highest scores.

However, it is important to note that all scores of the tests are on a scale of 100. It can be observed that even though there is an improvement in the average, the scores are still below 75, which is typically considered the minimum standard for satisfactory performance. Nevertheless, it is essential to highlight that both schools were selected as partner schools by the Kampus Mengajar program due to their numeracy and literacy results in the AKM assessment being significantly lower than the national average. Therefore, future studies could explore long-term interventions to determine whether sustained environmental changes can lead to further improvements in students' AKM results.

Additionally, we performed a Wilcoxon signed-rank test to examine whether there is a significant improvement within each school. For Public School A, we obtained $V = 0$ and the p-value of $5.723e-05$ ($p < 0.05$). The results indicated that all post-test scores were higher than or equal to pre-test scores, and the difference between pre-test and post-test scores was statistically significant. Similarly, for Private School B, we obtained $V = 0$ which indicated that all post-test scores were higher than or equal to pre-test scores. Then, the p-value is $5.866e-05$ ($p < 0.05$), suggesting the difference between pre-test and post-test scores of Private School B was also statistically significant. Therefore, we can conclude that there was a significant improvement after the intervention in both Public-School A and Private School B.

To compare the effectiveness of the interventions between the two schools, we conducted a Mann–Whitney U test on the gain scores. The result showed that $U = 351$ and a p-value of 0.05315 . It was apparent that the p-value we obtained was only slightly higher than 0.05 . This suggests that there is not enough statistical evidence to support a statistical difference in gain scores between the schools. Therefore, we can conclude that there is no significant difference between Public School A's and Private School B's results. This result may be due to several similarities shared by the two schools. It can be stated that both schools start from the same starting points. Both schools were situated in the same subdistrict, which might make the schools have similarities in environment and socio-cultural background. In addition, both were selected for the Kampus Mengajar program due to their low performance in numeracy and literacy based on the AKM assessment. The interventions implemented were also similar. Therefore, for future studies, it is recommended to involve a larger and more diverse sample of schools, with different baseline performance levels or from different geographical backgrounds.

2. Qualitative Findings

1) Physical Environment Interventions

In both schools, physical environment interventions were implemented to improve students' engagement with numeracy. At Public School A, numeracy wall displays had already been installed

in classrooms by teachers and students before the intervention. However, observations indicated that these resources were rarely integrated during teaching and learning activities. Therefore, the research team implemented additional interventions in the school's common areas, particularly the hallway where the school's bulletin board (mading) was. This school's bulletin board had previously been inactive, and the space was in a poor state. The team revitalized this space by reintroducing and regularly updating the bulletin board with numeracy-themed posters and numeracy puzzles, such as number riddles. These materials were updated weekly to maintain student interest and engagement. This intervention aimed at encouraging informal interaction with numeracy outside the classroom. The revitalized school's bulletin board is presented in Figure 1.



Figure 1. School's Bulletin Board

In addition, A makerspace was also set up in the school library called the Numeracy Corner. The space featured low-cost board games called *Ular Tangga Numerasi* and the Mystery Box (in Figure 2), containing math problems and math puzzles. The area was arranged in the school library due to the limited space in classrooms. The team also thought that it was better in the library so the students could visit the space anytime and play the games. Teachers could borrow the board games if they want to use them in their classes. This space allowed the students to play with numbers informally and encouraged them to apply their problem-solving ability and develop their numeracy even outside the classroom.



Figure 2. Board Games: *Ular Tangga Numerasi* & Mystery Box (left) and Numeracy Corner (right)

At Private School B, the team installed numeracy wall displays in the classrooms called *Pohon Numerasi* (in Figure 3) and posters in other common areas around the school, such as corridors between classrooms and near the school's garden. In addition to these visual materials, the research team also designed a similar board game to that in Public School A, *Ular Tangga Numerasi*. However, unlike what we established in Public School A's library, Private School B did not have enough space in the library to set up a Numeracy Corner. As an alternative, the team invited students to play the

game inside classrooms (as presented in Figure 4), particularly during free periods when teachers were absent or at the beginning and end of lessons. These interventions allowed students to engage with numeracy content inside and outside the classroom in an enjoyable and relaxed setting, while still reinforcing students' numeracy.



Figure 3. *Pohon Numerasi* in the Classroom



Figure 4. Students Playing *Ular Tangga Numerasi* in the Classroom

In conclusion, both schools implemented similar physical environment interventions to design a more numeracy-rich environment, but slightly different in some ways due to differences in available resources and space. In Public School A, the interventions focused on revitalizing unused common areas and creating a numeracy space in the library, allowing students easy access to interact with varied numeracy materials. Meanwhile, Private School B maximized classroom and outdoor areas to accommodate similar materials and activities, adapting to the space limitations. Despite these differences, both schools demonstrated increased opportunities for students to interact with numeracy beyond the classrooms, promoting informal learning, problem-solving, and engagement with mathematical concepts throughout the school environment.

2) *Non-Physical Environment Interventions*

Non-physical interventions in both schools were designed to enhance students' numeracy through meaningful, contextual, and cross-curricular learning experiences. These interventions were implemented into the learning activities in the classroom, school events, and the P5 (Projek Penguatan Profil Pelajar Pancasila) program.

At Public School A, at the beginning of the P5 project, students planned their small business project in which they sold snacks, food, or beverages. They calculated capital, set prices, estimated profits, and made financial decisions to avoid losses. Through this experience, students not only applied mathematical concepts like arithmetic and percentage but also developed decision-making and problem-solving skills in a real-world context. The culmination of this P5 was during the Literacy and Numeracy Festival. Students implemented their business project by making a food and beverage market. Another highlight of this event was the "Cerdas Cermat Matematika" (Math Quiz Competition). This competition aimed to encourage students to enhance their numeracy and math

concepts in an enjoyable and competitive environment. Another intervention was the integration of numeracy into non-mathematics subjects. In the Teknologi Informatika (TIK) subject and Prakarya, students learned to use Canva to design posters for their business products in P5. This activity enhanced their numeracy and visual arts by applying their spatial reasoning, creativity, and aesthetic appreciation. Furthermore, due to the presence of a biology-major student in the research team, we collaborated with science teachers to incorporate numeracy into Science lessons. In lessons about healthy lifestyles, students analyzed nutritional information, calculated calorie intake, compared sugar content in different snacks, and interpreted data to make healthier choices. These activities allowed students to connect scientific content with real-life numerical reasoning, reinforcing interdisciplinary understanding. This method is considered one of the most impactful ways to develop numeracy skills and has significant potential to enhance their learning empowerment (Getenet, 2024).

Similar efforts were made in Private School B. The Literacy and Numeracy Festival included both a Math Quiz Competition and a Recycled Craft Contest. In the Recycled Craft Contest, students created useful items from plastic waste and presented the estimated cost savings and potential profits if these items were to be sold. This required students to collect, measure, and categorize plastic waste, and apply mathematical calculations related to cost-efficiency and pricing. It also helped build their public speaking skills as they presented their process and findings to peers and teachers. In the P5 project, students were engaged in planting and maintaining a cassava garden in the school garden. They were responsible for taking care of the plants and eventually selling the harvest to the local community. Throughout the process, students learned how to track growth time, calculate planting costs, estimate yields, and determine appropriate selling prices. This hands-on project helped students see the value of mathematics in agricultural entrepreneurship. Like in Public School A, numeracy was also integrated into Teknologi Informatika (TIK) and Prakarya lessons. Students used Canva to design informative posters, promoting the sale of their garden produce or recycled items. This activity not only built digital literacy and creativity but also strengthened spatial understanding and numeracy related to layout, measurement, and visual balance.

3) *Teachers' and Students' Perceptions*

Interviews were conducted with students, teachers, and school principals from both schools. The aim was to explore the perceptions of the school communities about implemented interventions. In general, the interventions were received well by students and teachers. Students were delighted that they could play many different games and use interactive materials during the class. They were also very enthusiastic when joining the Literacy and Numeracy Festival. They particularly appreciated the opportunity to play and learn simultaneously during breaks. One student noted that

“Saya suka bisa belajar sambil bermain Ular Tangga dengan teman-teman di perpustakaan pas jam istirahat.”

(I like being able to learn while playing Snakes and Ladders with my friends in the library during break time.)

Similar positive responses were received from teachers. Some teachers mentioned that they gained new insights while collaborating with students on designing fun, student-centered, and numeracy-integrated learning. Likewise, school principals were also pleased with the student engagement they observed.

Despite the positive feedback, several challenges were identified during the interventions. A common challenge from both schools was to maintain students' focus when teachers were explaining

during the lesson, especially after engaging with games and play-based activities. In addition, there were space constraints, especially in Private School B, where the lack of space in the library made it difficult to set up a dedicated numeracy corner. Moreover, several teachers noted the difficulty in involving all fellow teachers in the implementation process. One teacher shared that:

“Tantangan yang saya hadapi ketika ingin mengajak semua guru untuk ikut aktif dan belajar pentingnya numerasi.”

(The challenge is getting all the teachers involved and helping them understand the importance of numeracy.)

Additionally, one principal suggested that they need more teacher involvement and professional development related to numeracy integration in learning, especially in non-mathematics subjects:

“Saya berharap ke depannya semua guru bisa diajak terlibat. Kalau bisa, diadakan pelatihan untuk semua guru tentang bagaimana cara mengintegrasikan numerasi dalam pembelajaran, khususnya guru selain guru matematika.”

(I hope that in the future all teachers can be involved. If possible, there should be training for all teachers on how to integrate numeracy into their teaching, especially those who are not mathematics teachers.)

Moreover, some teachers expressed interest in receiving more guidance and support to integrate numeracy concepts in their lesson plans. A similar finding suggested by the previous study (Coffey & Sharpe, 2023; Maghfiroh, 2022; Palinussa et al., 2023) is that teachers need professional development to understand numeracy more deeply, and policymakers must support schools in adopting cross-disciplinary, interdisciplinary, and transdisciplinary approaches to integrating numeracy throughout the curriculum.

4) Discussion

The findings from both the quantitative and qualitative data sources provide a comprehensive description (Almalki, 2016). While the test score improvements suggest noticeable gains, the qualitative insights help contextualize these results to provide a description of students' and teachers' experiences during the interventions. The improvement in students' post-test scores at both schools corresponds with positive perceptions gathered through interviews. Students reported increased motivation and enjoyment in learning, particularly when engaging with games and visual materials. Teachers also noted greater student participation and interest during numeracy-related activities. These perceptions support the quantitative evidence that learning outcomes improved following the interventions. These findings are similar to the studies of Abbacan et al. (2025), Adedigba (2023), dan Cayang & Ursabia (2024) that implementing game-based learning strategies in mathematics instruction is highly effective, stimulating cognitive interest amongst learners, resulting in a notable enhancement of learners' academic performance compared to conventional teaching methods.

Moreover, environmental changes, such as revitalized bulletin boards, classroom wall displays, and numeracy corners, have played a crucial role in supporting these outcomes. These spaces created opportunities for informal numeracy engagement, extending learning beyond the classroom. For example, students used break time to interact with numeracy materials in the library or play games when class was not in session. This suggests that the interventions not only supported academic learning but also created a more numeracy-rich school culture. The impact of the Numeracy Corner

was particularly evident, as it was frequently highlighted during interviews with members of the school community. In Public School A, the Numeracy Corner in the library, with its designated space and variety of board games, offered more sustained engagement opportunities. In contrast, although Private School B did not have a dedicated space like Public School A, it utilized classroom time to integrate play-based numeracy whenever possible. However, the quantitative analysis comparing the gain scores between the two schools showed no statistically significant difference, indicating that flexible adaptation of interventions can still be effective, even when space or resources are limited. This is similar to what was found by (Agustina & Zayyadi, 2023; Azis et al., 2022; Shabrina, 2022) that physical learning environments could influence the development of students' numeracy.

The differences in available resources between the two schools influenced the extent and style of implementation. Public School A had more library space, which allowed for a dedicated numeracy corner and a wider variety of materials. In contrast, space constraints in Private School B limited the scope of interventions, although teacher creativity and flexibility helped to mitigate these limitations. Teacher engagement also varied, with some staff members more actively involved than others, which influenced the consistency of intervention use. The limitation of this study is its relatively short duration and the limited school context, as it involved only two schools located within the same region. A longer intervention period may bring out more robust improvements and allow for deeper integration into teaching practices. Additionally, the sample was limited to two schools, thus requiring broader comparisons for more generalizable findings. While the statistical results showed significant improvements, the Mann–Whitney test revealed no significant difference in gain scores between the two schools, suggesting that both school contexts can benefit from such interventions regardless of resource availability, although outcomes may vary. These findings are in line with previous studies emphasizing the impact of school environment in supporting students' numeracy (Mallows et al., 2017; Ondog & Kilag, 2023; Sari et al., 2023). Hands-on activities, peer collaboration, and the use of concrete materials significantly contribute to students' conceptual understanding of numeracy. As applied to adults, providing opportunities to solve problems and make decisions, and providing support and resources to nurture the students' numeracy.

Furthermore, the study highlights the potential of physical and non-physical environmental changes (instructional atmosphere) in enhancing students' engagement and learning in numeracy. Teachers are encouraged to integrate varied learning tools, such as visual displays and board games, into their daily lessons to expose students to more enjoyable and accessible numeracy content. Additionally, the findings emphasize the importance of utilizing existing school spaces creatively to foster a culture of numeracy thinking beyond the classroom (Agustina & Zayyadi, 2023; Shabrina, 2022). The principals need to step up in facilitating and sustaining such innovations. Their support in providing space, encouraging teacher collaboration, and maintaining resources (e.g., updating bulletin boards, ensuring proper maintenance of the materials, and easy access to the materials) is essential for ensuring long-term impact. Leadership that values innovation and supports teacher development can drive great improvement in numeracy outcomes (Muir et al., 2018).

For policymakers, this study underscores the value of integrating environmental and play-based interventions within national education initiatives. Programs like Kampus Mengajar can be further developed to not only focus on student outcomes but also build school capacity to create engaging learning environments. Curriculum developers should consider designing guidelines and examples of low-cost as well as flexible environmental supports for numeracy teaching in mathematics and non-mathematics teaching. Policies need to promote school-based innovation and community involvement, especially in underperforming schools, to create more inclusive and equitable learning opportunities (Maier et al., 2017). Investments in professional development for teachers to help them

understand how to use physical space and visual aids for optimizing their students' numeracy skills (Gibson, 2020).

This study offers a model for future interventions in similar limited-resources school contexts. It demonstrates that even with minimum resources, meaningful changes can be made to improve learning outcomes as long as it is well-designed and context-sensitive (Evans et al., 2019). However, successful implementation requires collaboration between external facilitators, such as university lecturers or university students, and education authorities, such as the Head of the Local Education Authority or Guru Penggerak (Teacher Leaders). These findings align with Amin & Roberts (2008) who argue that situated knowledge creation is most effective when involving diverse forms of expertise and collaboration across organizational boundaries. Such collaboration could foster innovation that is sensitive to local context and practical needs. In addition, it should be considered to have longer intervention periods, more comprehensive teacher training, and regular monitoring and evaluation to assess and adjust strategies in future implementations. Moreover, more stakeholders (e.g., parents, local communities) can be considered to be involved to strengthen the impact of the intervention (Howard, 2006).

D. Conclusion

This study aims to improve Indonesian students' numeracy through a more supportive school environment. The findings confirm that the interventions implemented, both physical and non-physical, had a positive impact on students' numeracy development. The improvement is reflected by the increase from pre-test to post-test scores. The result is supported by the students' and teachers' positive responses. It shows that intentional changes to the learning environment can enhance engagement and mathematical understanding, even in schools with limited resources. The results of this study align with its original objective, demonstrating that integrating numeracy into the school's physical setting and across subjects through project-based and contextual learning can foster a numeracy-rich culture. Both schools showed statistically significant improvement from their baseline, indicating that such interventions are effective regardless of school type. These findings provide a valuable foundation for future implementation. Further research could involve longer intervention periods, broader school samples, and deeper teacher capacity building.

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