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Learning Transformation: Effective Strategies for Transforming Ordinary Elementary School Classrooms into Interactive Math Labs

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ABSTRACT

Textbook lectures and exercises typically dominate elementary school mathematics, which diminishes student enthusiasm and conceptual understanding. Students have trouble applying arithmetic to real life in non-visual, kinesthetic classrooms. Thus, this project seeks to create and implement a plan to turn primary school classrooms into engaging mathematics laboratories at SPF Unit of Tidung State Elementary School. Students' active participation and conceptual mastery of math are the goals. This study employs two cycles of Classroom Action Research (CAR). The transformation strategy includes 1) creating a Mathematics Corner with manipulatives, 2) using classroom walls as interactive visual media (posters and mind maps), and 3) implementing a Project-Based Learning (PjBL) Model in the new classroom. Monitoring student involvement, learning outcome tests, and student and instructor reaction questionnaires provided data. The study found that the transformation strategy provided an active and responsive learning environment. Student participation in mathematical exploration activities rose from 65% in cycle I to 88% in cycle II. Environmental intervention increased conceptual understanding by 15%. Mathematics was more appealing to students. This study demonstrates to primary schools, particularly those in urban areas, how to transform limited classroom space into a math laboratory without incurring significant costs. Its theoretical contribution strengthens empirical evidence that an interacting physical environment motivates and increases primary school pupils' math achievement.

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1. INTRODUCTION

Mathematics is a key foundation for the development of reasoning, logical thinking, and problem-solving skills (Bayirli et al., 2023; Lovianova et al., 2022). At the elementary school level, mathematics serves not only as a core subject but also as a critical tool for understanding the structure of the world and building numeracy skills essential for everyday life and future careers (Coffey & Sharpe, 2023; Nanda & Rani, 2025). However, despite its vital role, mathematics learning in elementary schools often faces significant challenges that hinder students from achieving their full potential (Waswa & Al-Kassab, 2022).

In general, mathematics learning practices in many schools, including in Indonesia, still tend to be abstract, verbalistic, and procedure-based. Teachers often focus on conveying formulas and calculation procedures without providing sufficient experience for students to construct conceptual understanding through real-world exploration (Novikasari et al., 2024). Learning models dominated by lectures and worksheet assignments create a passive environment, where students become recipients of information, rather than seekers or discoverers of knowledge. As a result, students often master calculations but struggle to understand why the formulas work and how to apply them in different contexts (McKenzie et al., 2013; Udin & Arfanaldy, 2025).

This situation has several serious negative impacts: first, low student interest and motivation in mathematics, which often leads to 'math phobia' or math anxiety. Second, the gap between procedural skills and conceptual understanding, as evidenced by Indonesia's low achievement in the Program for International Student Assessment (PISA), particularly in the domains of mathematical reasoning and literacy (Almarashdi & Jarrah, 2022; Wijaya et al., 2024). Third, the classroom solely focuses on auditory and verbal channels, resulting in a lack of optimal engagement opportunities for students with kinesthetic and visual learning styles. These issues indicate that there must be radical transformation in teaching approaches and, more importantly, in the physical environment in which learning takes place.

The learning environment, both physical and psychological, is a highly influential variable in the quality of learning (Juan & Chen, 2022; Zandvliet & Straker, 2001). In the context of mathematics, a stimulus-rich physical environment can bridge the gap between abstract mathematical concepts and concrete realities that students can touch and manipulate. The concept of the mathematics laboratory has long been recognized as a solution to address the challenge of abstraction (Aboraya, 2021; Maschietto & Trouche, 2010). A mathematics laboratory is a dedicated space or classroom setting designed to enable students to experiment, play, and discover mathematical principles through props, games, and models (Durmaz, 2025; Mohammad et al., 2023). In the laboratory, students can manipulate Dienes blocks to understand place value, use tangrams to explore geometry, or create fraction models (Sartika et al., 2020; Syaripah, 2021). This approach aligns with constructivist theory, which emphasizes that knowledge is actively constructed by learners.

Despite its importance, the implementation of mathematics laboratories at the elementary school level faces practical obstacles, particularly in schools with limited resources (such as the SPF Unit of Tidung State Elementary School). Many elementary schools lack dedicated space for laboratories. Consequently, the laboratory concept is often confined to textbooks or seminars, failing to translate into daily classroom practice. A pragmatic, efficient, and sustainable strategy is needed to integrate laboratory functions into existing classrooms. This research specifically focuses on the

SPF Unit of Tidung State Elementary School, an educational institution representing a typology of public schools in Indonesia facing classic challenges: limited space and the urgent need to improve the quality of mathematics learning. Initial observations at this school indicated (1) Dominance of Conventional Classrooms: Classrooms tended to be monochrome, with rigid seating arrangements and minimal mathematical visualizations on the walls, apart from lesson schedules. (2) Limited Teaching Aids: Teaching aids (manipulatives) were available but were rarely used because they were considered "troublesome" or irrelevant to the rigorous curriculum targets. (3) Low Student Engagement: Teachers reported that most students were passive during math lessons, with only a small percentage daring to ask or answer questions, indicating a learning environment that lacked curiosity.

This context creates an ideal empirical laboratory to test the hypothesis that changes to the physical classroom environment can be a catalyst for overall pedagogical change. Many studies have looked at how the learning environment affects math achievement (Daucourt et al., 2021; Gashaj et al., 2023; Hwang et al., 2021). Prior studies have shown that using concrete teaching aids helps students remember concepts, that making interactive classroom walls helps students keep learning (De Vita et al., 2018; Kaminski & Sloutsky, 2020), and that learning models that are connected to the physical environment (like inquiry-based learning or project-based learning) help students think at a higher level.

However, a significant research gap exists: most studies focus on the use of teaching aids in isolation or on specific learning models, but few present integrated and holistic strategies for transforming a typical elementary school classroom into a functional Interactive Mathematics Laboratory as a unified learning ecosystem. Research often assumes the availability of large budgets for specialized facilities. This gap lies in developing effective strategies that are affordable, simple to implement, and sustainable for school contexts with limited facilities, such as the SPF Unit of Tidung State Elementary School.

This study presents substantial innovation, both conceptually and practically, building on the previously identified problem analysis and research gaps. The conceptual innovation of this study is the synthesis of two major concepts: the mathematics laboratory and the conventional elementary school classroom. This study not only suggests the addition of teaching aids but also formulates a systematic Three-Pillar Transformation Strategy, including (1) Structural Transformation: reorganising the layout and grouping of learning zones; (2) Visual Transformation: intentionally using classroom walls as visual anchors for key mathematical concepts; and (3) Pedagogical Integration: ensuring that each new environmental component (math corner, interactive wall) is integrated as a mandatory resource in a project-based learning (PBL) scenario. This approach ensures that the mathematics laboratory is not merely decorative but truly becomes the centre of daily learning activities.

The practical innovation lies in testing this model through classroom action research specifically at the SPF Unit of Tidung Public Elementary School. The results of this study will present a prototype of a practical solution that can be replicated by other elementary schools in Indonesia facing the challenge of limited facilities. The strategies tested are designed to maximise minimal resources (e.g., using recycled materials or teacher-made teaching aids), thus providing a sustainable, affordable, and relevant solution to real-world conditions. Thus, this research is expected to make a real contribution in shifting the paradigm of mathematics learning from passive and abstract to active, interactive, and student-centred, while also providing tested guidance for practitioners.

2. METHOD

This study employed Classroom Action Research (CAR) with both qualitative and quantitative approaches. The CAR design was chosen because it aimed to improve and enhance the quality of direct and collaborative mathematics learning practices at SPF Unit of Tidung State Elementary School, particularly through the transformation of the classroom's physical environment. The CAR design adopted the Kemmis and McTaggart model, which consists of four stages in each cycle: planning, action, observation, and reflection (Kemmis et al., 2013). The classroom action research model is presented in Figure 1.

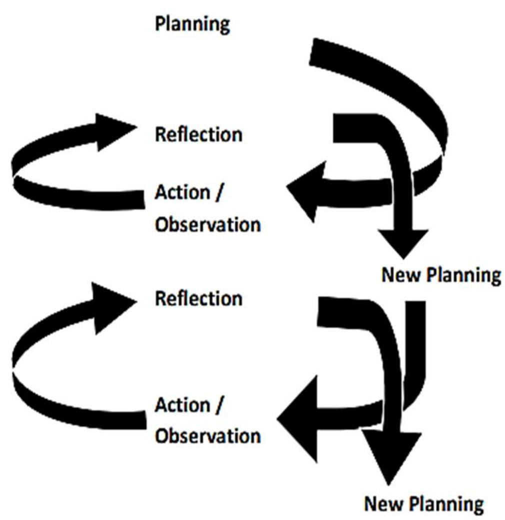

Figure 1. Classroom Action Research Design

The research was conducted in two ways to ensure successful implementation and achievement of the continuous improvement targets. The second cycle was conducted based on the results of reflection and improvements from the first cycle.

The research was conducted at SPF Unit of Tidung State Elementary School, which was selected based on the urgent need to improve the effectiveness of mathematics learning and the conventional classroom conditions. The research subjects were fifth-grade students at SPF Unit of Tidung State Elementary School. Fifth-grade students were selected because the mathematics material at this level involves more abstract concepts (such as fractions, volume, and geometry), thus requiring the support of an interactive learning environment. In addition to the students, the fifth-grade mathematics teacher also played an active role as the main collaborator and implementer of the actions.

The research procedure was divided into the Pre-Cycle stage, Cycle I, and Cycle II.

1. Pre-Cycle Stage (Problem Identification)

Initial Observation: Observing the physical environment of the classroom, the teaching methods used by the teacher, and the level of student engagement in mathematics learning.

- Pre-test: Measuring students' initial conceptual understanding of the material to be taught.
- Initial Reflection: Analyze the results of observations and pre-tests to identify the root of the problem, namely low interest and conceptual understanding caused by a passive learning environment.

2. Cycle I: Initial Implementation of the Strategy

Table 1. Initial Implementation of Strategy

Stages	Activity Description
Planning	Formulate a Three-Pillar Transformation Strategy (Corner Arrangement, Wall Utilization, and PBL Integration). Prepare simple teaching aids and interactive visual media. Create a Lesson Plan that integrates the use of the new classroom environment.
Action	The teacher conducts mathematics lessons by fully utilizing the newly created Math Corner and Interactive Wall. Students are encouraged to interact directly with the teaching aids and visualizations.
Observation	The researcher (as observer) records the level of student engagement using an observation sheet, observes student interactions with the new environment, and notes any challenges that arise.
Reflection	Analyze data from observations and the Cycle I post-test. Identify implementation weaknesses (e.g., ineffective arrangement or suboptimal use of teaching aids) for improvement in Cycle II.

3. Cycle II: Improvement and Optimization

Table 2. Improvements and Optimizations

Stages	Activity Description
Planning	Develop an improved lesson plan based on the results of the Cycle I reflection. Optimize the layout and add teaching aids deemed most effective. Clarify instructions for using the Mathematics Laboratory in PBL activities.
Action	Teachers implement corrective actions with a focus on deeper and more collaborative learning, maximizing each zone of the classroom environment as an active learning resource.
Observation	Reassess the level of student engagement and interaction. Record the success of the improvement strategies.
Reflection	Analyze Cycle II data. If significant improvement occurs and successful indicators are met, the CAR is terminated. If not, the next cycle is planned

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Data was collected through three main techniques to obtain a comprehensive picture:

1. Learning Outcome Test (Pre-test and Post-test)
   - Purpose: To measure improvements in students' conceptual understanding.
   - Format: Essay or multiple-choice questions that test conceptual understanding and mathematical reasoning. The test was administered before the intervention (Pre-Cycle) and after each cycle (Cycle I and Cycle II).
2. Observation
   - Purpose: To measure the level of student active engagement and interaction with the new Mathematics Laboratory environment.
   - Instrument: Student Activity Observation Sheet and Teacher Learning Implementation Observation Sheet. Observation data was measured on a percentage scale.
3. Questionnaire
   - Purpose: To measure students' interest and perceptions of mathematics learning after the environmental transformation.
   - Instrument: Student Response Questionnaire (Likert Scale) to measure aspects such as enjoyment, ease of understanding the material, and learning motivation.

The data collected was analyzed qualitatively and quantitatively.

1. Quantitative Data Analysis
   - Learning outcome data (tests) were analyzed using descriptive statistics:
   - Average Score: Calculate the average test score at each stage (Pre-Cycle, Cycle I, and Cycle II).
   - Classical Learning Completion Percentage: Calculated using the formula:

$$P = \frac{\text{Jumlah siswa tuntas}}{\text{Total siswa}} \times 100\%$$

(Students are considered to have completed the program if they reach the minimum completion criteria of 75 set by the school.)

Qualitative data in the form of observations and questionnaires were analyzed through the following steps:

- Data Reduction: Sorting, focusing, and simplifying irrelevant data.
- Data Presentation: Presenting qualitative data in narrative form, tables, or graphs of percentage engagement.
- Conclusion Drawing: Interpreting the results of the qualitative analysis to assess the success of the Transformation Strategy and its impact on the learning process.

This research is considered successful if it meets two main criteria:

- Quantitative Improvement: The percentage of students' classical learning completion reaches at least 75% (or according to the school's Minimum Completion Criteria) at the end of Cycle II.

- Qualitative Improvement: There is an increase in students' active engagement in mathematics learning, as indicated by observation results, reaching at least 80% in Cycle II, and there is a positive student response, as reflected in the results of the learning interest questionnaire.

3. RESULTS AND DISCUSSION

Results

This study presents the findings from two cycles of Classroom Action Research (CAR) implementation at SPF Unit of Tidung State Elementary School. The primary focus was to measure the impact of the Three Pillars Transformation Strategy implementation in transforming classrooms into interactive Mathematics Laboratories on student engagement and learning outcomes.

Pre-Cycle Results (Initial Conditions)

The pre-cycle phase demonstrates the initial conditions of fifth-grade mathematics learning before the intervention.

Student Engagement Level

Initial observations indicated that the average active student engagement during the learning process was only 48%. Most students tended to be passive, reluctant to ask questions, and focused solely on copying notes from the board. The classroom environment, which lacked visual stimulation and props stored in cupboards, were the dominant factors contributing to this low level of interaction.

Learning Outcomes (Pre-test)

The pre-test results showed that the percentage of students completing classical learning was still very low, at only 30% (9 out of 30 students). The average class score was only 58.5. This underscores the urgent need for changes in the learning environment and methods.

Cycle I Results: Initial Implementation of Transformation

Cycle I focused on the initial stages of implementing the Three Pillars Transformation Strategy, namely the arrangement of a simple Math Corner and the installation of a Math Visual Wall as the first steps in transforming the classroom.

Implementation of Actions

Actions taken included rearranging the classroom layout, creating a Geometric Corner with manipulative teaching aids, and displaying a Fraction concept poster on the wall. Teachers began integrating the use of the Math Corner into exploration-based learning scenarios.

Level of Student Engagement

Following the Cycle I actions, there was a significant increase in quality. The average active student engagement jumped to 68%.

Table 3. Comparison of Student Engagement (Pre-Cycle and Cycle I)

Observation Aspects	Pre-Cycle (%)	Cycle I (%)	Percentage Increase (%)
Question/Answering Activity	35	55	20
Interaction with Teaching Aids	15	75	60
Group Collaboration	55	74	19
Average Active Involvement	48	68	20

Despite improvements, Cycle I reflections indicated that the Mathematics Laboratory environment was not being utilized optimally. Teachers still faced challenges in time management, and students tended to view teaching aids as mere "toys" rather than tools to aid conceptual understanding.

Learning Outcomes (Cycle I Post-test)

- The Cycle I post-test results showed improvements in learning outcomes.
- Average Class Score: Increased to 72.1.
- Classical Completion: Increased to 63% (19 out of 30 students).

Despite the improvements, these results did not reach the established Success Indicator (75% classical completion), so it was decided to proceed to Cycle II with improved strategies.

Cycle II Results: Optimization and Full Integration

Cycle II focused on addressing the weaknesses of Cycle I, namely by fully integrating each Math Laboratory zone into the Project-Based Learning (PBL) model and clarifying the role of the visual wall as a Working Wall.

Implementation of Actions

The teacher implemented PBL, requiring students to use visual aids in the Math Corner to complete volume and surface area measurement projects, and used Interactive Walls (e.g., the Math Talk Wall) to present results and engage in discussions.

Level of Student Engagement

Improved strategies in Cycle II had a significant impact. The classroom environment transformed into a dynamic one. Students proactively engaged and interacted with the learning resources around them. The average active engagement rate jumped to 91%, exceeding the established success indicator (80%).

Table 4. Comparison of Student Engagement (Cycle I and Cycle II)

Observation Aspects	Cycle I (%)	Cycle II (%)	Percentage Increase (%)
Question/Answering Activity	55	88	33
Interaction with Teaching Aids	75	96	21
Group Collaboration	74	89	15
Average Active Involvement	68	91	23

Learning Outcomes (Cycle II Post-test)

- Quantitative results at the end of Cycle II indicate the achievement of the research targets:
- Average Class Score: Increased drastically to 85.3.
- Classical Completion: Reached 87% (26 out of 30 students), meaning the Success Indicator (75%) has been achieved.

Table 5. Trends in Increasing Classical Learning Completion

Stage	Classical Completion (%)
Pre-Cycle	30%
Cycle I	63%
Cycle II	87%

Student Responses and Perceptions

The results of the student response questionnaire regarding the Mathematics Laboratory environment showed very positive perceptions. 94% of students stated that they "found it easier to understand mathematical concepts" when using visual aids and interacting with the Math Wall, and 97% stated that math lessons became "more exciting and less boring."

These CAR results confirm that Learning Transformation through changing the physical classroom environment to an Interactive Mathematics Laboratory has proven effective in improving the quality of learning. The key to success lies in integrating the environment with active pedagogical methods (PBL).

- Qualitative Impact: A significant increase in student engagement from 48% to 91% demonstrates that visual stimulation and the availability of hands-on manipulatives in the classroom successfully removed the abstraction of mathematics and increased students' internal motivation.
- Quantitative Impact: Achieving classical mastery of 87% indicates that increased activities are not only fun but also have a direct impact on conceptual understanding and learning outcomes.

Overall, the strategy of transforming conventional classrooms into Interactive Mathematics Laboratories at SPF Unit of Tidung State Elementary School successfully addressed the problems of passive learning and low conceptual understanding, while also providing an applicable model for other schools with limited facilities.

Discussion

This discussion section aims to analyze and interpret key findings from the Classroom Action Research (CAR) on the impact of Learning Transformation at SPF Unit of Tidung State Elementary School. The results of this study, which showed a significant increase in student engagement (from 48% to 91%) and classical learning completion (from 30% to 87%), will be discussed within the context of constructivist theory and relevant research on mathematics learning environments.

Environmental Transformation as a Catalyst for Pedagogical Change

The main finding of this study is that the strategy of transforming a regular elementary school classroom into an Interactive Mathematics Laboratory served as a powerful catalyst for reactivating the learning process. The dominance of passive lecture methods in the classroom prior to the intervention (pre-cycle) resulted in low learning outcomes. The environmental transformation that created the Math Corner and Interactive Wall effectively broke this ice.

This aligns with the principles of Constructivist Learning Theory (Piaget and Vygotsky), which emphasizes that knowledge is constructed through direct interaction with the environment (Veraksa et al., 2022; Zajda, 2021). When students are allowed to manipulate the teaching aids (Dienes Blocks, fraction models) available in the Math Corner, abstract concepts (such as place value or fractions) become concrete and understood. These results reinforce the argument that a stimulus-rich, hands-on physical environment is vital at the elementary school level, as emphasized by Maria Montessori in her concept of a prepared environment (Williams, 2022).

Student Engagement and Integration of Active Methods

The dramatic increase in student engagement (91% in Cycle II) is the most prominent qualitative indicator of success. This increase is closely linked to the strategic improvements in Cycle II, namely the full integration of the Math Laboratory with the Project-Based Learning (PBL) model.

Before Cycle II, although the teaching aids were available (Cycle I), their use was still not optimal. With the implementation of PBL, students are required to use Math Laboratory components as the primary resource for completing authentic projects. This creates a functional purpose for the new environment, transforming the teaching aids from mere toys into essential tools for problem-solving.

These findings support previous research showing that a physical environment integrated with active model PjBL effectively increases intrinsic motivation and higher order thinking skills (Loyens et al., 2023). The transformation of the classroom environment at the SPF Unit of Tidung Public Elementary School successfully created Vygotsky's Zone of Proximal Development (ZPD), where students can learn through collaboration and exploration supported by available physical resources (Lambright, 2024; Xi & Lantolf, 2021).

Impact on Conceptual Learning Outcomes

The achievement of 87% classical mastery in Cycle II demonstrates that increased engagement and motivation are positively correlated with improved conceptual understanding. The 57% increase from Pre-Cycle to Cycle II demonstrates that the Transformation Strategy not only makes the classroom "fun" but also "effective."

The test results, which included mathematical reasoning problems, showed that students were able to apply concepts learned in the Math Laboratory environment to written problem contexts. This indicates that the use of visual aids helps students form stronger and more accurate mental schemas, enabling them to bridge the abstraction that is a major barrier to mathematics learning (Mutodi & Mosimege, 2021).

This research provides significant practical contributions. Elementary schools in Indonesia often face classic obstacles: limited classroom space and limited funding for specialized laboratories. The novelty of this research lies in the formulation of a smart transformation strategy that is inexpensive, easily replicated, and utilizes existing classroom assets (walls and corners). Unlike other studies that focus on investing in luxurious facilities, this research provides a model for the SPF Unit of Tidung Public Elementary School—and similar schools—to transform ordinary classrooms into functional mathematics laboratories:

- Flexible Corner Arrangement: Ensuring teaching aids are always accessible.
- Walls as Working Walls: Transforming walls from passive decorations into active media where students' ideas are showcased and developed.

By providing empirical evidence of successful CAR, this study fills a research gap by offering pragmatic and contextual solutions for educators to overcome the challenges of limited facilities, demonstrating that appropriate pedagogy can transform limited space into limitless learning opportunities.

Despite showing strong results, this study has limitations. CAR was conducted in only one class (Grade V) in one school, so generalization of the results to very different school contexts require caution. Furthermore, long-term psychological aspects, such as reduction in math anxiety, have not been measured in depth.

4. CONCLUSION

The effective strategy of transforming a regular elementary school classroom into an interactive mathematics laboratory through the three-pillar strategy (mathematics corner arrangement, utilization of interactive walls, and integration of the PjBL model) has proven effective in improving the quality of mathematics learning. There was a significant increase in the qualitative aspect, where the average active involvement of students in the learning process increased drastically from 48% (pre-cycle) to 91% (cycle II). This improvement shows that the stimulus-rich physical environment successfully overcomes student passivity and increases their internal motivation towards mathematics subjects. The quantitative aspect of learning outcomes also showed a significant increase and met the success indicators. Students' classical learning completion increased from 30% (pre-cycle) to 87% (cycle II), confirming that an interactive environment supports the formation of a stronger and more accurate conceptual understanding. This study successfully presents a pragmatic and affordable intervention model, proving that schools with limited facilities can create a learning environment equivalent to a dedicated laboratory without requiring a large allocation of space or budget. Overall, transforming the physical classroom environment is key to revolutionizing mathematics pedagogy, transforming students' learning experiences from abstract and passive to concrete, functional, and enjoyable.

As a recommendation, teachers are advised to maintain and expand the implementation of this transformation strategy to other materials and grade levels. The

Mathematics Laboratory environment should be considered a permanent asset, not just a research project. Ensure that all learning activities utilize or reference the Mathematics Laboratory components (walls and corners) to avoid a return to conventional lecture practices. Furthermore, school principals are advised to make the Interactive Mathematics Laboratory model a flagship school program and provide policy support for budgeting for raw materials (even minimal) for the maintenance and development of the classroom environment. Further research with a quasi-experimental design involving a control group is recommended to compare the effectiveness of the Interactive Mathematics Laboratory with conventional classrooms over a longer period. Testing the Three Pillars Transformation Strategy model in different school contexts (e.g., rural schools or private schools) is recommended to gauge the model's generalizability and adaptability.

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