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Development of School Environment-Based Math City Map on Congruence and Similarity Material

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ABSTRACT

This study aims to develop learning media based on Math City Map with the context of the SMP Negeri Air Lesing school environment on congruence and similarity material and to determine the media quality based on validity, practicality, and the improvement of student learning outcomes. This study used the Research and Development (R&D) method with the ADDIE model consisting of Analysis, Design, Development, Implementation, and Evaluation. Validation involved three experts: content expert, media expert, and language expert. Validation results showed that the media was in the very valid category, with percentage scores of 86.66% from the content expert, 86.15% from the media expert, and 97.14% from the language expert. Media practicality based on teacher and student responses reached 90.66% and 92.22% respectively, both falling into the very practical category. A trial involving 26 students showed an increase in average learning outcome scores from 26.38 in the pretest to 71.23 in the posttest. These results indicate that the use of media in the research trial context was accompanied by an improvement in learning outcomes in the moderate category. The implication of this study suggests that Math City Map-based learning media can serve as an alternative for teachers in applying contextual mathematics learning through the utilization of the school environment as a learning resource for congruence and similarity topics.

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Introduction

Improving the quality of education is one of the main focuses in realizing superior human resources. This effort is reflected in the Minister of Education, Culture, Research, and Technology Regulation No. 16 of 2022 concerning process standards, which serves as a guideline for student-centered learning implementation and the primary reference in

implementing the Independent Curriculum. As stated by Paramitha et al., (2024) education plays a crucial role in supporting the progress of a nation and state. This is due to the close relationship between the quality of education and the quality of the resulting human resources. Education is also a process aimed at developing students' potential by providing support and facilitating them in undergoing various learning activities (Wulan et al., 2026).

One field of education that plays a role in supporting students' thinking abilities is mathematics. Many daily life activities involve mathematics, showing an interconnection between mathematics and daily activities (Adha & Refianti, 2020). In other words, mathematics learning is not only oriented toward mastering concepts but also toward building a positive view of mathematics. This is important so that positive perspectives on mathematics improve, which in turn supports students in appreciating mathematics (Wulandari et al., 2024).

A mathematical branch requiring visualization skills and reasoning is geometry. Geometry encompasses various concepts regarding shapes, space, size, properties, and relationships between shapes, playing an essential role as a foundation for understanding various mathematical concepts (Rahmah et al., 2020). According to Samudra et al., (2025) geometry is a branch of mathematics that demands visualization skills, understanding of spatial relations, and high logical reasoning ability. Among the geometry topics studied by students, similarity and congruence relate to shapes, sizes, side ratios, and relationships between figures, serving as a fundamental basis for various geometry concepts and other mathematical topics.

However, mathematics learning in schools still faces various issues in reality. Mathematics instruction to date still heavily emphasizes memorizing formulas and working on routine exercises that have not been linked to students' real lives. Consequently, students experience difficulties in understanding mathematical concepts and applying them in everyday situations (Friansah et al., 2025). The concepts of similarity and congruence, being similar, confuse most students and lead to frequent mix-ups. Students experience difficulties solving similarity problems without diagrams, problems with overlapping figures, and problems with inverted figure positions (Fitriyani et al., 2020). In addition, uncreative and uninnovative material presentation is a factor contributing to students' difficulties in understanding similarity and congruence material (Suprih, 2020). Meanwhile, 21st-century learning emphasizes learning processes that actively train students' skills (Mardhiyah et al., 2021). This condition highlights the need for educational innovation capable of connecting mathematical concepts with students' real-life experiences.

Based on initial observations and interviews with mathematics teachers at SMP Negeri Air Lesing, the utilization of learning media as a learning resource remains suboptimal. Instruction relies mostly on teacher explanations, meaning students do not gain richer learning experiences. Observation results of 26 students showed that only 9 students achieved the Minimum Mastery Criteria (KKM) (34.62%), while 17 students had not reached the KKM (65.38%). These data show that most students have not achieved learning mastery.

Therefore, the researchers aim to introduce learning innovation that can create meaningful learning experiences for students. Utilizing Math City Map learning media is one innovation that can be implemented. Math City Map is a web- and app-based platform enabling teachers and students to create and follow math trails consisting of contextual tasks in surrounding environments, such as city parks, streets, buildings, and other public facilities (Jablonski et al., 2023). As stated by Cahyono & Ludwig, (2019) locations presenting mathematics in daily life contexts exist worldwide. Teachers can design mathematical tasks related to those locations. Tasks in a given area are connected to form a trail. Math trail activities assist students in exploring mathematics outside the classroom to recognize and solve mathematics in real-life contexts (Mataheru, 2025).

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These characteristics of Math City Map align well with similarity and congruence learning. Through math trail activities, students do not only solve provided problems but also observe and interact with real objects serving as task contexts. Objects such as blackboards, mural paintings, school gardens, information boards, and flag pole bases were utilized as part of the math trail. Students can compare corresponding sides and determine size ratio relationships on observed objects to understand similarity concepts. Meanwhile, observing the shapes and sizes of objects helps students identify characteristics of congruent figures.

A number of studies have developed and implemented Math City Map across various learning contexts. Research conducted by Maheswari et al., (2023) developed Math City Map-based learning media in the context of Fort Vredeburg Yogyakarta, obtaining a score of 4.56 out of 5 very good category. Similarly, research by Victory & Rudhito, (2025) showed that Math City Map-based learning activities obtained student responses with an average of 83% very practical category. Ludwig & Jablonski, (2021) also explained that Math City Map activities support mathematization by linking authentic situations, mathematical models, and learned concepts. Based on the described problems, learning innovation connecting mathematical concepts with students' real experiences is required. Therefore, this study developed school environment-based Math City Map learning media on Grade VII similarity material, aiming to produce valid, practical, and effective learning media as an alternative contextual learning approach to support student learning outcomes.

Method

Type of Research

Research and Development (R&D) is a process or series of research steps aimed at developing a new product or refining an existing one. The resulting product is then validated by experts and tested for practicality and effectiveness. The development model used in this study is ADDIE, consisting of 5 development phases: Analysis, Design, Development, Implementation, and Evaluation, as presented in Figure 1.

Figure 1. ADDIE Development Model Diagram

(Branch, 2009).

Analysis Phase Conducted through observations and interviews with teachers at SMP Negeri Air Lesing by identifying learning needs and issues as a basis for media development. This activity encompassed learning conditions, availability and use of learning media, student characteristics, and difficulties experienced by students. Design Phase Setting learning objectives, selecting similarity and congruence content, and selecting school environment objects to serve as stops on the math trail. Development Phase Realizing the designed plan into a product. It was then validated by three validators: a content expert (assessing curriculum alignment, concept accuracy, content depth, contextuality, item quality, and learning support); a media expert (assessing visual display, navigation, technical aspects, media features, integration, and practicality); and a language expert (assessing language usage, terminology, and readability).

Implementation Phase Conducted after the media was declared viable based on validation results and revisions. Implementation involved small-group testing to obtain preliminary

practicality information, followed by field testing with 26 students to determine media effectiveness. It was conducted over 3 sessions (4 x 40 minutes) led by the researcher accompanied by the mathematics teacher. Session 1 involved administering a pretest. Session 2 involved learning using Math City Map media, and Session 3 involved administering a posttest to measure media effectiveness. Evaluation Phase Conducted based on validation results, validator suggestions, and small-group trial results to identify usage obstacles and initial student responses to the media.

Subjects

The subjects of this study comprised validators, teachers, and students. Validators included a content expert, a media expert, and a language expert who evaluated the media validity. The practicality test was conducted during the small group stage involving one mathematics teacher and six Grade VII.3 students of SMP Negeri Air Lesing. Furthermore, a field test was conducted with 26 Grade VII.2 students of SMP Negeri Air Lesing to obtain learning media effectiveness data.

Instrumen

Research instruments included validation sheets, practicality questionnaires, and tests. Validation sheets collected evaluations from content, media, and language experts on media quality. Practicality questionnaires gathered teacher and student responses after using the learning media. Meanwhile, tests consisting of pretest and posttest collected media effectiveness data based on learning outcomes. Several research instruments are presented in Table 1.

Table 1. Research Instruments

Instrument	Respondents	Aspects Assessed
Content Validation Sheet	Content Expert	Curriculum alignment, concept accuracy, content depth, contextuality, item quality, and learning support.
Media Validation Sheet	Media Expert	Visual display, navigation, technical aspects, media features, integration, and practicality.
Language Validation Sheet	Language Expert	Language usage, terminology, and readability.
Teacher Response Questionnaire	Mathematics Teacher	Ease of use, content suitability, contextual learning, learning management, student response, efficiency, user guide, and feasibility display.
Student Response Questionnaire	Students	Ease of use, interest, material comprehension, learning assistance, learning engagement, motivation, and media feasibility.
Learning Outcome Test	Students	Identifying changes in learning outcomes before and after using media on similarity and congruence material.

The learning outcome test measured student learning achievements in similarity and congruence before and after media usage using identical items based on learning indicators in Table 2.

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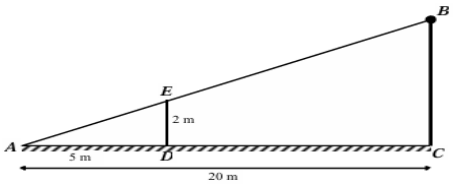
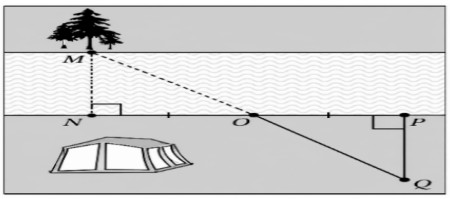
Table 2. Learning Indicators

Topic	Indicator	Problem Example
Similarity	Students can determine flag pole height and rope length using side ratios in similar triangles.	 Figure 2. Similarity Example Problem From the top of a flag pole, a rope is stretched and anchored to the ground. The distance from the anchor to the pole base is 20 meters. At a distance of 5 meters from the anchor, a 2-meter post is erected perpendicular to the ground, parallel to the flag pole, touching the rope. What is the height of the flag pole and the length of the rope?
Similarity	Students can determine tree height based on the ratio of tree and post shadow lengths.	Due to sunlight, a pine tree casts a shadow 25 meters long, and a clothesline post 2.25 meters high casts a shadow 3 meters long. Calculate the height of the tree!
Similarity	Students can determine model table width and height based on the ratio of actual table size to its model.	A table has actual dimensions of 90 cm length, 60 cm width, and 80 cm height. A toy model table is made with a length of 6 cm. Calculate the width and height of the model table!
Congruence	Students can determine triangle congruence based on image information and identify line segments to compute river width.	Amir wants to measure the width of a river near his tent. Amir drew a design to measure the river width figure 3.  Figure 3. Congruence Example Problem From the figure, are triangles MNO and QPO congruent? Which line segment can be used to calculate the river width?

Data Collection

Validity, practicality, and effectiveness tests were conducted to determine the quality of the developed media. Validity testing involved content, media, and language experts evaluating the learning media using validation sheets covering content appropriateness, visual quality, and language. Practicality testing involved one mathematics teacher and six students using response questionnaires after using the learning media in the small group phase. Effectiveness testing took place in the field test phase through pretests before learning and posttests after learning using Math City Map media.

Analisis Data

Data were analyzed across three aspects: validity, practicality, and effectiveness. Validity and practicality analyses used percentage formulas cited from (Suryati et al., 2022).

$$P = \frac{\sum X}{\sum X_i} \; x \; 100\%$$

Percentage validity results were interpreted based on criteria in Table 3.

Table 3. Validity Test Criteria

Interval	Description
81% - 100%	Very Valid
61% -80%	Valid
41% - 60%	Fairly Valid
21% - 40%	Less Valid
0% - 20%	Invalid

(Ilahi et al., 2021)

Practicality percentages were interpreted using criteria in Table 4.

Table 4. Teacher and Student Response Questionnaire

Interval	Description
$81\% - 100\%$	Very Practicial
$61\% - 80\%$	Practicial
$41\% - 60\%$	Fairly Practicial
$21\% - 40\%$	Less Practicial
$0 - 20\%$	Impracticial

(Miftah et al., 2022)

Effectiveness was analyzed using N-Gain calculated from pretest and posttest scores using the formula cited from (Coletta & Steinert, 2020).

$$N - g = \frac{Postcsore - Prescore}{100 - Prescore}$$

Obtained N-Gain values were interpreted based on improvement criteria in Table 5.

Table 5. Improvement Criteria

Range	Description
$g > 0{,}7$	High
$0{,}3 \leq g \leq 0{,}7$	Moderate
$g < 0{,}3$	Low

(Hake, 1998)

Results

This study produced Math City Map-based learning media utilizing the SMP Negeri Air Lesing school environment context for similarity and congruence material. Media was developed by linking similarity concepts to school objects, making learning more contextual. Development followed the ADDIE model (Analysis, Design, Development, Implementation, Evaluation).

The Analysis phase began with needs analysis, student characteristics, curriculum, and location analysis. Results indicated that learning on similarity and congruence was dominated by conventional methods with suboptimal media use. Conversely, students were accustomed to smartphones. The Independent Curriculum emphasizes student-centered learning, and SMP Negeri Air Lesing possesses various usable physical objects for contextual learning.

The Design phase involved constructing the math trail structure (determining routes, stop points, and activity sequences). Tasks were designed for each object point based on content. Visual layout was designed with appealing images and layouts easily understandable by students. The math trail visual interface is presented in Figure 4.

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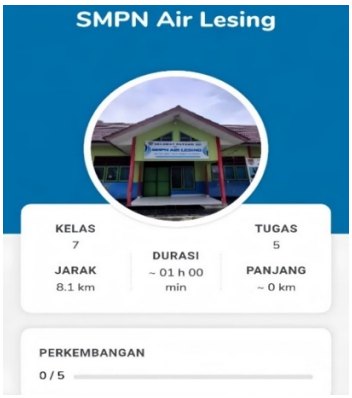

Figure 4. Math Trail Interface Display

The Development phase realized the prior designs into a product. It started by creating a Math City Map account at https://mathcitymap.eu/en/. Tasks and math trails were compiled along designed routes and points. Task interfaces in the media are presented in Figure 5.

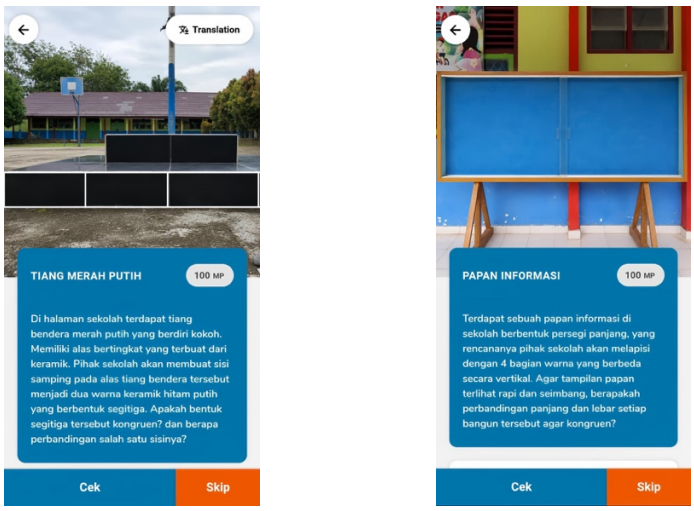

Figure 5. Task Display on Media

Content, media, and language experts evaluated content alignment, interface, and language. Summary of validator evaluations is shown in table 6.

Table 6. Summary of Expert Validation Results

Validator	Percentage	Description
Content Expert	86,66%	Very Valid
Media Expert	86,15%	Very Valid
Language Expert	97,14%	Very Valid
Average		**Very Valid**

Math City Map learning media obtained an average percentage of 86.66% from the content expert, 86.15% from the media expert, and 97.14% from the language expert, falling into the very valid category. Feedback was used to revise the media until deemed fit for use. Summarized validator feedback is presented in Table 7.

Table 7. Validator Feedback and Revisions

Validator	Before Revision	After Revision
Content Expert	Ineffective sentence usage in problem items and inconsistent coordinate point notations.	Problem wording refined to be communicative and clear; coordinate point usage aligned consistently.
Media Expert	Media usage guide lacked complete step-by-step instructions.	User guide expanded with detailed steps to facilitate teachers and students operating Math City Map.
Language Expert	Inappropriate word choices (diction) and sentences starting with "dan" (and).	Diction corrected to follow standard rules; conjunctions at sentence beginnings corrected.

Following revisions, the media was tested with one mathematics teacher and six Grade VII.3 students to determine practicality. Results are summarized in Table 8.

Table 8. Summary of Teacher and Student Responses

Respondent	Score	Percentage	Description
Teacher	68	90,66%	Very Practicial
Students	415	92,22%	Very Practicial
	Average		**Very Practicial**

Math City Map media obtained 90.66% from the teacher and 92.22% from students (very practical). Evaluated practicality aspects are listed in Table 9.

Table 9. Teacher and Student Practicality Aspects

Teacher Practicality Aspects	Students Practicality Aspects
1. Ease of Use	1. Ease of Use
2. Material Suitability	2. Interest
3. Contextual Learning	3. Material Comprehension
4. Learning Management	4. Learning Support
5. Student Response	5. Active Engagement
6. Efficiency	6. Learning Motivation
7. Guidebook	7. Media Feasibility
8. Display Feasibility	

Brief interviews were conducted with students after learning, presented in Table 10.

Table 10. Student Interview Excerpts

Researcher	**:** How do you feel after learning with Math City Map?
Student 1	**:** I felt learning was more fun because I could directly search for and measure existing objects.
Researcher	**:** Did this media help you understand similarity and congruence?
Student 2	**:** Yes, because we could see real objects around school, making it easier to distinguish between similar and congruent figures.
Researcher	**:** Did you experience difficulties using the media?
Student 3	**:** Not really. The instructions were easy to understand and the app was easy to use.

The Implementation phase involved 26 Grade VII.2 students at SMP Negeri Air Lesing. Pretests measured initial capabilities. Students then engaged in Math City Map learning by completing tasks at math trail points Figure 6.

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Figure 6. Implementation of Math City Map Media Usage

Posttest results following learning implementation are summarized in Table 11.

Table 11. Learning Outcome Improvement Results

Indicator	Result
Pretest Average	26,38
Posttest Average	71,23
N-Gain	0,61
Category	**Moderate**

Average student scores increased from 26.38 in pretest to 71.23 in posttest. The N-Gain score of 0.61 indicates learning outcome improvement in the moderate category. The Evaluation phase assessed and refined the product at each development stage. Language diction was corrected, user guide completeness was enhanced, and problem wording was clarified. Evaluation after small-group testing confirmed students encountered no major difficulties operating Math City Map.

Discussion

Developing Math City Map-based learning media achieved validator scores of 86.66%, 86.15%, and 97.14%, confirming content, media, and language feasibility. Revisions improved visual presentation, instructions, readability, and task conceptual accuracy. This aligns with Victory & Rudhito, (2025) who reported Math City Map validation scores of 85% and 86% very valid. Similarly, Maheswari et al., (2023) demonstrated that Math City Map ethnomathematics activities produced feasible learning support products. Practicality scores reached 90.66% (teacher) and 92.22% (students), supported by structured trail guidance. Obtaining information directly from physical environmental objects provided a distinct learning experience compared to paper worksheets. This mirrors findings by Tyas et al., (2024) at Sindu Kusuma Edupark and Pramudita & Pratini, (2024) who showed Math City Map supports contextual problem-solving. Implementation with 26 students showed significant gains pretest 26,38 increased to 71,23 in the posttest. The N-gain calculation result of 0,61 falls into the moderate. This improvement indicates that, following instruction using Math City Map, the student learning outcomes showed a positive change. Hands-on interaction with physical objects allowed students to connect geometric dimensions with mathematical principles directly.

These results support Febrian et al., (2023) and Ludwig & Jablonski, (2021) confirming that Math City Map promotes critical thinking and authentic mathematization. A key distinguishing feature of this media is using SMP Negeri Air Lesing's unique physical environment: flag pole ceramic tiers (congruence), murals (shape comparisons), school gardens (side ratios), blackboards (scaled modeling similarity), and bulletin boards (proportional area division). These objects served as active mathematical sources rather than mere passive

backdrops, contrasting with studies set in public tourist spots like Fort Vredeburg Maheswari et al. (2023), Sindu Kusuma Edupark Tyas et al., (2024), or Kaliurang Observation Tower Pramudita & Pratini (2024)..

Conclusion

This study developed a Math City Map learning medium that incorporated the environment of SMP Negeri Air Lesing to support Grade VII learning of similarity and congruence. The product demonstrated high feasibility, achieving very high validity in content (86.66%), media design (86.15%), and language (97.14%), as well as strong practicality based on teacher (90.66%) and student (92.22%) responses. In a field trial involving 26 students, participants showed a moderate pretest–posttest learning gain, with mean scores increasing from 26.38 to 71.23 (N-gain = 0.61). These findings provide preliminary support for the feasibility of the media and its potential to facilitate contextual geometry learning. However, the single-group pretest–posttest design does not permit a definitive causal inference regarding its effectiveness. Future studies should examine the intervention with larger and more diverse samples, a comparison or control group, and, where possible, effect-size estimates and delayed posttests to assess the robustness and retention of learning outcomes.

Conflict of Interest

The authors declare no conflict of interest.

Auhor Contributions

Z.A.A. contributed to research design, media development, instrument design, data collection/analysis, and manuscript drafting. R.R. contributed to research supervision, methodological guidance, and manuscript editing. D.F. contributed to instrument validation, result review, and final manuscript revision. All authors read and approved the final version. Contribution proportion: Z.A.A.: 50%, R.R.: 25%, D.F.: 25%.

Data Availability Statement

Data supporting the findings of this study are available from the corresponding author, R.R., upon reasonable request.

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