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Designing a VARK Learning Model Based on Langkat Malay Culture Assisted by GeoGebra to Enhance Students' Spatial Literacy

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ABSTRACT

Spatial literacy is essential in learning geometry because it helps students understand shapes, positions, and the relationships between objects visually. However, many students still struggle with these skills. To address this issue, this study aims to develop a culturally integrated learning model based on the VARK learning styles framework, supported by GeoGebra, to enhance students' spatial literacy. GeoGebra provides dynamic visualizations suitable for visual learners, while the model incorporates auditory explanations, written materials, and kinesthetic activities such as interactive tasks and cultural artifact exploration, ensuring each VARK modality is addressed. Employing a Research and Development (R&D) methodology, the study proceeds through several phases: needs analysis, model design, implementation, and evaluation, involving junior high school students in Langkat, North Sumatra. The novelty of this research lies in the integration of GeoGebra, a dynamic and interactive mathematical software, with the indigenous cultural elements of Langkat Malay. This innovative approach rarely explored in prior mathematics education research incorporates local features such as traditional motifs, architectural forms, and spatial patterns. The integration not only enhances GeoGebra's interactive visualizations but also aligns the learning experience with students' cultural backgrounds, thereby increasing contextual relevance. By linking abstract geometric ideas with familiar cultural representations, the model aims to create a more engaging and meaningful learning environment. This cultural contextualization supports a deeper understanding of geometry, fosters a stronger connection between students and mathematical content, and simultaneously reinforces their cultural identity and motivation to learn. Data collection employed a mixed-methods approach: interviews with teachers and students to gather insights, classroom observations to track implementation, pre-test and post-tests to assess improvements in spatial literacy, and questionnaires to evaluate student engagement and model effectiveness. To support the model, electronic student worksheets were also developed as interactive digital resources for both independent and guided learning, providing a structured, culturally grounded learning environment.

Keywords: GeoGebra, Langkat Malay Culture, Spatial Literacy, VARK

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Introduction

In mathematics education, especially in geometry, there is a growing need for instructional renewal. High-quality teaching requires not only improved curriculum content but also the use of innovative strategies and models (Maher & Sigley, 2020; Potari et al., 2019; Stephan, 2020). These efforts help students understand abstract concepts and apply them in real life problem solving (Affriyenni et al., 2020; Nhlumayo & Mofokeng, 2023). A key skill for learning geometry is spatial literacy the ability to visualize, interpret, and reason about spatial relationships (Lowrie et al., 2019; Pellas, 2025). Unfortunately, many students struggle with spatial reasoning, leading to misunderstandings and calculation errors (Mas'udah et al., 2021). A preliminary study illustrated this problem using a culturally relevant geometry task involving traditional Malay architecture. The problem stated: "In the Malay cultural tradition, triangular shapes are often used in the decoration of traditional house roofs. Adik wants to build a miniature model of a triangular roof using bamboo. She has two bamboo sticks measuring 15 cm and 36 cm. (1). Find the length of the third stick so that a triangle can be formed. (2). Does the third stick need to be longer than the two existing ones?".

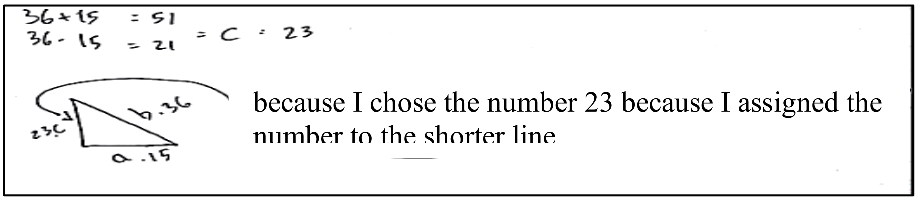

***Figure 1**. Student Answer*

To address this gap, instructional strategies that consider students' learning preferences become essential. One such approach is the VARK learning model, which categorizes learners into four modalities: Visual, Auditory, Reading/Writing, and Kinesthetic. Instruction tailored to these modalities has been shown to enhance student engagement and cognitive development (Apipah & Kartono, 2017; Subagja & Rubini, 2023). The effectiveness of the VARK model is further amplified when integrated with appropriate educational technology. GeoGebra, a dynamic and interactive mathematics software, provides visual and kinesthetic learners with tools to manipulate geometric objects, explore spatial relationships, and simulate mathematical situations with precision (Wu & Liu, 2023; Yuniarti et al., 2021). The combination of VARK and GeoGebra promotes a multisensory learning environment that supports deeper conceptual understanding and spatial reasoning.

In addition to learning preferences and technology, the integration of local cultural wisdom plays a vital role in making mathematical concepts more meaningful (Dosinaeng et al., 2025). The cultural heritage of the Langkat Malay community, for instance, offers rich contextual foundations that can be embedded into geometry learning (Ansya et al., 2024). Contextualizing mathematical instruction through culture not only enhances students' cognitive engagement but also strengthens their identity and appreciation of local traditions (Safrida et al., 2020). The combination of visual tools, cultural elements, and learning style alignment empowers students to engage in hands-on, reflective, and high order thinking activities (Huang et al., 2024). This results in more effective geometry instruction and a deeper understanding of spatial relationships (Muslim et al., 2023; Ziatdinov & Valles, 2022).

The novelty of this research lies in its integrative approach. Unlike previous studies that examine the VARK model, GeoGebra, or cultural integration separately, this study presents a comprehensive and unified learning model. It aims to bridge the gap between technology, pedagogy, and local wisdom, offering a culturally adaptive instructional strategy. Therefore, the purpose of this study is to develop and evaluate a culturally contextualized learning model that integrates the VARK framework and GeoGebra technology to enhance students' spatial literacy in learning geometry.

Methods

This study used a Research and Development (R&D) approach through structured and systematic steps to develop and evaluate learning tools. It started with a preliminary study that included a needs analysis, classroom observations, and a detailed literature review to understand students' learning difficulties, especially in 2D geometry. Based on the results of this phase, the product development stage included careful planning, designing prototype tools, small scale trials, and several revisions based on feedback from experts and users. The final step was testing the product's effectiveness to see how well it improved students' spatial literacy.

The development followed the ADDIE model, which includes five steps: (1) In the Analyze phase, data were collected to find out what students needed and what challenges they faced in learning 2D geometry. (2) The Design phase focused on creating culturally responsive tools such as electronic worksheets, lesson plans, and assessments based on the VARK learning styles. These tools were enriched with Langkat Malay cultural elements and supported by GeoGebra to help students better visualize and understand the concepts. (3) In the Develop phase, the tools were built and improved through expert reviews and small classroom trials. These activities ensured the tools were relevant, useful, and aligned with students' learning needs. A key part of this phase was the intentional integration of GeoGebra and cultural aspects of Langkat Malay. GeoGebra helped students interact with geometric ideas in a more visual, dynamic, and hands-on way. Meanwhile, the use of local culture helped make the lessons more relatable, making it easier for students to connect new concepts with their daily lives. This approach aimed to build stronger engagement and deeper understanding. (4) The Implementation phase involved using the tools in real classrooms to test how practical and effective they were. This was done in three settings: a small pilot class (VII-2, 15 students), an experimental class (VII-1, 32 students), and a control class (VII-3, 31 students). Besides testing the practicality of the tools, this phase also explored how the combination of local culture and digital technology could support the development of students' spatial literacy and make learning more meaningful. (5) Evaluation, vark learning model based on langkat malay culture assisted by geogebra to enhance students' spatial literacy.

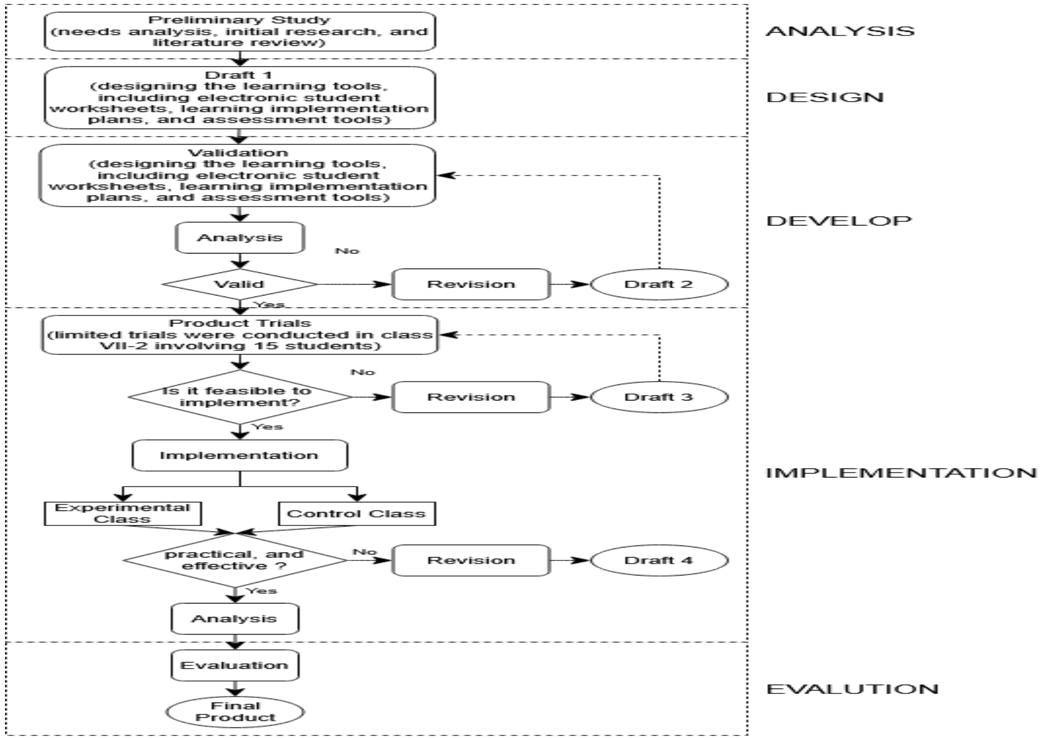

Figure 2. *ADDIE Process Flow Diagram*

The non test instruments included several types of questionnaires, such as validation sheets for the VARK learning model based on Langkat Malay culture with GeoGebra, validation sheets for lesson plans, student worksheets (pre-test and post-test), teacher and student response questionnaires, and questionnaires about the implementation of the learning model. The validity of the products was determined using data from these validation sheets, which were reviewed by experts. These reviews covered the VARK model, lesson plans, electronic worksheets, and the pre-test and post-test. A four-point Likert scale was used for scoring. An instrument was considered valid if it met the required criteria and was rated as "valid," meaning it could be used in the next stages of the research. The average expert ratings are shown in Table 1.

Table 1*. Expert Score Categories*

Mean Score	Category
$1{,}00 \leq \bar{X} < 1{,}75$	Less Valid
$1{,}75 \leq \bar{X} < 2{,}50$	Fairly Valid
$2{,}50 \leq \bar{X} < 3{,}25$	Valid
$3{,}25 \leq \bar{X} < 4{,}00$	Very Valid

Product practicality trials using teacher response questionnaires, student response questionnaires, and questionnaires. Implementation of the learning model. The criteria for the level of practicality are presented in Table 2. The percentage is calculated using the formula:

Table 2. *Category of Practicality Level*

Mean Score	Category
$85{,}01\% - 100\%$	Very Practical
$70{,}01\% - 85{,}00\%$	Practical
$50{,}01 - 70{,}00\%$	Less Practical
$01{,}00\% - 50{,}00\%$	Impractical

The test instruments used in this study included pre-test and post-test questions designed to measure students' spatial literacy. To evaluate the effectiveness of the learning tools, students' scores before and after using the model were compared. A product is considered effective if the average post-test score is higher than the average pre-test score, showing improvement in spatial literacy. Efficacy was also measured by testing the VARK learning model based on Langkat Malay culture and supported by GeoGebra in the experimental group. The product is considered efficacious if the improvement in the experimental group is greater than in the control group, which used traditional teaching methods. These results indicate that the developed learning model has a significant positive effect on students' spatial literacy.

Results and Discussion

This research produced several products: a development book for the VARK model based on Langkat Malay culture supported by GeoGebra, lesson plans, electronic student worksheets, and learning outcomes focused on mathematical literacy. The process was carried out in three main phases, which are explained below.

1. Preliminary Study

The preliminary study involved initial research, a needs analysis, and a literature review. The initial research was conducted at SMPN 5 Langkat by interviewing teachers and observing classroom activities. The results showed several problems: (1) the learning model used in class was unclear although the lesson plan stated it followed a PBL approach, the actual implementation did not match; (2) the shift from face-to-face to online learning was done without proper adjustments; (3) teaching materials and electronic student worksheets were still limited; and (4) practice questions given to students were not well developed. Based on these findings, a needs analysis was conducted and revealed four key needs: (1) a clearly structured learning model that aligns with the lesson plan; (2) detailed instructional steps that can be used in online, offline, or blended learning; (3) accessible electronic student worksheets to support learning; and (4) better development and variety in practice questions to increase student engagement. The literature review then focused on the main components needed for the learning model, including the VARK learning style model, Langkat Malay culture, GeoGebra, and spatial literacy. The VARK model, based on Fleming in 2006, categorizes students into four learning styles: Visual, Auditory, Reading/Writing, and Kinesthetic each based on how students best receive information through their senses (Razzak et al., 2019). The VARK model is applied in four stages. First, students' learning styles are identified using Fleming's survey and class observations. Then, students are grouped by their dominant learning style. In the second stage, the teacher creates a lesson plan, which includes setting clear learning goals, designing key activities, and preparing appropriate teaching materials like worksheets, group boards, color cards, and multimedia tools such as projectors, videos, images, or audio clips. The third stage is teaching the lesson as planned while being responsive to any challenges that arise and keeping students focused on the learning goals. The fourth stage is evaluating learning outcomes by observing students' participation, how they absorb and process information in groups, and how they apply what they've learned. The teacher also helps by filling knowledge gaps, removing irrelevant information, and correcting misunderstandings (Thoa & Anh, 2018). Meanwhile, ntegrating Langkat Malay culture into learning helps students connect mathematical ideas with everyday cultural practices. This approach supports their understanding, reflection, and use of math in real life contexts, which contributes to improving spatial literacy (Nurjanah et al., 2023). In this study, spatial literacy focuses on three main areas: visualization (forming mental or visual images of spatial objects), reasoning (thinking critically about spatial concepts and relationships), and communication (explaining spatial ideas clearly using different forms of representation).

2. Product Development

There are three phases in the product development stage. These phases include planning, initial development, and product testing and revision.

a. Initial Product Planning

Product development planning includes several key components: (1) The design of the VARK model based on Langkat Malay culture supported by GeoGebra, which covers learning syntax, social system, principles of reaction, support system, instructional impact, and accompanying impact. (2) The lesson plan, which outlines learning objectives, instructional steps, and assessment strategies important elements to ensure effective teaching and learning. (3) A web-based electronic student worksheet that students can access anytime and anywhere. (4) Pre-test and post-test questions designed to measure students' spatial literacy. Besides developing these products, the researchers also prepared instruments to evaluate the product's validity, practicality, effectiveness, and efficacy.

b. Initial Product Development

The draft of the GeoGebra-assisted VARK learning model based on Langkat Malay culture includes the model's syntax, social system, reaction principles, support system, and both instructional and accompanying impacts. The difference between this model and previous ones is in steps 2 and 3, where learning activities are tailored to students' learning styles and linked to Langkat Malay cultural content presented in the electronic student worksheet. The validated product development is shown in Figure 3.

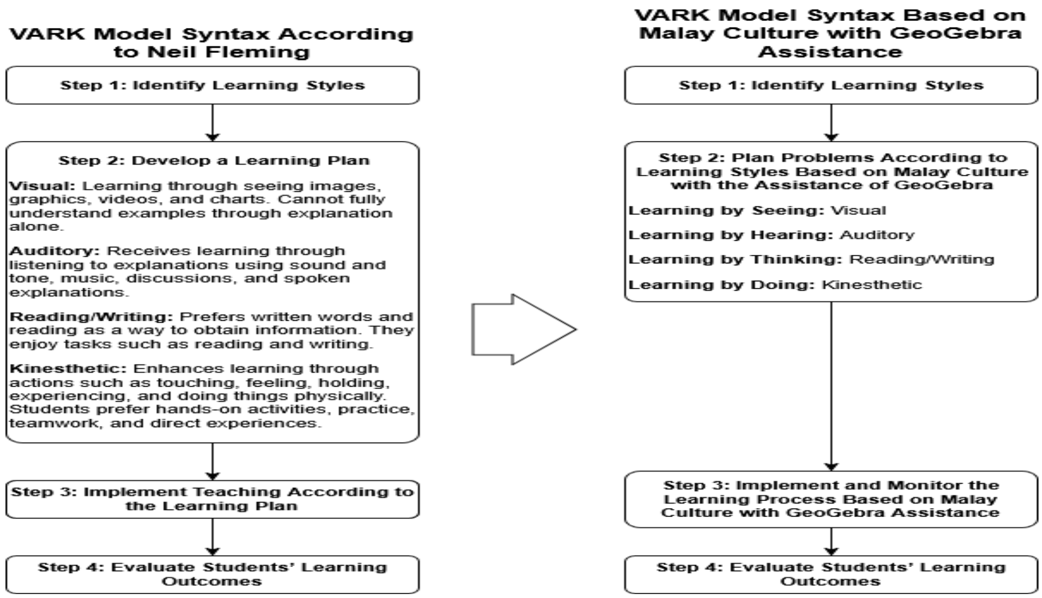

Figure 3. *The syntax of the VARK Model Based On Langkat Malay Culture Assisted By Geogebra Has Been Developed*

The learning tools developed include lesson plans adapted to the model's syntax, which consists of four stages: identifying students' learning styles, planning problems based on Langkat Malay culture using GeoGebra, implementing and monitoring the learning process based on Langkat Malay culture with GeoGebra, and evaluating student learning outcomes. The electronic student worksheet includes content related to Langkat Malay culture and is supported by GeoGebra. It also provides guidance based on spatial literacy indicators for 2D geometry. The worksheet is designed in web format using Canva. The contents of the electronic worksheet used in are shown in Figure 4.

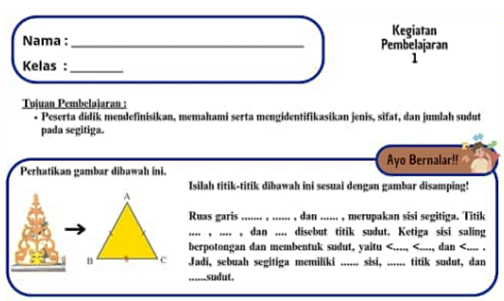

Figure 4. *Electronic Student Worksheet*

The preparation of questions includes both pre-test and post-test items designed to measure spatial literacy. Before writing the questions, a question blueprint was created, considering factors such as grade level, semester, material, basic competencies, question types and quantity, and time allocation. The questions were then developed based on this blueprint. A total of three questions were created, focusing on 2D geometry, aligned with the basic competencies and indicators for 7th-grade students. Once the questions were completed, a feasibility test was conducted to assess their validity, reliability, differentiating power, and level of difficulty.

c. Product Trial and Revision

After the first draft of the product was created, expert validation was carried out to ensure it was valid and ready for testing. This study involved three validation steps: reviewing the design of the VARK model based on Langkat Malay culture with GeoGebra, the lesson plans, and the learning materials. Group trials and field tests were also conducted to assess the product's practicality, based on feedback from students, teachers, and the actual use of the learning model.

1) The results of the validation of the design of the Langkat Malay culture-based VARK model assisted by GeoGebra were validated by three experts. The validation results are presented in Table 4.

Table 4. *Mean Score Results from Learning Model Design Expert*

Aspects	**Experts**		
	A	**B**	**C**
Supporting Theories	3,56	3,52	3,00
Syntax	3,42	3,00	3,15
Reaction Principle	3,89	3,86	3,40
Support System	3,70	3	3,65
Instructional and Accompanying Impact	3	3	3
Mean Score		3,43	
Category		Very Valid	

Based on Table 4, the validation results for the design of the Langkat Malay culture-based VARK model assisted by GeoGebra with an average total score of 3.43. The score is included in the valid criteria. The advice given by the validator is to emphasize the difference between the previous learning model and the developed learning model, especially in phases 3 and 4 in the syntax.

2) Results of the Validation Assessment for the Learning Implementation Plan

Expert validation of lesson plans was conducted by three experts. The results of the lesson plan expert validation are presented in Table 5.

Table 5. *Mean Evaluation Scores from Learning Model Design Expert*

Aspects	**Experts**		
	A	**B**	**C**
Formulation of Learning Objectives	3,23	3,12	3,50
Contents	3,82	3,55	3,65
Language	4	3,66	4
Mean Score		3,61	
Category		Very Valid	

Based on Table 5, the validation results for the lesson plan were obtained with an average total score of 3,61. The score is included in the very valid criteria. The suggestion given by the validator is that the assessment should accommodate the implementation of assessment for learning. In addition, the time allocation of the lesson plan must also be in accordance with the implementation of learning.

3) Material Expert Results

Material expert validation was conducted by three experts. The results of the material expert validation are presented in Table 6.

Table 6. *Mean Evaluation Score from Material Expert*

Aspects	Experts		
	A	B	A
Content Usefulness	3,57	3,10	3,65
Content Adequacy	3,40	3,25	3,85
Mean Score		3,47	
Category		Very Valid	

Based on Table 6, the material validation results have an average total score of 3,47. The score is included in the criteria very valid. The suggestion given by the validator is that the material provided should not only be in the form of video, audio, and worksheets. This feedback highlights the importance of diversifying learning materials to accommodate different learning preferences and enhance engagement. By integrating additional formats, such as interactive tools or readings, the learning experience can be further enriched, providing students with a broader range of stimuli to optimize their learning potential. The suggestion is in line with (Essa et al., 2023) opinion which states that various kinds of learning media can be combined in learning styles to optimize the potential of students (Dmitrichenkova, 2020). In this case, the combined media are power point and YouTube. The use of power point that does not require internet can be accessed anytime and anywhere by students.

4) Group Trial

After the product has been validated with valid results, a group trial is conducted to see the practicality of the product. Practicality is seen from the student response questionnaire, teacher response questionnaire, and model implementation questionnaire. The group trial was conducted in class VII-2 involving 15 students as respondents. Student response questionnaire has an average score of 81% and is included in the practical criteria. The results of the student response questionnaire are presented in Table 7.

Table 7. *Results of Student Response Questionnaire*

Observed Aspects	Percentage
Ease	80,00 %
Helpfulness	80,10 %
Usability	81,55 %
Overall Percentage Mean	80,55 %
Category	Praktical

Teachers also filled out a teacher response questionnaire with an average percentage of 80.55%, which means practical, which is presented in Table 8.

Table 8. *Results of Teacher Response Questionnaire*

Observed Aspects	Percentage
Ease	90 %
Helpfulness	89,90 %
Usability	85,55 %
Overall Percentage Mean	88,48 %
Category	Practical

The questionnaire for the implementation of the learning model was filled in by observers who observed the learning process. The average percentage obtained was 88.48% which means very practical. The questionnaire results of the model implementation based on the observed aspects are presented in Table 9.

Table 9. *Results of Questionnaire on Implementation of Learning Model*

Assessment Component	Percentage
Learning Activities	83,27 %
Syntax	80,35 %
Social System	85,56 %
Reaction Principle	83,65 %
Support System	86,00 %
Instructional and Accompanying Impact	83,89 %
Overall Percentage Mean	83,79 %
Category	Practical

The test instrument used to measure spatial literacy was tested to determine the reliability, distinguishing power, and difficulty level of the questions. To measure reliability, it was calculated manually using the Alpha technique with the one-time test method. The questions that were done were three description questions. The reliability of the pre-test instrument was 0.713 while the reliability of the post-test instrument was 0.719. Both are included in the reliable criteria because they meet the requirements so that the test instrument can be used. The calculation of the level of difficulty and differentiation in the pre-test and post-test is also presented in Table 10.

Table 10. *Level of Difficulty and Discriminatory Power of the Spatial Literacy Pre-Test*

Question Number	1	2	3
Difficulty Level	0,52	0,55	0,34
Distinguishing Power	0,73	0,82	0,85

The level of difficulty and distinguishing power of the spatial literacy pre-test items is categorized as good where the level of difficulty of an item is said to be good if the value is at the level of the test item. $0{,}3 \leq P \leq 0{,}7$ and the differentiating power is said to be good if $D \geq 0{,}30$. This also applies to the post-test items of problem-solving ability with the calculation results shown in Table 11.

Table 11. *Level of Difficulty and Discriminatory Power of the Spatial Literacy Post-Test*

Question Number	**1**	**2**	**3**
Difficulty Level	0,48	0,68	0,65
Distinguishing Power	0,84	0,68	0,88

5) Field Test

The implementation of the field test is after group testing and obtaining valid and practical results. Respondents are from the VII-1 class, consisting of 32 students, assigned as the experimental class and using the VARK model based on Langkat Malay culture assisted by GeoGebra which has been revised based on suggestions from validators and responses obtained after testing in the group test while VII-3 as many as 31 students as a control class using the learning model commonly used by teachers. The field test is used to measure the effectiveness and efficacy of the product.

6) Product Efficacy Testing

Product testing is carried out by experiments comparing experimental groups and control groups. To see the effectiveness and efficacy of the product, it is necessary to conduct a prerequisite test in the form of normality test and homogeneity test. The learning model is said to be effective if the learning model that has been developed is able to improve the spatial literacy of students as seen from the average post-test spatial literacy of the experimental class is better than the average post-test spatial literacy of the control class. The calculation results are shown in Table 12.

Table 12. *Mean Post-Test of Spatial Literacy ability*

Class	Score	Mean
Experiment	2599,7	64,9
Control	1873	50,3

The effectiveness of the learning model was tested using a one-tailed t-test. The results showed a t-value of 3.495, which is greater than the critical value of 1.665 at a 0.05 significance level. This means the null hypothesis (H_0) was rejected, and the alternative hypothesis (H_a) was accepted. In other words, the spatial literacy of seventh-grade students taught using the VARK model based on Langkat Malay culture with GeoGebra was significantly better than that of students taught with traditional methods. These results show that combining cultural context and digital tools in learning has a clear, positive impact on students' spatial literacy. It emphasizes the value of using culturally responsive teaching and interactive technology like GeoGebra in math education. Therefore, a learning model that blends students' learning styles, local culture, and digital tools can greatly improve understanding especially in abstract topics like geometry. During the implementation of learning in the experimental class, the researcher observed the level of student engagement and enthusiasm throughout the learning process, and evaluated the effectiveness of the VARK learning model based on Malay Langkat culture, integrated with the GeoGebra application, in enhancing students' spatial literacy skills in accordance with their individual learning styles.

Table 13. *Summary of the Overall Mean Scores of the Questionnaire*

Assessed Aspect	Mean Score	Category
Student Engagement	4,55	Very Good
Effectiveness of Learning Model	4,50	Very Good

The results of the questionnaire indicate that the VARK model, integrated with Langkat Malay cultural values and supported by GeoGebra, falls into the "Very Good" category for both student engagement (mean score 4,55) and learning effectiveness (mean score 4,50). These findings suggest that the model successfully enhances students' active participation and spatial literacy by aligning with their individual learning styles. The integration of local culture and interactive technology creates a contextual, engaging, and meaningful learning experience, while also strengthening students' connection to geometric concepts.

The implementation of the VARK model, adapted to Langkat Malay culture and supported by GeoGebra through interactive electronic worksheets, fosters student independence and actively engages learners in the learning process. This model accommodates various learning styles visual, auditory, reading, and kinaesthetic and integrates culturally relevant elements to deepen students' conceptual understanding and support meaningful learning experiences (Villegas & Lucas, 2002). According to Pitriani et al., (2021), when students are given opportunities to express their thoughts and opinions freely in solving teacher-presented problems, they are more inclined to engage in discussions and knowledge exploration. This becomes even more effective in the context of online discussions where the VARK model supported by cultural context and digital tools such as GeoGebra allows for collaborative decision-making and cognitive development in spatial literacy.

GeoGebra is an interactive mathematical tool that plays a key role in enhancing spatial understanding. It allows students to visualize and manipulate geometric objects, making abstract concepts more concrete (Chivai et al., 2024; Fiangga & Sari, 2024; Korenova & Schmid, 2024). The use of such tools promotes spatial reasoning and supports learning, especially when combined with problem-based learning approaches (Mas'udah et al., 2021; Wasi, 2022).

The VARK model becomes more effective when enriched with local cultural contexts, such as Langkat Malay culture. This integration not only personalizes the learning experience but also promotes culturally responsive pedagogy. By linking mathematical concepts to everyday cultural practices, students are better able to construct meaning and engage more deeply with the material. In addition, the learning syntax applied in this approach aligns with constructivist principles, encouraging students to actively build knowledge through exploration and discovery. This process is further enhanced by contextual scaffolding such as the use of local culture which supports learners as they navigate complex ideas (Triananda, 2022). As a result, students develop greater confidence and independence in problem solving. Findings from the needs analysis also affirm the relevance of the VARK model in classrooms with diverse learning preferences. This supports previous studies highlighting the model's adaptability and its effectiveness in accommodating heterogeneous student needs (Caetano et al., 2018; Jumrah et al., 2022). However, it is important to note that the integration of local culture must be more than a superficial addition; it must serve as a pedagogical lens through which students interpret mathematical ideas (D'Ambrosio, 2001; Rosa & Orey, 2011). Embedding cultural values in mathematics learning has been shown to strengthen students' critical thinking and conceptual understanding (Prahesti & Fauziah, 2021). The local culture, in this case, Langkat Malay, provides contextual examples such as traditional patterns, architecture, and spatial orientation in local practices that can be tied to geometry and spatial reasoning topics.

Further studies such as those show that the use of local culture in mathematics instruction increases student motivation and enhances cognitive connection due to the familiarity and relevance of the context. These findings are consistent with the culturally responsive teaching framework, which posits that students learn best when the curriculum reflects their cultural backgrounds and lived experiences. Therefore, the justification for selecting a VARK model assisted by GeoGebra and grounded in Langkat Malay culture lies in its multidimensional benefit: addressing learning diversity, enhancing spatial literacy, fostering cultural identity, and promoting independent learning. Literature studies should further examine how traditional practices, spatial orientation in local crafts, and community mapping in Langkat Malay culture can be integrated into mathematical problems to reinforce the cultural and conceptual relevance of geometry and spatial topics.

Conclusion

This study aimed to develop a culturally integrated learning model using the VARK framework, supported by GeoGebra, to enhance the spatial literacy of seventh-grade junior high school students. The development process included four stages: needs analysis, model design, product development, and effectiveness testing. The results showed that integrating the VARK model with elements of Langkat

Malay culture and the interactive features of GeoGebra successfully addressed students' diverse learning preferences. The model was validated as highly feasible by experts, found to be practical based on teacher and student feedback, and proven effective through statistical analysis. A one-tailed t-test revealed a significant difference in spatial literacy outcomes between the experimental and control groups ($t = 3.495 > t\text{-table} = 1.665$, $\alpha = 0.05$), confirming the model's effectiveness.

Integrating local culture provided meaningful context, helping students connect abstract mathematical concepts to familiar cultural elements such as traditional motifs and architectural designs. This approach not only improved understanding but also increased student engagement and motivation. GeoGebra's interactive tools, aligned with the VARK modalities, supported students in visualizing, reasoning, and communicating spatial ideas. The use of culturally responsive pedagogy grounded in constructivist principles also encouraged student independence and active learning. The model effectively accommodates varied learning styles while strengthening students' cultural identity and promoting meaningful learning experiences in geometry.

In conclusion, the VARK based learning model grounded in Langkat Malay culture and supported by GeoGebra meets the criteria of validity, practicality, and effectiveness. It holds strong potential for improving spatial literacy and serves as a valuable instructional approach in culturally diverse educational settings. Future research is recommended to further explore how traditional knowledge and spatial practices can be integrated into mathematics learning to deepen both cognitive and cultural connections.

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