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ANALYSIS OF THE MATHEMATICAL REPRESENTATION ABILITY OF GRADE X STUDENTS IN SOLVING QUADRATIC FUNCTION PROBLEMS REVIEWED FROM LEARNING STYLES

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ABSTRACT

Mathematical representation ability is a crucial competency for students to conceptualize mathematical ideas, especially in abstract quadratic function materials. This study aims to describe the variation in mathematical representation abilities of grade X students at SMAN 1 Kuta Baro based on differences in learning styles (visual, auditory, and kinesthetic). This study uses a qualitative approach with a case study type. The research subjects were selected through *purposive sampling* consisting of nine students who were categorized based on the results of the learning style questionnaire. Data were collected through mathematical representation ability tests and semi-structured interviews. Data analysis techniques include data reduction, data presentation, and verification/conclusion drawn. The results of the study show that there is a distinctive representation pattern in each learning style. Students with visual learning styles showed superiority in visual (graph drawing) and symbolic representations. Students with auditory learning styles tended to be dominant in verbal representations, where they were able to explain arguments orally fluently but experienced difficulties in pouring the ideas into graphs. Meanwhile, students with kinesthetic learning styles were more prominent in procedural representations, namely being able to model problems through structured activities but often having difficulties in theoretical justification. The conclusions of this study confirm that learning styles play a significant role in shaping students' mathematical representation patterns. These findings recommend the importance of implementing differentiated learning that accommodates a diversity of learning styles in order to optimize students' mathematical representation skills.

INTRODUCTION

National Council of Teachers of Mathematics (NCTM) in Hasnarika (2022) explained that the purpose of mathematics learning namely problem solving, representation, communication, connection, reasoning and proof. One of the important skills in mathematics learning is the ability to represent mathematics, i.e. the ability that can help students develop their maximum potential through various forms of conveying ideas, ideas, and understandings according to their characteristics and needs (Wahyuni, 2026). According to Rezkyanti et al., (2025) Mathematical representation has an important role for students and is even contained as one of the goals in the Independent Curriculum. So based on this, in the implementation of the Independent Curriculum, representation is one of the most important mathematical skills for students to have.

The term representation in the Ministry of Education and Culture Number 22 of 2016 is mentioned as communicating ideas through symbols, tables, diagrams or other media to clarify the situation or problem (Lestari & Adirakasiwi, 2022). Mathematical representation skills have an important role in the mathematics learning process. (Rosanti, 2024). Andriani & Fauziyah (2024) declare that the ability Mathematical representations can help students in understanding mathematical concepts and communicate mathematical ideas more clearly. Through representations, students can connect abstract concepts with more concrete forms so that the process of understanding is easier (Zakiya, 2026).

One of the mathematical materials that requires mathematical representation skills is the quadratic function. Quadratic functions are materials that are related to various forms of representation, such as algebraic forms, tables, parabolic graphs, and verbal descriptions (Fauzi & Prihatnani, 2020). Students are not only required to determine the value of a function or solve quadratic equations, but also need to understand the relationship between the shape of the equation and its graph characteristics (Sholekah et al., 2025).

In solving quadratic function problems, students' mathematical representation abilities can be seen from the way students turn contextual problems into mathematical models, present relationships between variables in the form of tables or graphs, use mathematical symbols and equations, and explain verbal solution steps (Ngilamele et al., 2025). If students are only able to perform calculations procedurally but have difficulty converting information into the form of graphs, tables, symbols, or verbal explanations, then the problem-solving process becomes less than optimal

The reality in the field shows that students' mathematical representation skills are still one of the aspects that need attention. Some students tend to rely on the procedures and formulas that have been given by the teacher without understanding the relationship between the various forms of representation. Difficulties can be seen when students are faced with problems whose presentation is different from the examples that have been given. Students may experience obstacles in translating story problems into the form of mathematical equations, determining graphs that correspond to a function, reading information from graphs, or explaining the reason for the completion steps taken. This condition shows that the ability to solve mathematical problems is not only influenced by mastery of the material, but also by students' ability to represent mathematical information and ideas.

These differences in abilities can be related to the characteristics and ways students receive, process, and understand information during the learning process. One aspect that can be reviewed is the student's learning style. Learning style is related to the tendency of the individual's way of receiving and processing information so that each student can show a different response when participating in mathematics learning (Rusli et al., 2023). In general, learning styles are often grouped into visual, auditory, and kinesthetic learning styles (Budi et al., 2021).

Students with visual inclinations have an easier time understanding information through pictures, graphs, diagrams, or written displays. Students with auditory tendencies tend to understand information more easily through explanations and verbal communication, while students with kinesthetic tendencies tend to understand information more easily through activities, hands-on experience, and involvement in the learning process (Dendodi et al., 2025).

These differences in learning styles are important to consider when analyzing mathematical representation skills. Students who have a certain learning style tendency may show different ways of understanding information and represent mathematical ideas when solving problems (I. Putri et al., 2022). These problems show the need for a more in-depth analysis of how students represent mathematical concepts when solving quadratic function problems. Analysis based on learning styles can provide an overview of the characteristics of students' mathematical representation abilities in each learning style tendency.

A number of previous studies have analyzed this problem, which generally examines the ability of mathematical representation in various materials or relates learning styles to problem-solving skills, concept understanding, and learning outcomes. However, research that specifically analyzes students' mathematical representation abilities in solving quadratic function problems by reviewing differences in learning styles is still relatively limited. In fact, quadratic function materials have characteristics that require students to connect various forms of representation, such as symbols, equations, tables, graphs, and verbs.

This gap is an important basis for this research to analyze more deeply the mathematical representation ability of class X students in solving quadratic function problems reviewed from learning styles. This study not only looks at the accuracy of students' answers, but also examines how students use and relate various forms of mathematical representation during the problem-solving process based on visual, auditory, and kinesthetic learning style tendencies. Thus, this research is expected to provide an overview of the characteristics of students' mathematical representation abilities and become a consideration for teachers in designing mathematics learning that is in accordance with the diversity of ways students understand and solve problems.

RESEARCH METHOD

This type of research is descriptive qualitative research with a case study approach. Qualitative research aims to understand the phenomena experienced by research subjects in depth through descriptions in the form of words and language in a natural context. This approach was chosen because the research aims to describe students' mathematical representation abilities in solving quadratic function problems reviewed from students' learning styles.

The stages of the research procedure that have been simplified in this study are as follows:

Figure 1. Research Procedure Chart

Data in the study was obtained through learning style questionnaires, mathematical representation ability tests, interviews, and documentation. The learning style questionnaire uses the VAK model, which is in the form of quadratic function questions that bring up elements of mathematical representation, such as visual (graphic), symbolic (algebra), and verbal (description) representations. Meanwhile, the mathematical representation ability test is in the form of quadratic function questions consisting of 15 questions that include three types of mathematical representation, namely visual representation, symbolic representation, and verbal representation. Data analysis is carried out with an interactive analysis model which includes data reduction, data presentation, and conclusion drawn.

Table 1. Assessment Rubric

Yes	Aspects/ Indicators assessed	Score 4 (Excellent)	3 (Good)	2 (Enough)	1 (Less)
1	Visual Representation	Correctly answer all questions (1–5), with logical, complete, and appropriate images.	Answered correctly for the most part (with the reason/ picture being pretty clear.	Answering correctly Some with inappropriate reasons/images.	Incorrect/incomplete answer
2	Symbolic Representation	All questions (1-5) are answered correctly, systematically, with mathematically correct reasons	Most of them are true, but there are a few misconceptions Calculation	Only partially true, inconsistent reasoning	Incorrect/incomplete answer
3	Verbal Representation	All questions (1-5) answered correctly, contextual explanations Logical, complete, and using the right mathematical language	Mostly true, contextual reasons are pretty obvious	Some are true, but the reason Improper interpretation	Incorrect/incomplete answer

This assessment uses 3 types of representations and 5 question items each, so:
Maximum score of 1 question = 4
Maximum score of 1 type of representation = 20
Total maximum score = 60

Then it is calculated with the percentage formula:

$$P = \frac{F}{N} \times 100\%$$

Description:
P = Percentage of Value
F = Score obtained by students
n = maximum score
100% = Percentage Constant

Based on the calculation of percentages, the classification of mathematical representation ability uses the following criteria:

Table 2. *Pretest–Posttest Control Group Research Design*

Group	Pre test	Treatment	Post test
Experimental	0_1	X	0_2
Control	0_1	−	0_2

Notes:
0_1 = Pre test prior to treatment
0_2 = Post test following treatment

RESULTS AND DISCUSSION

This study was conducted on grade X students at SMAN 1 Kuta Baro with a total of 41 students. Learning style data was obtained through a questionnaire that referred to three categories, namely visual, auditory, and kinesthetic. This assessment uses the following scales:

- Scale Yes = 1

  At this stage, students who choose the correct answer to each question on the questionnaire will get a score of 1 in each question.
- Scale No = 0

  Meanwhile, at this stage, students who choose the answer that is not suitable will get a score of 0.

  Meanwhile, the dominant learning style is determined based on the highest score.

Table 3. Results of the Student Learning Style Questionnaire by Category

Learning Style	Remarks	Number of Students
Visual	Tend Understanding material through vision, such as images and graphics.	14
Auditory	Tend Understanding material through Lisa explained.	18
Kinesthetic	Tend to understand the material through hands-on activities and practice.	9
Total		41

Based on the results of the table above, the selection of 9 students was carried out to represent three types of learning styles (visual, auditory, and kinesthetic) as many as three people each, thus allowing for a balanced and in-depth analysis. This number is also in accordance with the characteristics of qualitative research that emphasizes the depth of data, and uses purposive sampling techniques so that the selected subjects are truly in accordance with research needs. This research begins with giving a mathematical representation ability test to students who have been selected based on a learning style questionnaire. The abilities measured include three aspects, namely visual representation, symbolic representation, and verbal representation. Each aspect consists of 5 questions with a maximum score of 4 per question, so that the maximum score of each aspect is 20 and the maximum total score is 60. The score obtained by students is then calculated as a percentage.

Table 4. Results of the Student Mathematical Representation Ability Test

Yes	Student Name Code	Students' Mathematical Representation Ability Test Scores			Total Score of Mathematical Representation Ability Test
		Visual	Symbolic	Verbal	
1	ZA	13	14	20	47
2	S	13	13	13	39
3	SA	13	10	9	32
4	TS	13	14	20	47
5	TN	13	13	10	36
6	AR	10	9	11	30
7	AB	13	20	20	53
8	AM	9	11	9	29
9	MI	8	10	13	31
Number of Indicators Fairy Score		105	114	125	-
		Total Score			344

The level of students' mathematical representation ability is determined based on the results in the following table by grouping the test scores into ability classifications. The grouping is carried out based on the percentage of the total score so that it can be known the level of students' mathematical representation ability based on learning style.

Table 5. Classification Level of Mathematical Representation Ability Based on Learning Style

Yes	Student Code	Learning Style	Total Score	Percentage	Classification
1	AB	Visual	53	88,33%	Height
2	AM	Visual	29	48,33%	Low
3	THE BATTLE	Visual	32	53,33%	Low
4	S	Auditory	39	65,00%	Medium
5	TS	Auditory	47	78,33%	Medium
6	MI	Auditory	31	51,67%	Low
7	ZA	Kinesthetic	47	78,33%	Medium
8	AR	Kinesthetic	30	50,00%	Low
9	TN	Kinesthetic	36	60,00%	Medium

The results of the percentage of students based on the classification of mathematical representation abilities are as follows:

Table 6. Percentage Results by Classification Level

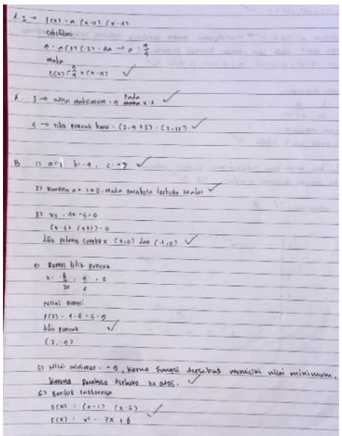
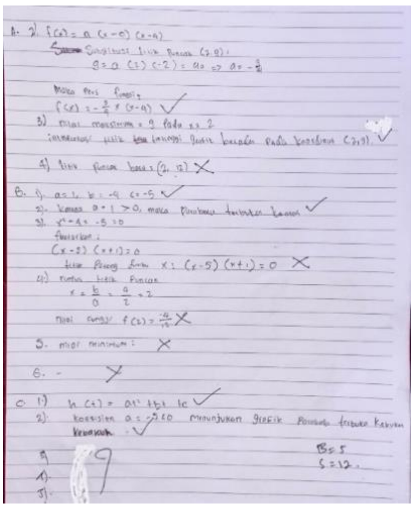
Classification Level	Many Students	Percentage
Height	1	11,11%
Medium	4	44,44%
Low	4	44,44%
Total	9	100%

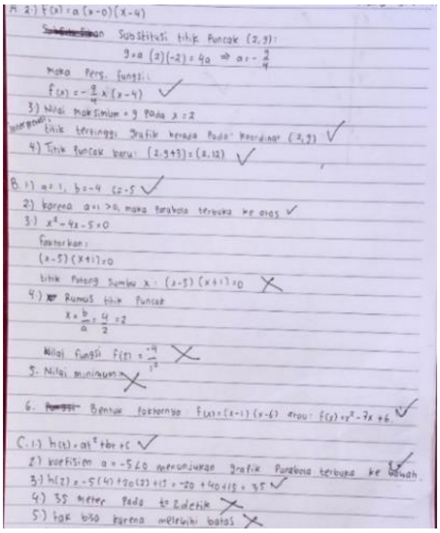
Based on the results of the analysis, students' mathematical representation abilities are divided into three categories, namely high, medium, and low. Of the 9 students, there was 1 student (11.11%) in the high category, 4 students (44.44%) in the medium category, and 4 students (44.44%) in the low category.

After the test was carried out, an examination of the students' answers was carried out and continued with interviews with 9 students who were selected based on the results of the learning style questionnaire and the mathematical representation ability test using *the purposive sampling technique*. The research subjects consisted of 3 students with visual learning styles, 3 auditory students, and 3 kinesthetic students. The interviews were conducted to obtain more in-depth information about students' mathematical representation abilities based on their respective learning styles.

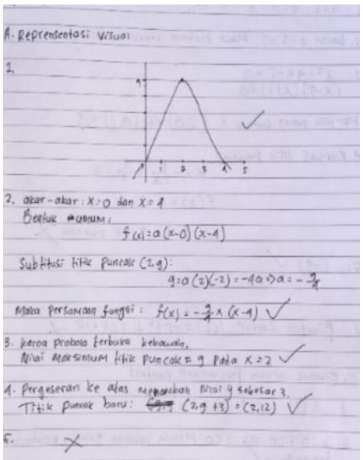
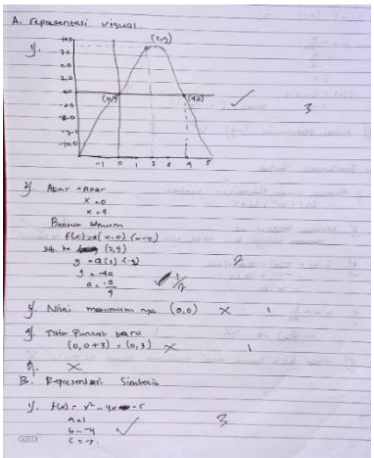
The results of the representation test and the results of student interviews per learning style category are as follows:

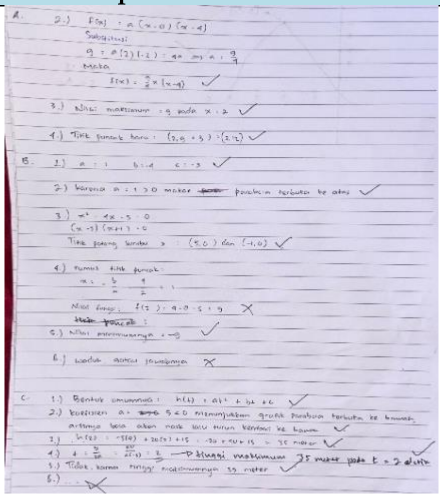
1. Students with Visual Learning Styles

Students	Representation Results Data	Interview Data
AB	 Score = 88.33%	- Understanding through chart visualization - Using Visual Picture in Thinking - Relying on visual representations - Understanding through images - Using Symbols visuals in explanation - Understanding through visual observation - Strengthen understanding through visual examples
AM	 Score = 48.33%	- Understanding through reading and seeing - Using visual references - Understanding through visual examples - Relying on written visual information - Explain through visual media - Understanding through observation Live visuals - Requires visual explanations from teachers

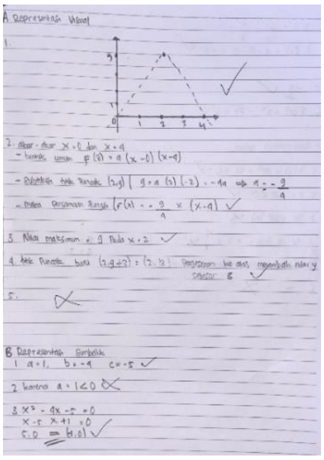
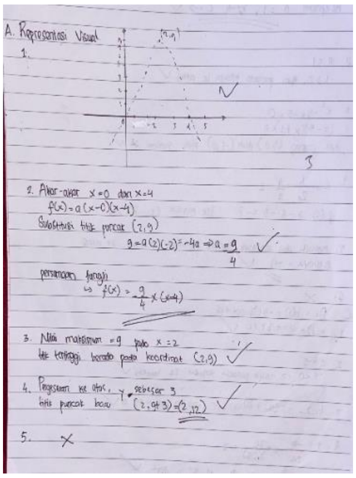
Students	Representation Results Data	Interview Data
THE BATTLE	 Score = 53.33%	- Understanding through reading - Use visual memory - Use visual symbols - Using familiar visual references - Explain through visual sequence - Understanding through visual observation - Need visual aids in learning

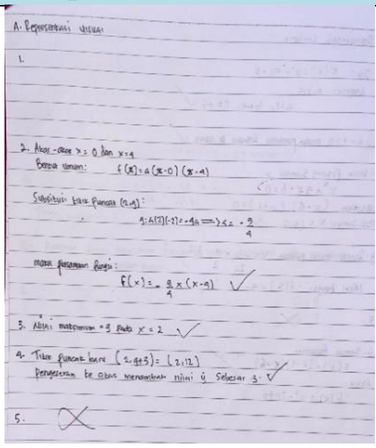
2. Students with Auditory Learning Styles

Students	Representation Test Data	Interview
S		- Understanding the problem through verbal repetition - Relying on memory of the teacher's explanation - Using verbal formulas - Using the methods that have been taught - Following Steps based on verbal instructions - Explain the material verbally - Understanding material through listening - Requires verbal interaction in learning
MI	 **Score = 51.67%**	- Understanding the problem through the teacher's explanation memory - Using formulas based on verbal explanations - Relying on the methods described - Understanding Through Listening - Explain the material verbally - Hearing helps understanding - Requires a direct explanation and examples.

Students	Representation Test Data	Interview
TS	 **Score = 78.33%**	- Understanding questions through verbal reading - Remembering the concept of the teacher's explanation - Using formulas as the basis for solutions - Using the methods that have been taught - Explain the material verbally - Understanding through the examples described - Requires explanation and hands-on practice.

3. Students with Kinesthetic Learning Styles

Students	Representation Test Data	Interview Data
TN	 Value = 60.00%	- Solve problems with hands-on practice - Understanding through hands-on activities - Learning through practice habits - Understanding through writing and counting - Explain through live demonstrations - Understanding through hands-on experience - Requires hands-on practice practice
ZA	 Score = 78.33%	- Solve problems through hands-on practice - Relying on experience in practice - Understanding through counting activities - Explain through practice and explanation - Combining explanations with hands-on practice - Understanding through hands-on practice and evaluation

Students	Representation Test Data	Interview Data
AR	 **Value = 50.00%**	- Solve problems through hands-on practice - Understanding through hands-on activities - Understanding through writing and counting - Explain through hands-on practice - Understanding through hands-on experience - Requires hands-on practice practice

Discussion

Mathematical representation skills Visual Learning Style Students

Based on the results of the mathematical representation ability test, students with visual learning styles showed different levels of ability. AB subjects obtained a score of 88.33% in the high category, while AM subjects obtained a score of 48.33% and SA subjects obtained a score of 53.33% which was included in the low category. This difference shows that despite having the same learning style, students' mathematical representation abilities still vary depending on the individual's level of understanding and ability

The results of the interviews showed that students with visual learning styles tended to understand mathematical problems through pictures, graphs, and other visual forms. Subject AB was seen to be able to build a visual picture independently when understanding the given problem. This can be seen from the way students use graphics and visual symbols to help understand the concept of quadratic functions. This ability shows that good visualization can help students understand the relationship between mathematical concepts so that it is easier to solve problems.

These findings are in line with research Natonis et al., (2022) which states that students with visual learning styles have a better tendency to use visual representations to understand mathematical concepts. In addition, research Hasyari et al., (2025) It also shows that visual representation skills play an important role in helping students connect abstract concepts to more concrete through graphics or images.

This also strengthens the opinion of the National Council of Teachers of Mathematics (NCTM) which states that representation is one of the important processes in mathematics learning, because through representation students can organize and communicate mathematical ideas more clearly (Rusli et al., 2024).

In contrast to AB subjects, AM and SA subjects still tend to depend on visual examples that have been given by the teacher or contained in books. Both subjects are not fully able to build visualization independently when facing the given problems. As a result, the use of mathematical symbols and formulas still follows the examples that have been studied before, so that the mathematical representation skills have not developed optimally.

These findings are supported by research Saodah et al., (2024) which states that students' mathematical representation skills are not only influenced by learning styles, but also by students' ability to develop concept understanding independently. Students who are not able to build their own representations tend to only imitate examples without understanding the meaning of concepts in depth.

Based on these findings, it can be concluded that the ability to mathematical representation in students with visual learning styles is greatly influenced by the ability of students to build a visual picture of the mathematical concepts studied. Students with high abilities such as subject AB are able to integrate visual, symbolic, and verbal representations better, while students with low abilities such as AM and SA subjects still have difficulty in developing representations independently.

Thus, the results of this study show that visual learning style provides an advantage in the visual aspect, but the mastery of mathematical representations as a whole still requires a strong understanding of concepts and continuous practice.

Mathematical representation skills Auditory Learning Style Students

Based on the results of the mathematical representation ability test, students with auditory learning styles showed abilities in the medium to low category . TS subjects obtained a score of 78.33%, S subjects 65.00%, and MI subjects 51.67%. These results show that the mathematical representation ability of auditory students is not completely evenly distributed, although some students have shown quite good abilities.

The results of the interviews showed that students with auditory learning styles were more likely to understand math problems through verbal explanations. Most students stated that they understood the problem by remembering the teacher's explanation that had been delivered in class. In understanding the problem, students usually read or repeat the information verbally to make it easier to understand. This shows that the thinking process of auditory students is greatly influenced by listening and speaking activities.

When solving problems, students with auditory learning styles tend to use the formulas and solution steps that have been explained by the teacher before. In other words, the process of solving the problem is carried out by remembering the methods that have been learned through oral explanations. TS subjects (78.33%) were seen to be more capable of applying these steps appropriately, while S subjects (65.00%) and MI (51.67%) still showed a fairly high dependence on the examples that had been given.

These findings are in line with research conducted by Natonis et al., (2022) which states that students' mathematical representation abilities vary based on learning styles, where students with auditory learning styles tend to be more dominant in using verbal and symbolic representations. In addition, research by Hasyari et al., (2025) It also shows that auditory students are more likely to understand the steps of settlement through oral explanations so that they are able to follow the settlement procedure quite well.

In addition, auditory students also show the ability to explain the steps to solve problems orally. This shows that auditory students' thinking processes are more influenced by the verbal communication they heard before. This ability is one of the advantages of auditory students compared to other learning styles, especially in the aspect of verbal representation.

However, dependence on the teacher's explanation also causes some students to experience difficulties when facing problems that are different from the examples that have been described. This can be seen in MI subjects (51.67%) who still need additional explanations to understand the direction of solving the problem. This finding is supported by research Darmawan et al., (2019) that states that the ability to Students' mathematical representations are greatly influenced by the understanding of concepts, and students who Too dependent on explanations, teachers tend to have difficulty solving varied problems.

Thus, it can be concluded that the mathematical representation ability of students with auditory learning styles is greatly influenced by verbal explanations and learning interactions that occur in the classroom. Students with higher abilities are able to utilize these explanations effectively, while students with lower abilities still depend on the examples given. Therefore, learning that is not only based on oral explanations is needed, but also encourages students to develop understanding of concepts and independence in solving problems.

Mathematical representation skills of Kinesthetic Learning Style Students

Based on the results of the mathematical representation ability test, students with kinesthetic learning styles showed abilities in the medium to low category. ZA subjects obtained a score of 78.33%, TN subjects 60.00%, and AR subjects 50.00%. These results show that the mathematical representation ability of kinesthetic students is not evenly distributed, even though some students have been able to show quite good abilities.

The results of the interviews showed that students with a kinesthetic learning style tended to understand math concepts through hands-on activities such as writing, arithmetic, and trying to solve problems independently. Most students stated that they found it easier to understand the problem when they tried to do it right away than just reading or listening to an explanation. This shows that physical involvement in the learning process is an important factor for kinesthetic students in understanding math concepts.

In the process of solving problems, the use of mathematical symbols usually appears when students carry out practical activities such as writing down the completion steps and doing calculations directly. ZA subjects (78.33%) seem to be more able to integrate practical activities with their understanding of concepts, so that they are able to solve problems better. Meanwhile, TN subjects (60.00%) and AR subjects (50.00%) still show limitations in understanding concepts in depth, so the results obtained are not optimal.

These findings are in line with research Wisdom & Uce (2025) which states that students with kinesthetic learning styles show increased understanding when given the opportunity to learn through hands-on activities and independent exploration. This shows that concrete learning experiences have a great influence on students' ability to represent mathematical concepts.

In addition, the research Putri et al., (2025) It also states that exercises that involve physical activity and repeated practice can help kinesthetic students in strengthening their understanding of concepts and improving their ability to use mathematical representations, especially in symbolic form.

However, the results of the interviews show that kinesthetic students still need repeated exercises to understand concepts better. TN and AR subjects still need more experience in solving problems in order to be able to develop mathematical representation skills optimally. These findings are also supported by research Salma & Sumartini (2022) which states that students' mathematical representation skills will develop if students have sufficient learning experience and a good understanding of concepts, not just doing meaningless activities.

Thus, it can be concluded that the mathematical representation ability of students with kinesthetic learning styles is greatly influenced by practical activities and hands-on experiences in the learning process. Students with higher abilities are able to combine these activities with concept understanding, while students with lower abilities still require more intensive practice and guidance. Therefore, learning that involves hands-on activities and continuous practice is indispensable to improve the mathematical representation skills of kinesthetic students.

CONCLUSION AND SUGGESTIONS

Conclusion

Based on the results of research that has been conducted on grade X students of SMAN 1 Kuta Baro, it can be concluded that students' mathematical representation abilities in solving quadratic function problems show clear differences based on learning styles, namely visual, auditory, and kinesthetic. This difference is not only seen in the level of ability, but also in the patterns and types of mathematical representations used by students in understanding and solving problems.

1. Students with visual learning styles show more dominant abilities in visual and symbolic representation, namely being able to graph quadratic functions and write mathematical models fairly precisely and systematically. This shows that visual students are more likely to construct mathematical concepts through the form of images and symbols, although they still experience limitations in verbal representation, especially in explaining the completion steps in detail.
2. Meanwhile, students with auditory learning styles tend to excel in verbal representations, i.e. they are able to explain the process of solving problems orally in a concise and clear manner. However, they have difficulty in representing ideas into visual form, such as drawing graphs of quadratic functions. This shows an imbalance between verbal comprehension and visual ability in mathematical representations.
3. Students with kinesthetic learning styles are more prominent in procedural and symbolic representations through direct activities, such as solving problems systematically through calculation steps. However, they still have difficulties in verbal and visual representations, as well as in providing justification or conceptual explanations for the steps taken.
4. In addition, students with high abilities are able to use various forms of representation (visual, symbolic, and verbal) in an integrated manner, while students

with medium and low abilities are still limited to one type of representation only.

5. Thus, it can be emphasized that mathematical representation skills are multidimensional abilities (visual, symbolic, and verbal) that have not been developed in a balanced manner in students, and are greatly influenced by their respective learning styles. Therefore, learning that is able to integrate various forms of mathematical representation and accommodate different learning styles of students is needed, so that the understanding of the concept of quadratic functions can develop more optimally and comprehensively.

Suggestions

Based on the suggestions that have been prepared, it can be concluded that improving students' mathematical representation skills requires a mutually supportive role between teachers, students, schools, and subsequent researchers. Teachers are expected to be able to implement varied learning and integrate various forms of representation according to students' learning styles, so that concept understanding can develop optimally.

On the other hand, students need to actively practice mathematical representation skills in various forms and recognize their learning styles in order to make the learning process more effective. Schools also have an important role in providing facilities and supporting the use of innovative learning methods to support the process.

In addition, for future researchers, it is necessary to develop research with a wider scope of material and subjects so that the results obtained are more in-depth and comprehensive. Thus, efforts to improve students' mathematical representation skills can be carried out in a sustainable and more optimal manner.

REFERENCES

Andriani, N. L., & Fauziyah, N. (2024). Analysis of Students' Mathematical Representation Ability in Terms of Math Anxiety. *JOHME: Journal of Holistic Mathematics Education*, *8*(2), 201–212. https://doi.org/10.19166/johme.v8i2.8357

Budi, S. S., Suhaili, N., & Irdamurni, I. (2021). The concept of learning styles and their implementation in the learning process. *Journal of Educational and Learning Studies*, *4*(2), 232–236.

Darmawan, A., Ramadhana, Z., Hadi, P., & Suyudi, A. (2019). Understanding the Concept of Prospective Teacher Students on Business and Energy Topics through Graphical Representation. *Journal of Physics Education Innovation and Its Integration*, *02*(02), 41–54.

Dendodi, Wulan Puspita, Mirna, & Rosi Sakira. (2025). Analysis of Student Learning Styles to Improve Learning Outcomes at the High School Level According to Educational

Psychology. *Journal of Community Service and Educational Research*, *3*(4), 1734–1741. https://doi.org/10.31004/jerkin.v3i4.744

Fauzi, I. S., & Prihatnani, E. (2020). Understanding the Concept of Quadratic Function Graphs for High School Students in Class X. *Journal of Scholars: Journal of Mathematics Education*, *4*(1), 82–103. https://doi.org/10.31004/cendekia.v4i1.162

Hasnarika. (2022). The Application of Metaphorical Thinking to Improve Mathematical Representation Skills and Habits of Mind in Junior High School Students. *Journal of Mathematics and Natural Sciences Education*, *12*(2), 255–264. http://ejournal.tsb.ac.id/index.php/jpm/index

Hasyari, W. S. F. A., Rosmery, L., & Siregar, N. A. R. (2025). Analysis of Mathematical Representation Ability Based on Students' Self Efficacy on Quadratic Function Material. *Indonesian Journal of Educators*, *6*(1), 40–46.

Hikmah, F., & Uce, L. (2025). Exploring Student Potential: The Role of Learning Style in the Educational Process. *Indonesian Journal of Education Research*, *2*(2), 407–414.

Lestari, A. A., & Adirakasiwi, A. (2022). Analysis of Students' Mathematical Communication Ability Reviewed from Mathematical Disposition. *Didactical Mathematics*, *4*(1), 283–293. https://doi.org/10.31949/dm.v4i1.2135

Natonis, S. F. M., Daniel, F., & Gella, N. J. M. (2022). Analysis of Students' Mathematical Representations Reviewed from Learning Styles. *Educative: Journal of Educational Sciences*, *4*(2), 3025–3033. https://doi.org/10.31004/edukatif.v4i2.2592

Ngilamele, A., Mataheru, W., & Ramadhani, W. P. (2025). Analysis of Students' Mathematical Representations on Quadratic Function Materials in Class IX of SMP Negeri 1 Kairatu. *Journal of Mathematics Education Unpatti*, *6*(2), 128–136. https://doi.org/10.30598/jpmunpatti.v6.i2.p128-136

Putri, A., Ramdhani, L., & Widia. (2025). The Effectiveness of Traditional Game-Based Kinesthetic Mathematics Learning Model on the Understanding of the Concept of Multiplication and Division of Grade II Students of SDN 3 Lape. *DIKMAT: Journal of Mathematics Education*, *6*(2), 29–39.

Putri, I., Handican, R., & Gunawan, R. G. (2022). Systematic Literature Review: An Analysis of Students' Mathematical Representation Abilities on Learning Styles. *Griya Journal of Mathematics Education and Application*, *2*(3), 577–588. https://doi.org/10.29303/griya.v2i3.168

Rezkyanti, Tahir, S. R., Nursakiah, & Ilhamsyah. (2025). Mathematical Representation Ability Reviewed from Students' Learning Styles. *Venn: Journal of Sustainable Innovation on Education, Mathematics and Natural Sciences*, *4*(3), 284–292. https://journal.web.id/journals/venn/article/view/313

Rusli, R., Dassa, A., Pebrianty, N., & Musa, H. (2024). Mathematical Representation Ability of Algebraic Form Material of Class VII Students at SMPN 7 Makassar. *ARRUS Journal of Mathematics and Applied Science*, *4*(2), 63–68. https://doi.org/10.35877/mathscience3402

Rusli, R., Suwatno, S., Rasto, R., & Muhammad, I. (2023). Identifying Student Learning Styles and Their Impact on Learning Outcomes: An Analysis at the Senior Secondary Education Level. *EDUCATION: Journal of Education and Learning*, *4*(2), 859–870. https://doi.org/10.62775/edukasia.v4i2.363

Salma, F. A., & Sumartini, T. S. (2022). Students' Mathematical Representation Ability between Contextual Teaching and Learning and Discovery Learning. *Plusminus: Journal of Mathematics Education*, *2*(2), 265–274. https://doi.org/10.31980/plusminus.v2i2.1868

Saodah, N., Mastur, Z., & Suyitno, A. (2024). Analysis of students' mathematical representation abilities reviewed from learning styles through the CORE learning model. *Tirtamath: Journal of Mathematics Research and Teaching*, *6*(1), 15.

https://doi.org/10.48181/tirtamath.v6i1.24508

Sholekah, I., Andaini, S. K., & Rofiki, I. (2025). Application of GeoGebra-Assisted Discovery Learning Model to Improve Learning Outcomes of Quadratic Function Materials. *MATHEdunesa*, *14*(1), 245–260. https://doi.org/10.26740/mathedunesa.v14n1.p245-260

Wahyuni, A. (2026). Trends and Innovations of E-Learning Research in Mathematics Education in the Face of Digital Transformation: Bibliometric Analysis. *Journal of Scholars: Journal of Mathematics Education*, *10*(1), 414–429. https://doi.org/10.31004/cendekia.v10i1.4806

Zakiya, A. (2026). Development of mathematical representation skills of madrasah students through an Open-Ended learning approach. *Maliki Interdisciplinary Journal (MIJ*), *4*(2), 565–570.