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Exploring the Impact of Student Orientation on Mathematics Learning Using Self-Organizing Maps: A Study with Middle School Students

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Abstract

Background/purpose. Mathematics education develops critical thinking and problem-solving skills, yet middle school students often face challenges, including didactical, epistemological, and ontogenic obstacles, that influence their academic orientation. This study investigates how Self-Organizing Maps (SOMs) can address these challenges by clustering students based on shared characteristics and designing targeted interventions.

Materials/methods. A mixed-methods design was used. Phase One analyzed data from 200 high school students to explore the link between middle school mathematics performance and academic orientation. Phase Two focused on 60 middle school students completing a mathematics assessment and orientation questionnaire. SOMs identified learning patterns and guided peer-learning interventions. Pre- and post-intervention performances were compared.

Results. SOM clustering identified four distinct student groups. Targeted interventions significantly reduced mathematical errors, with a 45% overall decrease. Post-intervention, there was a 20% increase in students choosing the scientific track, reflecting improved confidence and interest in mathematics.

Conclusion. SOM-based clustering effectively identifies and addresses learning obstacles, improves mathematical proficiency, and positively influences students' academic orientation. This approach highlights SOM's potential for customized education and its implications for teaching strategies and policy.

1. Introduction

Mathematics education is pivotal in developing students' critical thinking, problem-solving skills, and logical reasoning (Santos-Trigo, 2020; Yang, 2024), serving as a foundation for advanced studies and various career paths. In middle school, students transition from concrete arithmetic to more abstract mathematical concepts, making this period crucial for shaping their attitudes and proficiency in mathematics. Despite its importance, many students exhibit low performance and a lack of interest in mathematics, hindering their academic and professional prospects. Understanding the factors influencing mathematics learning during this formative stage is essential for educators and policymakers aiming to improve educational outcomes.

One significant factor influencing mathematics achievement is student orientation, which encompasses attitudes, beliefs, motivations, and learning strategies toward the subject. Positive orientation factors such as high interest, self-efficacy, intrinsic motivation, and effective learning strategies have been linked to better academic performance. Conversely, negative factors like mathematics anxiety and low self-confidence can impede learning and lower achievement. While these relationships have been explored in various studies, there is a need for a more comprehensive analysis that considers the complex interplay of multiple orientation factors and how they collectively impact mathematics learning.

Artificial intelligence (AI) revolutionizes education by enhancing learning processes and research efficiency. Tools like ChatGPT facilitate idea generation and assignment assistance, though ethical concerns like plagiarism remain (Nguyen et al., 2024). AI also streamlines academic resource management by integrating repositories and improving precision and analysis in research processes (Ramirez & Esparrell, 2024). In recent years, advanced analytical techniques like Self-Organizing Maps (SOMs) have emerged as valuable tools for uncovering hidden patterns and relationships in educational data (Bara et al., 2018; Delgado et al., 2021). SOMs are an artificial neural network used for unsupervised learning and data visualization, capable of projecting high-dimensional data onto a two-dimensional grid while preserving topological relationships. This method allows researchers to identify clusters of students with similar characteristics, providing deeper insights into how different orientation profiles relate to academic outcomes.

The focus on middle school students is particularly significant, as this stage is critical for developing foundational skills and attitudes toward mathematics. In the context of the Moroccan education system, where challenges such as low mathematics achievement and student disengagement persist, this research holds practical relevance. Educators can design targeted interventions to foster positive orientations and improve mathematics proficiency by understanding how various orientation factors contribute to learning outcomes.

Moreover, applying SOMs in educational research represents an innovative approach that can effectively handle complex, multidimensional data. Traditional methods may overlook subtle patterns or interactions between variables, whereas SOMs can capture these intricacies, providing a holistic view of the factors influencing mathematics learning.

This study aims to explore the impact of mathematics learning on student orientation by applying Self-Organizing Maps (SOMs). Specifically, the study seeks to:

1. Identify key orientation factors influencing mathematics achievement.
2. Examine relationships between orientation factors and mathematics outcomes.
3. Utilize SOMs to cluster students, providing insights into patterns that inform targeted interventions.

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The research questions guiding this study are:

RQ 1: What are the critical orientation factors that affect students' mathematics achievement?

RQ 2: How do these factors relate to academic performance and orientation choices?

RQ 3: How effective are SOM-based interventions in improving mathematics understanding and influencing academic trajectories?

2. Literature Review

Mathematics education during middle school is critical for developing foundational skills influencing students' future academic and professional trajectories. Numerous studies exploring the factors affecting mathematics learning among middle school students, such as motivation, self-efficacy, learning strategies, and emotional factors, highlight the importance of student orientation. Additionally, applying advanced analytical techniques like Self-Organizing Maps (SOMs) has provided deeper insights into the complex interplay of these factors and their impact on mathematics achievement.

Motivation and Goal Orientation are pivotal in shaping students' engagement and success in mathematics. According to Eduwem et al. (2017), psychological factors, including motivation, significantly influence secondary school students' academic performance in mathematics. Students with high intrinsic motivation are more likely to engage with mathematical content, leading to better understanding and achievement. Similarly, Ekene et al. (2023) found that social goal orientation predicts mathematics achievement, indicating that students motivated by social factors such as peer recognition tend to perform better.

Middleton et al. (2013) conducted a path analysis to examine the relationships among critical motivational variables and achievement in a reform-oriented mathematics curriculum. Their findings suggest that intrinsic motivation and mastery goals positively affect mathematics achievement. Furthermore, Samadi (2012) explored the relationship between motivational orientation and learning strategies, concluding that motivation directly influences the adoption of effective learning strategies, which in turn predict academic success.

Self-efficacy and self-concept are also crucial determinants of achievement in mathematics. Kang (2012) investigated the structural relationships among self-efficacy, self-directed learning ability, school adjustment, and learning flow in middle school students. The study revealed that higher self-efficacy enhances self-directed learning abilities and promotes better school adjustment, leading to improved learning and academic performance. Similarly, Al-Abed and Alshaara (2012) found that students with a positive mathematical self-concept are more likely to employ deep learning approaches, resulting in higher achievement levels.

Deringöl (2020) focused on middle school students' perceptions of their self-efficacy in visual mathematics and geometry. The study reported that students with higher self-efficacy in these areas demonstrated better performance, underscoring the importance of fostering confidence in mathematical abilities during the middle school years.

Learning Strategies and Self-Regulation play a significant role in academic achievement. Rabab'h (2015) examined the relationship between mathematics learning strategies and mathematics achievement among middle school students in Jordan. The study indicated that metacognitive strategies, such as self-monitoring and self-evaluation, correlate with higher mathematics achievement. Moreover, Ford et al. (2018) explored the effects of self-regulation strategies on middle school students' calibration accuracy and achievement. They found that students who effectively regulate their learning processes tend to have more accurate self-assessments and achieve higher academically.

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Integrating technology and self-assessment tools has enhanced self-directed learning and mathematics achievement. Phoodee (2023) investigated the effects of student self-assessment and the use of GeoGebra™ on students' achievements in mathematics. The study concluded that incorporating technology and self-assessment practices fosters self-directed learning skills and improves mathematical understanding in junior high students.

The concept of a Growth Mindset, defined as the belief that intelligence and abilities can be developed through effort and perseverance, has been linked to improved academic outcomes. Dong et al. (2023) examined how a growth mindset influences mathematics achievement among Chinese middle school students. Their findings suggest that students with a growth mindset exhibit greater resilience and are more likely to embrace challenges, leading to higher achievement in mathematics.

3. Methodology

3. 1. Research Design

This research employed a mixed-methods design conducted in two phases to explore the relationship between mathematics performance and academic orientation while assessing the impact of clustering and peer learning interventions. In Phase One, quantitative data were gathered by surveying 200 first-year high school students to analyze the connection between their middle school mathematics scores and their selected high school academic orientations (Literary, Scientific, Technical), establishing that mathematics performance influences students' choices. This phase informed the development of clustering and peer-learning strategies for Phase Two. In Phase Two, 60 middle school students completed an orientation survey and a seven-question mathematics assessment on square roots and exponents, indicating their future academic orientations. These students were then clustered using Self-Organizing Maps (SOM) to identify patterns linking mathematics performance and orientation factors. Qualitative insights from the clustering process were used to design targeted interventions, demonstrating that clustering enhances peer learning and shapes students' future academic choices.

3. 2. Participants

In Phase One, 200 first-year high school students aged 15-16 were selected using Cochran's formula for a finite population of 4890 students, with an acceptable margin of error of 7.5%. Although the formula suggested a sample size 172, the sample was expanded to 200 for greater robustness. These students represented the Literary, Scientific, and Technical academic tracks and were analyzed to explore the relationship between their middle school mathematics scores and their current academic orientations. In Phase Two, 60 middle school students aged 13–14 in their final year were randomly chosen from schools with an average population of 280 students, representing 20% of the typical student body. These students represented a diverse range of mathematics abilities and orientation factors, providing a suitable sample to assess the impact of orientation clustering on mathematics learning outcomes and future academic orientation decisions.

3. 3. Instruments

The instruments used included a brief survey for Phase One, which collected students' middle school mathematics scores, their chosen high school orientation, and reasons for their selections, thereby enabling analysis of the relationship between mathematics performance and orientation choices. For Phase Two, a comprehensive Student Orientation Questionnaire assessed factors such as mathematics interest, self-efficacy, anxiety, growth mindset, motivation, learning strategies, parental and teacher support, peer influence, career aspirations, study habits, and class attendance, using a 5-point Likert scale; additionally, a seven-question mathematics assessment focused on

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square roots and exponents was administered alongside a question regarding students' future academic orientation, providing data necessary for SOM clustering and subsequent analysis.

3. 4. Data Collection Procedures

Data collection for Phase One involved obtaining ethical approvals, securing informed consent from students and their guardians, and administering the survey during class time to ensure a high response rate; students provided their mathematics scores and orientation choices and qualitative data on their reasons for these choices were collected. In Phase Two, the orientation questionnaire, mathematics assessment, and future orientation question were administered to the 60 middle school students under standardized conditions; following data collection, the SOM algorithm was applied to cluster students based on orientation factors and mathematics performance, after which students participated in peer learning sessions organized according to their clusters; finally, the mathematics assessment and future orientation question were re-administered to evaluate changes in performance and orientation preferences.

3. 5. Data Analysis

Data analysis was conducted using SPSS for statistical computations (Field, 2024; McDonald, 2014) and Python for implementing the SOM algorithm (Kohonen, 2013) and data preprocessing. The aforementioned algorithm is an unsupervised neural network algorithm that projects high-dimensional data onto a low-dimensional grid, typically 2D, while preserving the topological structure of the input data. SOM works by organizing similar data points into neighboring nodes, allowing for visualization and clustering of complex datasets. During training, nodes (or neurons) compete to represent input data, adjusting their weights to better match the data structure over time. SOMs are widely used for data exploration, clustering, and pattern recognition due to their ability to reveal hidden patterns in multidimensional datasets.

4. Results and Discussion

In Phase One, descriptive statistics summarized mathematics scores and orientation distributions, while correlation analyses and chi-square tests examined the relationships between mathematics performance and orientation choices. In Phase Two, data were cleaned and normalized before applying SOM clustering to identify student groups with similar orientation profiles; subsequent analyses included paired t-tests to compare pre-and post-intervention mathematics assessment scores, McNemar's test to assess changes in future orientation choices, and regression analyses to explore how orientation factors predicted mathematics achievement and influenced orientation decisions, thereby assessing the effectiveness of SOM clustering and peer learning interventions on enhancing mathematics understanding and shaping students' academic trajectories.

4. 1. Phase 1

Table 1: Cronbach’s Alpha.

Cronbach’s Alpha	N of items
0.82	200

A Cronbach's alpha of 0.82 in Table 1 indicates good internal consistency among the survey items, suggesting that the items reliably measure the underlying construct of mathematics performance and orientation factors influencing academic choices.

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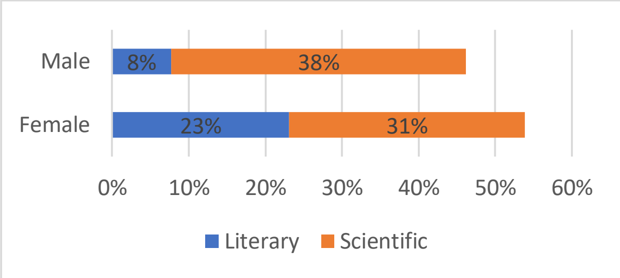

Figure 1: Education Path and Sex Distribution Chart.

Among the 200 middle school students surveyed, 54% were females, and 46% were males. Regarding educational orientation, 31% chose the Literary path—comprising 46 females and 16 males—while 69% of students opted for the scientific track, including 62 females and 76 males. These statistics indicate that a higher proportion of males preferred the scientific orientation compared to females, highlighting gender differences in educational preferences.

To establish the correlation between mathematics score and other variables, we consider the codification on orientation Choice (Scientific = 1, Literary/Professional = 0) and Likert Scale responses (Strongly Disagree: 1, Disagree: 2, Neutral: 3, Agree: 4, Strongly Agree: 5).

Table 2: Correlation between Mathematic Score and Orientation Factors.

	Mathematic Score		
	Spearman's rho	**Sig. (2-tailed)**	**N**
Actual path	0.75*	<.0001	200
I chose my current academic orientation because I excel in mathematics	0.68	<.0001	200
My interest in mathematics was a major factor in choosing my high school orientation	0.70	<.0001	200
If I had achieved a higher score in mathematics, I would have selected a different academic orientation	-0.65	<.0001	200

Table 2 presents Spearman's rho correlations between Mathematics Scores and factors influencing students' academic orientation choices. There is a strong positive correlation between the Mathematics Score and the Actual Path ($r = 0.75^*$, $p < .0001$, $N = 200$), where the asterisk (*) denotes the Point-Biserial Correlation Coefficient due to the dichotomous nature of the Actual Path variable. This indicates that higher mathematics scores are significantly associated with choosing the Scientific path. Additionally, positive correlations exist between Mathematics Score and the statements "I chose my current academic orientation because I excel in mathematics" ($r = 0.68$, $p < .0001$) and "My interest in mathematics was a major factor in choosing my high school orientation" ($r = 0.70$, $p < .0001$), suggesting that students with higher mathematics proficiency and interest are more likely to consider these factors in their orientation choice. Conversely, a significant negative correlation is observed between Mathematics Scores and the statement, "If I had achieved a higher score in mathematics, I would have selected a different academic orientation" ($r = -0.65$, $p < .0001$), implying that students with lower mathematics scores might have opted for a different path had their performance been better, highlighting the impact of mathematics achievement on academic decisions.

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4. 2. Phase 2

In this phase, we apply the SOM algorithm to analyze data collected from 60 students via a survey. Each student is represented by 45 features, capturing various aspects of their responses. This phase aims to group similar students into clusters, helping to identify patterns within the dataset. We use the SOM parameter values, as mentioned in Table 3, to ensure optimal performance in clustering the student data.

Table 3: Default Parameter Values for SOM Algorithm.

Parameter	Value
Number of neurons	25
Grid	5x5
Sigma	1.5
Learning rate	0.5
Iterations number	1000

The Silhouette Score in Figure 2 shows a steep decline after k=2. It stabilizes around k=4, making it an optimal choice using the elbow method, which identifies the point where adding more clusters has a diminishing return in improving the clustering quality.

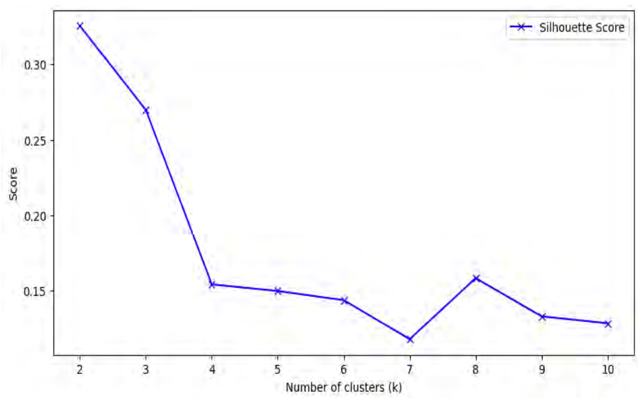

Figure 2: Silhouette Score vs Number of Clusters

As in Figure 3, the U-Matrix clearly reveals four distinct clusters, with the darker regions indicating the boundaries between the clusters. The lighter regions represent closer similarities within the clusters, confirming the choice of k=4 as an appropriate number of clusters. Thus, both the silhouette score and the U-matrix support k=4 as the optimal number of clusters for your SOM analysis.

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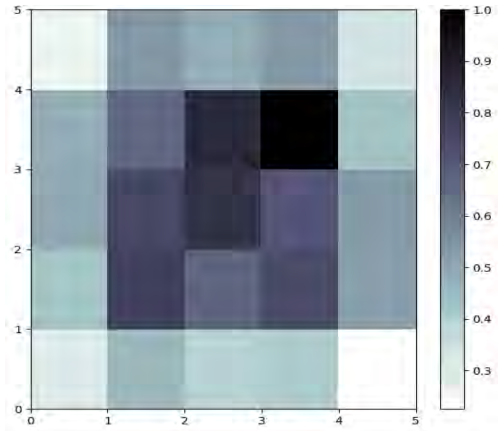


Figure 3: U-Matrix

Based on the SOM results and confirmed by the U-Matrix and silhouette score analysis, we identified four distinct clusters, as presented in Table 4 (See Appendix 1).

4. 3. Analysis of Errors Before and After Intervention

4. 3. 1. Before the intervention

After identifying four distinct subgroups using the Self-Organizing Maps (SOM) algorithm on data from 60 middle school students, we proceeded to measure the impact of clustering on students' understanding of mathematics. We have taken two courses, the square roots, and exponents, due to their foundational role in mathematics and their tendency to present common learning obstacles, making them ideal for assessing targeted interventions. Additionally, their relevance to middle school curricula ensures practical applicability and alignment with educational standards. The subgroups were based on orientation factors and initial mathematics performance, allowing for targeted educational strategies tailored to each group's specific needs. All 60 students were given a seven-question mathematics assessment focusing on square roots and exponents, as in Table 5

Table 5. Seven-question Mathematics Assessment.

Question	Purpose
Simplify the expression: $\sqrt{64}$	To assess students' ability to compute the square root of a perfect square and understand the concept of square roots.
Evaluate: 5^3	To evaluate students' understanding of exponents as repeated multiplication.
Simplify the radical expression: $\sqrt{18}$	To test students' ability to simplify radicals by factoring out perfect squares.
Find all real solutions for x if: $x^2 = 49$	To assess students' understanding of solving quadratic equations using identity III.
Simplify: $2^4 \times 2^2$	To evaluate students' knowledge of exponent rules, specifically the product of powers with the same base.
Simplify the expression: $(\sqrt{16})^2$	To test understanding of inverse operations between squares and square roots.
Simplify: $(3^2)^3$	To evaluate the understanding of the power-of-a-power rule in exponents.

During the initial assessment, several errors were identified in students' responses to the eight mathematics questions. These errors were classified into three types of obstacles: Didactical, Epistemological, and Ontogenic. Below, we present specific examples of these errors, referencing corresponding figures (Figure 4 to Figure 8), and discuss the difficulties faced by students in each category.

Figure 4. Question 4 answer

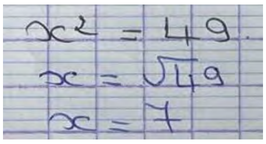
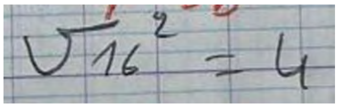


Figure 5. Question 6 answer



Didactical obstacles arise from instructional methods that lead to misunderstandings of mathematical concepts. For instance, as shown in Figures 4 and 5, students may not apply mathematical identities correctly or may fail to recognize that squaring a negative number yields a positive result, resulting in only one solution (x=7) for the equation $x^2 = 49$ instead of both (x=7) and (x=-7). This indicates a misunderstanding of the relationship between squaring and square roots and highlights the need for teaching methods that emphasize applying mathematical identities to find all possible solutions.

Figure 6. Question 2 answer

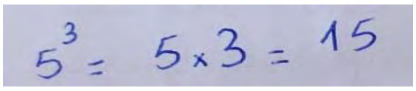


Figure 7. Question 5 answer

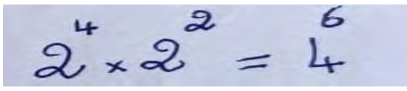
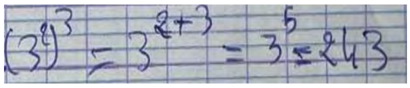
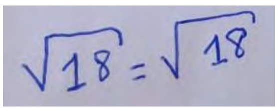


Figure 8. Question 7 answer



Epistemological obstacles stem from fundamental misconceptions about mathematical operations and principles. For instance, as shown in Figure 5, some students misconceived exponentiation as multiplication, writing five $5^3 = 5 \times 3$ instead of $5 \times 5 \times 5$. In Figure 4.3, misapplication of exponent laws is evident where students incorrectly calculate $2^4 \times 2^2 = 4^6$, failing to recognize that when multiplying like bases, exponents should be added: $2^4 \times 2^2 = 2^6$. Figure 4.5 illustrates incorrect application of the power of a power rule, with students simplifying $(3^2)^3 = 3^{2+3}$ instead of correctly computing $(3^2)^3 = 3^{2\times3} = 3^6$. These errors highlight a lack of understanding of foundational exponent rules, necessitating reinforcement of these concepts to develop accurate mathematical reasoning.

Figure 9. Question 3 Answer.



Ontogenic obstacles relate to students' developmental stages and readiness to grasp abstract concepts. For instance, as shown in Figure 9, a student may keep $\sqrt{18}$ unsimplified due to difficulty with the abstraction involved in manipulating radical expressions. This suggests that the student may not yet be developmentally prepared to handle advanced operations with irrational numbers, underscoring the importance of aligning instruction with students' cognitive development levels.

4. 3. 2. After the intervention

The intervention in this study is founded on the subgrouping of students through Self-Organizing Maps (SOM), which identifies clusters of students with similar characteristics in terms of mathematics learning orientation and performance. Based on the SOM clustering, educational activities were tailored to address didactical, epistemological, and ontogenic obstacles. With a focus on peer collaboration. Here below is what we made for each type,

Didactical Obstacles:

- Activity: For students struggling with exponents, activities using manipulatives (such as algebra tiles) and visual aids (like power pyramids) were employed to clarify the rules of exponentiation.
- Strategy: Step-by-step problem-solving workshops were organized, where students solved problems in pairs, allowing peer feedback and support.

Epistemological Obstacles:

- Activity: To address misconceptions about square roots, students engaged in calculator exercises and geometric demonstrations (e.g., visualizing square roots on a number line or area models).
- Strategy: Interactive discussions allowed students to reflect on their errors and confront misconceptions, improving conceptual understanding.

Ontogenic Obstacles:

- Activity: Students transitioning to more abstract algebraic thinking practiced with concrete-to-abstract examples, such as solving word problems by first modeling with diagrams before introducing algebraic expressions.
- Strategy: Peer collaboration was emphasized, with stronger students mentoring their peers, which fostered understanding through cooperative learning.

The mentioned activities demonstrated how the SOM-driven intervention directly impacted classroom instruction. The intervention was tailored to handle didactical, epistemological, and ontogenic obstacles in mathematics learning by grouping students based on their identified learning needs and promoting peer collaboration. The lesson activities provided opportunities for students to support each other, address misconceptions and gradually transition into abstract thinking. After implementing the intervention, we observed a significant reduction in errors, particularly in areas that previously presented challenges (e.g., exponents and square roots). This supports the conclusion that clustering students using SOM and applying targeted strategies significantly enhances learning outcomes. In Figure 10, the number of errors in all questions decreased significantly after the intervention, with the most noticeable reduction in Q5 and Q6. This indicates that the intervention was effective in reducing errors across the board.

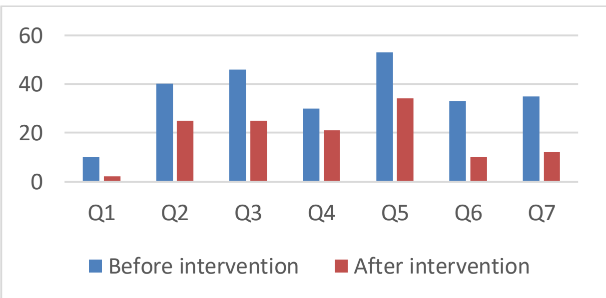


Figure 10. Error Reduction Before and After Intervention Across Questions

Table 6. Paired t-test Analysis of Errors Before and After Intervention

	Number of Errors	
paired Samples Test	Mean	16.857
	Std Deviation	6.334
	Std Error Mean	2.394
	t	7.042
	df	6
	Sig (2-tailed)	.000

In Table 6, the calculated t-statistic is $t(6)=7.042$ with a p-value $p<0.001$. Since the p-value is significantly less than the standard alpha level of 0.05, we reject the null hypothesis. This indicates a statistically significant reduction in the number of errors made by students after the intervention.

After the intervention, in Figure 11, there was a notable increase in the number of students choosing the scientific orientation, while the literary orientation saw a decrease. The professional orientation remained relatively unchanged. The SOM analysis highlighted patterns in student preferences, demonstrating that peer collaboration during the intervention and teaching strategies based on a taxonomy of the obstacles helped improve decision-making. Additionally, the increase in students' confidence allowed them to choose orientations that aligned better with their true interests and abilities.

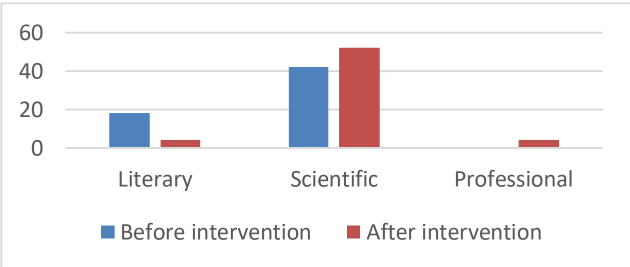


Figure 11. Future Educational Orientation Choices Before and After Intervention

5. Conclusion

This study explored the effectiveness of clustering 200 middle school students using the SOM algorithm and addressing the specific types of obstacles they face—didactical, ontogenic, and epistemological—to enhance their mathematical understanding and influence their future educational orientation choices. The findings demonstrated that such an approach could significantly improve students' grasp of mathematical concepts and positively affect their decisions regarding their educational paths.

By administering an initial mathematics assessment and analyzing the errors made by 60 students, we identified prevalent obstacles hindering their learning; classifying these errors into didactical, ontogenic, and epistemological obstacles allowed for the design of targeted educational interventions. The intervention focused primarily on peer collaboration, enabling students to collectively work within their clusters to address common challenges. Activities and teaching methods were tailored to each type of obstacle, challenging students' preconceived notions and guiding them toward formal mathematical reasoning.

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The results showed substantially reduced errors across all obstacle types, decreasing overall errors. Additionally, there was a notable shift in students' future academic orientation choices; the number of students opting for the scientific track increased significantly, indicating enhanced confidence and interest in mathematics.

6. Implications and Limitations

The findings of this study highlight the importance of leveraging clustering techniques, such as Self-Organizing Maps (SOM), to address individual learning needs. For teachers, this implies adopting data-driven, targeted interventions to tackle specific obstacles, enhancing students' understanding and engagement in mathematics. Policymakers can use these insights to design inclusive educational frameworks that integrate advanced analytical tools and peer-learning strategies, fostering personalized and equitable learning environments. Such approaches can improve overall mathematical proficiency and better prepare students for future academic and career paths.

While demonstrating the effectiveness of SOM-based clustering for improving mathematics learning, this study faced several limitations. First, the sample sizes in both phases, though representative, were relatively small, which may limit the generalizability of the findings. Second, relying on self-reported data for orientation factors could introduce biases, as students may not accurately assess their motivations and preferences. Third, the study's focus on specific mathematical topics, such as square roots and exponents, may not fully capture the broader applicability of the proposed interventions. Lastly, logistical constraints limited the ability to follow up on the long-term impact of the interventions on students' academic trajectories.

Declarations

Author Contributions. All authors read and approved the final version of the article.

Conflicts of Interest. The authors declare no conflicts of interest.

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Data Availability Statement. The data can be provided by the corresponding author upon request.

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Appendix I.

Table 4: The Four Clusters for the 60 Students Based on SOM Clustering

		Clusters			
		1	2	3	4
Sex	Female	1	8	8	15
	Male	2	12	9	5
Future path	Scientific	3	17	11	1
	Literacy	0	3	6	19
Mathematics score		11.3	14.9	11.5	7.8
Physic score		10.7	13.8	9.6	6.9
Life and Earth Science score		11.7	13.3	13.1	11.5
Arabic score		9.3	15.3	15.2	14.5
French Score		13.0	15.2	15.0	14.0
I enjoy learning mathematics.		1.3	4.2	2.1	1.6
Mathematics is one of my favorite subjects		1.0	4.0	2.1	1.4
I find mathematics interesting and engaging		1.0	4.1	2.0	1.7
I am confident in my ability to solve math problems.		1.3	3.6	2.6	2.1
I can understand even the most challenging math topics		1.7	3.6	2.1	1.4
I believe I can get good grades in math if I work hard		3.0	4.0	3.6	3.0
I feel nervous when I have to solve math problems		4.7	2.8	3.6	4.4
Math tests make me anxious.		4.0	2.5	3.8	2.3
I feel stressed when working on math assignments		4.3	2.3	2.9	2.3
I can always improve my math skills with practice		2.7	3.9	3.4	3.5
Challenges in math help me grow and learn		1.7	4.1	2.5	2.5
Making mistakes in math helps me understand better		1.3	3.9	3.8	2.2
I study math because I find it interesting.		3.0	4.0	2.0	1.4
I like learning new things in math		1.7	4.1	3.3	1.6
I enjoy solving challenging math problems		1.7	3.5	2.1	1.4
I study math to get good grades		4.0	3.8	3.6	3.0
Doing well in math will help me in the future		2.0	4.0	3.5	2.1

I work hard in math to make my parents and teachers proud	4.7	3.3	3.2	2.1
I try to relate new math concepts to what I already know	1.0	4.0	2.6	2.7
I make summaries or notes to understand math concepts better	1.0	3.3	2.7	2.0
I discuss math problems with my classmates to improve my understanding	4.0	3.7	3.4	2.6
My parents encourage me to do well in math	4.0	4.0	3.4	2.8
My family believes that learning math is important	4.0	3.6	3.9	2.8
My parents help me with my math homework when I need it	4.0	3.1	3.0	2.1
My math teacher is helpful when I have questions	4.0	3.9	4.2	2.1
My math teacher cares about my learning progress	3.7	3.4	4.1	2.1
I can ask my math teacher for help if I don't understand something	4.0	4.0	4.0	2.1
My friends think math is important	3.0	3.5	2.8	2.3
I often study math with my friends	4.0	2.3	2.4	1.8
My classmates encourage me to do well in math	4.0	3.1	2.1	2.1
I am considering a career that involves mathematics	1.0	3.3	1.6	2.3
I think mathematics is useful for my future career	1.0	3.8	2.6	1.8
I would like a job that uses mathematics	1.0	3.0	2.0	1.8
I set aside specific times each week to study math	2.0	3.8	2.4	2.3
I often review my math notes and homework	1.7	3.8	2.4	2.3
I rarely miss my math classes	2.0	3.3	3.2	2.6
I am attentive during math classes	2.0	4.2	3.6	2.6
I participate actively in math classes	1.3	4.1	2.9	2.3

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