

Conceptual Understanding of Mathematics of Vocational High School Students and Their Related Factors in Statistics

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ABSTRACT

Although mathematical conceptual understanding has been widely investigated, limited attention has been given to examining its relationship with demographic and educational factors among vocational high school students, particularly in statistics learning. This study aimed to describe students' mathematical conceptual understanding and analyze the factors associated with it. A quantitative approach with a descriptive-comparative method was employed involving 105 tenth-grade students of SMK Negeri 4 Pekanbaru. The research instruments consisted of a five-item essay test on mathematical conceptual understanding, a 34-item questionnaire, and a student profile form. Data were analyzed using descriptive statistics, the Independent Samples t-test, and One-Way ANOVA. The findings indicated that students' mathematical conceptual understanding was generally in the low category. In addition, the analysis of demographic and educational factors provided a more comprehensive description of the factors associated with students' mathematical conceptual understanding. The findings are expected to serve as a reference for teachers in designing learning strategies that are better aligned with students' characteristics.

Keywords: *Associated factors; mathematical conceptual understanding; statistics; vocational high school.*

Pemahaman Konseptual Matematika Siswa Sekolah Menengah Kejuruan dan Faktor-Faktor Terkaitnya dalam Statistik

ABSTRAK

Meskipun kemampuan pemahaman konsep matematis telah banyak diteliti, penelitian yang mengkaji keterkaitannya dengan berbagai faktor demografis dan pendidikan pada siswa Sekolah Menengah Kejuruan (SMK), khususnya pada materi statistika, masih terbatas. Penelitian ini bertujuan mendeskripsikan kemampuan pemahaman konsep matematis siswa serta menganalisis faktor-faktor yang berkaitan dengannya. Penelitian menggunakan pendekatan kuantitatif dengan metode deskriptif komparatif terhadap 105 siswa kelas X SMK Negeri 4 Pekanbaru. Instrumen penelitian terdiri atas tes uraian sebanyak 5 butir, angket 34 butir, dan lembar profil pendukung siswa. Data dianalisis menggunakan statistik deskriptif, *Independent Samples t-test*, dan *One-Way ANOVA*. Hasil penelitian

menunjukkan bahwa kemampuan pemahaman konsep matematis siswa masih berada pada kategori rendah. Selain itu, faktor demografis dan pendidikan yang dianalisis menunjukkan keterkaitan yang berbeda terhadap kemampuan tersebut. Temuan ini memberikan gambaran yang lebih komprehensif mengenai faktor-faktor yang berkaitan dengan kemampuan pemahaman konsep matematis serta dapat menjadi dasar bagi guru dalam merancang pembelajaran yang lebih sesuai dengan karakteristik siswa

Kata Kunci: Faktor-faktor terkait, pemahaman konseptual matematika, sekolah menengah kejuruan, statistika.

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1. Introduction

Education is a process that is consciously and systematically designed to develop the potential, knowledge, character, and skills of students as provisions in social life and the world of work (Kruja, 2024). In addition to playing a role in improving the mastery of science and skills, education also functions to form moral and ethical values that are necessary in daily life (Choiriyah, 2023). Therefore, education has an important role in developing the potential and talents of students so that they are able to develop optimally according to their abilities (Khaliil et al., 2024). One of the abilities that needs to be developed through the educational process, especially in mathematics learning, is the ability to understand mathematical concepts. This ability is the basis for students to understand, connect, and apply mathematical concepts to solve various problems faced.

In learning mathematics, students need to understand basic concepts first because success in solving mathematical problems is highly dependent on the level of understanding of concepts they have (Kholidah & Sujadi, 2018). Students who have a good understanding of concepts tend to be better able to choose and adapt problem-solving strategies flexibly when faced with complex mathematical problems (Gilmore et al., 2018). Understanding mathematical concepts is a fundamental aspect of mathematics learning because it allows students to understand, connect, and apply concepts appropriately in various situations. These abilities are not only obtained through the process of memorization, but also through a deep understanding of the concepts learned. In addition, mistakes made by students can be used as evaluation material to improve the learning process. However, in practice, there are still many students who have difficulty distinguishing between learning mistakes and learning difficulties they face, so that the process of understanding mathematical concepts has not run optimally (Yuliyanti & Tonra, 2021). The level of understanding of the student's mathematical concepts can be identified through the analysis of test results that illustrate the extent to which the students have mastered the concepts learned (Andriani et al., 2024).

Students' ability to understand mathematical concepts can be identified through the indicators of concept understanding shown in the test results. Students are said to have a good understanding of concepts if they are able to explain a concept in their own words, group objects according to the characteristics of the concept, provide examples and non-examples of a concept, present concepts in various forms of mathematical representations, determine the

necessary and sufficient conditions of a concept, choose and use the right solution procedures, and apply concepts or algorithms in solving mathematical problems. These indicators describe the extent to which students understand concepts as a whole, so that they can be used as a basis for assessing students' ability to understand mathematical concepts ([Rahayu et al., 2018](#)).

Various studies show that the ability to understand mathematical concepts of vocational school students is still relatively low. Students still have difficulty understanding, connecting, and representing abstract mathematical concepts. This condition is influenced by the complexity of mathematics material and the perception of students who think that mathematics has less relation to practical needs in the world of work ([Fauziyah et al., 2026](#)). In addition, various studies have also shown that the ability to understand mathematical concepts is influenced by the learning characteristics of each student. Each student has a different learning style in understanding a concept, whether through visuals, reading, oral explanations, or direct experience. In line with that, [Sarumaha \(2023\)](#) stating that students need to be able to have various mathematical concepts in stating that mastery of various mathematical concepts is an important basis in solving mathematical problems. The ability to understand concepts is also the foundation for the development of other mathematical thinking skills because students who understand concepts well will find it easier to analyze, connect, and apply knowledge in various situations ([Cahani et al., 2021](#)).

Various studies have also shown that the ability to understand mathematical concepts is influenced by both internal and external factors. From external factors, the family environment has an important role in supporting the development of students' mathematical concept understanding skills. The level of education of parents affects the motivation, direction, and learning support provided to children ([Cahyawati et al., 2023](#)). In addition, parental support is not only in the form of attention and encouragement to learn, but also the provision of facilities and facilities that support learning activities. This support can help students be more focused, motivated, and confident in following the learning process, including in understanding mathematical concepts ([Fauziyah & Mujazi, 2025](#)). Parental involvement in mathematics learning can also be done through home learning assistance, communication with teachers, and providing ongoing support to children ([Wang & Wei, 2024](#)). In addition, parents' work also affects the family's ability to provide learning facilities and learning assistance to children ([Nurhaniyah et al., 2025](#)).

From internal factors, the ability to understand mathematical concepts is also influenced by the characteristics of students, one of which is gender. [Nurfadila et al. \(2022\)](#) shows a difference in mathematical ability between male and female students. The findings are supported by [Nurani & Merliza \(2024\)](#) that states gender differences affect students' characteristics in learning mathematics. Furthermore, Syaifar et al., as cited in [Laily et al. \(2023\)](#), found differences in mathematical conceptual understanding between male and female students, with female students demonstrating better conceptual understanding than their male counterparts.

Although various studies have examined the ability to understand mathematical concepts and the factors related to them, most still focus on one or two factors, such as learning style, parental education level, parental occupation, or gender. Research that analyzes various demographic and educational factors simultaneously in Vocational High School (SMK) students, especially in statistical materials, is still limited. Therefore, research is needed that provides a more comprehensive picture of the factors related to these abilities.

Based on these gaps, this study aims to analyze students' ability to understand mathematical concepts and identify their relationship with various demographic and educational factors, including gender, participation in courses, parents' education level and work, preferred subjects, habit of repeating lessons at home, and parental support. The results of this study are expected

to provide a more comprehensive picture and become the basis for teachers in designing learning strategies that are in accordance with student characteristics

2. Research Methods

This study uses a quantitative approach with a descriptive method. The quantitative approach is a research method that uses data in the form of numbers and is analyzed using statistical techniques. This method aims to obtain objective results and explain research phenomena based on measurable data ([Waruwu et al., 2025](#)). The research was carried out at SMK Negeri 4 Pekanbaru by involving 105 students of class X from three classes, namely X Computer and Network Engineering (TKJ), X Building Modeling and Information Design (DPIB), and X Institutional Financial Accounting (AKL). Samples are determined using the *purposive sampling* based on characteristics that are in accordance with the purpose of the study.

The research instrument consisted of a mathematical conceptual understanding test and a student supporting profile sheet. The test was developed by the researcher based on the concept understanding indicator according to Sumarmo in [Rahayu et al. \(2018\)](#) on statistical material. The test consists of five description questions with a maximum score of 20 on each question so that the maximum total score is 100. Scoring was carried out using rubrics arranged according to indicators of mathematical conceptual understanding. Supporting profile sheets are used to obtain information on factors related to students' conceptual understanding of mathematics, including gender, parental education level, parental occupation, parental support, repetition habits, preferred subjects, and participation in tutoring. Before use, both instruments have been validated by two expert validators and revised based on the suggestions given.

Data were collected through the provision of a mathematical conceptual understanding test and the filling of supporting profile sheets by all respondents. Furthermore, the data was analyzed using SPSS Statistics version 23. Descriptive statistical analysis is used to describe students' mathematical conceptual comprehension abilities based on mean (*mean*), median, mode, standard deviation, variance, minimum value, maximum value, and percentage. In addition, *the Independent Sample t-Test* was used to analyze differences in abilities in variables consisting of two groups, while *One-Way ANOVA* was used for variables consisting of more than two groups with a significance level of 0.05.

The data analysis techniques used were descriptive statistical analysis and independent sample t-Test and One-Way ANOVA. Descriptive statistical analysis is used to describe students' ability to understand mathematical concepts based on *mean*, median, mode, standard deviation, variance, minimum value, maximum value, and percentage. Furthermore, test scores are divided into low, medium, and high categories based on the criteria presented in Table 1.

Table 1. Scoring criteria

Value	Categories
Score ≤ 60	Low
$60 \leq \text{score} \leq 80$	Medium
$80 \leq \text{score} \leq 100$	Height

Sources: (Aulia & Abadi, 2024)

In addition to descriptive analysis, data were also analyzed using the Independent Sample t-Test to determine the difference in the ability to understand mathematical concepts in variables that have two categories, such as gender and participation in tutoring. Meanwhile, One-Way ANOVA is used to determine differences in abilities based on variables that have more than two categories, such as the level of education of parents and the work of parents.

3. Results and Discussion

3.1 Ability to Understand Mathematical Concepts

The test of understanding of mathematical concepts was given to 105 students in class X of SMK consisting of 35 students of class X TKJ, 35 students of class X DPIB, and 35 students of class X AKL. Tests are given on statistical materials to measure students' abilities based on indicators of understanding mathematical concepts.

The test result data was then analyzed using descriptive statistics which included mean values, medians, modes, standard deviations, minimum values, and maximum values. The results of descriptive statistical analysis of students' mathematical conceptual comprehension skills are presented in Table 2.

Table 2. Descriptive statistics of students conceptual mathematics ability

Statistics	Value
Amount of data (N)	105
Red	59,66
Median	68.00
Mode	78
Standard Deviation	24.492
Minimum Score	7
Maximum Value	100

Based on Table 2, the average score of students' mathematical comprehension ability was 59.66 with a median score of 68.00 and mode 78. The standard deviation of 24,492 indicates that students' abilities vary quite a bit. The minimum score obtained by students is 7, while the maximum score reaches 100. The results show that students' ability to understand mathematical concepts is still in the low category based on the assessment criteria that have been set, namely in the score range ≤ 60 . The results of this study are in line with the research ([Afifah et al., 2024](#)) which shows that students' ability to understand mathematical concepts is still not optimal. This shows that understanding mathematical concepts is still a challenge for students in various mathematics materials, including statistics materials in this research. Thus, it can be concluded that in general, the ability to understand mathematical concepts of grade X students in vocational school in statistics material is still relatively low and needs to be improved through a learning process that emphasizes more on concept understanding so that students' ability to understand mathematical concepts can be improved. The results of this study are also in line with the research ([Khairi & Aziz, 2025](#)) which shows that students' ability to understand mathematical concepts needs to be improved. The low ability of students to understand mathematical concepts shows that they still have difficulties in understanding, connecting, and applying mathematical concepts to problem solving.

Table 3. Distribution of mathematical concept comprehension ability

Number	Category	Frequency	Percentage
1.	Low	40	38,10%
2.	Medium	51	48,57%
3.	Height	14	13,33%
Quantity		105	100%

Based on Table 3, it is known that as many as 40 students (38.10%) are in the low category, 51 students (48.57) are in the medium category, and 14 students (13.33%) are in the high category. The largest percentage is in the medium category, however, the number of students

in the low category is still quite high, thus showing that students' ability to understand mathematical concepts in statistical materials still needs to be improved.

3.2 Factors That Affect the Ability to Understand Mathematical Concepts

The results of the analysis of factors that affect students' ability to understand mathematical concepts are presented in Table 4 to Table 10. The analysis was carried out to see the difference in the ability to understand mathematical concepts based on several factors researched the questionnaire data was analyzed using the percentage technique. The results of the questionnaire analysis show the percentage of each class as presented in Table 4.

Table 4. Percentage of factors related to students' mathematical conceptual understanding

Number	Classes	Percentage
1.	X TKJ	75,90%
2.	X DPIB	77,16%
3.	X AKL	81,07%
Average		78,04%

Based on Table 4, the average percentage score of the measured factors was 78.04%. Among the three classes, Class X AKL obtained the highest percentage (81.07%), followed by Class X DPIB (77.16%), while Class X TKJ obtained the lowest percentage (75.90%). These percentages describe students' responses to the demographic and educational factors measured in this study. The higher percentage in Class X AKL indicates that students in this class reported higher scores on the measured factors than students in the other two classes.

To provide a more detailed description of the demographic and educational factors examined in this study, further analyses were conducted based on course attendance, gender, parents' occupation, parents' education level, parental support, preferred subjects, and the habit of reviewing lessons at home. The results for each factor are presented in Tables 5–11.

1. Based on Taking the Course

Table 5. Ability to Understand Mathematical Concepts Based on Following the Course

Group Statistics	Course attendance	N	Mean	Std. Deviation	Std. Error Mean
Data_Kursus	Yes	12	65.17	29.042	8.384
	No	93	58.95	23.933	2.482

t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
.827	103	.410	6.220	7.524	-8.701	21.142
.711	13.000	.489	6.220	8.743	-12.668	25.109

Based on the results of the *Independent Sample t-Test* in Table 5, it is known that there were 12 students who took the course with an average score of 65.17 (SD = 29.042), while 93 students who did not take the course had an average score of 58.95 (SD = 23.933). The test results showed a value of $t(103) = 0.827$, $p = 0.410$, with Cohen's $d = 0.25$ indicating a small effect size. These results show that there is no significant difference in mathematical concept comprehension ability between students who take the course and students who do not take the course.

2. By Gender

Table 6. Ability to understand mathematical concepts based on gender

		Gender	N	Mean	Std. Deviation	Std. Error
Data_JenisKelamin		Women	23	55.63	24.921	2.752
		Male	82	74.00	16.539	3.449
					95% Confidence Interval of the Difference	
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
-3.329	103	.001	-18.366	5.518	-29.309	-7.423
-4.163	53.095	.000	-18.366	4.412	-27.215	-9.517

Based on the results of the *Independent Sample t-Test* in Table 6, it is known that there are 23 female students with an average score of 55.63 (SD = 24.921), while 82 male students have an average score of 74.00 (SD = 16.539). The test results showed a value of $t(53.095) = -4.163$, $p < 0.001$, with Cohen's $d = 0.99$ indicating a *large effect* size. These results show that there is a significant difference in the ability to understand mathematical concepts between male and female students.

3. Based on Parental Work

Table 7. Ability to understand mathematical concepts based on parental work

Mathematical Conceptual Understanding						
	Sum of Squares	Df	Mean Square	F	Say.	
Between Groups	4878.363	9	542.040	.895	.533	
Within Groups	57505.294	95	605.319			
Total	62383.657	104				
Mathematical Conceptual Understanding						
	Sum of Squares	Df	Mean Square	F	Say.	
Between Groups	1543.510	8	192.939	.304	.963	
Within Groups	60840.147	96	633.752			
Total	62383.657	104				

Based on the results of the *One-Way ANOVA* test in Table 7, the value of $F(9.95) = 0.895$, $p = 0.533$, with $\eta^2 = 0.078$ which indicates the size of the medium *effect* on the father's work. Meanwhile, in the mother's work, the value of $F(8.96) = 0.304$, $p = 0.963$, with $\eta^2 = 0.025$ which indicates the size of the *small effect*. These results show that there is no significant difference in students' ability to understand mathematical concepts based on parental work.

4. Based on Parents' Education Level

Table 8. Ability to understand mathematical concepts based on parental education

Mathematical Conceptual Understanding					
	Sum of Squares	Df	Mean Square	F	Say.
Between Groups	5112.603	6	852.101	1.458	.201
Within Groups	57271.054	98	584.399		
Total	62383.657	104			
Mathematical Conceptual Understanding					
	Sum of Squares	df	Mean Square	F	Say.
Between Groups	2595.413	6	432.569	.709	.643
Within Groups	59788.244	98	610.084		
Total	62383.657	104			

Based on the results of the *One-Way ANOVA* test in Table 8, the value of $F(6.98) = 1.458$, $p = 0.201$, with $\eta^2 = 0.082$ which shows the size of the medium *effect* on the father's education level. Meanwhile, at the mother's education level, the value of $F(6.98) = 0.709$, $p = 0.643$, with $\eta^2 = 0.042$ which indicates the size of the *small effect*. These results show that there is no significant difference in students' ability to understand mathematical concepts based on the level of education of parents

5. Based on parental support

Table 9. Ability to understand mathematical concepts based on parental support

Parental support					
	Sum of Squares	df	Mean Square	F	Say.
Between Groups	3555.732	3	1185.244	1.035	.144
Within Groups	58827.925	101	582.455		
Total	62383.657	104			

Based on the results of the *One-Way ANOVA* test in Table 9, the value of $F(3.101) = 1.035$, $p = 0.144$, with $\eta^2 = 0.057$ which indicates the size of the *small effect*. A significance value greater than 0.05 indicates that there is no significant difference in students' ability to comprehend mathematical concepts based on the level of parental support. Although students had different levels of parental support, these differences did not show any significant differences in the ability to understand mathematical concepts in this study sample.

6. By Preferred Subject

Table 10. Ability to understand mathematical concepts based on the subject of preferred

Mathematical Conceptual Understanding					
	Sum of Squares	Df	Mean Square	F	Say.
Between Groups	5229.733	5	1045.947	1.812	.117
Within Groups	57153.924	99	577.312		
Total	62383.657	104			

Based on the results of the *One-Way ANOVA* test in Table 10, the value of $F(5.99) = 1.812$, $p = 0.117$, with $\eta^2 = 0.084$ which indicates the size of the medium *effect*. A significance value greater than 0.05 indicates that there is no significant difference in students' ability to understand mathematical concepts based on the subject they prefer. Although students have different subjects as their favorite subjects, these differences have not shown a difference in the ability to understand mathematical concepts in this study sample.

7. Based on the Habit of Repeating the Lesson

Table 11. Ability to understand mathematical concepts based on repeating lessons

Mathematical Conceptual Understanding	Sum of		Mean		
	Squares	Df	Square	F	Say.
Between Groups	2160.592	3	720.197	1.208	.311
Within Groups	60223.065	101	596.268		
Total	62383.657	104			

Based on test results *One Way-ANOVA*, obtained the value $F(3.101) = 1.208$, $p = 0.311$, with $\eta^2 = 0.035$ indicating a small effect size (*small effect*). A significance value greater than 0.05 indicates that there is no significant difference in students' ability to understand mathematical concepts based on persistence in repeating lessons. These results indicate that persistence in repeating lessons alone is not necessarily followed by an increase in the ability to understand mathematical concepts. This is suspected because the success of understanding concepts is not only influenced by the frequency of repeating lessons, but also by the quality of repetition, the learning strategies used, and the level of students' understanding when relearning the material. These findings are supported by Siregar et al. (2024) which states that regular repetition of the material is necessary to maintain the student's memory of the material that has been studied. However, in order for repetition to have an impact on concept comprehension, it needs to be done effectively and accompanied by the right learning strategy.

4. Conclusion

Based on the results of the study, it can be concluded that the ability to understand mathematical concepts of grade X students in statistics is in the low category with an average score of 59.66. The results of the analysis showed that the supporting profiles which included gender, course participation, parental education level, parental work, preferred subjects, habit of repeating lessons at home, and parental support did not show significant differences in students' ability to comprehend mathematical concepts. These findings show that the supporting profiles studied have not been a factor that differentiates students' ability to understand mathematical concepts statistically. Therefore, efforts to improve the ability to understand

mathematical concepts need to be more focused on the implementation of learning that is able to build an in-depth understanding of concepts through the provision of meaningful learning experiences, varied exercises, and learning activities that encourage students in the form of mathematical concepts by solving contextual problems.

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