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Misconception Analysis of Student Teacher Candidates Using Certainty of Response Index (CRI) and Interviews on the Subject of Calculus 1: Mapping by Gender

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ABSTRACT

This study aims to: 1) identify the misconceptions that occur in prospective students of mathematics teachers on the subject of calculus 1. 2) identify the misconceptions that occur in prospective students of mathematics teachers about the subject of calculus one based on gender. 3) find out the extent to which misconceptions occur in prospective mathematics teacher students on the subject of calculus 1. The research method used is descriptive with a quantitative approach. The population in this study were students majoring in mathematics education at one of the universities in Cirebon. The research instrument used was a written test in the form of essay questions accompanied by a confidence level column (CRI) and interviews. The results of the study found that the percentage of students who experienced misconceptions on the subject of calculus 1 with the limit function and derivative test material was 15.49% and smaller than the percentage of students who did not know the concept who got a rate of 42.76% and students who understood the concept well that is equal to 22.56%. The rest of the students who know the concept but are not sure get a percentage of 8.08%. While the percentage of misconceptions experienced by female students is 16.35%, for male students is 19.048%. The most common misconception among mathematics students is the concept of the derivative chain rules.

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1. INTRODUCTION

A misconception is a concept that is not under the concept recognized by experts. Misconceptions are errors in understanding the material received by students from teachers, lecturers, print media, or electronic media that make the concept of the material received different from the concept that has been agreed upon by experts [1], [2]. Misconceptions often occur in materials that are considered problematic by students. One

of the subjects that often occurs misconceptions is mathematics, which is seen as the most complicated for students to understand. Many students feel lazy to study mathematics because of this assumption. Misconceptions in mathematics occur at the primary level and among students, which means misconceptions also occur in prospective [3]–[6]. The materials they learn in college are sometimes misunderstood by students who have previously studied the same material in school [7]–[10].

This condition is, of course, dangerous considering that prospective teacher students have to undergo field experience practice, which requires future teacher students to practice directly to teach the material they have learned in front of students as an exercise for student teacher candidates. It cannot be thought that the practitioner teacher teaches students with materials that students will absorb while the concept of the material is wrong (misconceptions) or deviates from the concepts of scientists. Misconceptions are dangerous because they give students the wrong idea or feeling about knowing, limiting the mental effort they invest in learning, and there is interference between the concepts that have been studied (false) and the concepts being studied [13].

One way to diagnose misconceptions is using the Certainty of Response Index (CRI) [14], [15]. The Certainty of Response Index (CRI) method is often used to identify misconceptions. By using the Certainty of Response Index (CRI) method, teachers can distinguish which ones understand the concept, which do not know, and misconceptions. This can be supported by various types of tests prepared by teachers to detect misconceptions in their students, such as written tests, multiple-choice tests, concept maps, practicum accompanied by questions and answers, class discussions, and diagnostic interviews [14], [16]–[18].

Based on the type of concept, misconceptions are divided into three parts: classificational, correlational, and theoretical. Classificational misconceptions are misconceptions that occur due to misclassification of organized facts, and correlational misconceptions are based on errors that occur in correlated specific events, while theoretical misconceptions are those based on mistakes in studying a fact or event [19].

Many students still make mistakes in solving problems in calculus material. The reason is that in studying calculus 1, students are required to be careful and thorough in each answer writing. Students also often experience confusion finding answers to calculus one questions because of the many theorems. That underlies the calculus one material. That is why there are still many mistakes in working on calculus one problems.

Based on the acquisition of calculus one scores obtained by students of mathematics education occupying three different classes, it was found that the highest score in each class was the value of c+. This shows that mathematics students' mastery of the material in the calculus one course is quite lacking. Seeing this value raises the question of the author, "what causes the calculus one value obtained by a small math student?". Do students not understand the concept, or has there been a misconception in students' understanding of calculus 1?

The researcher is interested in the mistakes made by mathematics education students in studying calculus one and how students understand the concept of calculus one so that errors still occur in working on the questions. The wrong concept will be fatal because the

mathematics tadris students are prospective educators who will later teach mathematics to other students.

2. METHOD

The research method used in this research is a descriptive research method with a qualitative research type. The descriptive research method is a research method that aims to describe and explain the existing situation based on data and facts collected and then compiled systematically, which is then analyzed to get conclusions [20]. This study does not accept any treatment or manipulation that will change the results of this study and will describe a condition following the facts [21].

The conditions described using descriptive research methods are about the misconceptions among mathematics students regarding calculus I. The subjects in this study are prospective students of mathematics teachers at one of the universities in Cirebon. The future mathematics teacher students in question are students who contract calculus I course in semester I. By giving a written essay test accompanied by a Certainty of Response Index (CRI), researchers will find some students who have misconceptions, and also by using CRI researchers can distinguish students who understand concepts, do not know concepts and misconceptions.

The research design used in this study was a descriptive non-experimental research design. Descriptive research is conducted to describe or describe facts about the population accurately. The data collection technique used in examining the misconceptions among prospective mathematics teacher students is to use a type of written test coupled with a Certainty of Response Index (CRI). The written test used is a written essay test that is structured in the form of a structured statement, and students are expected to be able to organize each answer in their language. This test is instrumental in developing the ability to explain and express your ideas. In addition to using a written test, this study also uses an interview test to confirm further the answers given by the respondents in the written test.

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3. RESULTS AND DISCUSSION

3.1. Data Percentage of Student Writing Test Results Based on Certainty of Response Index (CRI) and Interviews

The results of the answers given by the students on the written test questions are in the form of essays accompanied by the level of confidence (Certain of Response Index) in tabular form. Each table contains the percentage of students' understanding of the tested material (Limit Functions and Derivatives) (See table 1 below). According to Paul Suparno [9], misconceptions occur due to several factors: students, teachers, learning methods, books, and contexts. Based on data analysis using the Certainty of Response Index (CRI)

with modifications to the level of student understanding, it resulted in four categories of understanding levels, namely Misconception (M), Do not Know the Concept (DC), Understanding Concepts Well (U) and understanding the concept but not sure (UNS) [22].

Table 1. Percentage Data for 4 Categories of Students' Level of Understanding of Limit Functions and Derivatives

NO.	QUESTION INDICATOR	CATEGORY (%)			
		DC	M	UNS	U
1.	Determine the left and right limits of a function.	69,70	15,15	3	12,12
2.	Calculating the limit value using the properties of the limit.	30,30	30,30	6,1	33,33
3.	Determine continuity at a point.	66,67	21,21	6,1	6,1
4.	Calculates the limit value of infinity.	45,45	3	12,12	39,40
5.	Determine the function's derivative from the function's sum, the product of the function, and the quotient of the function.	48,48	33,33	3	15,15
6.	Determine the derivatives of simple trigonometric functions.	30,30	15,15	24,24	30,30
7.	Finding the derivative of a simple compositional function.	51,52	6,06	3,03	39,39
8.	Determine the derivative of a simple function.	42,42	15,15	15,15	27,27
	Average	42,76	15,49	8,08	22,56

Based on table 1 above, the level of understanding of mathematics students in calculus one about function limits and derivatives is dominated by the Do not Know Concept (DC) category with an average percentage of 42.76%, with the most significant percentage falling into the Do not Know Concept category (DC) is in the question indicator to determine the left and right limits of a function with a percentage of 69.70% and the smallest percentage, which is 30.30%, is found in the question indicator for calculating limit values using the properties of limits and determining the derivatives of trigonometric functions.

The category of students who understand the concept but are not sure about the concept they understand (UNS) obtained an average percentage of 8.08%, with the most significant percentage in that category found in the indicator for determining the derivative of trigonometric functions with a large percentage of 24.24% while the percentage the smallest is obtained by the problem indicator determining the left and right limits of a function and determining the derivative of the function from the number of functions, the product of the function and the quotient of the function with a percentage of 3%. Then for the Misconceptions category (M) itself, it gets an average percentage of 15.49%, with the most significant percentage, which is 33.33%, in the question indicator of determining the derivative of the function from the number of functions, the product of the function and the

quotient of the function and the smallest percentage is found in the indicator. The problem of determining the limit value of infinity with a percentage number of 3%.

Furthermore, the category of students who understand the concept well (U) gets the second highest average percentage after the category of Do not Know the Concept (DC), which is 22.56%, and the most significant percentage is in the indicator of calculating the infinite limit value with a percentage of 39.40 % and 6.1% on the question indicators determine continuity at a point as the smallest percentage value in the category of Understanding Concepts Well. The results of this study are in line with the results of research conducted by Rizki Ramadhani [23] that the most dominating category in this study is the category of Do not Know the Concept (DC), followed by the category of Understanding Concepts Well (U), Misconceptions (M) and the last is Understanding Concepts but Not Convinced (UNS).

Question indicators that have a reasonably high level of understanding by students in the Misconception category are calculating the limit value using the properties of the limit, determining continuity at a point, and determining the derivative of the function from the number of functions, the product and the quotient of the function. This interview test is given to students to strengthen the answers that students showed during the written examination that was conducted previously. This test is given to several students as representatives of 3 categories of student groups obtained from the scores obtained during the written test: the upper group, middle group, and lower group.

1. Student 1

   Student 1 is an upper group student with the initials of TPS name. This TPS is the student who gets the highest score on the written test accompanied by a confidence level column (CRI). TPS can answer the questions with various categories of levels of understanding. In questions number 1, 2, 4, 5, 7, and 8, TPS responded correctly with the right reasons, and the level of confidence (CRI) given was included in the category of a high level of trust and was included in the category of Understanding Concepts Well (U). 3 TPS answered the questions correctly and gave the right reasons but provided a level of confidence (CRI) which was included in the category of low level of trust, which made the answer to question number 3 given by TPS into the type of Understanding Concepts but Not Convinced (UNS), while on the question Number 6 TPS gave an incorrect answer as well as an incorrect reason and provided a level of confidence (CRI) which was classified as a high level of trust, making the answer given to question number 6 fall into the category of Misconceptions (M).

2. Student 2

   Student 2 is a middle group student with the initials name RAM. This RAM is a student who gets a relatively large score on the written test. This RAM can also answer some of the questions asked nicely, but there are also some questions that this RAM cannot answer correctly. In questions 1 and 3, student 2 gave an incorrect answer, and the reasons were inaccurate. The level of confidence given was included in the low confidence group, which made the answers to questions number 1 and 3 presented by RAM fall into the category of Do not Know the Concept (DC); in questions number 2, 5, and 7 RAM cannot provide answers and reasons correctly, but at the level of

confidence RAM gives a value at a high level of confidence making the answers to questions number 2.5 and 7 fall into the category of Misconceptions (M) while on questions number 4, 6 and 8 RAM can provide solutions and reasons correctly and provide a high level of confidence value making the answers to questions number 4, 6 and 8 fall into the category of Understanding Concepts Well (U).

3. Student 3

   Student 3 is a student from the lower group with the initials ASF. According to the results of the written test, ASF could not provide answers to every question posed. Almost all the answers given by ASF fall into the Do not Know the Concept (DC) category. On questions 1-8, except for question number 2, it is included in the Do Not Know Concept (DC) category because ASF provides incorrect answers and reasons and provides a low level of confidence (CRI), making the answer given by ASF for question number 1,3, 4,5,6,7, and 8 fall into the category of Do not Know the Concept (DC), while in question number 2 ASF gives an incorrect answer and reason with a high level of confidence (CRI), making ASF's answer to question number 2 included. Into the category of Misconceptions (M).

3.2. Data on the Percentage of Misconceptions by Gender

The results of the analysis of students' written test answers accompanied by the level of confidence (Certain of Response Index), which are distinguished by gender of students, show the results of the level of understanding which is divided into four categories, namely, Do not Know the Concept (DC), Understand the Concept but Are Not Sure (UNS), Misconceptions (M) and finally Understanding Concepts Well (U).

Based on the results in table 2 below, the category of the understanding level of Do not Know the Concept (DC) still dominates mathematics students, both female and male, with an average percentage of 47.12% for female students and 46.03% for male students, which means that almost half of the mathematics students are female respondents who do not know the concept (DC) of the calculus one material being tested, namely the limit of functions and derivatives as well as male students. The most significant percentage obtained by female students, namely a percentage of 61.54%, is found in the question indicator of determining the right and left limits of a function and determining continuity at a point, while the smallest percentage is in the Do Not Know Concept (DC) category with a percentage of 30.77 % is found in the problem indicator for calculating the limit value using the limit properties and determining the derivative of a simple trigonometric function.

For male students, the most significant percentage is also found in the question indicator of determining the right and left limits of a function with a percentage of 100%, and the smallest percentage with a large percentage of 28.57% is found in the indicator about calculating the limit value using the properties of the limit, calculating the infinite value limit and determine the derivatives of simple trigonometric functions. This means that female students are more varied in answering the questions asked than male students [24]–[26], as shown in table 2 regarding differences in verbal abilities that females have better than males.

Table 2. Percentage Data for 4 Categories of Gender Students' Level of Understanding of Functional Limits and Derivatives

NO.	QUESTION INDICATOR	CATEGORY (%)				Gender
		DC	M	UNS	U	M/F
1.	Determine the left and right limits of a function.	61,54	19,23	3,85	15,38	M
		100	0	0	0	F
2.	Calculating the limit value using the properties of limit	30,77	26,92	7,69	34,62	M
		28,57	42,86	0	28,57	F
3.	Determine continuity at a point	61,54	23,08	7,69	7,69	M
		85,71	14,29	0	0	F
4.	Calculates the limit value of infinity.	50	3,85	7,69	34,46	M
		28,57	0	28,57	42,86	F
5.	Determine the function's derivative from the function's sum, the product of the function, and the quotient of the function.	50	26,92	3,85	19,23	M
		42,86	57,14	0	0	F
6.	Determine the derivatives of simple trigonometric functions.	30,77	15,38	26,92	26,92	M
		28,57	14,29	14,29	42,86	F
7.	Finding the derivative of a simple compositional function.	53,85	7,69	3,85	34,62	M
		42,86	0	0	57,14	F
8.	Determine the derivative of a simple function.	38,46	7,69	19,23	34,62	M
		57,14	42,86	0	0	F
	Average	47,12	16,35	10,10	26,44	M
		46,03	19,048	4,762	19,048	F

In the category of misconceptions (M), there is a difference in the ranking of the average percentage obtained by female students and male students. Female students in the Misconception category (M) got an average percentage score of 16.35%, the third highest average value. In contrast, for male students, the average percentage for the Misconception (M) category is 19.048%, the highest average score, the same as the Understanding Concepts Well (U) category.

The highest percentage value in the Misconceptions (M) category for female students is found in the indicator for calculating the limit value using the properties of the limit and determining the derivative of the function from the number of functions, the product of the function, and the quotient of the function with 26.92% and the smallest percentage with a large percentage 3.85% is found in the indicator of the problem of calculating the limit value of infinity. Meanwhile, for male students, the most significant percentage value is located in the question indicator to determine the derivative of the function from the number of functions, the product of the function, and the quotient of the

function, with a large percentage of 57.14% and the smallest percentage value with 0% is found in the question indicator to determine the right limit and left limit of a function, calculates the value of the limit at infinity and determines continuity at a point.

The category of Understanding Concepts but Not Convincing (UNS) obtained the lowest average percentage for both male and female students, with a percentage of 10.10% for female students and 4.762% for male students. This is the following table 2.1 regarding the state of the brain structure possessed by a female who is more able to feel emotional responses than a male, making female students more careful in providing confidence (Bastable, 2002). The most significant percentage obtained by female students of 26.92% is found in the indicator of determining the derivative of a simple trigonometric function. The smallest percentage is in the indicator of determining the right limit and left limit of a function, specifying the derivative of a function from the number of functions, the product of the function, and the quotient of the function, and determining the derivative of the composition function with a large percentage of 3.85%. Meanwhile, for male students, the most significant percentage is 28.57% which is found in the question indicator for calculating the limit value of infinity and the smallest percentage is on all question indicators except for the question indicator for calculating the limit value of infinity and determining the derivative of a simple function with a percentage of 0%.

As in the Misconceptions (M) category, in the Understanding Concepts Well (U) category, there are differences in the average percentage ranking between female and male students. Female students in the category of Understanding Concepts Well (U) are in the second largest ranking after the category of Misconceptions (M), with an average percentage value of 26.44%. In contrast, male students in the Understanding Concepts Well (U) get a score that is the same as the average value in the Misconceptions category (M), which is an average of 19.048%. This shows that the percentage of misconceptions (M) experienced by male students is greater than that of female students. The most significant percentage of female students is found in the indicators for calculating limit values using limit properties, calculating infinite limit values, determining simple composition functions, and determining simple function derivatives with a large percentage of 34.62% and the smallest percentage with 7.69% is found in the question indicator determines the continuity derivative at a point, while for male students the most significant percentage with 57.14% is in the question indicator determining the derivative of a simple composition function and the smallest percentage is found in the question indicator determining the right limit and left limit of a function, determining continuity in a function. The point determines the function's derivative from the number of functions, the function's product, the function's quotient, and the derivative of a simple function with a percentage of 0%.

3.3. Misconceptions in Prospective Mathematics Teacher Students

The misconceptions that occur in mathematics students have different percentages for each question indicator. Both female and male students have different percentages. The following table shows the percentage of misconceptions obtained by mathematics students and the average percentage of each question indicator.

Table 3. Data on the Percentage of Misconceptions of Prospective Mathematics Teacher Students

NO.	QUESTION INDICATOR	Misconception (M)		Average (%)
		Male (%)	Female (%)	
1.	Determine the left and right limits of a function.	19,23	0	9,615
2.	Calculates the limit value using the limit properties.	26,92	42,86	34,89
3.	Determine continuity at a point.	23,08	14,29	18,685
4.	Calculates the limit value of infinity.	3,85	0	1,925
5.	Determine the function's derivative from the function's sum, the product of the function, and the quotient of the function.	26,92	57,14	42,03
6.	Determine the derivatives of simple trigonometric functions.	15,38	14,29	14,835
7.	Finding the derivative of a simple compositional function.	7,69	0	3,845
8.	Determine the derivative of a simple function.	7,69	42,86	25,275

Table 3 above shows differences in the percentage of misconceptions experienced by mathematics students in each question indicator. In the first question indicator, which is determining the left and right limits of a function, female students get a percentage of misconceptions of 19.23%, in contrast to male students who earn a percentage of misconceptions of 0% on this question indicator, and on the average percentage for all students, both male and female, get the percentage of misconceptions of 9.615%. This percentage is relatively small compared to the average percentage of misconceptions in other indicators.

The second indicator is to calculate the limit value using the limit properties. For female students, the percentage of misconceptions achieved was 26.92%, while the percentage of misconceptions for male students was slightly above that of 42.86%. This reasonably high percentage figure causes the average value of the percentage obtained to be significant, which is 34.89%. The average percentage is the second largest average percentage value on all the indicators of the questions proposed. This shows that in the second question indicator, many students have difficulty understanding the concepts set by mathematicians. Students tend to have concepts that are different from existing concepts.

The third question indicator is to determine continuity at a point. In this indicator, the difference in percentage achieved by female and male students is not too big. Female students get a percentage of 23.08%, while male students are smaller than that, which is 14.29%. The average percentage achieved is equal to. This shows that not too many students experience misconceptions in question number 3.

The indicator for question four is to calculate the limit value of infinity, an indicator of questions in which students have minor misconceptions. The percentage

obtained by female students who experience misconceptions is 3.85%, while male students are 0%, which makes the average value of the percentage also received small, namely 1.925%, the average value of the smallest percentage of misconceptions among all other indicators. This means that many students are familiar with the established concepts of calculating the limit of infinity.

Furthermore, the fifth indicator determines the function's derivative from the number of functions, the function's product, and the function's quotient. In this indicator, many students are still wrong in providing concepts to answer the questions posed. This is illustrated by the large percentages obtained by both female and male students, respectively, of 26.92% and 57.14%. From this percentage, more male students misunderstand the derivative concept and do not match the established concept. The average percentage of this indicator becomes the average value of the most significant percentage of misconceptions, which is 42.03%.

The sixth indicator is to determine the derivatives of simple trigonometric functions. Many students have understood the derivative of the trigonometric function in question in this indicator, but some still have the wrong concept. The percentage of misconceptions in female students is 15.38% and for male students is 14.29%, while the average percentage of misconceptions between the two is 14.845%.

The next indicator is the seventh question indicator, which determines the derivative of a simple composition function. In this indicator, there are not many students who experience understanding the wrong concept or misconception, which is only found in female students of 7.69% while male students are 0%. This makes the average percentage obtained even small, only 3.845%, the second smallest percentage after the indicator for question four.

The last question indicator is to determine the derivative of a simple function. In the previous question indicator, not too many students experienced misconceptions. Some made mistakes in half of the answers to the questions. The percentage of misconceptions in female students is 7.69%, while for male students, the percentage of misconceptions obtained is quite large, almost half of male students have misconceptions, 42.86%, and the average percentage is 25.275%.

The question indicator that gets the average value of the most significant percentage of misconceptions is found in the indicator determining the function's derivative from the number of functions, the function's product, and the function's quotient. There are still many students who experience confusion in determining the derivative of a given function, not a few who make a mistake in determining the derivative of a function, making this indicator the indicator with the most significant percentage of misconceptions, which is 42.03%. At the same time, the smallest average percentage is found in the indicator of question number 4, which is calculating the infinite limit value of 1.925%. Many students use a fast way to find the limit value on an infinite function.

3.4. Research Limitations

The research was conducted using qualitative methods and primary data obtained through a written test in the form of essay questions accompanied by a Certainty of

Response Index (CRI) confidence level table in each question and interviews to explore the extent of misconceptions that occur in students. Several limitations must be considered when evaluating the results of this study.

First, data collection using an essay writing test accompanied by a confidence level table was carried out before the end of the semester exam, namely in December. This can have implications for several things: a) students may not be serious and careful in answering questions. b) there may be questions that students do not understand.

Second, the interview process is sometimes disturbed by the surrounding circumstances. Some students also studied who chose to go home at the time of the interview. This resulted in relatively little interview data.

Third, the subjectivity that exists in the researcher in interpreting the meaning implied in the interview, so the tendency to bias still exists. A cross-check was conducted to reduce prejudice between the answers given in the essay writing test and the answers given during the interview.

Fourth, the research only focused on the limit function and derivative material contained in the calculus one course. This resulted in misconceptions about other materials that the researcher did not know.

4. CONCLUSION

The results from the written test in the form of essay questions are accompanied by a Certainty of Response Index (CRI) confidence level table and interview tests conducted on mathematics students. There are still many students who have difficulty in providing answers along with the steps to answer the questions given to them, marked by the number of inaccurate answers given by students. From the results of the study, it was obtained that the percentage of students who had misconceptions about the concept of limit functions and derivatives was 15.49% and was smaller than the percentage of Do not Know the Concept of 42.76%, and the category of Understanding Concepts Well (U) with a percentage of 22.56. %. Meanwhile, for Understanding the Concept but Not Convincing (UNS), or it can be called guessing, the percentage is 8.08%. This shows the low level of mathematics students' understanding of the concepts of limit functions and derivatives.

The misconception category (M) seen by gender shows that the average percentage obtained by male students is 19.048% higher than female students, only 16.35%. This is supported by the differences between males and females in terms of the state of the brain structure and characteristics. Furthermore, in the categories of Do not Know the Concept (DC), Understand the Concept but Are Not Sure (UNS), and Understand the Concept Well (U), the highest average percentage was obtained by female students with an average percentage of 47.12%, 10.10%, and 26.44%. Most of the misconceptions are found in the indicators of determining the derivative of a simple composition function, specifying the derivative of a function from the number of functions, the product of the function and the quotient of the function, determining continuity at a point and calculating the limit value using the properties of the limit function.

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