Analysis of students' conceptual understanding ability of calculus courses during covid-19

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***Abstract*—Conceptual understanding in mathematical learning is an essential aspect of achieving learning outcomes, but the previous research showed a lack of conceptual understanding still high, especially in calculus courses. This study aimed to describe the students' conceptual understanding of the calculus course during the online learning process and analyze their mistakes when applying the concepts learned. This study used the descriptive qualitative method with 28 students as a sample. The collecting data used a conceptual understanding ability test and interviews with students. The data analysis used data triangulation in data reduction, data presentation, and conclusion drawing. Based on the results, the students' ability to understand the concept in online learning during the covid-19 pandemic was still low, with 17.9% of students getting poor and 21.4% getting unsatisfactory scores. Only 10.4% of students got excellent scores, 21.4% got good scores, and the average score was 28.6%. Students were confused when applying the interval concept for triple integral evaluation and the integral factor for differential equation solution. Online learning due to the covid-19 pandemic decreases student motivation because of the problems of the learning process, obstructing students from learning based on problem-solving learning. Some solutions that can address this problem are 1) using interactive problem-solving learning, 2) providing opportunities for students to construct their knowledge and understanding, 3) designing a learning model and learning media that can motivate students.**

***Keywords*—calculus II, conceptual understanding, online learning, pandemic covid-19**

I. INTRODUCTION

Mathematics had a significant role in sciences and technologies development. Therefore various disciplines such as economics, social, medicine, and management applied mathematical concepts in their studies [1]. The Minister of Education and Culture Regulation of the Republic of Indonesia number 59/2014 also explained the importance of mathematics widely used in various fields [2]. In addition, modern technology also used mathematics as a basis for development. Due to these reasons, mathematics was one of the compulsory subjects at various levels of education Bernard & Sanjayawati in [2]. In engineering science, one of the compulsory mathematics courses for first-year students was Calculus II. As a basic knowledge for engineering study, understanding the concept was mandatory for studying Calculus II.

Conceptual understanding is one of the essential abilities possessed by students in learning mathematics. A good understanding of mathematical concepts for students in a material will be the basis for understanding the concepts in the following materials [3]. Conceptual understanding is one of the goals of learning mathematics [4], [5]. Reference [3] refers to the Minister of Education Regulation number 22/2006 stated that the learning mathematics objectives for secondary education were students can understand the concepts, explain the concept's linkages, and apply these concepts correctly and efficiently. In another opinion, conceptual understanding is the ability to understand comprehensively various mathematical ideas [6]. In [7], Kilpatrick et al. defined conceptual understanding as the ability to understand a concept, operation, and relation in mathematics. Reference [8] said that conceptual understanding is a skill representing abstract ideas into a new form to understand the concept easily. According to [3], the basis for solving mathematical problems is understanding the concepts. Even though there are many variations of the mathematical concepts, students have to understand them properly [4]. So, the teacher should deliver the learning material from modest concepts to complex concepts for instilling the concepts to students [8]. Learning calculus needs a conceptual understanding because students must understand many basic concepts to memorize formulas and understand these concepts well. If students do not understand the concept well, this will impact low learning outcomes. The lack of conceptual understanding in calculus will impact the other subjects using calculus's concept in their problem-solving.

Some indicators define the students' conceptual understanding. Payadnya said conceptual understanding indicators were formulating solutions, applying simple calculations, and using symbols to express a concept [6]. The conceptual understanding indicator in [9], defined by the Ministry of Education, are restatement capability, classifying capability, representative capability, mathematical represent capability, proper procedure electing capability, concept problem-solving implementation capability [9]. According to Sa'dijah in [8], there are seven indicators of understanding mathematical concepts, namely: 1) restating a concept, 2) grouping objects based on specific properties, 3) giving examples and not examples of a concept, 4) presenting concepts in representative mathematical form, 5) developing the necessary or sufficient conditions for a concept, 6) utilizing and selecting specific procedures, 7) applying the concept or problem-solving algorithm. Moreover, Kilpatrick in [10] states that there are several indicators of conceptual understanding, including: 1) stating the definition of the concept, 2) finding

examples and non examples, 3) grouping objects based on certain properties according to the concept.

The students' conceptual understanding ability in mathematical learning had made many previous researchers. For instance, [6] analyzed students' conceptual understanding abilities in the Statistics I course during the covid-19 pandemic and found that few students scored good concept understanding abilities. Moreover, a study conducted by [5] found that students' conceptual understanding at SMPN 3 Majalengka was still low. Many junior high school students only know the formula but do not understand its concept. Other studies conducted by [11], Karimah in [12] found that students' conceptual understanding abilities were still low. Reference [3] also found that the ability to understand mathematical concepts of class VIII SMPN 1 Matapura was still relatively low. Many factors caused these phenomena. For example, students cannot understand the problem well and cannot apply the concept in problem-solving.

The covid-19 pandemic appearing in Indonesia since March 2020 has significantly impacted people's lives [6]. Massive changes occurred in the activities and patterns of people's lives from various aspects such as economic, social, and also education. The government has taken a policy to implement physical and social distancing to break the chain of transmission of covid-19. It has resulted in all activities carried out by humans turning into work from home [13]. It also impacts education systems, where the government takes a policy to enforce online learning from students' homes (Rahmawati in [13]). The regulation obligating the teacher and student to transfer the knowledge remotely impacts the use of technology for learning processes [14]. It commonly uses several platforms for the learning process, such as applications, websites, social media, and learning management systems [15].

Implementation of online learning is not an easy thing to do. It is a challenge for teachers, parents, and students. Many previous studies have tried to see the implementation of online learning. For example, [16] conducted research that researched online lectures on differential calculus during the covid-19 pandemic, showing that most students have an audio-visual learning style, so that video conferencing is preferred. Another research conducted by [17] relates to Wolfram CDF technology and Schoology to assist online learning activities. Other studies showed the problem occurring in online learning, such as decreasing students' understanding due to the challenge of learning material accessibility [18] and little interaction between students due to numerous homework [19]. Due to online learning, the calculus learning method using the class learning process and orienting on conceptual understanding affected, so the conceptual understanding ability impacted students who need the class learning process and direct interaction with teacher and friends.

Based on the description above, the researcher is interested in analyzing students' conceptual understanding abilities during the covid 19 pandemic. The aim is to observe students' conceptual understanding abilities during online learning in calculus II courses and to find out the obstacles and difficulties of students during learning. The indicators of the ability to understand concepts used in this study include: 1) Presenting mathematical concepts, 2) choosing certain procedures, 3) applying concepts. The results of this study are expected to research to improve students' conceptual understanding and overcome the difficulties students face while studying online.

II. METHOD

The research design in this study used a descriptive qualitative method describing students' conceptual understanding and motivation in calculus II courses during online lectures. This research was conducted at the S1 Telecommunication Engineering Department, Institut Teknologi Telkom Purwokerto. The subjects in this study were students of class S1 TT-A in the second semester. The learning process is carried out in the Calculus II course in the 2020/2021 academic year. The learning process used Google Meet and learning management system (LMS) provided by the campus. In addition, other platforms used in the learning process are WhatsApp and learning videos made by the lecturer.

Data collecting used an instrument to test students' conceptual understanding and to interview the student. The test is used to see how the students' conceptual understanding ability in learning calculus 2. The test is carried out at the end of the semester. The questions given are in the form of essay questions with a total of three. The material is about triple integral, first order linear differential equations and in homogeneous diferensial equations. The goal of this question is that student were able to apply the triple integral concept and perform calculations correctly. The second question is order student can using the correct procedure to determine the general solution of the first-order linear differential equation. The final question is order to student can choosing a solution procedure to determine the general solution to a inhomogeneous linear equation Before this test is given to students, these test questions are validated first with other lecturers in charge of the calculus II courses to see the suitability of the content and if there are still writing errors. The results of this test are assessed using the rubric for assessing the ability to understand concepts based on indicators prepared previously. Each student's answer will be assessed using an analytical rubric. The results of the test scores obtained are then calculated and categorized according to Table 1 refer to [20] .

TABLE I. SCORE INTERPRETATION FOR CONCEPTUAL UNDERSTANDING ABILITY

Score Range	Category
85.00 – 100	Excellent
70.00 – 84.99	Good
55.00 – 69.99	Average
40.00 – 54.99	Poor
0.00 – 39.99	Satisfactory

Due to the test results clarifying, interviews were conducted to find more in-depth information related to students' conceptual understanding abilities. Interviews were conducted using interview guidelines that had been prepared previously. The data analysis technique used to clarify the results of the student's conceptual understanding test is to use the data triangulation method, which is carried out in three stages, namely: a) the data reduction stage by reviewing the test results and interview results, b) the stage of presenting data using tables and making text to the results of the interview, c) the stage of providing conclusions from what has been done.

III. RESULT AND DISCUSSION

Online learning in the calculus II course used three platforms during the learning process: Google Meet, LMS, and WhatsApp groups. Synchronous learning used Google Meet used to explain and embed learning materials directly to students. LMS is used to collect assignments, exercises, quizzes, and exams and send learning videos made by the lecturer. WhatsApp group is used for discussion between student and lecturer. Reference [16] also stated that the WhatsApp group is a medium for discussion between lecturer and student with lower quotas and signals. If the lecturer asks whether they understand the concept during the learning process, only certain students want to ask the lecturer while other students prefer to be silent. Based on interviews conducted with students, information was obtained that students did not ask their lecturers directly because they were ashamed of their friends and were afraid to be laughed at by their friends. In addition, most students prefer to discuss with their friends if material concepts are not understood. During the learning process, it can be seen that the presence of students on time during the online learning process can be said to be good where only very few students are present late.

Online learning using Google Meet created several obstacles for students. Constraints that students often face are network problems, power outages, and running out of internet quotas. This finding was in line with [16] research, which found that the poor condition of the internet during video conferences was an obstacle faced by students. Network conditions that are not strong enough cause students to enter and exit Google Meet. Meanwhile, students who experienced power outages and ran out of internet packages could not attend lectures that day. The consequence of this obstacle is that the student is not able to understand the concept of the material well. It can be seen when the lecturer asks again what has been studied previously at the next meeting, students who have problems are not able to answer the lecturer's questions correctly. If this condition continues, it will cause student learning outcomes to be less than optimal.

Overcoming the obstacles faced by the students, the lecturer made a learning video related to the material studied on that day. Then the lecturer uploaded it to the LMS. It is done so that students can learn and repeat the material that the lecturer has delivered. So, if students cannot join on that day, they can still learn through the learning video. Based on the interviews conducted, it was concluded that the learning videos provided by the lecturers were beneficial for them. It is in line with research conducted by Purbayanti, which states that one of the learning media that can be used for learning at home is video learning [21].

At the end of learning, students are given a conceptual understanding ability test in the form of essay questions to know how students understand concepts during the learning process. Based on the test results, it will be seen how the students' conceptual understanding abilities are. The results of students' conceptual understanding abilities are presented in Table II. Table II shows that the standard deviation obtained is 20.71. The higher the standard deviation or standard deviation, the more heterogeneous the performance of each student in the class, in this case, is the ability to understand students' concepts [22]. It shows that class A students have the ability to understand various concepts. The highest score obtained by students on the concept understanding ability test was 91, while the lowest score obtained by students was 25.

TABLE II. RESULT OF STUDENTS' CONCEPTUAL UNDERSTANDING ABILITY TEST

Description	Result
mean	56.7
standard deviation	20.71
maximum value	91
minimum value	25

Table III describes the frequency distribution of scores obtained by students.

TABLE III. SCORE FREQUENCY DISTRIBUTION OF STUDENTS' CONCEPTUAL UNDERSTANDING ABILITY

Score	Frequency	Percentage	Category
85.00 – 100	3	10.7	Excellent
70.00 – 84.99	6	21.4	Good
55.00 – 69.99	8	28.6	Average
40.00 – 54.99	5	17.9	Poor
0.00 – 39.99	6	21.4	Satisfactory

Table III shows that the ability to understand mathematical concepts from class A is very diverse. The highest percentage is in the average category, which is 28.6%. The lowest percentage is in the excellent category. In this category, only three people scored above 85. Students who were included in the category of poor and satisfactory concept understanding ability were quite large. The number of students who fell into these two categories was 11 people with 39.3%.

Based on the results of the student's ability to understand mathematical concepts, an analysis was carried out on the answers made by students. The first problem deals with the concept of triple integrals. The results of the answer analysis showed that only a few students were able to apply the triple integral concept and perform calculations correctly. Meanwhile, for other students' answers, there are still some errors. The error that occurs is when connecting the integral boundary with the axis to be integrated, namely the x, y, and z axes. It is in line with the results of research conducted by [23],

which found that the error made by students was when writing the integral fold limit. Another conceptual error made by students is when calculating the triple integral when students integrate the equation to x, students also integrate functions y and z. They do not make functions other than x as constant. The concept of calculating the triple integral is that when integrating the interior concerning x, y-variable are considered constants [24]. In addition, there are also student answers whose integral and boundary writings are correct but are wrong in applying the integral concept where the student is working on it as a derivative. Some of these misconceptions caused their answers to be not as expected. Another answer found was that some students did not understand the problems given, so that the answers written by students did not use the concept of triple integral but used the concept of derivatives. It deals with first-order linear differential equations and inhomogeneous equations. The analysis of student answers found that some students were still wrong in writing the concept to calculate the integral factor of a first-order linear differential equation. It resulted in the general solution being produced not in line with expectations. Another error found was using the correct procedure to determine the general solution of the first-order linear differential equation. This error occurs because students do not understand the concept well. In addition, another mistake made by students was wrong in choosing a solution procedure to determine the general solution to a nonhomogeneous linear equation.

Interviews were conducted to obtain more in-depth information about the causes of student errors in applying the concept of triple integrals and differential equations. The information obtained from the interviews is the cause of errors in applying the integral concept because students do not understand the integral concept in the previous course. When faced with the triple integral, they find it more challenging to solve the given problem. Embarrassment to ask during online lectures about concepts that are not understood is also one of the causes of errors in doing questions. Another student conveyed the cause of errors in applying the concept of fold integral because of the difficulty in determining the integral limit with its axis. It was often reversed in writing the integral limit. Students also said that when the lecturer explained the material on google meet, he understood it well, but when he was given a question, he became confused about solving it. At the same time, the answers from other students were caused by a lack of practice in answering questions related to triple integrals and differential equations so that the concepts of the material could not be adequately understood. Students' other information is that the lack of conceptual understanding of the material presented is due to a poor network. They often go in and out of Google Meet to understand what the lecturer is saying. Even though there was a learning video, he still could not understand the concept well.

We can improve students' conceptual understanding skills and reduce errors made by students in working on questions to provide more examples and practice questions made in learning videos so that students can repeat them to understand them and better understand the concept Material well again [16], [21]. In addition, the results of the analysis are expected to be the basis for further research so that models and learning media can be created that can be used for online learning so that students' conceptual understanding abilities can be improved to obtain maximum results. One of the learning model that can be used is discovery learning. This is in accordance with research conducted by Trianingsih who found that the ability to understand mathematical concepts using the guided discovery model was quite good after using the model of discovery learning [12].

IV. Conclusion

The finding shows that the lacking of students' conceptual understanding ability occurred in online learning during the covid-19 pandemic. Based on the results, the students' ability to understand the concept in online learning during the covid-19 pandemic was still low, with 17.9% of students getting poor and 21.4% getting unsatisfactory scores. Only 10.4% of students got excellent scores, 21.4% got good scores, and the average score was 28.6%. Students were confused when applying the interval concept for triple integral evaluation and the integral factor for differential equation solution. Online learning due to the covid-19 pandemic decreases student motivation because of the problems of the learning process, obstructing students from learning based on problem-solving learning.

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