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EFFORTS TO OVERCOME STUDENT DIFFICULTIES IN FUNCTION CONTINUITY MATERIAL THROUGH THE USE OF STRUCTURED WORKSHEETS

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ABSTRACT

This study aims to overcome students' difficulties in understanding the material continuity of functions through the use of structured worksheets in differential calculus courses. The research subjects were 26 students in second semester of the Mathematics Education Study Program, Faculty of Teacher Training and Education (FKIP), University of Muhammadiyah Tangerang (UMT). This type of research is Classroom Action Research which is carried out in two cycles where each cycle consists of two meetings. Continuity of Function material consists of several parts, namely set intervals of numbers, limits of functions and graphs, function continuity tests. The data obtained in this study are the activities and abilities of students in understanding the material. Student activity data was obtained by observing while student abilities were obtained by using a student understanding ability test. Furthermore, the data collected in this study were analyzed by descriptive analysis. Results analysis was carried out in each cycle to determine the success of using structured worksheets in overcoming student difficulties. The percentage of students who experienced difficulties in cycle 1 was 66.67% and in cycle 2 it was 26.92%. This figure is in the weak qualification range of 20% – 40% of the number of students, thus showing success in this classroom action research. Meanwhile, student activity in learning increased from the poor category (58%) in cycle 1 to the good category (88%) in cycle 2. This result was also reinforced by interview data which stated that students had a good impression of the learning they experienced. Students are enthusiastic in discussing, answering questions and expressing opinions to conclude their learning. Thus, the use of structured worksheets can overcome students' difficulties in understanding functional continuity material.

Keywords: Structured Worksheets, Continuity of Functions, Student Difficulties

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PRELIMINARY

Continuity of a function is part of the subject matter of Limits in differential Calculus courses (Sudaryono, 2017). Prospective mathematics teacher students are required to master all material in the course in the second semester. This is a prerequisite for taking advanced courses in the following semester, especially in integral calculus to algebra courses. The ability to master the continuity of functions material is supported by a good understanding of the material in the first semester in introductory basic mathematics

courses, especially on the subject of number operations, sets, and relations to mathematical logic. A good understanding of this material helps students learn introductory material in differential calculus courses before studying limit and continuity material, namely introductory calculus and functions.

Students learn that a function is declared continuous in a certain interval if the graph of the function is intact and unbroken or has no discontinuous points in that interval. Proof of a function that is continuous at certain intervals or points can be done by carrying out continuity tests supported by the graph of the function. Students show pictures of function graphs to support the results of the continuity testing that has been done. This requires students to be able to draw graphs well, so material for graphic sketches of a function must be studied on the subject of introductory calculus and functions in differential calculus courses.

The learning method used in the learning process of differential calculus courses is the discovery learning method. Students are directed to be able to determine the continuity of a function at certain intervals. Through this method, students are directed to be active in discovery activities from the stages of testing the continuity of functions to drawing a graph of the specified function. Student activities directed at making discoveries need full attention from educators so that they are on the right track (Mujiati, 2017). Students test a function through three stages of testing, then compare it with an image from the graph of the function. The results of the tests given to students as pre-research data were 32.81. This result is classified as in the low category, so it is necessary to improve the student's ability to master the continuity of functions material. Improvement begins with digging for information on the difficulties experienced by students.

Based on previous research (Purbaningrum, 2019), it is known that there are three kinds of difficulties experienced by students. Students who are less able to use a number line in formulating each function equation at each given interval, experience difficulties in carrying out the 3 stages of testing, especially in determining the left and right limits, to the point where they are mistaken in drawing the graph of the function according to the given interval. This difficulty must be overcome immediately so that students have a good understanding of the continuity of functions material. Based on direct observation when learning is carried out, it is known that the portion of time for studying this material is more used to record important points in the discussion of the material. This resulted in students not focusing on the discovery process of the material being studied. Only a small proportion of students go through the process, while the rest still need further direction

from the lecturer. Passive learners occur when students are less enthusiastic in the learning process, lack focus as evidenced by limited attention to the teacher's explanation, and have difficulty understanding the material being taught. These factors need to be addressed to minimize low learning outcomes (Nasution, et al., 2023). An idea arises that students need teaching material that completely explains these important points, while still directing students in the discovery process. These problems can be solved with student worksheets that are based on discovery learning created by educators. Because many considerations are made by educators in developing student work sheets both in terms of delivering material and selecting good methods during learning activities so that satisfying learning objectives are achieved (Khodijah, et al., 2020). The teaching material is a structured worksheet for students. Through this worksheet, the role of students will be more dominant compared to the role of lecturers who are only facilitators and organizers in class. With this teaching material, students are required to be independent and work together optimally in their groups (Purbaningrum, et al. 2020).

Structured worksheets are teaching materials that direct students to conclude the material or problems provided (Pamungkas & Yuhana, 2016). Structured activity sheets help educators direct students so they can play an active role in the learning process so that the expected competencies are achieved (Purbaningrum & Safitri, 2019). Based on Research conducted by Rahmawati (2015), shows that the use of structured worksheets has a positive effect on students' motivation and learning outcomes. According to the role of the structured worksheet, it is hoped that students can focus more on understanding the material being studied. For this reason, a study is needed with the title "Efforts to Overcome Student Difficulties in Functional Continuity Materials Through the Use of Structured Worksheets". This research was conducted in the form of classroom action research, so the formulation of the problem in this study was "How to overcome the difficulties of semester II students of the UMT FKIP mathematics education study program in understanding the material continuity of functions through the use of structured worksheets?"

Structured worksheets are worksheets designed to direct students in a learning work program with a little help from educators to achieve these learning objectives (Naba, 2020). According to Jaya (2014), structured worksheets help teachers apply the discussion method well, provide media for students to explore all the information provided, and elaborate on the concepts and facts of the subject matter taught in learning activities. Meanwhile, according to Purbaningrum & Safitri (2019), structured worksheets help

educators direct students so they can play an active role in the learning process to examine concepts in the material and formulate solutions to the problems given to achieve the expected competencies.

The purpose of the worksheet according to the Implementation of Strengthening the Work of Mathematics Teachers is; 1) as a tool to direct student learning activities and introduce understanding, concepts, principles and skills, 2) can speed up the learning process with the principles of effectiveness and efficiency, and 3) train students' thinking power so that their mastery is more stable in study lesson material. This is because students are actively involved in the learning process. So by developing worksheets, it is hoped that they can help students in the learning process (Khuzaini & Nurjanah, 2019). Based on research conducted by Lestari, et al. (2014) it was found that structured worksheets can reduce students' difficulties in solving problems.

Based on research conducted by Lestari, et al. (2014) found that structured worksheets based on Problem Based Learning were able to reduce high school students' difficulties in solving particle dynamics problems in physics subjects. This becomes a strong foundation for implementing the use of structured worksheets to overcome students' difficulties in understanding the continuity of functions material. Worksheets are of good quality if they meet the following requirements (Salirawati, 2019):

1. Didactic requirements; following the principles of effective teaching and learning, such as paying attention to individual differences, emphasizing the process of finding concepts, having a variety of stimuli through various media and student activities, being able to develop social, emotional, moral, and aesthetic communication skills in oneself students, the learning experience is determined by the personal development goals of students
2. Construction requirements; following the principles of using language so that it can be understood by students, such as using language that is appropriate to the maturity level of students, using clear sentence structures, having a sequence of lessons that are appropriate to students' ability levels, avoiding questions that are too open-ended, not referring to resource books that are beyond the readability of students, provide enough space to give freedom in writing answers or drawing on worksheets, use simple and short sentences, use more illustrations than words, can be used for all students, whether slow as well as fast ones, have clear learning objectives and are useful as a source of motivation, have an identity to facilitate administration.

3. Technical requirements: related to the use of writing, displaying pictures, and worksheet tables, such as using printed letters and not using Latin or Roman letters, using bold letters that are rather large for topics, not ordinary letters which are underlined, using nothing more of 10 words in one line, using frames to distinguish command sentences from student answers, trying to compare the size of letters to the size of pictures and matching tables.

METHODS

The type of research conducted is Classroom Action Research/CAR. This type of research was chosen to be able to provide corrective solutions to students' difficulties in understanding functional continuity material. The subjects of this study were 26 second semester students of the mathematics education study program FKIP UMT Academic Year 2022-2023 and the object of this research was to increase students' understanding of functions so that they could overcome students' difficulties in understanding functional continuity material through the use of structured worksheets. This research was conducted in two cycles with each cycle consisting of two meetings. Each cycle will go through four stages, namely: (1) planning, (2) action, (3) observation/evaluation, and (4) reflection which is shown below.

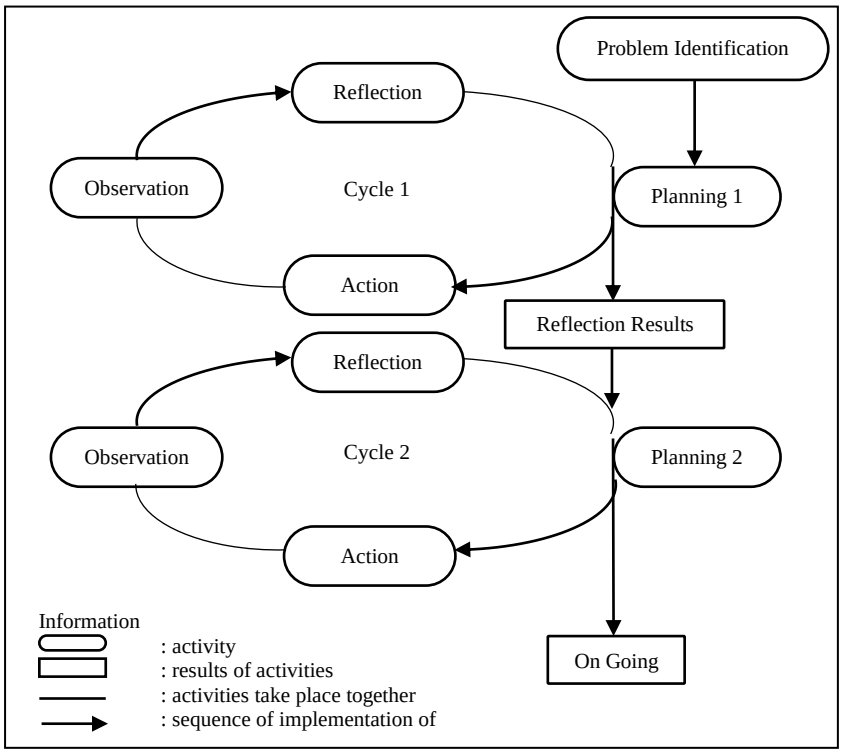

Figure 1. CAR scheme developed by Kemmis and Taggar (Hidayat & Asip, 2015)

The important points that must be carried out in planning are formulating research problems and objectives, determining actions, designing research settings, determining the number of cycles and meetings, determining teaching materials, determining data collection techniques and instruments and drawing up a research schedule. What must be designed includes a learning plan for meetings in the first cycle. Planning needs to be prepared systematically, logically and contextually so that it can assist in the process of implementing learning in each cycle.

Actions and observations are carried out simultaneously. In this step the researcher and collaborators gather in the class where the research subject is located. Researchers or other teachers carry out learning according to the learning plan that has been prepared as naturally as possible. Collaborators as observers are present in the class and take positions around the students to record activities on the observation sheet. The observer's job is only to record data, they have no right to intervene in learning. Teachers who carry out learning need to also make notes regarding the implementation of the learning carried out. The contents of these notes can include a description of feelings in carrying out learning, findings from observations of student learning activities, the suitability of the lesson plan to its realization, implementation time, the impact of the learning tools used on learning activities and so on. The collected data is then combined and confirmed with data from the observer's observations. When researchers and collaborators have finished carrying out one cycle of meetings, reflection activities are carried out. Reflection includes activities of analysis, synthesis, interpretation, and explaining data collected through observation activities. After processing this data, it is then compared with the targets set in the success criteria. The results of the reflection are recommendations for improvement which will be taken into consideration in planning the next cycle.

The instruments in this study consisted of observation sheets and tests of student's understanding of the continuity of functions material. Observation sheets are used by collaborators as observers to provide direct observation data at the action stage. The data analysis technique used is to use qualitative data analysis techniques (Setyosari, 2016). Observation data uses an assessment scale with a range of values in numbers (5,4,3,2,1) for assessing student activities in learning. Calculate the average percentage of student learning activity and then select the activity category that matches that percentage, namely very good (90-100%); good (79-89%); fair (68-78%); less (57-67%); very less (46-56%).

Tests are given to students at the end of each cycle to determine the difficulties students are still experiencing. This test is in the form of questions that have been used to

determine the difficulties often experienced by students in previous research so that it is valid for use in measuring students' understanding abilities (Purbaningrum, 2019). This classroom action research is known to have been successful if the maximum student difficulty level is in a weak qualification at the end of the cycle, meaning that it is in the range of 20% - 40% of the number of students (Riduwan, 2014). List the percentage of each aspect of difficulty in each cycle and calculate the average percentage of difficulty for each cycle.

RESULT AND DISCUSSION

1. Description of Class Conditions

The research was carried out in class 2A1, namely semester II students for the 2022/2023 Academic Year. The process of implementing cycle 1 is on May 24, 2023, and May 31, 2023, while cycle 2 is on June 7, 2023, and June 14, 2023. This is by the order of learning material in the Differential Calculus course which has been formulated in the lesson plan, where Limit and Continuity material is given at the 8th to 11th meeting. The total number of students is 26 people with 4 male gender and 22 female gender who have various abilities.

For this class, learning is carried out through the use of structured worksheets that direct students to conduct investigations and draw conclusions from the information obtained from the problems given. Structured worksheets help educators to direct students to play an active role in the learning process so that the expected competencies are achieved. To encourage students to get the expected material concepts that are by learning indicators. The problems in the worksheet are structured, with the hope that students will be helped by the instructions given. With this activity sheet, the role of the student will be more dominant than that of the lecturer. Because the position of the lecturer here is only as a facilitator and organizer in class. With this teaching material students are required to be independent and work together optimally. Learning independence demands great responsibility from students to try to carry out various activities to achieve the expected learning goals (Sukmawati & Purbaningrum, 2022).

The learning material delivered in treatment/action is related to the following three basic competencies: (1) Be able to identify each rule at the appropriate domain boundary interval on the function; (2) Able to sketch function graphs according to intervals on functions; (3) Able to determine the requested limit value according to the conditions for the existence of the limit; (4) Able to perform function continuity requirements test.

Before taking action, students are given directions to look at the instructions given on the worksheet used. Students must follow the steps described in the worksheet in exploring the information obtained from the problem given. After the treatment was carried out to overcome student problems through learning activities using the cycle method. At meeting 1 (May 24, 2023) of the first cycle, students were directed to determine the interval limit according to the domain of each rule for a given function and then set it on the number line to outline the graph of the function. At meeting 2 (May 31, 2023) of the first cycle, students were directed to carry out continuity testing based on the studies carried out at the previous meeting. So that at the end of the first cycle, students begin to understand how to solve the problem of continuity of function. In the second cycle, students' comprehension skills increased so that most students did not experience significant difficulties.

2. Description of Research Data

After going through the process of implementing classroom action research (CAR), this section describes the results of observations, interviews, and written tests conducted in each cycle (Arikunto, 2021). Before providing learning material that is conveyed in the treatment/action in each cycle, researchers need to determine basic competencies so that they can formulate appropriate structured worksheets. The worksheet must be able to direct students through the instructions given according to the basic competencies desired to be achieved in the material. Researchers as subject lecturers, become facilitators in the learning process so that students get used to working independently optimally.

Cycle 1

The first meeting will be on May 24, 2023 with a duration of 2×50 minutes. The basic competency that is being studied is identifying each rule at the interval limit corresponding to the domain of the function to sketch the graph of the function according to the interval on the function. The learning process consists of three stages, namely 1) using a number line in formulating interval limits to the existing rules for the function, 2) sketching the graph of the function according to the intervals on the function, 3) determining the required limit value according to the conditions for the existence of the limit. Before the first stage

Figure 2. Cycle 1

begins, the lecturer gives directions on how to use structured worksheets to students. The briefing lasts 15 minutes at the beginning of the lesson.

In the first stage, the activities carried out are assigning functions to the number line. This activity begins by determining the interval limit and then placing function rules at each interval on the number line. Students use a number line to place interval scales and function rules accordingly. Then students calculate the value of the function (y) according to the input given (x). This stage lasts for 30 minutes.

In the second stage, the activity carried out is to draw a graph of the function according to the domain and the rules according to the function. This activity begins with determining the coordinate points (x, y) that are representative of each interval scale, then placing them on the coordinate system of the angles that have been studied before, and drawing lines or curves that correspond to these coordinate points. This stage lasts for 30 minutes.

In the third stage, the activity carried out is to determine the requested limit value according to the conditions for the existence of the limit. This activity begins with determining the value of the limit towards the left and right with the help of a number line in the first stage, then concludes whether the limit value is defined or not at a certain point x. This stage lasts for 20 minutes. The duration of 5 minutes at the end of the entire learning process at this first meeting, the lecturer provides an opportunity for students to provide a concluding review of the material that has been studied.

The second meeting will be held on May 31, 2023 with the same duration of 2×50 minutes. The basic competency that is being studied is to test the continuity of function requirements. The learning process consists of three stages after the lecturer explains for 15 minutes the condition of a function that can be said to be continuous or not at a certain point x. Students carry out the first stage in the same way as the previous lesson. Students use a number line to place interval scales and function rules accordingly. Students follow the directions from the instructions given on a structured worksheet. Students need to draw a number line that contains interval information that corresponds to a given function equation. In functions with different rules, several intervals have different function equations. The number line is drawn with interval boundaries and the appropriate function equations are given for that interval. Through this number line, students will find it easier to test the continuity of the function at each given interval. This stage of activity lasts for 20 minutes.

In the second stage, students carry out a function continuity test at a certain point. Three stages of testing need to be carried out to prove that a function can be declared continuous or not. Students need to prove whether the three stages of testing have been fulfilled or not. Continuous function satisfies all three stages of the test. This stage of activity lasts for 20 minutes. The next activity is to draw a function graph at each given interval so that it can support the results of the function continuity test. The learning process ends by giving a 30-minute test to students to measure their ability to understand the continuity of functions material.

During the learning process, the collaborator records the activities that occur on the observation sheet that has been formulated. Then interviews with six students regarding the responses and constraints experienced by students in the learning process in cycle 1. Then the Researchers and Collaborators reflect on the readiness of students to use structured worksheets requiring stimulus from the lecturer to understand the instructions given so that the student's work process requires a longer duration, especially in the process of sketching function graphs. Analysis of the results of data processing on the observation sheet in cycle 1 obtained a percentage value of 58% which was in the poor category. This is supported by interview results which show that students are still hesitant to answer questions or give opinions in the learning process. Then, analysis of students' work results obtained scores as follows:

Table 1. Cycle 1 Test Results

Mean	42,115	Sample Variance	654,35
Median	34,5	Range	86
Mode	18	Minimum	14
Standard Deviation	25,58	Maximum	100
Sum	1095	Count	26

Cycle 2

Figure 3. Cycle 2

Before carrying out the second cycle, it is necessary to make improvements according to the reflection results in the first cycle. The improvements made include setting the duration for each stage in one meeting, providing written directions to completing structured worksheets according to student needs in working on each given problem. The first meeting was in cycle 2 on June 7, 2023. The learning process was

carried out as in the first meeting in cycle 1. Students were familiar with the directions and rules that apply, so students were faster in working on the worksheets given. Students have understood each step or stage needed in solving problems which include the use of number lines, and right-angled coordinates to determine the limit value according to the conditions for the existence of a limit.

The second meeting will be held on 14 June 2023 with the same duration. Students have a good understanding of placing interval scales and the appropriate function rules on the number line. Continuity testing is carried out by students with the help of the number line to sketch the graph of the function. Students give a positive response in learning to minimize the direction needed from the lecturer. Analysis of the results of data processing on the observation sheet in cycle 2 obtained a percentage value of 88% which was in the good category. Meanwhile, analysis of students' work results obtained scores as follows:

Table 2. Cycle 2 Test Results

Mean	79,72	Sample Variance	196,51
Median	76,33	Range	37,33
Mode	100	Minimum	62,67
Standard Deviation	14,02	Maximum	100
Sum	2072,67	Count	26

Through the use of structured worksheets, students are directed to play an active role in the learning process so that they can grasp the concepts in the material being studied to solve the problems given. Student worksheets are able to help students grow and increase learning independence (Sukmawati, 2020).

Table 3. Percentage Comparison of Student Difficulties

Difficulty Aspect	Pre-Cycle	Cycle 1	Cycle 2
Define functions and intervals on the number line	73,08	38,46	0,00
Perform a continuity test	92,31	76,92	34,62
Sketch a function graph	92,31	84,62	46,15
Average Value	85,90	66,67	26,92

A comparison of the percentage of student difficulties in Table 3 shows a decrease in each aspect of difficulty. The average decrease in the percentage of difficulty in cycle 1 was 19,23% (from 85,90% to 66,67%) or about 9 students who experienced a decrease in difficulty. The average value of student difficulty percentage in cycle 1 (66,67%) is not in the range of 20% - 40% of the number of students, so it continues with cycle 2. In cycle 2 it was 39,74% (from 66,67% to 26,92%) or about 19 out of 26 students who experienced a decrease in difficulty. The percentage of difficulty in cycle 2 for the first aspect is to

determine the function and the interval on the number line is 0%. This means that all students do not experience difficulties in this aspect. In the second aspect, the percentage of difficulty is 34,62%, meaning that 17 out of 26 students can carry out functional continuity tests. However, the percentage of difficulty in the third aspect is 46,15%, or only 14 out of 26 students who successfully support testing the continuity of the function at a certain point with a graphic sketch.

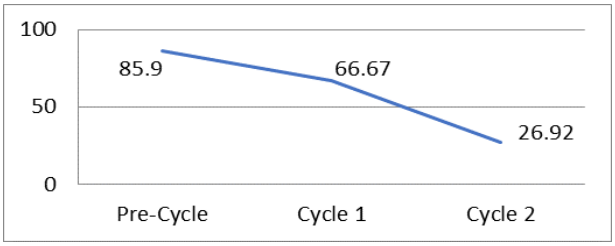

Figure 4. Presentation of Student Difficulties

Based on the data obtained from each cycle, it can be seen that there is a decrease in the percentage of student difficulties in cycles 1 to cycle 2 (Figure 4). The following is a comparison of the results between cycle 1 and cycle 2. The decrease in the percentage of difficulty in cycle 2 shows that students are able to learn functional continuity material well when compared to pre-cycle. These results are in line with research conducted by Silalahi (2022) which shows that the use of worksheets by students can improve problem-solving skills. Likewise, the results of research from Nurmi et al. (2020) said that worksheets can be a source of learning that can develop the potential abilities of students and improve student learning outcomes. The percentage of student difficulties in cycle 2 provides information that 7 students are still experiencing difficulties or around 26.92% of all students are in weak qualifications at the end of the cycle. This figure is in the range of 20% - 40% of the number of students, thus indicating success in this classroom action research.

CONCLUSION

The results of the study can be concluded that students' comprehension skills have increased so that most students do not experience significant difficulties. The percentage of students who experience difficulties is 26.92%, in the range of 20% - 40% of the total number of students. Apart from that, student activity in learning increased from the poor category (58%) in cycle 1 to the good category (88%) in cycle 2. This result was also reinforced by interview data which stated that students had a good impression of the

learning they experienced. Students are enthusiastic in discussing, answering questions and expressing opinions to conclude their learning.

Based on the discussion and conclusions of the results, the researcher recommends that lecturers should be able to apply a structured worksheet to create competent learning that can improve comprehension skills while minimizing student difficulties in the learning process.

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