Study of factors affecting student learning outcomes in Real Analysis lectures during the Covid-19 pandemic

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Abstract. The competencies to be achieved in the Real Analysis course are 1) prove simple math statements with familiar concepts and 2) develop critical, creative, structured, and systematically thinking skills. This competence can be improved by using flow proof-based teaching materials and direct interaction in class between lecturers and students. During the Covid-19 pandemic, direct interaction in class was replaced with online learning. Of course, online interactions will affect student learning outcomes. What are the factors that affect student learning outcomes in real analysis lectures during the Covid-19 pandemic? By using a questionnaire, data about these factors were obtained. The factors affecting of learning outcomes during the Covid-19 pandemic are student background, learning attitude, and learning style. In particular, the indicators that influence student learning outcomes are the ease of obtaining internet access, the need for time to study that is not in accordance with the schedule, not confident in solving Real Analysis problems/exercises, not being able to understand Real Analysis material independently, and student learning styles.

1. Introduction

Lectures will be meaningful if students participate actively. In active learning, students must be involved and learn a lot. They use their minds to find ideas, solve problems, and apply what they have learned. Active learning refers to techniques where students do more than just listen to lecturers' lectures.

The competencies that must be achieved after studying the Real Analysis course are 1) prove simple math statements with familiar concepts and 2) develop critical, creative, structured, and systematical thinking [1]. Students interpret reasoning and communicate their understanding, make connections between definitions/theorems and use them to solve mathematical problems. The material of real analysis contains about definitions and theorems that must be proven. The example of the problem in Real Analysis is

Let \( S \subseteq \mathbb{R} \) and suppose that \( s^* := \sup S \) belongs to \( S \).
If \( u \notin S \). Show that \( \sup(S \cup \{u\}) = \sup\{s^*, u\} \)

This competencies can be improved by using flow proof-based teaching materials and direct interaction in class between lecturers and students [2]. During the Covid-19 pandemic, direct interaction in class was replaced with online learning. Of course, online interactions will affect student learning outcomes.
Students' difficulties in preparing solutions to the problems given and structuring their thinking patterns logically and systematically cannot be resolved properly. This can be resolved if there is interaction in class [3] [4]. As a result, the problems given to Real Analysis courses cannot be solved by students. This is the cause of the low student learning outcomes in Real Analysis lectures during the Covid-19 pandemic. Students must understand and be able to interpret the definitions and theorems in Real Analysis. Students must learn how to analyze a statement and use it to solve a problem independently. Students look for and describe every piece of information they have and use the information they get [6].

Solving problems related to proof is not easy for students to solve. Research by Cirillo and Herbst [8] on Geometry material showed that it is often difficult to write the premise and statements to be proven, as well as building proofs, it appears that the problem of proof can be solved but students must be given the opportunity to make reasons from an assumption and evaluate. mathematical argument and prove it. In addition, research by Miyazaki, Fujita, Keith [9][10] also on Geometry material shows that the use of using open problems encourages students' understanding of the structure of evidence by providing various assumption relationships with their conclusions.

The completion of a proof presented in the Real Analysis book does not provide a clear explanation of the reasoning process, so that students do not understand the analysis of their thinking if there is no interaction in class. This affects student learning outcomes. There are several factors that influence learning outcomes, namely student backgrounds, interests, attitudes, motivations, and learning styles [5] [6]. What are the factors that affect student learning outcomes in real analysis lectures during the Covid-19 pandemic?

2. Research methods
This is a descriptive study. This study describes the state of the subject [7]. The subjects in this study were students of the Mathematics Education Program at the Mathematics Department, Universitas Negeri Padang. The total is 87 students. The students are in three classes. To achieve the research objectives, questionnaires and learning outcomes tests were used. Through the results of the questionnaire and learning outcomes test, the data were processed using descriptive statistics.

3. Results and discussions
There are five factors that are asked in the questionnaire, namely backgrounds, attitudes, interests, motivations, and learning styles of students. The five factors broke down into 26 indicators. There are general indicators and there are indicators that refer to lectures during the Covid-19 pandemic.

Regarding the backgrounds factor, the indicators are the grade in the introduction to basic mathematics course (V1), living in an environment that encourages them to study (V2), living in an area that has wide internet access (V3), and can use IT media well (V4). The grade in the introduction to basic mathematics courses and the learning environment support them to get good learning outcomes. The results about the grade can be seen in Figure 1

![Figure 1. Grade in the introduction to basic mathematics course](image-url)
Approximately 79.5% of these students passed the introduction to basic mathematics course. This can be seen from the number of students who get grades in the range A to C+. The results of the questionnaire show that although 91% of students can use IT media well, only 58% of students live in areas with wide internet access. The results of the questionnaire about that can be seen in Figure 2.

![Figure 2. Student background](image)

Indicators of the interest factor are being interested in studying the Real Analysis course (W1), paying attention to Real Analysis courses well (before implementing online lectures) (W2), being actively involved in Real Analysis courses (before implementing online lectures) (W3), provide funds to buy an internet package if they are in a place where there is no Wi-Fi (W4), monitor information about lectures on the WhatsApp group (W5), and are actively involved in Real Analysis courses (during implementing online lectures) (W6). The results of the questionnaire indicated that students' interest in studying Real Analysis was not a problem, both before and during implementing online lectures. The results of the questionnaire about that can be seen in Figure 3. There are more than 80% of students showing behavior in accordance with the indicators of the interest factor.

![Figure 3. Student learning interest.](image)

In the learning attitude factor, the indicators are the discipline of using logical rules in solving problems / exercises (X1), confidence in solving problems/exercises (X2), learning Real Analysis according to the schedule (during implementing online lectures) (X3), submit the assignment report on time (during implementing online lectures) (X4), and confident in solving problems/exercises (during implementing online lectures) (X5). The results of the questionnaire about that can be seen in Figure 4. Approximately 45% of students cannot study Real Analysis according to the schedule. However, they always try to submit assignment reports on time. Before implementing online learning, 82% of students felt confident in solving Real Analysis problems/exercises. However, during the implementation of online learning, only 72% of students felt confident in solving Real Analysis problems/exercises.
Indicators on the learning motivation factor are trying to be successful in doing the Real Analysis task (Y1), believe Real Analysis gives good results for logic (Y2), and prefer to have discussions in studying Real Analysis (Y3). The results of the questionnaire indicated that there is no problem in student motivation in learning, both before and during implementing online lectures. The results of the questionnaire about that can be seen in Figure 5.

The indicators of the learning style factor are 1) before implementing online lectures, that are easier to understand Real Analysis material by seeing, reading or writing (Z1), understanding Real Analysis material after hearing lecturers' explanations (Z2), understanding Real Analysis material after discussion with friends (Z3), preferring to discuss learning Real Analysis (Z4), it is easier to understand Real Analysis after doing problem solving exercises (Z5), 2) during implementing online lectures, that are being able to understand Real Analysis material independently (Z6), requires a lot of learning resources in studying Real Analysis (Z7), can understand Real Analysis with the help of learning resources made by lecturers (Z8), preferring to discuss when studying Real Analysis (Z9), discuss with friends via social media in studying Real Analysis (Z10). The results of the questionnaire about that can be seen in Figure 6. Students understand Real Analysis more easily by viewing, reading, or writing. They prefer to discuss in studying Real Analysis. So, they understand the Real Analysis material after being explained by the lecturer, discussing with friends, and doing problem solving exercises. During the implementation of online learning, only 34.61% of students can understand Real Analysis material independently. Students need many learning resources. Students can understand Real Analysis with the help of learning resources made by lecturers. Only 75.64% of students like to discuss studying Real Analysis. They discuss with friends via social media.
Based on the learning outcomes data, it can be seen that the score of learning outcomes obtained by students varies for each material. These learning outcomes have not achieved maximum results. The learning outcomes can be seen in Figure 7. The lowest achievement is in the material Functions and The Algebraic Properties of R. The achievement is less than 25%. The achievement of more than 70% is in the material Sets and The Order Properties of R.

During the Covid-19 pandemic, if the problem of interaction in learning can be deal with, as found in several indicators of these factors, the achievement of learning outcomes can be improved. These indicators are the ease of obtaining internet access, the need for time to study that is not in accordance with the schedule, not confident in solving Real Analysis problems/exercises, not being able to understand Real Analysis material independently, and student learning styles. As for these factors, before implementing online lectures, there was a relationship. The factors affecting of learning outcomes are student background and learning style. Student background and learning styles are affected by student interests. Student interests are affected by student learning attitudes and learning motivation [11]. Therefore, during implementing online lectures, this factor was also influenced by the availability of the internet.

4. Conclusion
The factors affecting of learning outcomes during the Covid-19 pandemic are student background, learning attitude, and learning style. In particular, the indicators that influence student learning outcomes are the ease of obtaining internet access, the need for time to study that is not in accordance with the schedule, not confident in solving Real Analysis problems/exercises, not being able to understand Real Analysis material independently, and student learning styles.
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