Implementation of real analysis module with PQ4R strategy in facilitating self-regulated learning (SRL)

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Abstract. Students do not have teaching materials that suit their needs. The need for students to improve their learning outcomes, independent learning, and teaching materials that are easy to understand and structured according to the learning outcomes of FKIP students. Therefore the steps in the PQ4R strategy can help students in organizing texts, and organize itself to obtain more in-depth information by means of broader elaboration. So students will be more independent in learning. Independence in learning is termed Self-regulated Learning (SRL).

The purpose of this study is to describe the implementation of real analysis learning with the PQ4R strategy and produce a product in the form of "real analysis teaching material to facilitate effective Self-regulated Learning (SRL)" of students. This research is a follow-up research of development research with the development model used is the ADDIE development model. The analysis phase, design phase, and development phase have been completed in previous research. In this study continued with the Implementation phase. The results showed that the implementation of real analysis teaching materials with the PQ4R strategy in facilitating student Self-regulated Learning (SRL) went well, which is in the category of very good and good. Real analysis learning with the PQ4R strategy, which through preview and question activities allows students to have self-planning, and through read and reflect activities allows students to monitor themselves, as well as through recite and review activities, students conduct self-evaluation. Real analysis teaching materials to facilitate quality Self-regulated Learning (SRL) are effective on medium category with an N-Gain value of 0.43 and Self-regulated Learning (SRL) students are in the medium category.

1. Introduction

This study is a follow-up study of the development of Real Analysis teaching materials. Students do not have teaching materials that suit their needs. The need for students to improve their learning outcomes, independent learning, and teaching materials that are easy to understand and structured according to the learning outcomes of FKIP students. Previous research stated that this teaching material had met the valid and practical criteria. In the first draft this teaching material was revised on the recommendations, suggestions, and comments of the validator and then revised again based on users on a small scale. In this study, teaching materials will be implemented to users on a large scale. On a large scale what is meant is that teaching material will be implemented in real learning. The implementation of this teaching material will be given to one group with criteria more than 20 and less than 35. This is adjusted to the assessment and theory aimed at the implementation of this teaching material, namely this teaching material will be seen its effectiveness in the learning process.
This teaching material is still at the development stage so that the implementation is not carried out for all groups (classes) in the Mathematics Education Faculty of Mathematics and Natural Sciences Unja in real analysis courses. The implementation of this teaching material will be used in the learning process for one semester so that it requires certain approaches, strategies and methods that determine how the learning process and results will be obtained. In mathematics learning reading skills are a form of mathematical communication skills and have a central role in learning mathematics. Through reading students construct mathematical meanings\(^1\). Furthermore\(^2\) stated that a reader is said to understand the text he reads meaningfully if he can express ideas in the text correctly in his own language.\(^3\) revealed that one of the most widely known strategies to help students understand and remember the material read by students is the PQ4R Strategy.

This material was designed using the PQ4R strategy which has detailed explanations, Questions, Read, Reflect, Recite and Review which will guide students in embedding concepts and strengthening the concepts of real-topic topics in accordance with the stages in the PQ4R strategy. Therefore the implementation of this teaching material will use the PQ4R strategy so that scenarios are planned, and the learning design is adjusted to the foundation used in the teaching material.

Implementing this will certainly require many roles in supporting good learning outcomes, not only about the strategies used but also supporting strategies or other methods that will be involved. Nevertheless, the expected ability is for students to be able to design, run, and reflect back on every process that is carried out. Based on the results of previous research and the experience of researchers working on this subject, the ability expected to exist in the student in question is not something that is easy for students to do. This is due to habituation factors, and several other factors that cause students to still be directed or guided intensely. Whereas one of the benefits of implementing the PQ4R strategy in learning is that it can confine students to learning independence. This ability is defined by students being able to arrange, review, and reflect on the learning process and results. The ability of independence is also called Self-regulated Learning (SRL). Fauzi (2018) say that “Students with high self-regulated learning certainly have high achievement, and vice versa students with low self-regulated have low achievement”. So that, it is related with our focus research. And also for facilitated that, this research using modul. Students with self-regulated learning have an awareness of their performance. They can plan their level of performance based on planned performance.

The objectives of this research are describe the implementation of real analysis learning with the PQ4R strategy in facilitating Self-regulated Learning (SRL) and producing a product in the form of "Real Analysis Teaching Material" to facilitate effective student self-regulated learning.

2. Method
This research is classified as development research. It said development research because this research was still continued from the development of real analytical teaching materials to facilitate Student's self-regulated learning. The development model used is the ADDIE development model. ADDIE stands for analyzing, designing, developing, implementing and evaluating. From the concept of development ADDIE evaluation occurs at every four stages, with the aim of revision needs. The steps in the development of the ADDIE model are procedural, in research on the implementation of real analysis teaching materials with the PQ4R strategy the procedures undertaken are analyzing, and implementing teaching materials in learning and revised based on comments and suggestions obtained.

2.1. Product Testing
After making a real analytical teaching material product, the product is tested to determine the effectiveness of the product being developed.

2.1.1 Expert Trial. According to [5] after the instrument has been constructed about aspects that will be measured based on certain theories, it is then consulted with experts. The experts were asked for their opinions on the instruments that had been prepared in the form of validation. In this case the validation of the expert in developing the observation sheet instrument, the Self-regulated Learning
(SRL) Questionnaire, and also the pretest and post test questions were conducted by one lecturer, a mathematics education expert.

2.1.2 Limited Trial. The limited test was carried out in two stages, namely testing of test questions given to one class of students who took part in the real analysis class R-004 Year 2016 semester VI. This was done to test the reliability, different power, and SEM in the pretest and post test.

2.1.3 Research Trial Subjects. In this study, the subject of the trial was the mathematics education student of FKIP Jambi University who took part in real analytical learning in 2019. The student was a class of 2016 semester VI student in class R-001. It aims to see the effectiveness of teaching materials on learning.

2.2 Data and Data Collection Instruments

2.2.1 Data. According to [6] data is the result of research records, both in the form of facts and figures. The data used in this study are primary data. The primary data in this research development are instrument validation data from relevant experts, SRL questionnaire data, observation sheet data, pretest and posttest results of real analysis teaching materials with the PQ4R strategy.

2.2.2 Data Collection Techniques and Instruments. Student's Self-regulated Learning (SRL) data using the Self-regulated Learning (SRL) questionnaire will be given to students who take part in the learning process with this teaching material. For effectiveness data, the instrument used was an observation sheet on the implementation of learning and a test of learning outcomes. Observation sheet of the implementation of learning is given to the observer, namely one lecturer and a test of learning outcomes is given to students of mathematics education who use this teaching material as teaching material for lectures.

2.3 Data Analysis Techniques
Data analysis technique is done by descriptive analysis. Data analyzed included qualitative data in the form of instrument validation sheets from experts which contained responses, suggestions and inputs. The scale used in this research development is the Likert scale. The validation of the research instrument refers to the category on the Likert scale while the quantitative data analysis technique scores the expert assessment of the instrument is carried out with the following steps:

a. Calculate the average score on the assessment component on the observation sheet and convert the score into a category value using a reference according to [7].

b. Change the average score of the Self-regulated Learning (SRL) Questionnaire into a category value using a reference according to [7].

c. The effectiveness of teaching materials seen using the N-Gain Scoring. According to [8].

3. Results And Discussion
The results of research conducted on the implementation of teaching materials are in the form of research data including pretest and posttest data on each topic of real analysis courses, Self-regulated Learning (SRL) questionnaire data, and data on the observation sheet. In addition, there are results of instrument validation.

The research instruments used included pretest-posttest sequence topics, series, metric spaces, and topology; Self-regulated Learning (SRL) questionnaire, and observation sheet of learning activities. Before all instruments are used to obtain research data, these instruments are validated by instrument experts to see the validity and suitability in data collection. Validation results show that
92% of items on the instrument show validity and can be used but there are some revisions, including language compatibility, and question markers and commands that are still inconsistent. In the pretest-posttest instrument readability testing was performed on small groups. The results obtained from small group students that the pretest-posttest can be used for data collection. It can be seen that students are able to understand the language, problems, and context of the given problem.

After all instruments have been revised, they can be used to retrieve data. The following is a description of the observation sheet data on the implementation of the learning strategy activity and all activities that lead to Self-regulated Learning (SRL), and the Self-regulated Learning (SRL) questionnaire data is to see the level of Self-regulated Learning (SRL) for students during the learning process. Furthermore, the pretest-posttest data to be used to see the effectiveness of teaching materials during implementation. The effectiveness of teaching materials using the N-Gain Formula is based on the inventor of [8].

3.1 Description of Data on Implementation of Observation Sheet Implementation

The following shows the exposure to data on the implementation of learning on the results of observations by observers. The implementation of teaching and learning materials by lecturers and students.

**Table 1. Implementation Data through Lecturer Observation sheet**

| Item Statement | Score | Sequence | Series | Metric | Space | Topology | Total |
|----------------|-------|----------|--------|--------|--------|----------|-------|
| Total          |       | 14       | 14     | 16     | 11     | 55       |
| Maximum Total  |       | 16       | 16     | 16     | 16     | 64       |
| Percentage (%) |       | 87.5     | 87.5   | 100    | 68.75  | 85.94    |
| Categories     |       | Very Good| Very Good| Very Good| Good | Very Good |

From the data presentation in table 1, it can be seen that the implementation of real analysis teaching materials with the PQ4R strategy in facilitating Self-regulated Learning (SRL) for implementation by lecturers in general is in the very good category. Specifically for the topics of sequences, series, metric space and topology are in very good categories, very good, very good and good in a row.

**Table 2. Implementation Data through Student Observation Sheet**

| Item Statement | Score | Sequence | Series | Metric | Space | Topology | Total |
|----------------|-------|----------|--------|--------|--------|----------|-------|
| Total          |       | 44       | 40     | 48     | 38     | 170      |
| Maximum Total  |       | 48       | 48     | 48     | 48     | 192      |
| Percentage (%) |       | 91.67    | 83.33  | 100    | 79.17  | 88.54    |
| Categories     |       | Good     | Very Good| Very Good| Good | Very Good |
Meanwhile, the implementation of learning by students from the data presentation in Table 2 in general is in the very good category. Specifically for the topics of sequence, series, metric space and topology are in the category of very good, very good, very good and good in a row.

3.2. Implementation

Lecturer Observation Sheet and Student Observation Sheet

Implementation of real analytical teaching materials with the PQ4R strategy in facilitating Self-regulated Learning (SRL) was carried out for 1 semester (16 meetings). Topics covered include sequences, series, metric spaces and topology. In this study, researchers filled in the lecturer and student observation sheets once for each topic.

In general, based on lecturer and student observation sheet data, it can be seen that the implementation of the PQ4R strategy in real analysis learning goes according to plan. Based on the activities compiled activities that lead to learning independence or Self-regulated Learning (SRL) are as follows.

The preview stage is carried out for each topic, where the lecturer asks students to read the preview section that presents the topic and the scope of the material presented including the learning objectives that must be mastered by students related to the topic. The question stage is carried out for each topic in the lecturer activity asking students to read the questions that have been presented in the question section related to the topic and referring to the learning objectives, while the lecturer activity asks students to make additional questions carried out on the topic of metric spaces and topology topics, while for the topic sequences and series of observations are made without any direction from the lecturer to make a question a small number of students have discussed in the group the additional questions suggested in the question section this happens because most of the students who already have questions in the question section already represent their curiosity. Real analysis learning with the PQ4R strategy, through preview and question activities allows students to have self-planning on learning real analysis.

The read phase is carried out for each topic, where the lecturer directs students to read and discuss the topics presented in the "read section" about definitions or theorems related to the topic. Likewise, the reflect stage is carried out for almost all topics, where the lecturer directs students to read and discuss examples on the "reflect section" in their groups. The lecturer also directs students to do the exercises in the "reflect section" by discussing in groups. For the topic of topology lecturers do not do this activity because when observations are made the material discussed in the topic of topology is the properties associated with the topology concept of students currently working on analyzing a theorem in their respective groups so that there is no direction from the lecturer of this activity still done by students. So that through reading and reflect activities enable students to monitor themselves in learning real analysis.

Recite stage, the lecturer guides students to answer and discuss questions contained in the "Question section" which is the essence of the topic, at this stage of the lecturer and student observation data only carry out on the topic of metric space discussion, this is not because there is no activity to answer questions on the question section on other topics, but students often discuss in practice questions students also directly discuss the questions in the question section, so that at this stage of the recite students immediately conclude the subject matter. The review stage is almost on all topics at each meeting, where the lecturer guides students to re-check the concept of topics, exercises, and digest which have been discussed only on the topic of topology sub-topic. Properties related to the concept of topology whose material was discussed in 2 meetings. Through this recite and review activity students automatically conduct self-evaluation in learning real analysis.

3.3 Description of Questionnaire Self-regulated Learning (SRL) data

As previously stated that Self-regulated Learning (SRL) data collection uses a questionnaire, SRL data is obtained using a questionnaire given to students after each topic has been discussed. In this study
the focus is on three aspects of Self-regulated Learning (SRL) including designing, monitoring, and evaluating learning, each score obtained as shown in the following table.

| No | Aspect                                      | Max score | Average score | Categories of each aspect | Classic max total score | Average Classical | % Classical | categories |
|----|---------------------------------------------|-----------|---------------|--------------------------|------------------------|--------------------|-------------|------------|
| 1  | Item designing their own learning process   | 9         | 7.66          | Very good                |                        |                    |             |            |
| 2  | Items monitoring the self-learning process  | 6         | 5.65          | Very good                | 25                     | 21.75              | 87%         | Very good  |
| 3  | Items evaluating self-learning outcomes     | 10        | 8.45          | Very good                |                        |                    |             |            |

Table 3. shows that the highest average score is when monitoring the learning process yourself. while the average score is lowest when evaluating results. Although the difference in each average is not so far away, this can indicate that the students' habit of realizing their own learning process still needs improvement. Starting from the preparation of learning to the stage of realizing the results of their own learning. The percentage of each aspect is an integral part of all aspects meaning the percentage of each aspect that contributes to the independence of student learning or Self-regulated Learning (SRL) by 30.63% to design their own learning, 22.59% implement (monitor their own learning), 33.78% evaluate their own learning and there are 13% that students do not do as a form of learning independence. Classically, students' Self-regulated Learning (SRL) is 87%. This is included in the "very good" category. Of the several items students must do to demonstrate self-regulated learning, students stated honestly through a questionnaire that students could not make their own questions when designing learning activities. The initial knowledge of students about the topic is still lacking so that it will develop during the process of discussion and analyzing theorems during the learning process. This is reinforced by the observers' observations during the learning meeting.

![Figure 1. Student Self-regulated Learning (SRL) Data Diagram](image-url)
From Figure 1 it is known that from the SRL questionnaire given to students, aspects of designing the learning process itself contributed to the students' learning independence by 31% from 36% of the ideal percentage. The monitoring aspect of the learning process itself contributes to student learning independence by 22% from 24% of the ideal percentage. While the evaluation aspects of learning outcomes themselves contribute to student learning independence by 34% from an ideal percentage of 40%. Based on the data above, it is obtained that the implementation of teaching materials with the PQ4R strategy can facilitate student Self-regulated Learning (SRL) by 87%. The lowest percentage of self-monitoring aspects is not implemented, namely 2%, self-designing aspects of the percentage of non-implementation of 5%, the aspect of evaluating the results of own percentage of 6% not implemented. So there is 13% that is not done by students as a form of lack of learning independence. Of course it is necessary to study further the causes and efforts that can be made so that all aspects of learning independence can be fully implemented.

| Table 4. Self-regulated Learning (SRL) Data on Each Topic |
|-------------|---------------|-------------|
| No. | Topic | Score Average | Categories |
| 1 | Sequence | 21.56 | Very Good |
| 2 | Series | 21.78 | Very Good |
| 3 | Metric Space | 21.50 | Very Good |
| 4 | Topology | 22.16 | Very Good |

From Table 4, the average score of the Self-regulated Learning (SRL) questionnaire is presented based on each topic in the real analysis course. The table shows that the Self-regulated Learning (SRL) category of the four topics in the category is very good.

3.4 Description of N-Gain Data
Pretest-posttest results obtained in the form of student quiz results on each learning topic. The learning topics are sequence topics, series topics, metric space topics, and topology topics. Each pretest and posttest obtained an average value then formulated using the N-Gain formula. The results obtained are as follows.

| Table 5. N-gain score on the implementation of teaching materials. |
|-------------|-------------|-------------|
| No. | Pretest | Posttest | N-Gain |
| 1. | 21.26 | 54.96 | 0.43 |

In Table 4.4a, it is known that the N-gain value is 0.43. This means that the score is included in the medium category. The effectiveness of the implementation of teaching materials is stated to be moderate. If you look at Table 5, the average post-test score jumped twice as big as the pretest. Look closely for each topic, from the acquisition of pretest and posttest scores obtained N-gain for each topic as in the following table.

| Table 6. N-gain score of each topic on the implementation of teaching materials. |
|-------------|-------------|-------------|-------------|-------------|
| No. | Topics | Pretest | Posttest | N-Gain | Categories |
| 1. | Sequence | 35.12 | 70.41 | 0.54 | Medium |
| 2. | Series | 5.47 | 46.41 | 0.43 | Medium |
| 3. | Metric Space | 18.81 | 53.91 | 0.43 | Medium |
| 4. | Topology | 25.66 | 49.13 | 0.32 | Medium |

In Table 6 it is known that the value of N-gain and the category of implementation of real analysis teaching materials for each topic are as follows: 0.54 (medium category), 0.43 (medium category), 0.43 (medium category) and 0.32 (medium category), for sequence topics, series, metric spaces and topologies. Based on the above data, the implementation of real analysis teaching materials
for the topic of sequence, series, metric spaces and topology is medium effective, this data shows that it is necessary to study in depth the causes of the N-gain values for all the topics medium effective.

3.5. Discussion
Preliminary activities carried out in learning by means of, among others, lecturers ensure that each student has real analytical teaching materials, and lecturers write topics about metric spaces and ask students to read the preview section on teaching materials to ensure that students know the topics, the scope of the material to be studied, and learning objectives to be achieved by them. By asking students to read the question section and making other questions at least 2 questions that are relevant to the learning objectives, this will help students learn in reference to the achievement of learning objectives. Real analysis learning with the PQ4R strategy, through preview and question activities allows students to have self-planning on learning real analysis.

Learning real analysis with the PQ4R strategy, through read and reflect activities allows students to monitor themselves on learning real analysis. In the core activity the lecturer asks students to read the read section on teaching materials and discuss the material with group members. Students also discuss the material with the group through the examples given in the reflect section. Students with their groups then try to do the exercises contained in the reflect section on teaching materials as a means of monitoring themselves and their understanding.

The final learning activity is carried out by the lecturer by asking students to read the recite part of the teaching material. In the recite section students will discuss the essence of the material and answer the questions contained in the questions and questions that they make themselves. Students are also asked to read the review section on teaching materials, where students will do a re-examination of the answers they give both in the exercise section or in the question section. Through this recite and review activity students conduct self-evaluations in real analysis learning.

Learning topology concepts at the thirteenth meeting discussed the topic of limit points and close sets. Each topic is discussed one by one with the PQ4R strategy. By asking students to read the preview section of the teaching material, students can find out the topic of the subject to be studied and also be able to know the learning objectives that they must master. Of course, by doing so students know exactly what will be discussed and which will be addressed so that students will be able to plan and direct their learning activities. Through reading the question section on teaching materials and making questions related to learning objectives students will better understand the objectives to be achieved and how to achieve these objectives so that it will help their planning in participating in learning activities.

The core learning activity is carried out by asking students to read the read section on teaching materials about the definition of the limit point and also about the set of caps. Students in group discussions are asked to discuss the material presented and to better understand it students are also asked to read and discuss the examples given in the reflect section. Through reading and reflecting activities it is possible for students to monitor themselves at the learning point limit as well as the closing set. In the reflect section it is also possible for students to monitor their understanding by working on and discussing the exercises given.

The final learning activity of the limit points is also the closing set through reading the recite section, making conclusions related to the limit points as well as the closing set and trying to answer the questions contained in the question section then conducting a review of everything they have done allowing students to evaluate themselves in the learning of the limit points also the set is closed.

This research also getting support from [9] that In sum, it appears that self-regulated learners, who are active in their own learning motivationally, behaviorally, and metacognitively, are likely to achieve at high level. Then, this research is in line with the previous research.
4. Conclusions

4.1 Conclusion

1. The implementation of real analysis teaching materials with the PQ4R strategy in facilitating students' Self-regulated Learning (SRL) went well, with seen in the observation sheets of students and lecturers up to 88.54% and 85.94%. Implementation of real analysis learning with the PQ4R strategy, where through the preview and question activities students have self-planning, and through the read and reflect activities students monitor themselves, as well as through recite and review activities, students conduct self-evaluation. The level of student Self-regulated Learning (SRL) is classified as good, reaching 87%.

2. Real analysis teaching materials to facilitate effective Self-regulated Learning (SRL), with an N-Gain value of 0.43

4.2 Suggestions

The suggestion from this research is that it needs to be sharper analysis and pay attention to aspects of soft skills and hard skills.

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