Difficulties analysis of mathematics education students on the real analysis subject

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Abstract. Real analysis is one of the challenging subjects for most students. The difficulties of this subject include the understanding of theorems and its proof. To solve this problem, we do study with the aim to describe the difficulties of students in Mathematics Education of FKIP UIR in Real Analysis Course. The study was conducted on the even semester for academic year 2016/2017. This research was qualitative research using a used descriptive method. The research population of this research was all students of FKIP-UIR in the 4th semester. Data collection techniques were test techniques, questionnaires, interviews, and observations. Data analysis was done by questionnaire analysis, interview sheet analysis, observation result analysis, and analysis of test result about Real Analysis. The domain results showed that the difficulties of experience by students in learning Real Analysis are: students are difficult to find the initial idea of the proof process; students still do not have the ability to think critically, logically, creatively, reasoning, and proper systematic; and students are difficult in expressing ideas into nonverbal Language. The implication of this study is to create an instrument namely book of Real Analysis, Work Sheet of Real Analysis or hand out of Real Analysis.

1. Introduction
Courses taken by students had been arranged so that the students did the learning process gradually from the lowest difficulty level to the highest difficulty level. One of all the subjects they had to go is Real Analysis course. Students obtained this course on the 4th semester, and the student must first consider the prerequisite courses that were Calculus and Number Theory. The courses are very relevance. Usually, the result obtained in the calculus and the Number Theory is directly proportional to the results obtained in the Real Analysis.

Course that is perceived to have indirect benefits is Real Analysis. Often students ask questions about what the benefits of studying this course. But before the students were asked about it, usually the lecturer gives a preliminary description of this course.

At the beginning of the meeting, the researcher attempted to give a preliminary questionnaire directly to the students taking the course of the Real Analysis and to the students who had taken this course. The results of the open-ended questionnaire show that most students do not like Real Analysis as they do not understand the material, they found the contents confusing and challenging (in term of connecting the theorems), complicated and difficult to understand. It also found that Real Analysis could train the use of sound logic, practice precision, and prudence, discover the origin of a concept, promote good reasoning skills and collaborative learning together, train patience, assist the next course, as well as improve the analysis, critical and systematic thinking skills. Furthermore, the results
also reveals that students had difficulty in understanding the material, remembering the theorem and relating theorems, proving indirectly, finding the initial idea to prove, analyzing the theorem, being concentrated, providing good reasoning, being confused in choosing the theorems to be used, generating critical thinking patterns, and using logic (4). Some students who are afraid of learning Real Analysis will answer the materials of this course are difficult.

The results of these initial interviews in line with research conducted by Darmadi [1] if students began to have trouble learning Real Analysis since the beginning of the meeting. Darmadi [2] said that "almost all (99%) students find the difficulties in learning Real Analysis. The difficulties of learning Real Analysis according to the students are due to the material and the way of presentation, and the difficulties of the students start from understanding the concept that starts from the formal definition, the lack of the references or perhaps laziness of students".

Another thing was also expressed by Darmadi [3] namely "students become afraid to advance due to lack of confidence. It also causes the students to become passive in following the learning, including in learning the formal definition given".

The Real Analysis course is closely related to previous courses of Calculus and Number Theory. For the basic subjects that have been studied in the previous course, lecturers should no longer explain in detail to the students but can apply them directly. However, this can't be done because the understanding of the concept of the previous course is also not good. Therefore, students become confused, hesitant, and not confident in conducting the process of proof in this real analysis course. This also affects the low outcomes of students in the Real Analysis course.

Students had difficulties in doing the proof, though the proofing process is something that essential in this Real Analysis course. Knuth [4] says that "proof acts as: (1) to motivate that a statement is true, (2) to explain why a statement is true; (3) to communicate mathematical knowledge; (4) create new mathematics; (5) systematize the statement into an axiomatic system".

Some research results show that students are challenging to construct evidence even if the evidence is simple or routine though. The results include the introduction of proof [5], real analysis [6] and, abstract algebra [7]. Students generally do not specify what is stated in a proof [8] and the student can’t determine whether a proof is valid or not.

This problem had been detected for an extended period of times by researchers; even researchers had tried to apply a learning strategy that purposes to stimulate problem-solving skills and critical thinking in the real analysis. However, the results showed that there is no influence between the applied strategy of metacognitive, the problem-solving ability and critical thinking of the students. Therefore, researchers are interested in exploring the problems or difficulties experienced by students in studying Real Analysis courses.

2. Method
This research type was qualitative research with descriptive method. The population in this study were all students of Mathematics Education Universitas Islam Riau on 4th-semester year academic 2016/2017, while the number of samples studied was 55 students of 4th semester, consist of two classes. Sample selection technique used was purposive sampling. Purposive sampling is a technique for determining samples with specific considerations. The researcher's consideration is because we teach real analysis in 2 classes so we could quickly be taking the data. Furthermore, the problem designed on the test can also be adjusted with the learning materials that have been given.

The research variables used in this study is one independent variable that is the difficulty of the student in Mathematics Education Universitas Islam Riau on Real Analysis course. Instruments and techniques of data collection used were (1) Sheet Questionnaire and questionnaire; (2) interview sheets and interviews; (3) observation and observation sheets; (4) test sheets and tests of Real Analysis courses. Data analysis techniques used were: (1) questionnaire data analysis; (2) data analysis of interview result; (3) observation data analysis; (4) data analysis of real test result.

After distributed the questionnaire to the students who were the research samples, the questionnaire data were reviewed and grouped according to the relevant answers. The result of the questionnaire was
then described to be interpreted and drawn a conclusion related to the difficulties experienced by students in studying Real Analysis.

Interviews were conducted after we obtained the results of the real analysis test. This activity aimed to get in-depth information from the questionnaire data and to gather information about the causes of the difficulties and mistakes made by students. Because this interview aims to obtain detailed data about the causes of students making errors, then we selected the students who made many mistakes in the test results. After collecting data from the interview, the data was analyzed descriptively.

3. Result and discussions

3.1. The result of questionnaire analysis

The provided questionnaire is an open questionnaire to get a lot of information about student difficulties in studying Real Analysis. The questionnaires given to the students consist of 23 questions, and then we ask the students to provide reasoning based on the answers given. The result of the questionnaire of student difficulty in studying Real Analysis would be described for each question included: Based on the description of the result in the questionnaire that had been described, the following conclusions were obtained: (1) Students admitted having difficulty in finding the initial idea of the proof process; (2) Students still did not have the ability to think critically, logically, creatively, reasoning, and systematic good; (3) Students easily give up, lack of confidence, lack of care, and less ability to socialize with a heterogeneous group of peers; (4) Students felt difficulty in conducting direct and indirect evidence in determining what type of proof to use; (5) Students perceived difficulty in expressing ideas in nonverbal Language; (6) Do not remember/do not understand the previous theorem; (7) Students did not have a good understanding of the prerequisite materials; (8) Prove that it will prove or substitute the numbers into the proof of the theorem; (9) Students just memorized the theorem without understand it; (10) Difficulties in relating definitions and theorems to the given problem; (11) The lack of a source book to support the learning process.

3.2. The analysis of interview results

The analysis of the interview results is based on the interview sheets designed, but for some students, there may be addition or subtraction of questions according to the answers given by the students to the previous question. The interview was conducted with 19 students. Here are the results obtained through interview by researchers to students, namely: (1) Most of students found the difficulties to explain the existing in the book, still need additional explanation from friends or lecturers; (2) It is true that the indirect proof is difficult for the students; (3) Difficulty in composing words in writing evidence; (4) Material that is deemed difficult is the material after middle semester because theorem is not mentioned in definition or theorem to be used; (5) It is difficult to predict the direction of problem-solving; (6) Fear to try to resolve even more if there is a wrong step, it will be confused for the next step.

3.3. The analysis of observation results

The observation sheets were aimed to observe the activities undertaken by students and lecturers during the real analysis process of learning takes place. The following will be described as the results of observations when learning Real Analysis, namely: (1) The learning process takes place both in the sense of smooth, safe, comfortable, not tense, relaxed, and interspersed with humor; (2) There is a process of cooperation that occurs between group members; (3) There is also communication between lecturers and students; (4) The lecturer gives the student opportunity to discuss the proof with the group mates, to be discussed together at the end of the meeting; (5) Students are active to try to write their answers in front of the class; (6) The lecturer never demanded that the student should prove it correctly, but only asked the student to manipulate the idea. However, it appears that some students are afraid to write their answers to the front of the class; (7) each student has at least one reference
book; (8) Lecturers provide keywords that can lead the students in conducting the proof; (9) there is one student who does not communicate with his or her peers but the student points on himself to present the answer in front of the class; (10) Students look enthusiastic in learning as indicated by students frequently communicating with the lecturer asking if there are constraints in the settlement; (11) There are some students who have note from senior students which is helpful in the proofing process; (12) Some students are confused during the learning process as indicated by their inactivity in writing in notebooks, discussions with peers, and not willing to write the answer in front of the class.

Based on the description of research results obtained data about the difficulties experienced by students in studying Real Analysis. The difficulties are supported by data on the results of the questionnaire, the interview sheet, and the participant's observation. Some of the core difficulties are that students have difficulties finding the initial idea of proof, difficulty in indirect proof, and difficult to express ideas nonverbally. For other difficulties can be seen from the previous explanation.

The difficulty of expressing ideas is nonverbal languages also a difficulty in learning Real Analysis. Students also have difficulty in choosing the right words to make the introduction or linking words between one process and another. For example, students are still difficult to distinguish the use of words if, suppose, select, given, and take. Students are also not accustomed to using such connecting words so, then, therefore, accordingly, by means of use, because of, and consequently. Students are accustomed to the direct process to the point. While in Real Analysis, each step should be described in detail, clearly, systematically, and there is a basis for ensuring that step. Sometimes students also have ideas, but it is difficult to transfer their ideas into written language, so it is difficult to explain them to their friends. The students should express the idea to the lecturers first, and then the lecturers help to write down the idea so that the other friends can understand. Students are also sometimes impatient with the systematic process that must be done, so some steps are passed.

The difficulties also happened to other students outside Mathematics Education Universitas Islam Riau. This is known from several previous studies. The difficulties faced are mostly the same. This suggests that to an excellent Real Analysis ability, students must be supported by excellent analytical skills so it can easily find the initial idea to be proven. The students' critical thinking ability is also low because students are unfamiliar to the given theorem, are experiencing difficulties and are confuse if conditions on the theorem are incomplete, or data is reduced, or even added. Less critical in responding to existing evidentiary evidence so as not to know the step is correct or not, is there a wrong step, not realized by the students.

The implication to develop learning instruments for the subject of Real Analysis using a specific strategy to help students in minimizing the difficulties. The instrument namely book of Real Analysis, Work Sheet of Real Analysis or hand out of Real Analysis.

4. Conclusions
The difficulties experienced by students in learning Real Analysis, namely: (1) Students find that it is challenging to find the initial idea of the proof process; (2) Students still do not have the ability to think critically, logically, creatively, reasoning, and systematic good; (3) Students are still easy to give up, lack of confidence, lack of care, and less able to socialize with a heterogeneous group of friends; (4) Difficulty in conducting indirect and indirect evidence in determining what type of proof to use; (5) Difficulty in expressing ideas into nonverbal Language; (6) Do not remember/do not understand the previous theorem; (7) Not having a good understanding of the prerequisite materials; (8) Prove that it will prove or substitute the numbers into the proof of the theorem; (9) Just memorize the theorem without understanding it; (10) Difficulties in relating definitions and theorems to the given problem; (11) The lack of a sourcebook to support the learning process.

Implication: to develop learning instruments for the subject of Real Analysis using a certain strategy to help students in minimizing the difficulties. The instrument namely book of Real Analysis, Work Sheet of Real Analysis or hand out of Real Analysis.
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**References**

[1] Darmadi 2011 Imajeri mahasiswa dalam pembelajaran analisis real (Studi kasus di IKIP PGRI Madiun) *Proc. FMIPA UNY*

[2] Darmadi 2008 Spektrum hasil belajar Analisis Real mahasiswa program studi pendidikan matematika IKIP PGRI Madiun tahun akademik 2008/2009 *Seminar Nasional UNY*

[3] Darmadi 2009 Pengembangan model pembelajaran Analisis Real berbasis teori David Tall Paper presented at Seminar Nasional Universitas Negeri Surabaya; Surabaya; 2009 Aug 8

[4] Sucipto L and Mauliddin M 2016 Analisis kesulitan belajar mahasiswa dalam memahami konsep bilangan real *Beta Jurnal Tadris Matematika* 9 197

[5] Moore R C 1994 Making the transition to formal proof *Educational Studies in Mathematics* 27 249

[6] Bills L and Tall D 1998 Operable definitions in advanced mathematics: The case of least upper bound *Proceedings of The Conference of The International Group for 111*

[7] Weber K 2001 Student difficulty in constructing proofs: The need for strategic knowledge *Educational Studies in Mathematics* 48 101

[8] Recio A M and Godino J D 2001 Institutional and personal meanings of proof *Educational Studies in Mathematics* 48 83