Effectiveness of problem-based learning to optimize student learning outcomes in regression analysis course

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Abstract. This study aims to determine the effectiveness of the implementation of Problem-Based Learning (PBL) model in optimizing student learning outcomes in the regression analysis course at Mathematics Department, Udayana University. The type of research used is action research, with a classroom action research design model. Sources of data in this study are students of the fourth semester who took a course of Regression Analysis. Data collection techniques are tests, interviews, and observations. Statistical analysis technique with analysis of variance is used to test student scores on the three cycles performed. The action procedure is designed in three cycles, with stages of planning, implementation, observation and reflection. The results showed that descriptively the average of student learning outcomes in cycle I = 54.15; Cycle II = 75.25; and cycles III = 90.15 which means an increase in students' understanding and reduced misconceptions that occur in using regression analysis. Further analysis using analysis of variance obtained F count = 34.76 with P value = 0.000 indicates the null hypothesis is rejected, it's means that the three cycles have different effects on student learning outcomes, with a tendency to increase students' ability at every stage of the cycle.

1. Introduction
The learning process is the process of interaction of learners with educators and learning resources in a learning environment. In order for the learning process to make changes to the students in the four domains, namely the cognitive, affective, psychomotor, and cooperative, the quality standards of the learning process in each program are required. In addition, to meet the competence of graduates, the standard of assessment is required at every stage of the learning process to achieve the targeted competencies.

This Regression Analysis course is a compulsory subject for mathematics students who take an interest in statistics. Regression Analysis course discusses the relationship between response variables with predictor variables or explanatory variables. In linear regression analysis, the response variable is required to have a minimum interval measurement scale, while the explanatory variables can be either quantitative or qualitative data. Regression analysis is widely used in both exact and non-exact research. Research in pure sciences such as biology, chemistry, physics, as well as applied sciences such as research in agriculture, animal husbandry and other fields. In non-exact research, regression analysis is widely used in economic and social studies.

Regression analysis in its application, there are still many inappropriate/improper application in using regression analysis by researchers. One of the misuse of linear regression analysis is often done
on a scale of measurement of response variables that are not scaled intervals or ratios. As explained by Indriantoro [1], gives an example to the accounting student's thesis that examines the factors that affect customer satisfaction. Customer satisfaction is a response variable measured by Likert scale. Likert scale is the process of scoring is done by making the classification and categories of answers to questions on the questionnaire according to the responses of respondents. The respondent answered the question on the questionnaire by cross-marking (x) on the answer provided with the five available possibilities. Scores given on each question are: 1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree. It is clear that the scale of measurement of response variables here does not meet the proper requirements if linear regression analysis is used.

Other mistakes that are also often performed in research using regression analysis are: (1) Significant on testing hypotheses simultaneously does not indicate that all explanatory variables are significant; (2) The value of coefficient of determination ($R^2$) is not a measure that the regression model has been obtained is good, because the addition of more explanatory variables will surely increase the value of the coefficient of determination. So a better measure is the corrected coefficient of determination that is the coefficient of determination that has been corrected by the degrees of freedom of explanatory variables; (3) Corrected coefficient of determination ($R^2$) obtained less than 50% means that the model obtained must be improved, one of them by adding non linear factor; and (4) The need to ensure that the data has met the assumptions required in the linear regression analysis namely: linear relationship, multivariate normality, no or little multicollinearity, no auto-correlation, and homoscedasticity.

The real condition in the Mathematics Department, Udayana University shows that the achievement of student learning outcomes for regression analysis course in the last three years shows the students' learning achievement which is not improved. Students' learning outcomes in this course range from 65.00 to 75.00. Based on the evaluation of the learning process conducted by the lecturer of this subject course and the Quality Assurance Team of the department, it is found that the low of student learning result is caused by the misconception experienced by the student during the interpretation of data analysis and misconception on diagnosis assumptions required in linear regression analysis.

Starting from the above fact and referring from the research cases which is misuse of linear regression analysis, as well as the importance of regression analysis understood by all fields of science, the determination of the appropriate method of learning process is very important to do. This is an effort to optimize the learning process and improve student learning outcomes in this course in particular, and improve the quality and GPA of graduates in general from quality learning process.

One of the methods that can be applied to optimize the learning process that leads to improving student learning outcomes is to implement Problem-based Learning (PBL) combined with the support of e-learning media. Utilization of e-learning media in this research is intended to provide easy access of teaching materials to students of Mathematics Department who take courses regression analysis as well as for general users outside Mathematics Department students who need regression analysis for analysis of research data in the framework of completion of final project, as well as the completion of other structured tasks within Udayana University and the wider environment.

Problem-based learning is not just a teaching method but also a method of thinking, because in problem-based learning can use other methods starting with finding data to draw conclusions[2]. The problem-based learning method is obviously trying to guide students to be able to think logically, to find cause and effect, and find the key to solving the problem and summarize it as an expected answer. Educating students to want to use their own minds and not just to accept something from others is a way that should be developed in the updating and refinement of education in general and teaching methods in particular in college.

Based on some of the above learning problems, as well as to prove scientifically supported by empirical data about implementation of problems-based learning, especially related to the optimization of learning processes that can maximize students learning outcomes, then need to be studied and tested empirically whether the PBL model with the support of e-learning media that will be applied
effectively used to optimize the learning process and student learning outcomes in the course of Regression Analysis?

Based on the orientation about the effectiveness of the use of PBL model in an effort to optimize the learning process and student learning outcomes in the course of Regression Analysis, can be identified various research questions: what are the factors affecting the mastery of the concepts of regression analysis in students?; how misconceptions experienced by students in regression analysis courses?; what are the factors that influence the use of PBL model in the learning process?; how effective the application of this PBL in minimizing student misconception?; how is the influence of using PBL model on the mastery of the concepts of regression analysis? The problem of this research is focused on optimizing the learning process to improve student learning outcomes, with the aim of this research is to know the effectiveness of the implementation of Problem-Based Learning (PBL) model in optimizing the students' learning outcomes in the regression analysis course at Mathematics Department, Udayana University.

Problem-based learning model not just a teaching method but also a method of thinking, because in problem-based learning can use other model starting with finding data to draw conclusions [2]. Nasution [3] states that problem solving is a learning method that requires students to find the answer (discovery) without special help. By solving the problem students find new rules that are higher in degree even though he may not be able to formulate them verbally. Based on some opinions above can be drawn a sense that the problem-based learning model model is a way of teaching that provides opportunities for students to on their own initiative is able to do analysis and synthesis of the problems faced so obtained the solution.

2. Research methods

The research design used is Classroom Action Research. Classroom action research is a research conducted by teachers in their own classes through self-reflection, with the aim of improving teacher performance so that student learning outcomes are further improved[4]. According Arikunto[5], classroom action research is a reflection of learning activities in the form of an action, which deliberately appear and occur in a class together. Classroom Action Research by Kemmis & McTaggrat (Arends [6]), provides limits on implementation in the stages of planning, action, observation/evaluation, and reflection stage. Based on the aforementioned opinions it can be concluded that the meaning of classroom action research is a corrective action by practitioners to improve the tasks and conditions of learning.

This research is conducted in Mathematics Department, Udayana University, with consideration of Regression Analysis subject is compulsory subject of statistics interest field. Therefore, learning in Regression Analysis courses needs to be made more interactive, innovative, and IT-based, so that the misconceptions experienced by students to be reduced. The whole research was conducted for six months, while the implementation of giving treatment in the form of problem-based learning model with e-learning assistant, was done for four months.

Data collected to evaluate the implementation of the learning process are: (1) The result of the student's work in doing the test questions given by the lecturer of the subjects; (2) The result of the student's performance in doing regression analysis, especially the existing cases of misconceptions; (3) The results of interviews with students in accordance with the development of conceptual understanding; (4) Observations during the learning process; and (5) Evaluation results during the learning process. The subject of this research is the fourth semester students who take the regression analysis course at Mathematics Department, Udayana University, in the even semester of 2016/2017.

Data collection techniques in this study were conducted through tests, interviews, and observations. The test is done to see the conception of students about the concept of simple linear regression analysis, which is done before given the learning and to know the change of student conception after following the learning. Tests on student performance results in completing tasks on research cases using regression analysis. This test aims to determine the ability of students to analyse the data and interpret the results of analysis appropriately and correctly.
The results of the students' work on each test or task given will be explored through interviews, to gain a deeper picture of the progress of understanding or the difficulties students experience in learning, expressing their ideas, and feelings. Observation is used to document/record events during the learning activities. The observations contain descriptions relating to teacher activity, student activities, and situations and conditions during the lesson.

Data obtained from test results on learning with Problem-based Learning (PBL) model was analysed by statistical technique with variance analysis. Statistical analysis technique with variance analysis is used to test student scores on the three cycles performed. The hypotheses tested were:

- \( H_0 \): \( \mu_1 = \mu_2 = \mu_3 = 0 \) (the implementation of PBL model is not effective in improving student learning outcomes in the regression analysis course at Mathematics Department, Udayana University)
- \( H_1 \): At least one \( \mu \) is not equal to zero (the implementation of PBL model is effective in improving student learning outcomes in Regression Analysis course at Mathematics Department, Udayana University)

The calculated statistic used to test the above hypothesis is the F test statistic. \( H_0 \) will be accepted if the value of \( F_{\text{count}} \) is greater than the value of \( F \) table with \( \alpha = 0.05 \) and \( H_0 \) is rejected otherwise [7].

The procedure of action in this study begins with an initial reflection. At this stage, the test is given and followed by interviews to the students, with the aim of obtaining a clear picture of student conception in analyzing data using regression analysis. Then summarized the data obtained as a basis for establishing and formulating the design of learning. The next step is the implementation of classroom action research designed in three cycles. Each cycle includes stages: planning, implementation of the action, observation, and reflection.

3. Results and discussion

3.1. Implementation of action research in cycles i, ii, and iii

The result of the research shows that at the beginning of the action, most of the students had problems with the lack of mastery of the application concept of linear regression analysis that was below the value of 65 of the Minimum Criterion Score. After the action is given through the three cycles of action research, the results obtained descriptively the average of student learning outcomes in cycle I = 54.15; Cycle II = 75.25; and cycles I-II = 90.15, which means an increase in students' understanding, indirectly also activities on the third cycle in addition to applying regression analysis, also improve misconceptions that occur in using regression analysis. The average increase from cycle I to cycle III shows that there has been an increase in the ability of students in solving cases that use regression analysis.

The increase of conceptual mastery between cycle I and cycle II by average 65.74%, between cycle II and cycle III the average increase in concept mastery percentage is 22.42% and after given action in cycle III there is an increase of conceptual mastery of analysis linear regression application by average 93.95% when compared with cycle I. Thus the average percentage increase in student mastery of the material provided between the action cycle I and after the action cycle III has increased significantly by average 93.95%. Descriptively student learning outcomes on the material given with PBL showed results that increased at the end of cycle III compared with the previous cycle.

Implementation of PBL model that is done well, earnestly, and professionally will be able to increase the student's mastery of the material concept given in accordance with expectations. Only with the condition of students who have been motivated to engage in group discussion activities in solving problems given by lecturers will get good results as well as will impact on the results achieved. In addition to good preparation by lecturers in facilitating learning, as well as support from e-learning media also contribute to the learning outcomes achieved by students. Provision of on-line learning objects in the form of text, images/photos, audio, video/animation, simulation, assessment (quiz/task/self-test/formative test/summative-test) provided through e-learning media strongly support students in accessing learning resources.
In this research, there is no further study about how this e-learning media contributes to the improvement of student learning outcomes. The use of e-learning facilities in this study solely serves to provide easy access to learning resources to students. Further studies on the impact and effectiveness of using e-learning in assisting learning need to be further investigated by other researchers.

Observations during the learning process can be noted that during the problem-solving activities in cycle I, it appears that some students seem to be good enough in cooperation, participation, initiative, thoroughness and courage to express their opinions, are in sufficient category compared to before cycle I. These aspects still need to be improved in the next cycle. In this first cycle students are given research cases using the correct regression analysis on terms and assumptions, with the results of the analysis is satisfactory. In this case the students have not found any problems that may be contained in the regression analysis.

The result of observation after the learning process of cycle II, student (group) has been improved from enough category to good category, that is cooperation aspect, participation in group, and courage to express opinion, while the aspect of accuracy and initiative remain in enough category. Based on observations of results in this cycle II, the emphasis needs to be given more on both aspects that have not increased. The initiative aspect is very important, besides the aspect of accuracy is needed in solving linear regression analysis problem. Troubleshooting is not done carefully will result in problem-solving that is not in line with expectations. This needs to be emphasized, because in this second cycle students begin to discuss the case of research which is wrong in the application of regression analysis and also misconception in analyzing it. The mistakes made by researchers, which many found such as the measurement scale of research variables are not appropriate.

The result of observation after cycle III is given, the whole aspect reaches the good category. Students have done their job well, cooperate in groups, participate actively in group, be honest, dare to express their opinion, and have increased their accuracy in solving problems and more initiative compared with learning in previous cycle. In the final stages of this cycle, the research cases discussed are more complex, because in addition to the students’ mistakes and misconceptions in applying regression analysis, students are also emphasized on the interpretation of regression analysis results.

The results of observation during the learning process with PBL indicate that the PBL applied in this course can improve aspects of doing the task well, cooperate in groups, participate actively in the group, honest, courage to express opinions, improve student’s accuracy in solving problems, and increase the initiative students in solving problems.

The findings of this study are in line with Graaff & Kolmos [8] explained that PBL education builds on the students' background, expectations, and interests. Further explained that students to be motivated to work much harder with the PBL model than with traditional teaching methods. With PBL students spend more time on their studies and more participating compared with traditional models. The authors argues that the PBL models appear to inspire a higher degree of involvement in study activities and, consequently, a higher level of complex comprehension. A possible drawback is the risk of gaps in specific knowledge areas. Therefore, it is crucial that the students in a PBL curriculum become lifelong learners who have learned to take responsibility for their own learning process.

The results of Inel & Balim [9] explain the same thing, that the PBL method is results in positive development in students'academic achievement. PBL helps students learn by discussing their existing knowledge and skills. Further explained that PBL positively affects concept learning. This positive change is arguably caused by the fact that they are found in group environments to construct their knowledge.

3.2. Effectiveness of implementation of Problem-Based Learning Model

Description of student learning outcomes with the application of problem-based learning (PBL) model on the mastery of the application concept of linear regression analysis, on three cycles of action research conducted obtained results as in Table 1.
Table 1. Description of Student Learning Outcomes in Cycle I, II, and III

| Cycle | N  | Mean   | Std. Deviation | Minimum | Maximum |
|-------|----|--------|----------------|---------|---------|
| 1     | 20 | 52.55  | 22.01070       | 27.00   | 97.00   |
| 2     | 20 | 73.05  | 11.50229       | 50.00   | 98.00   |
| 3     | 20 | 77.85  | 1.46089        | 87.00   | 92.00   |

Sources: Primary data (2017)

The mean value of the three cycles is obtained that the mean of cycle III is the highest, and the mean of cycle I is the smallest, with the least diversity level in the third cycle (standard deviation = 1.46089). The standard deviation value shows how varied the student evaluation results are. The greater the standard deviation value, the more varied the evaluation value of the students. In this study it is expected that the evaluation value of students has a small variance, because it implies the ability of students who are almost the same. While the increasing mean indices from cycle I to cycle III indicate that the average student ability increases in each cycle. The minimum value from cycle I to cycle II is 27, 50, 87, based on this value is seen that the student's ability is increasing. However, based on the maximum value of 97, 98, 92, the tendency is not visible, this may be because there are no students who dominate to get the highest score.

The next analysis is to study the PBL model that is applied effectively to improve student learning outcomes on subject of linear regression analysis, the hypothesis tested using analysis of variance.

Table 2. Results of analysis of variance of student learning outcomes

|                      | Sum of Squares | Df | Mean Square | F       | Sig.  |
|----------------------|----------------|----|-------------|---------|-------|
| Between Groups       | 14340.400      | 2  | 7170.200    | 34.756  | .000  |
| Within Groups        | 11759.250      | 57 | 206.303     |         |       |
| Total                | 26099.650      | 59 |             |         |       |

Sources: Primary data (2017)

The result of variance analysis in Table 2 obtained the value of $F = 34.756$ with the significance value of 0.000. The value of this significance compared with the significance value of $\alpha = 0.05$ is smaller, it indicates that $H_0$ is rejected or $H_1$ accepted, meaning that there are differences in learning outcomes in the application of PBL model assisted by e-learning applied into three cycles.

Table 3. Tukey Multiple Comparison Test Results

| (I) cycle | (J) cycle | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval |
|-----------|-----------|-----------------------|------------|------|-------------------------|
|           |           | Lower Bound           |            |      | Upper Bound              |
| 1         | 2         | -22.70000*            | 4.54205    | .000 | -33.6301 - 11.7699       |
| 3         | 1         | -37.60000*            | 4.54205    | .000 | -48.5301 - 26.6699       |
| 2         | 1         | 22.70000*             | 4.54205    | .000 | 11.7699 - 33.6301        |

*. The mean difference is significant at the 0.05 level.

Which cycle is different? then continued with the Tukey multiple comparison test, the results are presented in Table 3. Tukey test results show that in cycle I compared with cycle II and cycle III obtained significant value 0.000, this significance value is smaller than the significance level that has been determined that is 0.05, this means there are differences in student learning outcomes in cycle I.
with cycle II and cycle III. Tukey test results between cycle II with cycle III also resulted in a decision that states there are differences in student learning outcomes. Based on Tukey test results can generally be stated that with the implementation of PBL model applied in three cycles of classroom action research effectively can improve student learning outcomes in the course of Regression Analysis.

The findings of this study show that results the application of PBL is effective in improving student learning outcomes in the course of Regression Analysis optimally. Inel & Balim [9] explains that during the process of problem-based learning, students identify the information they lack, make up for these shortcomings in their knowledge about a subject, share information in group environment, and have the opportunity to construct their knowledge in social and cognitive terms. Authors argued that the problem-based learning method can be used to ensure better construction in students' minds for the concepts in science and technology course.

Research on the effectiveness of the application of this PBL has been done by many previous researchers. A number of studies show the pros and cons of the effectiveness of PBL. Strobel & van Barneveld [10] indicated that PBL is superior when it comes to long-term retention, skill development and satisfaction of students and teachers, while traditional approaches are more effective for short-term retention as measured by standardized board exams. Furthermore Kyeong [11] explains that although the background of learners might affect the effectiveness of PBL, the roles of the teacher in designing the problem-based scenarios remain the key to the successfulness of PBL. Author explained that in mathematical study, teacher's instructional ability is critical to engage students in gathering information and apply their knowledge in their respective fields. Simons, Klein, & Brush [12] explains that in general, the PBL process is anchored by a complex, ill-structured problem, the students proceed through a variety of activities to frame their understanding of the problem, access resources, increase understanding, and recommend solutions.

From another perspective, Ribeiro [13] in his article on the pros and cons of problem-based learning from the teacher's standpoint explains that PBL also seems to distribute teaching workload more evenly throughout the semester than traditional methods do. This hinders routinisation and constrains teachers' autonomy. On the other hand PBL appears to foster the teacher’s development of his teaching knowledge base, especially regarding the knowledge of the students, their reasoning modes and interests.

4. Conclusions and recommendations

4.1. Conclusions

After given the action in the form of Problem-based Learning (PBL) model with assisted E-learning, an increase in the average percentage of mastery of the concept between cycles I and II of 24.92%, in the second and third cycle of 16.63% and after the action is given in cycle III there is an increase in the average percentage of mastery of the concept of linear regression analysis of 39.91% compared to cycle I. So the average percentage increase in student mastery of the material given between the action cycle I and after the action cycle III average of 39.91%.

The result of the analysis of variance, shows that there is a difference of value on the implementation of PBL model that is applied into three cycles. Further test with Tukey multiple comparison test, the result of the three cycles gives significant difference of results, so it can be stated that with the implementation of PBL model applied in three cycles of classroom action research, effectively can improve student learning outcomes in Regression Analysis course.

Implementation of PBL model that is done well, earnestly, and professionally will be able to increase student's mastery of the concept of the given material. Only with the condition of students who have been motivated to engage in group discussion activities in solving problems given by lecturers will get good results as well, will also impact on the results achieved. In addition to good preparation by lecturers in facilitating learning, as well as support from E-learning media also contribute to the learning outcomes achieved by students. Provision of on-line learning objects in the
form of text, images/photos, audio, video/animation, simulation, assessment (quiz/task/self-test/formative test/sumative test) provided through e-learning media strongly supports students in accessing learning resources.

4.2. Recommendations
In this research, there is no assessment of the extent to which this e-learning media contributes to the improvement of student learning outcomes. The use of e-learning facilities in this study solely serves to provide easy access to learning resources to students. Further studies on the impact and effectiveness of using e-learning in assisting learning need to be further investigated by other researchers.

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