Analysing the problem-solving ability through the Problem-Based Learning model on the subject statistics in the grade VIIIB of Kanisius junior high school Kalasan

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Abstract. Through the conduct of the study, the researcher would like to: (1) describe the learning stages for the subject Statistics through the implementation of the problem-based learning model; and (2) identify the problem-solving skills of the Grade VIIIB students in the Kanisius Junior High School Kalasan for the subject Statistics. As a result, the study belonged to the design research. During the conduct of the study, the subjects who have been involved were the students of Grade VIIIB Kanisius Junior High School Kalasan and the study itself took place from March until April 2019. Then, the data gathering method that had been implemented was the documentation record and the learning test administration while the instrument that had been implemented was the field note and learning test results. After the data had been gathered, the subsequent stage was data reduction, data presentation and conclusion drawing or verification. In overall, the results of the study show that: (1) the learning stages in the problem-based learning model for the subject Statistics with two meetings have already been in accordance to the design; and (2) the problem-solving skills among the students have been various. In the first subject, four out of five indicators of mathematical problem-solving skills by NCTM have been met. On the contrary, in the second subject the five indicators of mathematical problem-solving skills according to NCTM have been met.

1. Introduction
Based on the results of the preliminary observation toward the students of Grade VIIIB Kanisius Junior High School Kalasan, the researcher has concluded that the students have low capacity in solving the mathematical problems that are related to the real world and have not been accustomed to put their ideas into both the oral and the written form. In addition, the students also have difficulties in defining the problems, selecting the stages for finding the appropriate solutions and defining the pattern that might be implemented. On the contrary, the students favour the number-based test items more because they might directly identify the problems without having to interpret the problems first.

In the learning process of Mathematics, there are several skills that the students should possess and one of these skills are the problem-solving skill. Mathematical problem-solving skills are ultimately important for the students. The importance of the mathematical problem-solving skills has been asserted in NCTM [1] through the statement that problem-solving activities are an integral part of the mathematical learning process. As a result, problem-solving skills should not be separated from the mathematical learning process. Not to mention, problem-solving skills themselves are the objective of the learning process in Mathematics.
Departing from the above situation, the factors behind the students’ difficulties in solving the mathematical problems might come from either the students or the teachers. The factors from the students are: (1) the students have been accustomed to learning by means of memorization; and (2) the student display lack of learning interest and motivation. On the contrary, the factor from the teachers is that the teachers have implemented the learning strategies that do not sufficiently develop the mathematical problem-solving skills. Most of the teachers practice the conventional learning process, implement the less challenging tasks and problems so that the students’ concept understanding is not sufficiently explored and provide less opportunities for the students to communicate the ideas for their problem-solving activities.

In relation to the problem-solving skills, Hesti & Ririn [2] state that in order to improve the students’ problem-solving skills a support in the form of appropriate learning method should be afforded. One of the learning methods that might fit into the needs of the support is the problem-based learning method or also known as the problem-based learning model. The results of a study by Yuli [3] show that the problem-based learning model offers a learning form that involves the students actively into the learning process. Problem-based learning model is a learning model that has orientation toward the authentic problems so that the students might design their own knowledge and develop higher skills. The addition of the structured task provision will support the learning process of the problem-based learning model. Through the structured task, the students’ learning activities will improve. The students will attain their own knowledge directly through their own learning process. Each student will have the opportunity to gain their own knowledge. Thereby, the problem-based learning model with the structured task provision might develop the students’ mathematical problem-solving skills.

Returning to the case in the study, this case shows that the mathematical learning process in the given classroom has not implemented a learning model that might assist the students to develop their problem-solving skills. Therefore, the mathematical learning process should be improved in order that the students might develop their mathematical problem-solving skills. The objective of pursuing the improvement is to develop and to improve the students’ mathematical problem-solving skills so that the students will be able to implement these skills in the context of their daily life. Then, one of the efforts that might be pursued for improving the students’ mathematical problem-solving skills is performing innovation on the learning model that has been implemented. In relation to the statement, and as having been explained previously, one of the learning models that the teachers might implement for improving the students’ mathematical problem-solving skills is the problem-based learning model.

According to Trianto [4], problem-based learning model is a learning approach in which the students are faced by the authentic (real) problems under the expectation that they will be able to design their own knowledge, to develop their higher order thinking skills and inquiry, to be independent and to improve their self-confidence. The problem-based learning model consists of five main stages that proceed from the introduction of the problems to the students by the teacher until the presentation and the analysis of the learning results by the students. In brief, the five learning stages in the problem-based learning model might be consulted in Table 1 below.

| Phase                                                                 | Teacher Activity                                                                 |
|-----------------------------------------------------------------------|---------------------------------------------------------------------------------|
| Phase 1: Providing the problem orientation to the students             | The teacher discusses the learning objective, describes multiple logistic needs  |
| Phase 2: Organizing the students to conduct a research                 | that might be important and motivate students to be involved into the problem-   |
| Phase 3: Helping the students in their independent and collaborative   | solving activities.                                                             |
| investigation                                                         | The teacher helps the students to define and organization the learning          |
|                                                                        | assignments that might be related to their problem.                             |
|                                                                        | The teacher encourages the students to attain appropriate information, to        |
|                                                                        | perform experiment and to find solution.                                         |
Phase 4: Developing and presenting the students’ artefact and exhibit
The teacher helps the students to plan and prepare the artefacts (artworks) that might be relevant, such as report and model, and also helps the students to present the artefacts in front of other people.

Phase 5: Analysing and evaluating the problem-solving process
The teacher helps the students to perform reflection or evaluation toward their investigation and the process that they have performed.

Source: Richard I. Arends [5]

Then, departing from the overall elaboration, the researcher would like to conduct a study under the following title: “Analysing the Problem-Solving Skills through the Problem-Based Learning Model on the Subject Statistics in the Grade VIIIB of Kanisius Junior High School Kalasan.” Therefore, the problem formulations that will be proposed in the study are as follows:

a. How is the learning plan implemented in the Grade VIIIB Kanisius Junior High School Kalasan?

b. How is the students’ problem-solving skills in the case of Grade VIIIB Kanisius Junior High School Kalasan?

Through the conduct of the study, the researcher would like to: (a) describe the learning process by means of problem-based learning for the subject Statistics; and (b) to identify the problem-solving skills of the Grade VIIIB students in Kanisius Junior High School Kalasan.

2. Research Methods
Within the study, the researcher implemented the design research method. According to Gravemeijer & Cobb (in Prahmana R.C.I) [6] the three phases in the design researcher are design experiment preparation, design experiment and retrospective analysis. With regards to the phases, each of the phase in the study would be explained as follows:

2.1. First phase: Design Experiment Preparation
The first phase begun by clarifying the objectives that should be achieved by the students and proceeded to the definition of the preliminary points in the learning process. Then, the phase continued to the assumption of the local learning theory from the design that would be put into experiment. The local learning theory contained the assumption on the learning process sequence, the productive learning process, the desired classroom culture, the proactive role of the teachers within the learning process and the students’ thinking process within the learning activities. All of these aspects were summarized into the hypothetical learning trajectory (HLT).

2.2. Second phase: Design Experiment
The purpose of the design trial is to test and improve the predictions of learning theory that has been developed in the first phase and develop an understanding of how the design works. The objective of the second phase was to test and to improve the learning theory assumptions that had been developed in the first phase. In the same time, the objective of the second phase was also to develop an understanding about how the design would work.

2.3. Third phase: retrospective analysis
The objective of the third phase was to develop the local learning theory. The activities that had been conducted in the third phase were related to analysing the data that had been gathered.

The study took place in Kanisius Kalasan Junior High School from March until April 2019. The subjects that had been involved in the study were 30 students from the Grade VIIIB of Kanisius Junior High School Kalasan. Then, the objects of the study were the HLT and the problems that had been related to mean, median and modus. Furthermore, the data gathering methods that had been implemented in the study were written test, observation and documentation. Last but not the least, the data analysis technique that had been adopted referred to the theory of Salim [7] namely: (a) data reduction; (b) data display; and (c) conclusion drawing/verification.

3. Results and Discussion

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The study took place in two meetings. In the first meeting, the researcher discussed the subject Statistics, specifically the sub-chapter of Mean, and implemented the HLT design that had been prepared. These activities consisted of material delivery, discussion, question and answer session, presentation and material enrichment. On the other hand, in the second meeting the researcher repeated the previous learning materials in the learning process, namely Mean, but in the same time the students also learned the new materials namely Median and Modus. The learning activities in the second meeting were similar to those in the first meeting.

3.1. Design Test Preparation
In this phase, the researcher designed the learning model that would be implemented into the learning process of Statistics and the backbone of the design was the problem-based learning model. The development of the Hypothetical Learning Trajectory (HLT) in each learning activity was the most important part in designing the learning activities for the student. The learning design then served as the concept map that the students should go through during the learning process. The learning activities and the students’ thinking results were hypothesized in the HLT as well.

3.2. Design Experiments
The design experiment within the study proceeded through the following stages.

3.2.1. Directing the students’ orientation toward the problem. In this phase, the teachers provided the real problem to the students under the objective that the students would find the mean. The real problem that had been provided was as follows:

*The average score of the continuation Mathematic test from 11 students is 7.2. If the score of the continuation Mathematics test from Ramos is not included because he has admitted that he was cheating during the test, then the average score will be 7.0. Define the score of the continuation Mathematics test that Ramos has!*

The interaction between the teacher and the students during the explanation over the problems took place in the form of group discussion.

*Teacher: Okay, I have a problem that you should discuss. You will be assigned into a groupwork. Now, please pay attention to the problem. Is there anything that you do not understand?*

*Student: What is meant by median and modus on the problem 2 Sir?*

*Teacher: So, median is the central value after the data have been ordered. On the contrary, modus is the value that most frequently appears in the given data.*

3.2.2. Organizing the students to learn. In this phase, the students (along with the teachers – if necessary) started to plan their investigation toward the problem. The students were asked to identify the activities that they should perform and the knowledge that they should have in order to solve the problems. Then, the teachers assigned the students into several groups so that the students might cooperate from one to another within their group in order to find the answer from the problem that had been provided. The interaction between the teacher and the students during the learning organization might be consulted in the following conversation.

*Teacher: Based on what we have discussed at the beginning of the learning process, all of you will use the available information to solve the problem that has been provided. Then, please divide yourself into four groups.*

*Student: How should we divide the group, Sir?*

*Teacher: Please divide yourself into a group of six people. The group members might be the
friends who sit next to you or who sit behind you. After the groups have been assembled, please solve the problem that has been provided.

Student: Yes, Sir!

3.2.3. Guiding both the independent and the collaborative problem-solving activities. As the facilitator, the teacher observed the students by going from one group to another during the problem-solving activities.

![Image](image1)

**Figure 1.** The researcher guided the students to solve the problem that had been provided.

From the above picture, it is apparent that the teacher encouraged the students to calculate the score of an individual when the average score had been identified. The results of the group discussion might be consulted in the following conversation:

Teacher : Have you checked all of your answers?
Student 1 : Yes, Sir! I have.
Teacher : What have you learned about mean?
Student 1 : Looking for mean is summing all data values and dividing all data values with the data frequency.
Teacher : Then, how should we define the score of Ramos?
Student 1 : We sum 7.2 for 11 times and 7.0 for 10 times; then, we subtract the summation results in order to identify the score of Ramos.
Teacher : Do all group members understand this explanation?
Student 2 : I have not done that Sir.
Teacher : (Smiling) Those who have understood the solution might explain the solution to your friends who have not understood it.
Student 2 : All right Sir.

3.2.4. Result Presentation and Development. In this phase, the teacher appointed several groups to present the problem-solving result and to help the groups who had the difficulties over the problem. This activity was useful for identifying the students’ understanding and problem-solving result. During the presentation, there were several groups who had not understood the problem-solving sequence and therefore the teacher provided the opportunities for these groups to raise questions and provide feedback.

![Image](image2)

**Figure 2.** The students presented the results of their discussion.
In the presentation by Group 3, the problem that had been provided to the Group 3 was that the group had been asked to define the score of Ramos. Through the data that had been identified, it was found that the average score of 11 students (including Ramos) had been 7.2 but because Ramos cheated during the test the score of Ramos was not inputted. As a result, 10 students administered the test and the average score of 10 students was 7.0. In order to solve the problem, the first stage was adding the score 7.2 from the 11 students. Then, the second stage was adding the score 7.0 from the 10 students. Next, the third stage was looking for the gap in the summation of the score from the two data group. After the gap had been found, automatically the score of Ramos would be found as well. The interaction during the discussion process might be consulted in the following conversation:

**Teacher:** Okay, from the presentation is there any group who would like to share their opinion?
**Student:** Our group, Sir. We, Group 1, has concluded that the score of Ramos has been 9.2. In our opinion, the sequence performed by Group 3 is already correct but the process for attaining the mean score is incorrect.

**Teacher:** Because we have to find the score of Ramos, we should rely on the average score after the score of Ramos has been excluded. The average score after the score of Ramos has been excluded is equal to the total amount of the overall data subtracted by the score of Ramos (X11) divided by the number of data frequency (10). We can identify the score of Ramos by summing all data values and subtracting the data values with the average score. As a result, the score of Ramos is different from one to another but the concept that you have implemented is already correct. Now, for the next problem, is there any opinion?
**Student:** No, Sir.

Departing from the conversation, it might be concluded that the students had been able to solve problem by implementing the formula of median (mean).

3.2.5. **Problem-Solving Skills Analysis and Evaluation.** In this phase, the teacher should assist the students to analyse and evaluate the process and the results of investigation that they had undergone. Then, the teachers asked the students to reconstruct their thinking by means of question and answer session with regards to the problem: the score of the student that had been missing whereas the mean score of the overall students had been available. The interaction in this phase might be consulted in the following conversation:

**Teacher:** what have you learned today?
**Student1:** Calculating mean Sir.
**Teacher:** If the total score is 200 whereas the frequency is 10 then what will be the mean score?
**Student2:** The mean score is 20 Sir.
**Teacher:** Why do you think that the mean score is 20?
**Students:** I guess the mean score is 20 because the total score 200 is divided by the frequency 10 and thus the mean is 20.
Teacher: All right then. That will be all for today. For next week, we will proceed to median and modus. Let’s pray together.

3.3. Retrospective Analysis
In the second meeting, the researcher analysed the learning results that the students had attained. The analysis on the problem-solving skills of the students might be explained as follows.

The following data display the height of 10 students in Grade VIIIB Kanisius Junior High School Kalasan.

\[154\ 153\ 159\ 165\ 152\ 149\ 154\ 151\ 157\ 158\]

a. What is the mean score on the height of the students in Grade VIIIB Kanisius Junior High School Kalasan?

b. What is the median on the height of the students in Grade VIIIB Kanisius Junior High School Kalasan?

c. Define the height that is most frequently appeared in the Grade VIIIB!

In this problem, the researcher found several answers that had been various and interesting. The problem that had appeared was defining the mean, the median and the modus of the given data. Looking at the results of the students’ work, it was apparent that the students attained different results and progressed through less appropriate procedures.

With regards to the situation, the researcher sampled the answers from two subjects. The answer from the first subject might be consulted in the Figure 4 below.

Figure 4. The learning results of the first subject

The data that had been provided was the height of 10 students. In the data, the students were asked to define the mean, the median and the modus. The students looked for the mean by summing the overall data values and dividing the overall data values by the data frequency; thus, the mean score of the data was 155.2 cm. Then, in looking for the median, the students should draw the central value of the data; however, since the data frequency was in the even number the students should sum the two central values and divide the sum of the two central values by two. Then median that had been attained was 150.5 cm. Next, in looking for the modus the students should find the height with the highest frequency namely 154 cm.

Departing from the answers in Figure 4, in overall the first subject had shown the appropriate procedure because the first subject had been able to answer all questions and to draw conclusions. Unfortunately, the first subject’s answer for the question item number 2 was inappropriate. The reason was that the first subject did not organize the data in order. Consequently, they attained the incorrect results. The results of the identification toward the first subject’s answers based on the indicators of problem-solving skills according to NCTM were as follows:
1. The first subject had been able to identify the elements that had been found, the elements that should be investigated and the elements that should be sufficient. Departing from the results of the first subject’s work, the elements that had been found by the first subject were the height of the students and the frequency on the height of the students. Then, in order to solve the given problem, the first subject should sum all the data values and divide the overall data values by the data frequency.

2. The first subject had been able to formulate the mathematical problem or to design the mathematical model. Looking at the above results, it was apparent that the first subject had been able to formulate the mathematical model.

3. The first subject had not been able to implement the strategy for solving numerous problems (both the typical ones and the new ones) inside and outside Mathematics.

4. The first subject had been able to explain the results based on the origin of the problem. Within the above results, the students had been able to draw or define the conclusions from the problem that had been provided; as a result, the students’ response on the indicator had been sufficient.

5. The first subject might implement Mathematics usefully. Within the first subject’s results, it was apparent that the first subject had implemented the mathematical knowledge under their possession for solving the problems.

Based on the identification of the problem-solving process that had been provided, the first subject had already met the four indicators of problem-solving skills by NCTM.

On the contrary, different results had been found from the second subject. The data and the problem were still the same. The data that had been provided were the height of the 10 students, while the problem was that the second subject should look for the mean, the median and the modus from the given data. In order to find the mean, the second subject should sum all data values and divide the overall data values with the data frequency; the mean score of the given data was 155.2 cm. Then, the students should attain the median by drawing the central value of the data; since the data frequency was in the even number the students should sum the two central values and divide the sum of the two central values by two. Then median that had been attained was 154 cm. Next, the students should look for the modus of the data by identifying the data that had most frequently appeared namely 154 cm. The results of the second subject might be consulted in Figure 5 as follows.

![Figure 5](image-url)

**Figure 5.** The learning results of the second subject

From the results that had been displayed in Figure 5, it was apparent that in overall the second subject had understood the material and the core of the given problem. As a result, the second subject carefully responded to each test item under the structured procedures until the second subject had been able to draw the conclusions. The results of the identification toward the second subject’s answers based on the indicators of the problem-solving skills by NCTM were as follows:

1. The second subject had been able to identify the elements that had been found, the elements that should be investigated and the elements that should be sufficient. Departing from the results of the second subject’s work, the elements that had been found by the second subject were the total values
for height of the students (1552) and the frequency on the height of the students (10). Then, in order to solve the given problem, the first subject should sum all the data values and divide the overall data values by the data frequency.

2. The second subject had been able to formulate the mathematical problem or to design the mathematical model. Looking at the above results, it was apparent that the second subject had been able to structure the problem-solving process from the beginning until the end.

3. The second subject had been able to implement the strategy for solving numerous problems (both the typical ones and the new ones) inside and outside Mathematics. In relation to the above test item, the second subject had been able to identify the mean score, the median and the modus on the height of the students.

4. The second subject had been able to explain the results based on the origin of the problem. Within the above results, the students had been able to draw or define the conclusions from the problem that had been provided; as a result, the students’ response on the indicator had been sufficient.

5. The second subject might implement Mathematics usefully. Within the first subject’s results, it was apparent that the first subject had implemented the mathematical knowledge under their possession for solving the problems.

Based on the identification of the problem-solving process that had been provided, the second subject had already met the five indicators of problem-solving skills by NCTM.

4. Conclusion
Departing from the results of the study, the data processing activities and the data analysis with regards to the implementation of the problem-based learning model on the students of Grade VIIIIB Kanisius Junior High School Kalasan, the researcher would like to draw the following conclusions:

a. The design of the problem-based learning model in the study has been good and has been able to assist the students in solving the problems related to the subject of Statistics.

b. Based on the indicators of problem-solving skills by NCTM, the problem-solving skills of the students have not been maximum in relation to the identification of the mean, the median and the modus. However, several students have already met the intended indicators. The obstacle behind the students’ inability to identify the median is that the students have not organized the given data in order. The first subject, four out of five indicators of mathematical problem-solving skills by NCTM have been met. On the contrary, in the second subject the five indicators of mathematical problem-solving skills according to NCTM have been met. In the first subject, four out of five indicators of mathematical problem-solving skills by NCTM have been met. On the contrary, in the second subject the five indicators of mathematical problem-solving skills according to NCTM have been met.

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