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***Research paper***

# Problem Based Learning Method with GeoGebra in Mathematical Learning

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## Abstract

Research objective was to find effect of local culture-problem-based learning method application with used GeoGebra in mathematics learning for senior high school students. Type of this research was quasi-experiment research with post-test only group design. Research sample used three learning class that was chosen by purposive sampling method and was selected from senior high school in Sumatera Utara, Indonesia. Students in experiment-I class was taught with local culture-problem based learning used GeoGebra, students in experiment-II class was taught with problem-based learning and students in control class taught with conventional learning method. Data was analysed with descriptive and inferential through one way-ANAVA test then continued with Tuckey test if data had normal and homogenic distribution, if data had abnormal and/or heterogenic distribution then it was analysed with Kruskal-Wallis test and continued with Mann-Whitney U-Test. Research result showed average value of students' statistical thinking ability test from experiment-I class higher than experiment-II and control class. Based on this research result, then mathematic teachers on senior high school were suggested to applicate local culture-problem based learning with GeoGebra method in mathematics learning and developed mathematic matters which close to students' local culture experience.

***Keywords:*** *Problem-Based Learning, Local Culture, GeoGebra*

## 1. Introduction

21st century education expects student to develop real problem analysis skill in counting context. One of learning method that can be implicated is problem-based learning. Problem based learning focuses student on real non-routine problems solving. Real problem presentation option is selected because there are many students who have difficulty in solving that mathematics problem. Abstract presentation of problem become unusual to many students for solving is mathematics problem essence on school [1], [2]. It is due to mathematics learning that has logical and organized system concept, also implicate those things in every value counting and evaluation, even learning concept analyse uses symbol sign [3], [4].

Unsuitable method application become trouble to several students for solving real and non-routine matters. Students can't comprehend what the problem that should be solved is and how to find the right step to solve that problem. It is happened because abstractly problem presentation. Students also aren't usual to take decision for determining right completion steps. Students tend to focus for final result and ignore process that compose the result [5], [6]. Then, solution for breaking that trouble is applicating problem-based learning method which is delivered by Polya in 1957.

Problem based learning is a learning approach which is centered to students that build them into small learning groups, so learning process run focus and actively. Students are faced to real problem situation on this problem based leaning approach in small groups. Teacher can help students to focus in real problem-solving context, motivates them to consider proper situation in determining solution from that real problem context while applicates problem-based learning [7], [8]. On problem-based learning application step, students are asked to build their knowledge own self about mathematics ideas that can be guidance in non-routine problem solving [9]–[12]. Because of this problem-based learning demand is pushing students to establish new knowledge, then student needs collaboration with other students, so that new information can be validated before they applicate it to solve non-routine matter. Therefore, from problem-based learning, learning groups usage is important for optimal yield. Problem based learning application is not only can be applicated on mathematics matter, but also can be applicated on other science subjects that increase critical thinking ability, problem solving ability and communication ability [13]–[15]. Problem based learning gives different experience for students, because they can solve non-routine matters which is close to their neighborhood especially their culture. Learning environment become more actively when problems that they should solve are related to their culture, for example is Malay-Deli as local culture in Medan, Sumatera Utara, Indonesia. Frudhental supports local culture integration in mathematics learning, due to mathematics should be connected with reality around, but still close to students' situation and has relevancy to social environment. This is point of view that involves mathematic not only as science subject, but also as society activities which is close to local culture [16], [17].

Beside learning method application, using learning media also gives real contribution for increasing mathematics learning quality to high school students. Learning activity on 21st century also

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give more space in developing and applicating techno-media for mathematics learning at school, interaction between theory and practice that supports technology integration in mathematics learning can stimulate increasing of new knowledge about real problem and new learning experience for solving that mathematics matters [23][24]. Media application of GeoGebra is chosen because GeoGebra can aid students to represents mathematics problem solving result in statistical subject that has diagram form. Students still manually present data in chart and diagram as picture it with paper and pencil, then they also transfer diagram and chart into digital form through GeoGebra assistance [20].

The object from this research is describing effectivity of local culture-problem based learning usage with GeoGebra assistance, GeoGebra as learning media gives increasement to students' statistical thinking ability in mathematics learning. For seeking learning method usage effectivity, then local culture-problem based learning with GeoGebra assistance is compared with problem-based learning without local culture integration and learning techno-media, also conventional learning method.

## 2. Methodology

Research uses pseudo-experimental research method with post-test only group design. Previous research has started with develops learning media using 4D development model (Define, Design, Develop and Disseminate) [26]. Learning media usage on developing stage is evaluated through pseudo-experimental research. Correspondingly with research purpose, this research is compares conventional learning method usage, problem-based learning method and local culture problem-based learning with GeoGebra assistance. Research has taken twelve weeks with four hours face-to-face conference (forty-eight learning hours totality). Experiment class I, experiment class II and control class use same learning subject and teacher that one of researcher for this article. Teacher hasn't any connection with students or school where this research is done, so research gives objective result.

Data on this research is students' statistical thinking ability test that consist of four essay tests. Statistical thinking ability test developed compatible with its indicators that been created by Shaugnessy [27] are (1) describing data displays (D); (2) organizing and reducing data (O); (3) representing data (R); and (4) analyzing and interpreting data (A), which is abbreviated as DORA indicator. Data were collected through various collection data techniques including tests, questionnaires and observation sheets. Data was analysed with descriptive, such as the mean and standard deviation, and inferential statistical analysis, such as ANOVA-One Way sample and Tuckey Test for normal and homogenic distribute, but if there was abnormal or/and heterogenic data, then it was analysed with Kruskal-Wallis Test and Mann-Whitney U-Test. That tests are used to determine the effect of the three different teaching methods (i.e., the problem-based learning uses local culture, the problem-based learning and conventional teaching learning methods) on students' mathematical learning. In this study, all statistical analysis procedures and results were calculated using SPSS, and the statistical significance was set at 0.05 levels with two tail tests. Data distribute normality examined with Kolmogorov-Smirnov Test and data variance homogeneity examined with Levene's Test of Equality.

## 3. Results and Discussion

Students' statistical thinking ability which was taught by used local problem-based learning with GeoGebra better than used problem-based learning method and conventional learning method. Post-test average score of students' statistical thinking ability which was taught by local problem-based learning with GeoGebra 77.26 (good category), while post-test average score of students' statistical thinking ability which was taught by problem-based learning method and conventional learning method only reached 75.24 (good category) and 64.26 (fair category). Average post test score distribution of students' statistical thinking ability is described on Table 3.

**Table 1:** Comparison analysis of the three groups student statistical thinking ability scores on post-test

| Observations | Learning Group | Paired differences | | |
|---|---|---|---|---|
| | | N | Mean differences | SD |
| Post-test | EG-I | 38 | 77.26 | 6.479 |
| | EG-II | 38 | 75.24 | 6.902 |
| | CG | 38 | 64.26 | 8.186 |

Based on Table 1, there is difference about average significant value for three of learning method application. Based on Cohen statement, this diversity has greater value than common casesz [28]. However, students' average value for three of groups increases significantly, but EG-1 more increasing than comparison groups (EG-II and control class). The same with deviation standard value, they have significant difference on it. Then it can be concluded that every inspected data fully scatters and has difference tendency each other. So, all of used data is heterogenic type [29]. Students' statistical thinking ability data distribution normality test both in experiment-I, experiment-II and control class used Kolmogorov-Smirnov test while data variance homogeneity test used Levene's test. Normality and homogeneity calculation result test summary is described on Table 2.

**Table 2:** Comparison analysis of the three groups student statistical thinking ability scores on post-test

| Observations | Learning Group | Paired differences | |
|---|---|---|---|
| | | Test of Normality (Kolmogorov-Smirnov) | Test of Homogeneity of Variances (Levene Statistic) |
| Statistical Thinking | EG-I | 0.027 | 0.195 |
| | EG-II | 0.006 | |
| | CG | 0.004 | |

Students' statistical thinking ability post test result on experiment-I, experiment-II and control class have same variance value (homogenic) based data on table 4, because its significant value was greater than significant standard value 0.05 (0.195 > 0.05). Both their statistical thinking ability post-test value on experiment-I class, experiment-II class and control class, have abnormal distribution (0.0027 < 0.05; 0.006 < 0.05; and 0.004 < 0.05). Based on summary of data normality and homogeneity calculation result test from table 4, then it can be concluded that students' statistical thinking ability post test result data was not relevant to analyse used ANOVA-One Way and Post Hoc-Tuckey Test but can be analysed by used Kruskal-Wallis Test and Post Hoc-Mann-Whitney U Test. Counting result summary of both post test data analyse learning groups used Kruskal-Wallis Test and Post Hoc-Mann-Whitney U Test is displayed on Table 3.

**Table 3:** Counting result summary Kruskal-Wallis Test

| Observation | Learning Group | Ranks | | Test Statistics[a,b] | | |
|---|---|---|---|---|---|---|
| | | N | Mean Rank | Chi-Square | df | Sig. |
| Statistical Thinking | EG-I | 38 | 76.7 | 45.17 | 2 | 0.00 |
| | EG-II | 38 | 67.0 | | | |
| | CG | 38 | 28.8 | | | |

a. Kruskal Wallis Test
b. Grouping Variable: Learning Group

Based on Table 3, it can be seen on Mean Rank that show each learning method application rank. Local culture-problem based learning method (experimental-I class) has higher average rank than problem-based learning method (experimental-II class) and so as problem-based learning method (experimental-II class) has higher average rank than conventional learning method (control class). However, those differences don't have statistical value yet. So, it's needed to be tested by using Kruskal Wallis statistical test,

this test measured how far statistical average significant rank among all of this learning method is.

Table 3 also show Sig. that refers to P value. This research got P value as 0.000 that below 0.05 as critical limit, it means research result is accepting $H_1$ hypothesis decision which there is effect from local culture-problem based learning method with GeoGebra assistance (experimental-II class) to students' statistical thinking ability on mathematics learning. After been tested by Kruskal-Wallis test as omnibus check that only can finds statistical difference without knows which treatment different is, then it continues with post hoc. This research used Mann-Whitney U Test as post hoc to check their mean between one learning group or treatment with others.

This research did three steps Mann-Whitney U Test as post hoc, that is:

1. Diversity of students' statistical thinking ability average value between local culture-problem based learning method (experimental-I class) and problem-based learning method (experimental-II class);
2. Diversity of students' statistical thinking ability average value between local culture-problem based learning method (experimental-I class) and conventional learning method (control class);
3. Diversity of students' statistical thinking ability average value between problem-based learning method (experimental-II class) and conventional learning method (control class);

Mann-Whitney U test result for experimental-I class, experimental-II class and control class is described by Table 4:

**Table 4:** Counting result summary Mann-Whitney U-Test between experimental group-I and experimental group II

| Description | Statistic Thinking Skills in | | |
|---|---|---|---|
| | EG-I and EG-II | EG-I and CG | EG-II and CG |
| Mann-Whitney U | 564.500 | 149.500 | 203.500 |
| Wilcoxon W | 1305.500 | 890.500 | 944.500 |
| Z | -1.655 | -5.978 | -5.421 |
| Asymp. Sig. (2-tailed) | 0.098 | 0.000 | 0.002 |

Based on Table 4, it's showed significant value in EG-I and EG-II is 0.098 > 0.05, it means that students' statistical thinking ability which was taught by used local culture problem-based learning method (EG-I) have not significant different with problem-based learning method (EG-II). The significant value in EG-I and CG is 0.000 < 0.05, it means that students' statistical thinking ability which was taught by used local culture problem-based learning method (EG-I) have significant difference with conventional learning method (CG). The significant value based in experimental group-II and control group is 0.002 < 0.05, it means that students' statistical thinking ability which was taught by used problem-based learning method (EG-II) have significant difference with conventional learning method (CG).

Based on Table 4, it can be concluded that average students' statistical thinking ability value in EG-I has significantly difference value with average students' statistical thinking ability value in control class and also average students' statistical thinking ability value in EG-II has significantly difference value with average students' statistical thinking ability value in control class. Even though, learning method in EG-II have better influence than control class, but local culture-problem based learning with GeoGebra assistance (EG-I class treatment) is the best learning method for increasing significantly average students' statistical thinking ability value. It can be seen from P value from EG-I higher than EG-II and control class.

Research result showed that student's statistical thinking ability which was taught used local culture problem-based learning method with GeoGebra (EG-I) have better influence than problem-based learning method (EG-II) and conventional learning method (control group), because local culture problem-based learning method uses local culture issue with GeoGebra as real mathematics problem, so students can directly feel and involve on that problem**.**

Local culture effect can have motivated students for understanding presented problem, students discuss that mathematics problem actively with significant debriefing to solve problem. Local culture application was adjusted with updating issue, so students can see if presented problem still relevant or not and students got obvious learning experience. Local culture application assisted students to develop their new knowledge. Contributions of local culture application on mathematics learning had been researched with some people earlier, like Cheriani [30] who had made problem-based learning development model based on Bugis culture. Yusra [31] that had developed joyful learning model based on Malaya culture learning design. Local culture problem-based learning steps gave chance to develop and increase statistical thinking ability for students.

GeoGebra as media application like figure 5 make students easier to understand and present diagram that compatible with solution from given mathematical problem. Students also get new experience through GeoGebra as techno-media application in mathematical learning progress at their school. Techno-media application make students more actively and creative in displaying chart from given data than manual method where they draw diagram with manual stationary. So, GeoGebra application in mathematical learning progress on class make learning situation more effective, efficient and interesting for students [32]–[34].

Students can have increased and developed their mathematics problem solving thru local culture problem-based learning application method, especially related to statistical thinking skill development. It's relevant with statement of Mellin-Olsen [4], students' cognitive level in mathematics was not determined only on students' capability, but also teacher's skill that involved students on mathematics learning activity with problem-based learning method which was supported by constructivism and constructionism. Constructivism theory which was supported by many researchers like Perkins, Piaget and Vygotsky explains that everyone able to build their knowledge thru environment situation. Students can build new education with investigation and interaction. on their surroundings [35]

## 4. Conclusion

Mathematics learning with GeoGebra assistance of local culture-problem based learning gave real impact for developing mathematics non-routine matters solving. Students understand easier about mathematics problem that they found in daily life through local culture-problem based learning method. The new experience gave them also new knowledge especially for high school students. Students' analyse ability increased through problem solving investigation process, until they can have found solution from that mathematics problem. Analyse ability and finding conclusion from problem is statistics ability indicator that should be developed to high school students.

Researcher is not only applicated local culture-problem based learning on this research, but also technology integration as assistance media in learning progress at class. Media integration in learning progress is on of effort to introduce students some digital tools that can help them for solving mathematics problem. GeoGebra as media techno application help students to presentate diagram and chart from real problems. Diagram presentation from GeoGebra assistance was proved to help students in understanding new science from real problem solve.

Researcher is not fully get explanation yet about impact measurement of local culture-problem based learning with GeoGebra assistance to students' performance in solving real problem around them. There is possibility on learning internal factor like motivation, default ability, gender or external factor like economics status or additional education that influence students for solving

problems. Advanced research process is needed to seek and analyse other factors that influence students' performance in mathematics problem solving.

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