Mathematics Learning Assisted Geogebra using Technologically Aligned Classroom (TAC) to Improve Communication Skills of Vocasional High School Student

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Abstract. The purpose of this study to analyze mathematical communication skill’s student to resolve geometry transformation problems through computer Assisted Geogebra using Technologically Aligned Classroom (TAC). The population in this study were students from one of Vocasional High School Student in West Java. Selection of sample by purposed random sampling, the experimental class is taught Technologically Aligned Classroom (TAC) with GeoGebra, while the control class is taught by conventional learning. This study was quasi-experimental with pretest and posttest control group design. Based on the results; (1) The enhancement of student mathematical communication skills through TAC was higher than the conventional learning; (2) based on gender, there were no differences of mathematical communication skills student who exposed with TAC and conventional learning; (3) based on KAM test, there was significant enhancement of students' communication skills among ability of high, middle, and low KAM. The differences occur between high KAM and middle KAM, and also between high KAM and low KAM. Based on this result, mathematics learning Assisted Geograebra using Technologically Aligned Classroom (TAC) can be applied in the process of Mathematics Learning in Vocasional High School.

1. Introduction
Mathematics is a very important branch of science in life, the branch of mathematics can be applied in solving various problems of life. Mathematics makes people accustomed to solve a problem quickly, precisely and accurately. In learning mathematics in school there is one of the mathematical ability of students to be developed is the ability of mathematical communication, mathematical communication skills is the ability where students can express, explain and communicate mathematical ideas.

To measure mathematical abilities required indicators. Indicators mathematical communication abilities in mathematics according to NCTM [1], the ability of the students are: (1) organize and consolidate mathematical thinking (mathematical thinking) them through communication; (2) communicate their mathematical thinking coherently (arranged logically) and clear to his friends, teachers and others; (3) analyze and evaluate the mathematical thinking (mathematical thinking) and the strategies used by another person; (4) use the language of mathematics to express mathematical ideas correctly. Meanwhile, according to Sumarmo [2], communication skills include the ability of the student (a) connecting the real objects, drawings, and diagrams into the idea of mathematics; (b) explain ideas, situations and relationships mathematical orally or in writing with real objects, pictures,
graphs and algebra; (c) declare a daily occurrence in the language or math symbol; (d) listening, discuss, and write about mathematics; (e) read with comprehension or writing mathematical presentation; (f) make a conjecture, make arguments, formulating definitions and generalizations; (g) explaining and making inquiries about the math they have learned.

1.1. Technologically-Aligned Classroom (TAC) learning model

The Technologically-Aligned Classroom (TAC) Technological Learning Model combines the activity approach behaviourism with constructivism. The teacher gives the Inquiry approach to the students but GeoGebra is also used as a teacher tool to describe student observations and to verify their allegations, the students are listening to the material displayed on the screen in front of the class. After the teacher explains the material, students use the computer and do the exploration in accordance with the explanation of the material, so this class is called Technologically-Aligned Classroom (TAC).

Technology can change the nature of school mathematics by engaging students in more active mathematical practices such as experimenting, investigating and problem solving that bring depth to their learning and encourage them to ask questions rather than only looking for answers (Farrell, 1996; Makar & Confrey, 2006) [3].

1.2. GeoGebra software

GeoGebra is free open-source dynamic software for mathematics teaching and learning that offers geometry and algebra features in a fully connected software environment. It was designed to combine features of dynamic geometry software (e.g. Cabri Geometry 3D, Geometer’s Sketchpad) and computer algebra systems (e.g. Derive, Maple) in a single, integrated, and easy to-use system for teaching and learning mathematics (Hohenwarter, Jarvis, & Lavicza) [4]. This dynamic mathematics software program was created by Markus Hohenwarter and now has been translated to 40 languages. Users all over the world can freely download this software from the official GeoGebra website at http://www.geogebra.org. The following is a picture of geogebra integration to help students understand the concept of geometry transformation:
The problem in this research is the enhancement of students’ mathematical communication ability who receive learning Technologically Aligned Classroom (TAC) with Geogebra is higher than the ability of students to obtain a mathematical Communication of the conventional learning (CL), in terms of a) general; b) gender (male and female); c) prior mathematical skills (KAM) (low, middle, high) ?

2. Experimental Method
This study is an experimental research in quasi form (quasi experiment). Therefore, the sample subject is not a random choice. The sample subject is the learning group in their classes, so if the sample is random, it would be difficult and disrupt the teaching activity. This study engages mathematics communication skills with gender (male and female) and student’s KAM factor (high, middle, and low).

The research sample consisted of two homogeneous Form Four classes from one of Vocational High School Student in West Java, Indonesia. A total of 65 students involved. Experiment class is given with Technologically Aligned Classroom (TAC) while control class with Conventional Learning (CL).

The conducted research design is Pretest-Posttest Control Group Design (Ruseffendi, 2005) [5]. Briefly, the conducted research design can be defined as below:

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Explanation:
- \( X \) : TAC (Technologically Aligned Classroom)
- \( O \) : pretest = posttest mathematics communication abilities

The study engages mathematics communication skills with gender (male and female) used the quasi-experimental study with non-equivalent control group post-test only 2 x 2 (gender x treatment) factorial designs. Briefly, the conducted research design can be defined as below:

### Table 1. Factorial Design with engages mathematics communication skills with gender.

| Gender | Student’s Group   |
|--------|-------------------|
|        | TAC               |
| Male   | TAC (M)           |
| Female | TAC (F)           |
|        | Conventional Learning |
| Male   | CL (M)            |
| Female | CL (F)            |
The study engages mathematics communication skills with KAM (High, Middle & Low) used the quasi-experimental study with non-equivalent control group post-test only 3 x 2 (KAM x treatment) factorial designs. Briefly, the conducted research design can be defined as below:

**Table 2. Factorial Design with engages mathematics communication skills with KAM.**

| KAM    | Student’s Group       | TAC          | Conventional Learning |
|--------|-----------------------|--------------|-----------------------|
| High   | TAC (H)               | CL (H)       |
| Middle | TAC (M)               | CL (M)       |
| Low    | TAC (L)               | CL (L)       |

3. Result and Discussion

3.1. Result

Analysis using SPSS version 20 used for: 1) Descriptive analysis (describing raw data), 2) Test requirements data analysis (test of normality and homogeneity), and 3) hypothesis test used One way Anova (Sugiyono, 2009) [6]. The following table shows differentiation Test of the Student’s Communication Enhancement both Learning Group.

**Table 3. Differentiation test of the student’s communication enhancement both learning group**

| Learning Group | n | Mean | t  | Sig. (1-tailed) | H\textsubscript{0} |
|----------------|---|------|----|-----------------|---------------------|
| TAC            | 33| 0.661| -2.444 | 0.017          | Rejected           |
| CL             | 32| 0.571|           |                 |                     |

Table 3 shows that the value of the probability or sig. (One-tailed) is smaller than \( \alpha = 0.05 \), so \( H_0 \) rejected. Thus, students who earn TAC had an average increase significantly of communication skills is higher than students who received Conventional Learning.

**Table 4. Two way ANAVA on N-gain mathematical communication skills based on gender**

| Source                | Type III Sum of Squares | df | Mean Square | F      | Sig. | H\textsubscript{0} |
|-----------------------|-------------------------|----|-------------|--------|------|---------------------|
| Learning Model        | 0.078                   | 1  | 0.078       | 4.266  | 0.043 | Rejected            |
| Gender                | 0.006                   | 1  | 0.006       | 0.337  | 0.564 | Accepted            |
| Learning Model * Gender | 0.081                 | 1  | 0.081       | 4.395  | 0.040 | Rejected            |

Based on the results in Table 4 we can conclude:

Learning Model:
The influence of the learning model on the test scores in the model. If Significance (Sig.) <0.05 (Alfa) = Significant. From the data above 0.043 means the learning model has a significant effect.
Gender:
Gender influence on test scores in the model. If Significance (Sig.) < 0.05 (Alfa) = Significant. From the data above, 0.564 means gender has no significant effect.

Gender * Learning Model:
Gender Influence * education on test scores in the model. If Significance (Sig.) < 0.05 (Alfa) = Significant. From the data above, 0.040 means learning model * gender has significant effect.

Table 5. Two way ANOVA on N-gain mathematical communication skills based on KAM

| Source           | Type III Sum of Squares | df | Mean Square | F     | Sig. | H₀     |
|------------------|-------------------------|----|-------------|-------|------|--------|
| Learning Model   | 0.119                   | 1  | 0.119       | 6.992 | 0.011| Rejected |
| KAM              | 0.176                   | 1  | 0.088       | 5.112 | 0.009| Rejected |
| Learning Model * | 0.011                   | 1  | 0.006       | 0.329 | 0.721| Accepted |

Based on the results in Table 5, we can conclude:
Learning Model:
The influence of the learning model on the test scores in the model. If Significance (Sig.) < 0.05 (Alfa) = Significant. From the data above, 0.011 means the learning model has a significant effect.

KAM:
Gender influence on test scores in the model. If Significance (Sig.) < 0.05 (Alfa) = Significant. From the data above, 0.009 means KAM has significant effect.

KAM * Learning Model:
Gender Influence * education on test scores in the model. If Significance (Sig.) < 0.05 (Alfa) = Significant. From the data above, 0.721 means learning model * KAM has no significant effect.

In order to see which KAM is significant, the after test of ANOVA (poshoc) is conducted as shown on Table 6. Based on Table 6, the result shows that the significant difference of mathematical Communication enhancement occur between high KAM and middle KAM, and also high KAM and low KAM.

Table 6. Mathematical communication enhancement poshoc (Tukey) test based on KAM and learning

| (I) KAM | (J) KAM | Mean Difference (I-J) | Sig. | H₀  |
|---------|---------|-----------------------|------|-----|
| High    | Middle  | 0.1063                | 0.027| Rejected |
| High    | Low     | -0.1063               | 0.027| Rejected |
| Low     | High    | 0.0074                | 0.981| Accepted |
| Low     | Middle  | -0.0137               | 0.017| Rejected |

The result of two way ANOVA test based KAM in Table 6 significance value less than 0.05 or p(sig) > 0.05, which means there are significant average enhancement of mathematical communication
ability between high, middle, and low KAM. The differences occur between high KAM and middle KAM, and also between high KAM and low KAM, or in other words the ability of student’s communication between KAM high, middle and low different significantly.

3.2. Discussion

The results show that students learning by using the Technologically Assisted Learning (TAC) learning model have a higher average mathematics communication ability than students using conventional learning. This result is possible because through TAC learning, students are facilitated in constructing knowledge or mathematical concepts built on spatial ability, so students gain a better communication. For example, how students find the concept of translation, reflection, rotation and dilatation in figure 1,2,3 and 4. Through TAC learning, students are given the opportunity to understand the movement of objects for translation, reflection, rotation and dilatation, students learn to analyze the displacement from point to point of reflection after undergoing transformation, animation via GeoGebra Helps student’s spatial ability to see the transformation through the sense of sight, as well as students' mathematical communication skills are also facilitated by GeoGebra with animation to make it easier for students to communicate the various transformations they see. By using GeoGebra software, The following is an example of a problem to measure the ability of mathematical communication

Consider the triangular image below:

![Figure 5. Example question to measure communication skills student](image)

| Problem No. 1 : |
|----------------|
| a). Determine what steps should be taken to become a quadrilateral A "B" C"! . (Write down your idea) |
| b). Write down the mathematical notation and transformation matrix that reflects the above transformation! |
| c). Is there more than one combination of transformations that makes it possible to produce a quadrilateral shadow A "B" C "? |

Problem no.1 measures students' mathematical communications abilities with indicators: (1) organize and consolidate mathematical thinking (mathematical thinking) them through communication; (2) communicate their mathematical thinking coherently (arranged logically) and clear to his friends, teachers and others; (3) analyze and evaluate the mathematical thinking (mathematical thinking) and the strategies used by another person;
Problem No. 2:
Transformation maps the shadow of an ABC triangle from the coordinates A (-4.2) B (0.4) and C (-4.6) to the coordinates A' (-2.1) B' (0.2) and C' (-2.3).

a). Explain the type of transformation that maps the triangle ABC!

b). Is there more than one combination of transformations that makes it possible to produce a quadrilateral shadow A' B' C'?

c) Determine the shadow of an triangle C (-2.1) D (-2.0) and E (-2.6) with same transformation?

From some of the above examples, students can deduce the concept of geometric transformation. In line with Dahlan [7], who stated that computer-based learning through software gives users the means to develop ideas and power of imagination in building geometric shapes, learning by using TAC learning model provides an opportunity for students to better understand mathematics, especially transformation geometry, in terms of These teachers provide opportunities for students to develop their true abilities. Students who find it difficult to develop their spatial abilities, enlist the help of other friends who already understand. At that time students to communicate and also simultaneously develop mathematical communication skills. When students experience difficulties then the teacher will be ready to help provide scaffolding to help these students.

Meanwhile, through discussions with friends bench or ask teachers and discussed in the classroom together the potential ability of students to develop more so that students' math communication deeper. One of the foundations that can be used to achieve this goal, among others, is the Proximal Development Zone (ZPD) of Vygotsky [8], which states that learning can produce stored mental processes can only be operated when one interacts with an adult or collaborates with friends of the same age. In one study, Singapore secondary students who spent a considerable amount of time working with GSP in transformation geometry were found to make significant increases in their test scores in the Wheatley Spatial Ability Test (Leong, 2002) [9].

Statistical analysis showed that there was a significant difference between students who received TAC learning with students who received conventional learning, from data processing of mathematical communication ability seen average student of TAC class higher than conventional class.

4. Conclusion
Based on the results of research and discussion above, it can be concluded: (1) in general, the of student’s enhancement mathematical Communication with Technologically Aligned Classroom (TAC) learning higher rather than students in conventional learning. (2) in school level (high and Middle), there are no significant differences in the enhancement of ability of students’ between high and middle level students. (3) According to KAM (high, middle, and low) there are significant average enhancement of mathematical Communication ability between high, middle, and low KAM. The differences occur between high KAM and middle KAM, and also between high KAM and low KAM. Learning with Technologically Aligned Classroom (TAC) recommended to be applied in the process of mathematics learning in Vocasional High School.

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References
[1] National Council of Teachers of Mathematics 2000 Principle and Standards for School Mathematics (Reston: VA NCTM)
[2] Utari S 2003 Thinking and Mathematical Disposition: What, Why, and How developed on Primary and Secondary School Students. (Bandung: ITB.)
[3] Makar K, Confrey J 2006 How are learners using it to conduct databased investigations? Proceedings of the 17th Study Conference of the International Commission on Mathematical Instruction (Hanoi: Hanoi Institute of Technology)

[4] Hohenwarter M, Jarvis D, Lavicza, Z 2009 Linking Geometry, Algebra, and Mathematics Teachers: GeoGebra Software and the Establishment of the International GeoGebra Institute [Article], International Journal for Technology in Mathematics Education: Research Information Ltd.

[5] Ruseffendi E.T 2005 Dasar-dasar Penelitian Pendidikan & Bidang Non-Eksakta Lainnya. (Bandung : Tarsito)

[6] Sugiyono. (2009) Metode Penelitian Kuantitatif Kualitatif R&D. (Bandung: Alfabeta).

[7] Dahlan JA, Kusumah, YS, Sutarno H 2009 Pengembangan Model Computer Based E-Learning untuk Meningkatkan Kemampuan High-Order Mathematical Thinking Siswa SMA. Penelitian Hibah Bersaing Perguruan Tinggi. (Bandung: Universitas Pendidikan Indonesia)

[8] Vigotsky L.S 1978 Mind in Society: the Development of Higher Psychological Processes. (Cambridge, M.A : Harvard University)

[9] Hoong L Y, Khoh, Lim-Teo S 2003 Effects of geometer's sketchpad on Spatial Ability and achievement in transformation geometry among secondary two students in Singapore. (Singapore: Nanyang Technological University)