The Effect of STAD cooperative model by GeoGebra assisted on increasing students' geometry reasoning ability based on levels of mathematics learning motivation

Rahmat¹*, Fahinu¹, Sayahdin Alfat², and Era Maryanti¹

¹Mathematics Education, Universitas Halu Oleo, Jl. H.E.A. Komodompit, Kendari 93232, Indonesia
²Physic Education, Universitas Halu Oleo, Jl. H.E.A. Komodompit, Kendari 93232, Indonesia

*Email: rahmat_lison@uho.ac.id

Abstract. This study aims to analyze the improvement of geometric reasoning abilities of students of SMA Negeri 1 Sampara, Kabupaten Konawe, Sulawesi Tenggara, Indonesia. Here, we compare three models of learning; (1) STAD cooperative model by GeoGebra assisted; (2) a model of the STAD cooperative without assistance from GeoGebra; and (3) conventional learning models. This study was applied to three different classes, where each class consisted of the high, medium, and low motivation students. Data collection was done by giving a mathematics learning motivation questionnaire and giving a test of students' geometric reasoning abilities. The data analysis technique uses inferential statistics to test normal assumptions and homogeneity and hypothesis testing using the One-Way ANOVA Test. Based on the results of the study showed that the effect of using the STAD type cooperative learning model with the help of GeoGebra was higher when compared to the other two models. That difference occurs at all levels of motivation. On the other hand, the STAD model without GeoGebra only affects high and moderate motivation students. Meanwhile, low motivation students did not show significant differences with the direct learning model.

1. Introduction
The reasoning is a particular type of thinking that is concerned with drawing conclusions drawn from premises [1]. Based on the model, the reasoning is divided into deductive reasoning and inductive reasoning [2]. Based on the field of study, the reasoning is divided into several fields. One of them is geometrical reasoning [2]. Geometric reasoning is the process of defining and deducing the properties of a geometric entity using the intrinsic properties of that entity, its relationship with other geometric entities, and the rules of inference that bind such properties together in geometric (Euclidean) space [3].

The process of developing human thinking starts with concrete things. Concrete things are closely related to geometry. Almost all objects that are around us are part of the geometry, both the two dimensions and the three dimensions. Therefore, to improve students' mathematical abilities, it must begin with an increase in geometrical reasoning. Geometric reasoning involves three types of cognitive processes that fulfill certain epistemological functions. The three cognitive processes are: (1) the visualization process, for example a visual representation of geometric statements, or heuristic exploration of complex geometric situations; (2) construction process (using tools); (3) the process of...
reasoning - specifically the discursive process for the expansion of knowledge, for explanation, as evidence [4].

To improve students' geometrical reasoning abilities, the learning process of mathematics should use the right method and attract students' attention. The learning method is adapted to the psychological conditions of students. Besides, the learning model should also vary so that students are not bored. The presentation of subject matter should be able to attract students' attention. Presentation of material should be using learning media that interesting for students. Effective media in learning is interactive media. One of the interactive media is using computer applications, an easy-to-use, and open-source application is GeoGebra. Also, the GeoGebra method makes lessons more interesting, practical, and easy to understand [5].

GeoGebra is an interactive geometry system. GeoGebra represents dynamic mathematical software for all levels of education that joins arithmetic, geometry, algebra, and calculus [6]. With learning media like this, students can make observations and explore directly on geometric objects. GeoGebra students can do constructions with points, vectors, segments, lines, conic sections as well as functions and change them dynamically afterward [6] and reduce calculation errors when compared with calculations by hand [7]. On the other hand, equations and coordinates can be entered directly. Thus, GeoGebra can deal with variables for numbers, vectors, and points find derivatives and integrals of functions [6]. GeoGebra provides flexibility to students to investigate deeper into a geometric shape. They can express various things that may not be found or do when they use paper and pencil in constructing geometric objects [7]. Thus there will be a process of construction of knowledge in students. As a result, the reasoning process will occur.

Ideally, this method can be done by the teacher to improve students' geometrical reasoning abilities. But the reality is not the case. Not all teachers teach using varied models of learning. Most mathematics education research, the problem faced is the low student achievement caused by the use of monotonous learning models. This is thought to be the main cause of students becoming bored with learning. As a result, students' mathematics learning achievement is low, including in it is reasoning ability. The low reasoning abilities of students also have an impact on students' low geometrical reasoning abilities.

The problem of difficulties students understand geometrical reasoning, generally occurs in almost every middle school student in Indonesia. This can be seen from the low achievement ratings of Indonesian students in TIMSS and PISA [8]. The problem of the low reasoning abilities of students almost occurs evenly in Indonesia. One example of a school that can be used as the object of research is in the SMA Negeri 1 Sampara, Kabupaten Konawe, Indonesia. To obtain the initial data on students' geometrical reasoning abilities, observation is carried out do SMA Negeri 1 Samara. Observations were carried out in the form of tests on students. Besides, interviews were also conducted with several mathematics teachers and students. From the results of the test, the average geometry reasoning of students of SMA Negeri 1 Sampara was 45.70. This value is low. From the results of the interview, information was obtained that students were bored with mathematics. One reason is that the teacher does not activate and arouse the interest of students learning. The teacher uses a conventional learning model. In this study, students are passive and only pay attention to the teacher's explanation. As a result, students become bored and lazy to learn mathematics.

Problems that occur in the school can be overcome by trying out a learning model that can motivate students. One of the learning models that can increase student learning motivation so as not to be bored in learning is to use cooperative learning. It is teaching methods in which children work in small groups to help one another learn. This learning model is called Student Teams-Achievement Divisions (STAD) [9]. Besides, to attract the attention of students, learning media are needed that can attract students' attention. One of the interesting media is a computer, namely the GeoGebra application. The combination of the two solutions is the STAD Cooperative Learning model assisted by the Dynamic GeoGebra Worksheet [7]. This learning is believed to be able to improve the geometrical reasoning abilities of students at SMA Negeri 1 Sampara. To examine whether students can be motivated by this learning, students need to be grouped at the level of learning motivation.
2. Method
The design of this study was a pretest-posttest control group design [10]. Therefore the implementation uses experimental group students and control group students. The experimental group consisted of two classes, namely the first experimental class and the second experimental class. In the first experimental class, the researcher treated the learning using the STAD type cooperative learning model assisted by dynamic GeoGebra worksheets. In the second experimental group, the researcher treated the learning using only the STAD type cooperative learning model. In the learning control group given is conventional learning. In each class grouped by level of motivation: (1) high motivation; (2) moderate motivation; and (3) low motivation.

This research was conducted in Konawe Regency of Southeast Sulawesi Province at XI grade 1 SMA Negeri 1 Sampara, Indonesia. The population of this study was all students of SMA Negeri 1 Sampara. The sample in this study consisted of three groups of class XI students from the class XI IPA selected randomly [10]. Determination of the GeoGebra (A1) assisted STAD class, the GeoGebra (A2) unaided STAD class, and the conventional class (A3) of the three IPA program classes were conducted in a simple random. The results of the random selection obtained classes A1: XI IPA 3; class A2: XI IPA 2; and class A3: Class XI IPA 1.

The data in this study were collected through tests, observation sheets, and attitude scale questionnaires. Data related to students' geometrical reasoning were collected through tests (pretest and posttest). Its related to student learning motivation were collected through motivation to learn mathematics. Meanwhile, to obtain data on student attitudes of learning is collected through questionnaires and student observation sheets.

Geometric reasoning is measured based on Van Hiele's theory, which states that students' geometrical reasoning abilities go through the five stages of development of thinking in learning geometry. The five stages of development of thinking of Van Hiele are stage 0 (visualization), stage 1 (analysis), stage 2 (informal deduction), stage 3 (deduction), and stage 4 (rigor) [11]. However, because of research at the high school level, the measured geometrical reasoning ability only reaches stage 3 (deduction). Stage 4 (rigor) is intended for the college level. Geometric reasoning rubric refers to the geometry reasoning rubric based on Van Hiele's level, i.e., the score of the visualization stage is 1, the analysis stage score is 2, the informal deduction stage score is 4, and the deduction stage score is 8 [12]. Meanwhile, Learning motivation can be measured by indicators (a) there is a desire and desire to succeed; (b) there is encouragement and need for learning; (c) future hopes and aspirations; (d) appreciation in learning; (e) there are interesting activities in learning; (f) feeling happy about the lesson; (g) the existence of a conducive learning environment, which enables students to learn effectively and efficiently; (h) dare to compete; and (i) fear of failure [13].

In this study, the data analysis was used descriptive analysis and inferential analysis. The inferential analysis aims to test the research hypothesis. Data used in hypothesis testing in the form of a Normalized Gain (N-gain) score [14]. Gain is the difference between the posttest and pretest values compared to the difference between the ideal maximum value and the pretest value. Gain shows an increase in understanding or mastery of student concepts after learning is done by the teacher. Hypothesis testing uses a one-way ANOVA test. Processing data used by Microsoft Excel and the SPSS 20.

3. Result and Discussion
3.1. Description of Research Results
The data of the geometric reasoning ability of the results of the study showed that the average increase in N-gain geometry reasoning ability of students of class XI IPA 1 (GeoGebra-in assisted STAD learning) was 0.64, class XI IPA 2 (conventional learning models) was 0.60 and class XI IPA 3 students (GeoGebra-assisted STAD learning) was 0.69. Based on the three N-gain averages, this geometrical reasoning ability shows that the highest average was achieved by the XI IPA 3 class, and the lowest average was achieved by XI IPA 2 class. Furthermore, N-gain data geometry reasoning capabilities are grouped according to learning motivation categories, then the average achievement of increasing geometric reasoning abilities in each group was showing in the table 1.
Table 1. The average N-Gain geometry reasoning ability based on learning motivation groups.

| No. | Learning motivation groups | Class XI IPA 1 (STAD) | Average N-Gain Class XI IPA 2 (Conventional) | Class XI IPA 3 STAD GeoGebra |
|-----|----------------------------|------------------------|--------------------------------|-------------------------------|
| 1   | High                       | 0.74                   | 0.70                          | 0.79                          |
| 2   | Moderate                   | 0.64                   | 0.58                          | 0.68                          |
| 3   | Low                        | 0.54                   | 0.50                          | 0.61                          |

Table 1 shows that students in the learning group achieved the highest N-Gain average with the GeoGebra-assisted STAD model at the level of high learning motivation with an average N-Gain value of 0.79. The lowest average N-Gain was obtained by students in the learning group with conventional models at the level of low learning motivation with an average value of N-Gain was 0.50.

3.2. Hypothesis testing

The hypothesis tested was Ho: There is no difference in the average increase in geometric reasoning abilities between students taught with GeoGebra-assisted STAD learning, STAD without GeoGebra and conventional learning at all levels of student learning motivation. The opposite of this hypothesis is H1. To test the hypothesis is done by a one-way ANOVA test. The testing criteria is if a significant value ≥ $\alpha = 0.05$, then accept Ho, whereas if the significant value < $\alpha=0.05$, reject Ho. The test results were using the one-way ANOVA test to test the difference in the average increase in geometric reasoning ability (N-gain) of the three classes studied based on the categories of high, medium and low learning motivation are as table 2.

Table 2. One-way ANOVA test table for N-Gain data based on learning motivation.

| ANOVA                        | Sum of Squares | df | Mean Square | F          | Sig. |
|------------------------------|----------------|----|-------------|------------|------|
| Geometrical Reasoning        |                |    |             |            |      |
| Between Groups               | .778           | 8  | .097        | 87.743     | .000 |
| Within Groups                | .099           | 89 | .001        |            |      |
| Total                        | .877           | 97 |             |            |      |

Based on the results of the one-way ANOVA test to test the difference in the average increase in geometric reasoning ability (N-Gain) based on the high, medium and low learning motivation groups in the ANOVA table, it can be seen that the significance value for the F test is 0.000. When compared with $\alpha = 0.05$, then the significance value is $0.000 < \alpha = 0.05$. This means that Ho is rejected and accepts H1. Thus, it means that there are differences in the average increase in geometric reasoning ability (N-gain) based on the group of high, medium, and low learning motivation in the three classes given different treatments.

Because the results of the F test above show a difference in the average increase in geometric reasoning ability (N-Gain) based on the group of high, medium and low learning motivation of the three classes given different treatments, it is necessary to have tested further in the ANOVA test. The advanced test aims to find out which groups of the 9 N-Gain groups differ in geometrical reasoning abilities — the advanced tests using Post Hoc Tests. Because from the results of the similarity variance test, it shows that of the 9 groups based on the category of high, medium and low learning motivation of the 3 treatment classes are all homogeneous, the type of analysis in the Post Hoc Tests
used is the Tukey HSD test. The Tukey HSD test results can be presented in the following Post Hoc Tests table.

### Table 3. Post Hoc Tests N-gain based on the level of motivation to learn mathematics.

| Dependent Variable: Geometrical Reasoning (N-Gain) | Multiple Comparisons |
|-------------------------------------------------|----------------------|
| Tukey HSD                                        |                      |
| (I) Sub_Class                                   | (J) Sub_CLASS        |
| Mean Difference (I-J)                           | Std. Error           | Sig. | Ho          |
| STAD-GeoGebra-High Motivation                   | STAD-High Motivation |
| .046182*                                        | .014199              | .041 | reject      |
| Conventional-High Motivation                    |                      |
| .094273*                                        | .014199              | .000 | reject      |
| STAD-GeoGebra-Moderate Motivation               | STAD-Moderate Motivation |
| .046545*                                        | .014199              | .038 | reject      |
| Conventional-Moderate Motivation                |                      |
| .100909*                                        | .014199              | .000 | reject      |
| STAD-GeoGebra-Low Motivation                    | STAD-Low Motivation  |
| .069091*                                        | .014199              | .000 | reject      |
| Conventional-Low Motivation                     |                      |
| .104845*                                        | .014549              | .000 | reject      |
| STAD-High Motivation                             | Conventional-High Motivation |
| .048091*                                        | .014199              | .028 | reject      |
| STAD-Moderate Motivation                         | Conventional-Moderate Motivation |
| .054364*                                        | .014199              | .007 | reject      |
| STAD-Low Motivation                              | Conventional-Low Motivation |
| .035755                                         | .014549              | .267 | accept      |

Table 3 shows that if we compare the significant values in each sub-class with a value of \( \alpha = 0.05 \), then only the average difference test N-Gain STAD-Low Motivation and Conventional-Low Motivation, which received Ho. Meanwhile, the test of the difference in the average N-Gain for the other groups shows the results of rejecting Ho. Thus it can be said that there is a significant difference in the average increase in geometrical reasoning ability between students who are given GeoGebra-assisted STAD learning and students who are given STAD learning without GeoGebra at each level of learning motivation. Likewise, there is a significant difference in the average increase in geometrical reasoning abilities between students who were given GeoGebra-assisted STAD learning with groups of students given conventional learning. On the other hand, if we compare the average increase in geometrical reasoning between students who were given an unaided STAD learning GeoGebra with groups of students given conventional learning, then STAD learning and conventional learning differ only in high and medium learning motivation groups, while for groups low motivation did not indicate a difference.

### 3.3. Discussion

This study compared three classes that were treated differently. The determination of the experimental class and comparison class was done randomly. The results of randomization in choosing two experimental classes and one control class obtained the results of class XI IPA 3 as the first experimental class, class XI IPA 1 as the second experimental class (STAD) and class XI IPA 2 as the control class (conventional). The experimental treatment was given to the XI IPA 3 class in the form
of cooperative learning from the GeoGebra-assisted STAD. In this study, students were introduced to mathematical software called GeoGebra. To make it easier for students to understand circle material, students were prepared with GeoGebra circle application material files. With these GeoGebra files, students could experiment themselves, repeating while reasoning in understanding circle material. The teacher only directs the beginning of learning about how to use GeoGebra circle files and instructions for working on LKS based on GeoGebra files. With the GeoGebra application, students are easier to recognize and identify parts of a circle.

For the second experimental class (XI IIPA 1), that is the class given STAD learning. Learning in this class is almost the same as learning given in class XI IPA 3; the difference is that students in the STAD class are not taught with the help of GeoGebra media. Students are given LKS as STAD learning in circle material learning.

In the control class, the class was taught using conventional models. When the research carried out learning that was often used in SMA Negeri 1 Sampara was a direct learning model. Direct learning was often used by teachers in teaching mathematics because it was easy, practical and can pursue the completion of curriculum targets in each semester.

After the circle material learning was completed teaching, the students are given the final evaluation called the posttest. In the posttest given, all students from the three classes studied showed an increase in the value of the pretest. In the posttest results, most students are only able to answer questions to the level of the stage of analysis thinking, and informal deduction, whereas for the stages of thinking deduction there are only a small number of students who can reach but not to completion.

To examine the effect of GeoGebra-assisted STAD learning on geometrical reasoning abilities in terms of student learning motivation, the research sample classes are grouped according to the motivation learning category. The aim is to test whether there is a difference in geometrical reasoning abilities based on the level of learning motivation. To achieve these objectives, the research class is grouped according to the learning motivation category, where each class is divided into three categories of learning motivation, namely students with the category of high learning motivation, moderate learning motivation and students with low learning motivation.

In the category of high, medium and low learning motivation, by comparing the average achievement of N-gain values between the experimental classes (XI IPA 3) with GeoGebra-assisted STAD learning, class XI IPA 1 with STAD learning and class XI IPA 2 with conventional learning then the real difference was the class with STAD learning assisted by GeoGebra and STAD class and STAD class assisted by GeoGebra and conventional classes. The STAD and conventional classes in the category of high and medium learning motivation also showed that there were significant differences. Meanwhile, the STAD class and conventional class for the low learning motivation category did not show significant differences.

This shows that differences in geometric reasoning abilities at SMA 1 Sampara with STAD-assisted GeoGebra learning can improve geometrical reasoning skills from both the high learning motivation groups, and are low. Whereas for STAD, learning only can improve the ability of geometrical reasoning for students with high and medium learning motivation categories. For the category of low learning motivation, between the STAD class and conventional classes do not show differences.

These results indicate that the provision of teaching aids in the form of GeoGebra application in circle learning can facilitate students in learning and lead students to think of things that can be seen (visualization) to the abstract stage. This stage of thinking geometry, as stated in Van Hiele's theory with the level of thinking starts from the stage of visualization. From the visualization stage, it leads to the second stage, called the analysis stage, the informal deduction stage, the deduction stage, and finally, the geometrical thinking stage is the rigor stage. But at the high school level aged 16-20, the ability achieved by students only reaches the stage of thinking formal deduction [12]. Meanwhile, the rigorous stage is for college levels. This research has been carried out in several universities, one of which is at the University of Pretoria, South Africa [15].

The use of learning media in the form of geometric applications needs to be given to students as a medium that allows students to experiment and experiment on their subject matter until students can reason things so abstract about geometry material. The use of computer media can make it easier for
students to understand the characteristics of geometric shapes that are so abstract. With GeoGebra, media students can also control their work done manually by comparing it with the results displayed by the computer. If there is a difference, the student can review, which part is not right. Thus the application of gebera in mathematics learning is not only as a medium to make it easier for students to understand circle material but can be used as a tool to control the truth of their work results manually.

In general, this study shows that the use of GeoGebra media in learning circle geometry can improve geometrical reasoning abilities in the students of SMA Negeri 1 Sampara, Kabupaten Konawe, Indonesia. The results of the comparison of the three classes given different learning show that the average increase in the learning ability of the geometry of the classroom with GeoGebra as a teaching aid proved to be higher than the other comparison classes. This is in line with the results of research at SMA Negeri 1 Wundulako, Kolaka, Indonesia that van Hiele's learning model has a greater influence than conventional learning models for students' geometric reasoning abilities [16]. Besides, students taught by the GeoGebra method performed better than their counterparts who did not use GeoGebra [5]. With using the GeoGebra, mathematics learning is more effective than traditional mathematics learning [17].

The high geometrical reasoning abilities achieved by GeoGebra-assisted STAD learning classes are due to the media using computer applications. The use of GeoGebra enhanced the students’ performance in learning Coordinate Geometry [18]. With computer applications in the form of GeoGebra, students are easier to experiment and experiment themselves so that they can generate reasoning abilities [19]. Reasoning ability can arise when students carry out repeated studies through a computer. This finding is supported by findings from previous research findings that examine the use of computer media to improve the ability of students' geometrical reasoning [20]. In his research, students are directed to define the characteristics of triangles, quadrilaterals, and so much so that they can solve problems using dynamic geometry software. Another study also previously was a merger of learning models (Problem Based Learning) with the help of GeoGebra worksheets [7].

Therefore, it can be said that the STAD cooperative model assisted by GeoGebra influences on improving geometrical reasoning abilities in terms of the level of student learning motivation. This is evident from the results of the pretest, before learning, reasoning ability achieved by students there was no statistically significant difference. But after being treated with GeoGebra-assisted STAD-type cooperative learning, the increase in scores from pretest to posttest achieved by students exceeded the abilities of other students both taught by STAD cooperative model and conventional (conventional) learning. The difference in geometric reasoning ability achieved by students with STAD cooperative model assisted by GeoGebra was significantly different from the increase in geometrical reasoning abilities achieved by the class of classrooms, namely classes with STAD learning and conventional learning.

4. Conclusion
This study concludes that in improving students' geometrical reasoning abilities, the effect of using the STAD cooperative model assisted by GeoGebra was higher when compared to the STAD cooperative model without GeoGebra and direct learning models. That difference occurs at all levels of motivation. On the other hand, the STAD model without GeoGebra only affects students with high and moderate learning motivation. Meanwhile, students with low motivation did not show significant differences in the direct learning model.

Acknowledgments
With respect and sincerely, the writing team thanked the Rector of the University Halu Oleo for supporting the author in presenting this article. We also convey our gratitude to the ISSAMEs' committee team who have provided many directions and instructions in writing this article.

References
[1] Jasinski J 2001 Sourcebook on Rhetoric (SAGE Publications)
[2] Rzesz S T 2011 Perspectives on the teaching of geometry for the 21
[3] Arbab F and Wing J M 1987 Geometric Reasoning: A New Paradigm for Processing Geometric
Information Des. Theory CAD 145–59

[4] Jones K and Bills C 1998 Geometry Working Group Visualisation, Imagery and the Development of Geometrical Reasoning Proceeding of the British Society for Research into Learning Mathematics

[5] Tay M K and Mensah-Wonkyi M-W 2018 Effect of using Geogebra on senior high school students’ performance in circle theorems African J. Educ. Stud. Math. Sci. 14 1–17

[6] Valerian A 2009 Limits of Educational Soft “GeoGebra” in a Critical Constructive Review Ser. Inform. VII 47–54

[7] Joko S 2016 The Development of Students Worksheet Using GeoGebra Assisted Problem-Based Learning and Its Effect on Ability of Mathematical Discovery of Junior High Students Proceeding 3rd Int. Conf. Res. ME 385

[8] Wulandari N F and Jailani 2015 Indonesian Students’ Mathematics Problem Solving Skill in Pisa and Timss Indones. Students’ Math. Probl. Solving Ski. PISA TIMSS 17–9

[9] Slavin R E 2008 Cooperative Learning, Success for All, and Evidence-based Reform in education Education Didact. 2 149–57

[10] Sugiyono 2010 Metode Penelitian Pendidikan (Bandung: Alfabeta)

[11] Vojkuvkova I 2012 The van Hiele Model of Geometric Thinking Van Hiele theory WDS’12 Proc. Contrib. Pap. Part I, 72–5

[12] Mateya M 2008 Using the Van Hiele Theory to Analyse Geometrical Conceptualisation in Grade 12 Students: A Namibian Perspective

[13] Uno H B 2011 Teori Motivasi & Pengukurannya: Kajian & Analisis Di Bidang Pendidikan (Jakarta: Bumi Aksara)

[14] Meltzer D E 2002 The relationship between mathematics preparation and conceptual learning gains in physics: A possible “hidden variable” in diagnostic pretest scores Am. J. Phys. 70 1259–68

[15] Kekana G R 2016 Using GeoGebra in transformation geometry: an investigation based on the Van Hiele model

[16] Ramlan A M 2016 The effect of van hiele learning model to ward geometric reasoning ability based on self-efficacy of senior high school students J. Math. Educ. 1 64–71

[17] Ibrahim K and Ilyas Y 2016 Teaching a concept with GeoGebra: Periodicity of trigonometric functions* Educ. Res. Rev. 11 573–81

[18] Saha R A, Ayub A F M and Tarmizi R A 2010 The effects of GeoGebra on mathematics achievement: Enlightening Coordinate Geometry learning Procedia - Soc. Behav. Sci. 8 686–93

[19] Jones K 2000 Providing a Foundation for Deductive Reasoning: Educ. Stud. Math.

[20] Forsythe S and Jones K 2009 BSRLM Geometry working group: tasks that support the development of geometric reasoning at KS3 Sue Forsythe 29 115–20