Students’ learning outcome through the implementation of guided inquiry learning model using Autograph

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Abstract. Innovations in learning mathematics using technology are needed to improve the students' learning outcomes. This research aimed to investigate the students' learning outcome through the implementation of guided inquiry learning model using Autograph in the trigonometric function graph at a senior high school in Aceh Besar, Indonesia. Quantitative approach employing experiment was used in this research. The research samples were Year 10 science students from class X as the experimental class taught with guided inquiry learning model using Autograph, and Year 10 science students from class Y as the control class taught with guided inquiry learning model without using Autograph. The research instruments were pretest and posttest consisting of four essay questions of trigonometric function graph. After the test requirement has been mett-test was conducted with a significant level of 0.05 to examine the improvement of students' learning outcomes between the experimental and control class. The research findings indicated that the improvement of students' learning outcome applying guided inquiry learning model using Autograph was better than those without it. The application of guided inquiry learning model using Autograph improved the students’ learning outcome.

1. Introduction
Mathematics is one of the sciences that serve as the basis of science and technology development. It aims to improve humans' thinking and analyzing ability. Mathematics has a vital role in humans' life development. The high demand for mathematics role has direct implications for the development of mathematics learning and objectives at school. Mathematics is science that is based on analyzing, reasoning and decision making to train students' critical thinking. Teachers should change the students' paradigm about mathematics being difficult. Teachers should also motivate them to learn actively using convenient learning model and atmosphere, for example, using innovations and technology in learning to improve the students' results. As NCTM stated that "NCTM concern on the importance of technology because it is the essential facility to teach and learn mathematics effectively, technology can expand the mathematical studies and improve students' learning" [1].

Ministry of Education regulation of Republic Indonesia (Permendiknas) Number 16 the Year 2007 asserted that mathematics teachers should have abilities to use the information and communication technology to achieve pedagogical competences [2]. Unfortunately, the teachers in Aceh Besar do not
use computers optimally at schools including in learning mathematics. The utilization of technology, particularly computer technology, can develop learning efficiencies and effectiveness.

Students should be competent to use technology effectively in mathematical learning to conduct the investigation, communication, organization, and evaluation [3]. It is in line with Incheon declaration: “Information and communication technologies (ICTs) must be harnessed to strengthen education systems, knowledge dissemination, information access, quality and effective learning, and more effective service provision” [4].

The curriculum 2013 directed mathematical teaching in the learning process to discovery/inquiry learning. Teaching and learning of mathematics are expected to improve students’ skills to be productive, critical, creative, and innovative as the theme of the 2013 curriculum development. Bruner introduced guided inquiry learning model. The model asks students to be active in learning and the teachers to be creative in creating active students to construct their own knowledge in a convenient class situation [5]. The guided inquiry learning model can encourage students’ interaction with the teacher and other students, and involve them in finding a concept. Teachers motivate the students to learn by experiments that enable them to figure out new ideas as their concept experiences [6]. The model allows students to find/produce something new using ideas, imaginations, and experiment for the first time [7].

The guided inquiry learning model is used to build students’ understanding of the concept by teacher supervision and direction [8]. The model is one of the cognitive learning models that require teachers’ creativity in facilitating students’ learning by inquiring their knowledge independently. The independent inquiry will ease the students to understand and remember the learning material. The knowledge will stay longer when the students figure out their own knowledge and get involved directly in the knowledge construction concept [9]. The formation of students’ ability to have free invention competence in the future can be implemented by using a guided inquiry learning model. Direct learning experiences of finding a concept through investigation is the core of the guided inquiry model [10].

Students presume that trigonometry is one of the problematic materials in learning mathematics, starting from the formula of trigonometric identities related angles and special angles in trigonometric to the graph of trigonometric functions. Drawing the trigonometry function graph manually is difficult for students. Besides taking much time, the graph result is not correct as of the expectation. [10] explained that the ability of students’ concept understanding was not satisfying, particularly in the topic of trigonometry function graph. They founded the data of students’ initial test for basic competence of drawing or reading the trigonometry function graph in the school did not meet the minimum mastery criteria. It was indicated from students’ ability in drawing the trigonometry graph function that they were not able to draw and explain the graph adequately.

The researcher’s experience as a teacher in one of the senior high schools in Aceh Besar showed that the students were incapable of finding the concept independently. They could not analyze the trigonometry function graph, so they felt bored in learning it. Another reason for unsatisfying students' learning outcome in trigonometry concept was that the learning process tended to focus on the teacher [11]. Students did not involve in constructing their knowledge. The teacher only transferr the information to the students. Therefore it was quickly forgotten.

Teachers can help students to find new concepts or ideas in learning mathematics in the topic of trigonometry using technology-based learning [5]. It is also suggested to use technology in learning mathematics to improve students’ learning outcome [12]. One of technology-based mathematics learning media was Autograph. Autograph is one of the technology media in mathematics learning that helps teachers in learning [13]. The software is easily used and applied in geometry, trigonometry, statistics, calculus, and graph drawing. The learning process applying the guided inquiry learning model enables students to find the trigonometry concept easily by using the Autograph [10].

Investigated the mathematics learning outcome improvement of Year 10 students at a senior high school in Kerinci by applying guided inquiry learning model. The findings indicated that the model improved the students’ learning outcome. The number of students who passed the minimum mastery criteria reached 71.875% [11]. [14] examined the improvement of learning activities in trigonometry of students Year X in a senior high school in Palu by implementing guided inquiry model. The result
showed that the model developed student learning activities. It was essential to conduct a study on this topic because the previous studies examine the students' learning outcome by a conventional guided inquiry model.

The research question of this study is: "Whether the students' learning outcome by guided inquiry learning model using Autograph in the topic of trigonometry function graph better than those without it?"

2. Method
The research used a quantitative approach, the type of experimental research, the Pretest Posttest Control Group Design [15]. The research data were the quantitative data of student learning outcomes from the experimental class (20 students) and the control class (18 students) of each class. Class X, as the experimental class that experienced the learning using guided inquiry model assisted by Autograph, and class Y as the control class taught by guided inquiry learning model without Autograph. T-test was used to examine the mean difference between the two samples after the test requirements were met. The test to examine the average N-gain score differences was also conducted to evaluate the improvement of student learning outcomes in the experimental and control class. After the learning process for each class, a final test was administered to examine the improvement in student learning outcomes of each class. The research instruments wastest related to the graph of a trigonometric function, namely pretest and posttest. The research instruments were pretest and posttest consisting of four essay questions of trigonometric function graph.

Three experts validated the lesson plan and student worksheet, namely: Mathematics Education Lecturer, Mathematics Teacher Supervisor of Aceh Education Office and Mathematics Teacher in the selected school. The validation involved the writing format, content and language used. The validation result showed that the lesson plan and student worksheet could be used with a little revision. Data analysis employed t-test with the hypothesis that the increase in student learning outcomes in the class taught with guided inquiry learning models using Autograph is better than its counterpart.

The research hypotheses are as follows:
\[ H_0 \] : The improvement of the learning outcomes of students who experience the learning applying guided inquiry learning model using Autograph is equal to those who experience the learning applying guided inquiry learning model without Autograph.
\[ H_1 \] : The improvement of the learning outcomes of students who experience the learning applying guided inquiry learning model using Autograph is better than those who experience the learning applying guided inquiry learning model without Autograph.

3. Results and discussion
To examine the improvement of students’ learning outcome between the experimental and control class, t-test was conducted with a significant level of 0.05, after the test requirement has been met. The test criteria with a significant level of \( \alpha = 0.05 \) was that \( H_0 \) was accepted if \( \alpha \geq 0.05 \) [16]. In summary, the mean differences in N-gain of the student learning outcomes were 0.001, less than \( \alpha = 0.05 \). The t-value \( = 3.440 \geq 2.02 \) (t-table = 2.02), indicating that the increase in student learning outcomes that applying guided inquiry learning model using Autograph was better than those without it. Students need the use of technology to become an effective problem solver, communicator, collaborator and creator. Students can utilize digital technology to manage, integrate, and build information/knowledge [3]. The results of the study conducted by [10] also reported that improvement of students’ conceptual understanding of the trigonometric function graph applying guided inquiry approach using Autograph is greater than those using the conventional approach.

The better improvement of students' learning outcomes in the experimental class showed that students could understand well the concepts through the implementation of the guided inquiry learning model using Autograph. Besides, this learning model requires students to do more problem-solving activities in the Student Worksheet, facilitated by the teacher.
Students usually study in classrooms; in this study, they studied in a computer laboratory. Thus, the learning atmosphere was more relaxed. Students listen carefully to the teacher's instruction and try to use the Autograph independently and enthusiastically. The student activities in guided inquiry learning using Autograph also improved during the learning (five lessons). In the first and second lessons, students were still not familiar with the guided inquiry model and Autograph so that the students were not active. The students listened to the teacher’s instruction and explanation, but they were not confident to do experiments and investigations independently. Thus the teacher was dominant in conducting guidance.

In the next lesson, the students started to be engaged in learning because they were more familiar with the guided inquiry model, and they understood the use of Autograph. The teacher only provided guidance when the students experienced difficulties. Students were more dominant in investigating to discover the concepts about the graph of a trigonometric function. The students were already independent in using and working on the student worksheet. The students discussed the worksheet in their groups; they interacted with their group members and jointly built their knowledge and deepened their understanding through the worksheet. This is in line with [17] who revealed that student learning activities implementing the guided inquiry using Autograph were better than those without it. The students’ attitude in the experimental class was also more positive [17].

The learning outcomes in the class, applying the guided inquiry learning model using Autograph was better than those without it because the learning environment engaged the students. The results suggested that in the guided inquiry learning model using Autograph, students were actively involved in the learning process so that concepts were more embedded in the students’ memory. The implementation of guided inquiry learning model using autograph also emphasized more on discovering the concepts by themselves or with teacher guidance, so that they can remember the concepts and their learning outcomes improve [18].

4. Conclusion
Based on the results of the study, it can be concluded that the improvement of students’ learning outcome applying the guided inquiry learning model using Autograph was better than the students' learning outcome applying the guided inquiry without Autograph. It is recommended for teachers to implement this learning model for their future lessons. Further studies should also be conducted for different topics.

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