



A Comparative Study of Student Learning Outcomes in Geography Learning Using ArcGIS Application and QGIS Application

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Abstract: One of the characteristics of learning geography in the 21st century is that teachers must strive to develop technology that supports learning. This study aims to discover differences in learning outcomes in geography learning using the ArcGIS application and the Quantum GIS application for senior high school students. The method used was a quantitative experiment with a quasi-experimental form. Determination of the sample by purposive sampling consisted of two experimental classes, with each class totaling 34 students. Students' learning outcomes were tested with a two parties t-test which previously tested data normality, data homogeneity, and the hypothesis. The results of this study show that the experimental class using the ArcGIS application has a post-test average score of 83.03 and the class using the Quantum GIS application has a post-test average score of 77.50. Therefore, there are differences in the learning outcomes of the two experimental classes, which show that using the ArcGIS application is more effective in geography learning in senior high schools than the Quantum GIS application. The results of this study can be used as material for consideration of implementing the use of innovative learning media and improving mapping skills for high school students.

Keywords: learning media, application, arcgis, quantum gis, learning outcomes

Recommended citation: Aurellia, S. C., Tampubolon, B., & Anasi, P. T. (2023). A Comparative Study of Student Learning Outcomes in Geography Learning Using ArcGIS Application and QGIS Application. *Journal of Innovation in Educational and Cultural Research*, 4(2), 229-237.

INTRODUCTION

According to the Minister of Education and Culture No. 22 of 2016 concerning process standards on learning principles, one of which is the use of information and communication technology to increase the efficiency and effectiveness of learning. It is related to this principle that learning in schools today must improve its efficiency and effectiveness by utilizing information technology. In learning at school, the delivery of theory is not enough for students, so it is necessary to use technology that can improve students' creativity, improve their ability to accept the material being taught, and assist teachers in evaluating students (Rahman et al., 2022). One of the characteristics of learning geography in the 21st century is that teachers must strive to develop technology that supports learning. There are four skills in the 21st-century characteristics, namely: communication, collaboration, critical thinking, and creativity. However, Fullan and Langworth further developed it into 6: citizenship, communication, critical thinking, collaboration, and imaginative creativity (Andriana et al., 2022; Gonzales et al., 2020).

The mandate of the 2013 curriculum, which is contained in the Minister of Education and Culture 81 A Appendix 4, demands scientific application consisting of five skills: observing, asking questions, gathering information from various sources, reasoning, and communicating. Scientific determination is highly recommended when discussing senior high school geography subject matter (Susiati et al., 2016). Geography learning must encourage and inspire students to think spatially, analytically, and accurately in identifying, understanding, solving problems, and applying geography learning material based on spatial principles (Kiik, 2020). In 21st-century learning, it is also taught that students are equipped with knowledge and skills to make they can later have critical and creative thinking (Kurniawati et al., 2021). A good implementation of 21st-century learning can bring a good impact on the students and they will be able to compete nationally and internationally in the future.

In this study, the application is applied to the basic knowledge of mapping material which focuses on mapping. Mapping is a science that studies the appearance of the earth by using a tool to find out accurate results (Fikriyah & Furoida, 2021). The primary material for mapping is material received by class X students. In this material, students are taught the basics of mapping and the process of mapping. Geography learning mapping material is now used only to contain the theory but does not directly practice the technology used for mapping. Students need help with this. Students in the 4.0 era prefer to practice their learning outcomes directly rather than just learning theory. The media provided by the teacher strongly influences student learning outcomes; the more interesting the media is offered, the higher the value is produced (Nofrion, 2018). It can

be said that learning media can improve student learning outcomes (Faradila & Aimah, 2018). For this reason, it is necessary to introduce information technology. One of the applications that can be used for mapping is a geographic information system (GIS). GIS is a spatial information system that processes georeferenced data (Hamidi, 2007).

Meanwhile, supported by previous research, the results of research conducted by Kurniati (2020) from Faculty of Teacher Training and Education of Universitas Tanjungpura. The result of this study shows an influence of students' learning outcomes who apply the GIS application in the learning process, where the effect is quite significant, namely 78.6 for those who apply the application and 67.6 for those who do not apply the application. The applications used in this study are the ArcGIS application and the Quantum GIS application (QGIS), intending to compare the two applications by giving the same treatment to the experimental class to find out the differences in students' learning outcomes and to find out which application is considered the most effective in using it in schools, especially SMA 2 Pontianak. A comparative study is an approach to comparing or finding out comparisons of two or more characteristics (Sofiana, 2020). What is being compared is the learning outcomes of the two classes that apply the GIS application. Student self-assessment, seen from student ability or achievement, defines learning outcomes (Nurhasanah & Sobandi, 2016).

ArcGIS application is a software that can be used as a geographic information system with high sophistication in making maps and spatial analysis. ArcGIS application has a main interface consisting of five applications, namely: ArcMAP (select, process, and display maps), ArcCatalog (to manage spatial data for GIS), ArcToolbox (display 3D maps connected directly to the internet), and the last one is ArcScene (processing and displaying maps in 3D (Nirwansyah, 2017). The advantages of the ArcGIS application are that it has good facilities for publishing maps and the ability to add data (raster, layer, and shape files) (Widharma, 2019). ArcGIS is designed to meet users' needs in various fields. For example, it maps school locations in education (Booth & Mitchell, 2001). ArcGIS facilitates its users by providing tools to model and analyze spatial data (Shekhar & Xiong, 2008). Because the ArcGIS view that integrates with the layout view will facilitate the process of making maps according to the stages. However, even though the ArcGIS application has many advantages, it also has disadvantages. The cost of using it is high because not all features in ArcGIS can be used for free. There are many of the features used must be charged in advance (Fikriyah & Furoida, 2021).

Meanwhile, Quantum GIS (QGIS) application is software used as a geographic information system that offers many functions available in the plugin, namely, to create, edit, manage, and export data. Unlike ArcGIS, which is paid for, QGIS offers it for free because it is Open Source (Sulistiyo, 2021). QGIS is an open-source GIS software that provides several tools for data visualization and analysis. It is mainly written in C++ code, but it also allows us to extend the functions thereof through API and plugins written in Python. QGIS application has two features, namely: menus (which contain menus for the mapping process) and toolbars (functional icons) (Budiyanto, 2016). QGIS application creates maps with the data format in a shape file abbreviated as 'shp' and users of various Esri products are familiar with it. The facilities provided by the QGIS application are also complete, and the primary processing of digital maps is more comprehensive with the appearance of the latest version, which gives a stunning, simple, professional, and the most crucial aspect is that the QGIS data visualization is straightforward. After that, QGIS can be accessed for free and simply used to visualize important spatial patterns in various fields (Flenniken et al., 2020). QGIS has a useful, comprehensive Web site with plenty of resources to get you started. Beyond the free application download, we will find a wiki, help forums, and loads of documentation. QGIS has versions for Mac OS X, Windows, and several variants for Linux users: source, Debian, Ubuntu Gutsy, and OpenSUSE. The drawbacks that QGIS has are the location of its features which are difficult to find, when it is installed, it must be set up first if you want to use it, the QGIS features are not complete as other applications, and during operation sometimes there are errors so when making maps you have to frequently saved (Imran et al., 2020).

The problem of this research is that digital technology needs to be used in the geography learning process at the senior high school, so it is necessary to apply digital technology, especially in mapping materials. There are three important sub-materials including map material, remote sensing material, and geographic information system material or commonly abbreviated as GIS. In this study, the focus of the application of the two applications is on geographic information system material. With this geographic information system manufacturing technology, the purposes of the research are to identify what mapping applications are most effective and to improve student learning outcomes. If the learning outcomes with the two applications are the same then both applications are well implemented in a high school, otherwise if only one of the applications is superior, then the application is feasible to be implemented in high schools. This is done to make the application of ICT, especially in shifting geography learning materials, being maximized according to the results obtained from the research.

METHODS

The type of research used in this study was quantitative research with experimental methods with the two applications used. Experimental research is a study that aims to find a causal relationship between free and bound variables where free variables are controlled and manipulated intentionally or given different treatments from bound variables (Jakni, 2016). This research used a quasi-experimental design with a non-equivalent control group design, namely, experiments on two groups to experiment. The research design carried out was.

Table 1. Research Design

Class	Pre-test	Treatment	Post-test
Experiment I	O ₁	X	O ₂
Experiment II	O ₃	X	O ₄

The research design above was given information that the results of the initial knowledge test for the experimental class I were marked with code O₁, the results of the initial knowledge test in the experimental class II were marked with code O₃, the final test results for the experimental class I were marked with code O₂, the final test results for the experimental class II is marked with code O₄, and treatment was marked with code X (Sugiyono, 2019). From the research design above, it is clearly described that the researcher used two experimental classes with different treatments. Each experimental class was given a pre-test and post-test to see differences in learning outcomes before and after being given treatment. The intended treatment was to provide the use of the ArcGIS application in the experimental class I, and QGIS in the experimental class 2. To reach the peak of the research, namely the final test, the researcher had targeted a month from giving the initial test.

Data sampling used purposive sampling techniques, which means specific considerations (Rinaldi & Novalia, 2020). The classes sampled were those that had almost the same average score on the pre-test and the same geography subject teachers. The research samples were two selected classes: class X PIPS 8, which was treated with ArcGIS application, and class X PIPS 6, which was treated with QGIS application. The data collection tools in this research used post-test and pre-test questions for student learning outcomes. Test results were collected quantitatively to determine the degree of a particular aspect compared to a particular standard and the appropriate or relevant unit of measurement. This research consisted of three stages, namely the preparation stage, the implementation stage, and the final stage. The data analysis used in this study aims to answer problems or test hypotheses which can be called inferential statistics (Sutopo & Achmad, 2017). Statistical formulas are the main instrument for analyzing quantitative research. Therefore, the researchers obtained data from practicum results and final test results of students in both sample classes. The steps taken to analyze the data were.

Table 2. Data Normality Test Results

Information	Experimental Class I	Experimental Class II
X Count	4,81578	2,82786
X Table	11,070	11,070
Conclusion	Accepted	Accepted

Table 3. Data Homogeneity Test Results

Information	Experimental Class I	Experimental Class II
Number of Samples	34	34
Variance (S ²)	94,09	134,79
F Count		1,43
F Table		1,84
Conclusion	Accepted	Accepted

Hypothesis testing using *the separate variance t-test*. From the calculation results, it is obtained that t_{count} is 2.099 and t_{table} is 1.997. Based on t_{table} freedom degree 66 at 5% signification, with a two-party t-test, it is 1.997. The calculated t value is 2.099, while t_{table} is 1997. So it can be concluded that t_{count} is smaller than t_{table} ($2,099 < 1,997$). It can be concluded H_a is accepted and H_0 is rejected.

RESULT AND DISCUSSION

The stages carried out were to provide supply materials for two weeks during the study. Then, a group is formed and divided into five groups for each class. The first implementation stage is to enter shp data from folders into each application. The shp data in question is data in the shp/shapefile format. Shapefiles are vector

data formats for storing attribute information and geographic data. This data was developed by Esri (2014) and consists of features such as points, lines, or polygons (GIS Resources, 2014). The vector data model is often used because it is based on coordinate value points (x, y) which when connected will form polygons or areas (Anggriani, 2010).

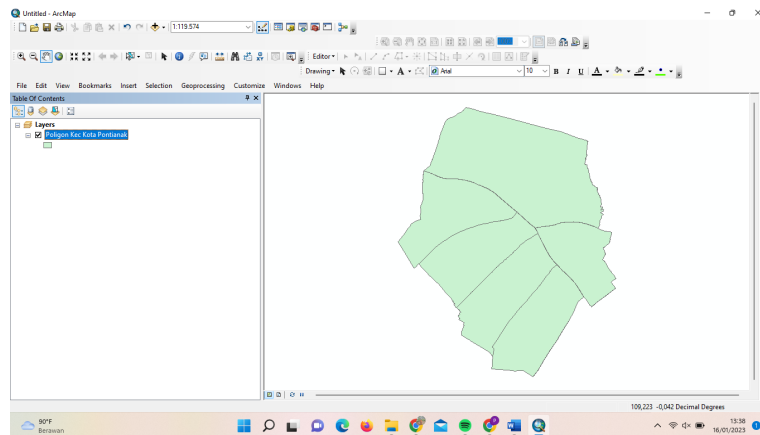


Figure 1. Stages of Entering Shp Data with ArcGIS Application

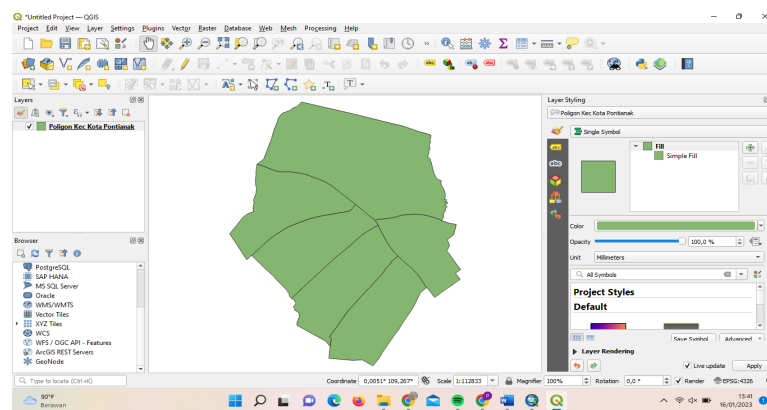


Figure 2. Stages of Entering Shp Data with the QGIS Application

After entering the necessary data, proceed to provide symbologies on the map. Symbology is intended to provide information in shapes or colors that map readers can interpret. Map symbology is a term to describe how features or objects on a map are visualized (Hussein, 2022). Giving symbology to the map must be following the object so that the map reader understands the meaning of the symbology given on the map. Making map symbol designs must consider the perceptions and aspirations of map readers so that symbology can be used properly (Laksoni & Raharjo, 2013).

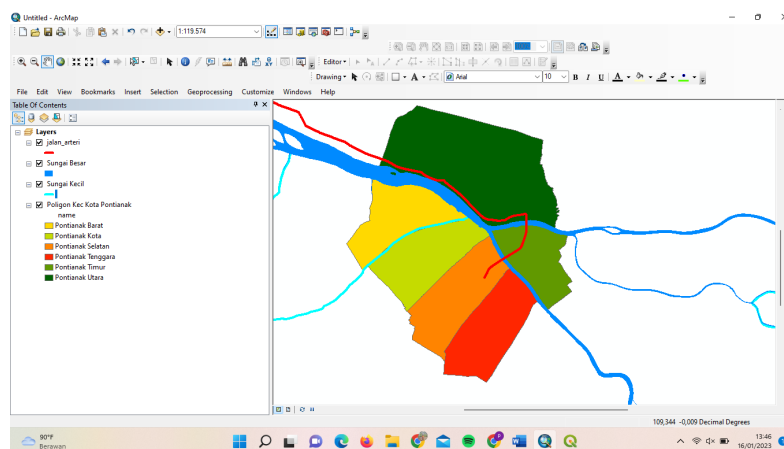


Figure 3. Symbology Stages with ArcGIS Applications

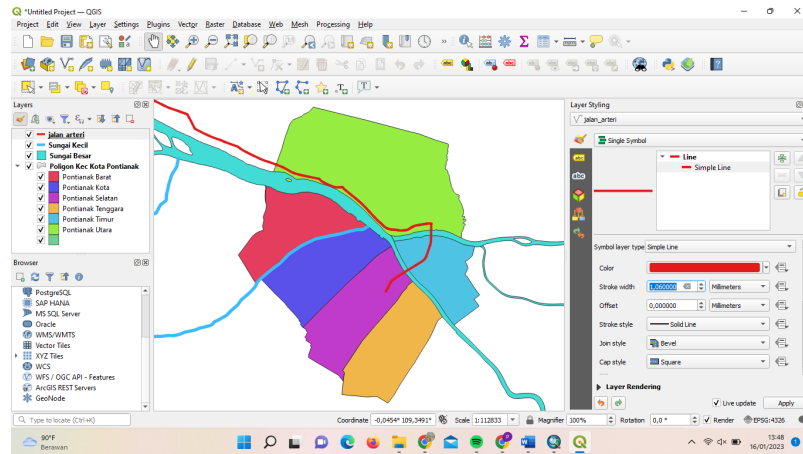


Figure 4. Stages of Symbology with QGIS Application

If the symbology stage has been carried out properly, it is time to enter the stage of giving naming or what is known as labeling on the map that has been symbology earlier. The map will not be complete if the labeling process is not carried out because one of the factors in the formation of a map is at this stage (Amlund et al., 1985). This stage is helpful for map readers; they know what map we are making because it is crucial and should be noticed. In the labeling process, problems often occur in applying general cartographic processes that are not suitable for placement on maps that should be automatic and efficient (Been et al., 2006).

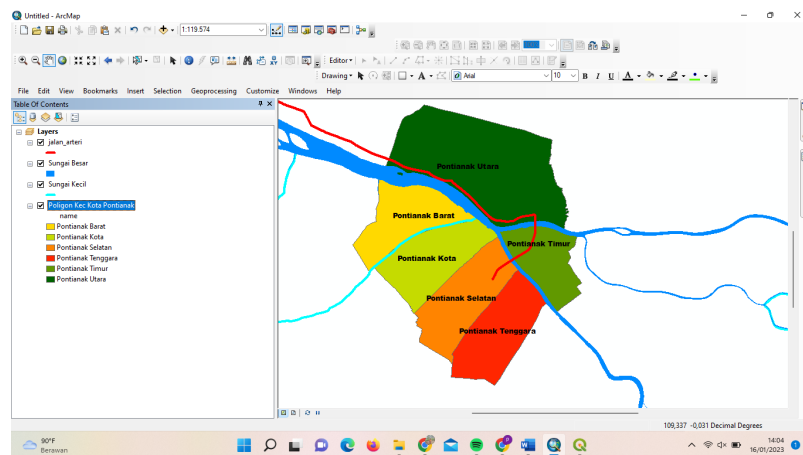


Figure 5. Stages of Labelling with ArcGIS Applications

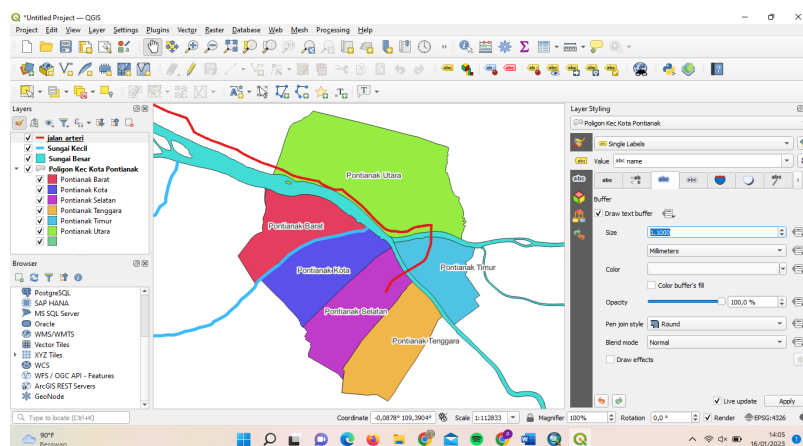


Figure 6. Stages of Labelling with the QGIS Application

The last stage is called the map layout and closes by exporting the map to Jpg or PNG. The final stage (completion) is carried out to edit and evaluate the art of the map that has been made, whether it is interesting or not depends on this stage (Noeroel, 2020). The map layout is to frame the map and insert the components in the map so that the data map can be said to be the actual map and then printed as we expect. Usually, the

map layout often uses the display position on A3 and Landscape paper so that the information and legend that will be conveyed on the map can be presented clearly on the right (Nugraha, 2013).

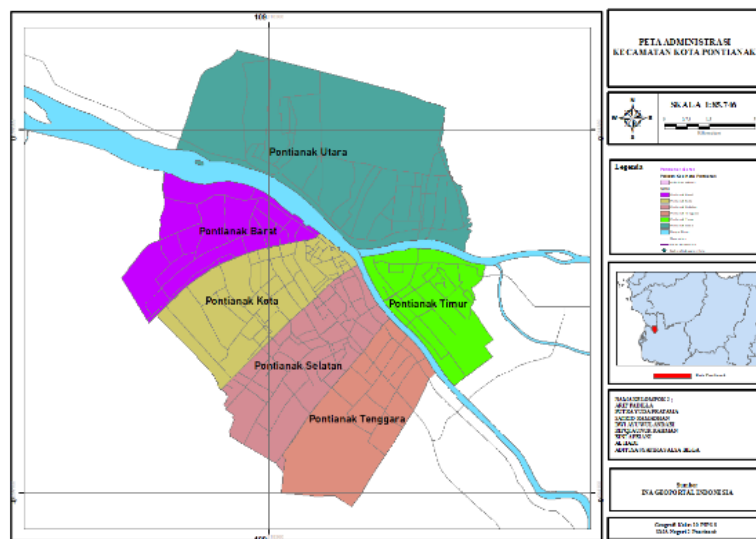


Figure 7. Stages of Layout and Map Export

Table 4. Average and standard deviation of the ArcGIS application user-grade end-of-class knowledge test

Result Data	
X	83,03
SD	9,81
S ²	96,2361/9,81

There were 34 students who took the post-test. From the post-test, the researcher found that there 9 students had a score below the passing grade, and 25 students had a score above the passing grade. Meanwhile, the minimum completeness in the school is 76. The post-test results showed that the highest score student achieve is 95 and the lowest score is 65. Next, the ArcGIS application was well received by senior high school students. The implementation of the ArcGIS was carried out in groups by providing extra teaching facilities, namely 1 operator in each group. The operator's role is to justify the wrong steps but not 100% help the process. It is expected that the students independently and correctly understand what was applied. The use of the ArcGIS application is well carried out with excellent acceptance and is also welcomed by students so that they feel that learning by the ArcGIS application can increase enthusiasm for learning and is considered exciting. It is also supported by [Jumardi et al. \(2021\)](#), in a journal titled Geospatial Information to Improve the Competence of Geography Teachers in Lawu Regency. He stated that the ArcGIS application could improve the insights and skills possessed by geography teachers. It becomes clear evidence that the implementation of ArcGIS applications in schools to map materials is effective for students and teachers of geography subjects. Factors that improve learning outcomes include good teachers who can teach by looking at class situations and making learning fun for students and the existence of learning media ([Nurrita, 2018](#)).

Table 5. The average and standard deviation of the end-of-class knowledge test of the QGIS application user

Result Data	
X	77,50
SD	11,61
S ²	134,79/11,61

There were 34 students who took the post-test. From the post-test, the researcher found that 12 students had scores above passing grade and 22 students below passing grade. Meanwhile, the minimum completeness in the school is 76. The post-test results showed that the student's highest score is 90 and the lowest score is 50. Just like the ArcGIS application, the implementation of the QGIS application in other classes by dividing groups and providing facilities for 1 GIS operator in each group. At the time of the research, the

initial QGIS application group received a welcome and was proven by discipline during the process of entering data to labeling. However, when entering the layout stage, the students seem busy on their own and immediately find it difficult to control the class. Meanwhile, the researcher found that students' learning outcomes have improved but not drastically. It is supported by Nia Kurniati (2020) from Universitas Tanjungpura titled The Influence of GIS Media Use with QGIS on Geography Learning on Student Learning Outcomes of Class X Senior High School 6 Pontianak. She stated that QGIS affects improving student learning outcomes. The application of media can be categorized as a renewable learning media in the experimental/research class if the results obtained increase indicating that the learning media is used effectively (Ferdiansyah et al., 2020).

The average score possessed by experimental class I, a class that uses the ArcGIS application in learning the geography of mapping materials, is higher than the average score possessed by experimental class II, which uses the QGIS application. It can happen because, during the learning process of practicum 1 and practicum 2, these two classes have shown different disciplines. When the teacher entered the classroom, students in the experimental class I had prepared themselves before the teacher entered the class. In contrast to the experimental class II, which looks not focused and busy oneself so that the teacher arranges to sit in a group so that the class conditions are not conducive when starting teaching and learning. Another thing visible from the teacher's observations is the students in the layout process. During the layout process in experimental class I, the student who felt that the appearance was missing immediately raised their hands to ask for help to be corrected by the teacher. In contrast, experimental class II felt that the separate layer layout made it difficult for students to go back and forth, so the enthusiasm for entering this stage was reduced. At the time of the discussion, the experimental class I flocked to wanted to answer. In contrast to the experimental class II, students were busy with the group, so they were not paying attention to the teacher in front of the classroom.

Supported by previous research by Hawi (2018) who states that in the aspect of satisfaction, ArcGIS tends to be higher with a value of 68.5 compared to QGIS with a value of 54.5. Satisfaction is an aspect of user satisfaction that shows that ArcGIS satisfaction levels are higher than QGIS. This is why when the post-test, the experimental class I score was higher than experimental class II. It is because the students in the experimental class I well prepared themselves than students in experimental class II. After that, if the students in the experimental class I were confused in practice, they hurried up to raise their hands and continue the practice. Meanwhile, the students in experimental class II felt it challenging to go back and forth between layout-layer pages. At the time of class discussion, experimental class I was more excited and active than experimental class II. However, there is also a journal by Jumardi et al. (2021), which is clear evidence that the application of ArcGIS applications in schools to mapping materials is effective not only for students but for teachers of geography subjects as well.

CONCLUSION

Using applications in mapping materials obtained good improvement results in both experimental classes. The average score of students' learning outcomes using the ArcGIS application is 83.03 and the standard deviation is 96.24 which shows superiority over learning outcomes using the Qgis application, namely 77.50 and the standard deviation is 134.79. The hypothesis is accepted with differences in learning outcomes using the ArcGIS application and the Quantum GIS application obtained from t count is 2.009 and t table is 1.997 so it is concluded that t_{count} is smaller than t_{table} . This shows that the ArcGIS application is the most effective application used in high school geography learning mapping materials. The first stage carried out in making a map using ArcGIS is entering shp data, then followed by the symbology and labeling stages, and ending with the layout and map export stages. The skill of making a map is judged by the person making the best symbology and labeling.

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