GeoGebraAs a Tool to Enhance Student Ability in Calculus

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GeoGebraAs a Tool to Enhance Student Ability in Calculus

Florentina Yuni Arini and Nuriana Rachmani Dewi

Abstract

This paper described the use of GeoGebra software to help students in understanding Calculus material and its applications. GeoGebra is already used by more than 100 million students around the world. GeoGebra has the ability to minimize the difficulties of students who get Calculus subjects, especially students majoring in Natural Sciences and Engineering because this subject becomes a compulsory subject and a fundamental foundation in mathematics and its application across multidisciplinary fields such as medical, social sciences, psychology, and economics. Usually, the calculus course is given to first-year university students as the foundation for next course requirement. However, the manual calculation in Calculus sometimes takes a long time as it requires mathematics skills to solve the problem. Therefore, the advantages of using GeoGebra are (a) helping to convey the Calculus concept material to be more interesting, especially for the delivery of material concepts of functions, limits, derivatives, and integrals, (b) providing a more realistic image, especially for more complex calculus material, and (c) providing a faster and accurate solution.

Keywords: GeoGebra, Natural Sciences, Engineering, Mathematics, Calculus

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1. Introduction

Learning mathematics for some students becomes something unpleasant but in reality mathematics becomes the basis that can actually be found in daily real life. As the example, when managing finances we not only need to know the science of accounting but also the basic mathematical calculations used in the accounting sciences. So that the instructors and practitioners try to find the right way through research, as well as the experiments and tools used that help in calculations.

With the development of internet technology, various tools are used to facilitate learning mathematics easily and quickly, including from "The Tech Edvocate", "Common Sense Education", or "The Math Learning Center". To be more interactive and fun, some of these mathematical applications can be easily obtained, including (a) Pentagon Math, which is a mathematical application that focuses on algebra, ratios, trigonometry, geometry, and statistics; b) Mathalicious, which helps learners in understanding mathematical

concepts in a fun way; (c) Photomath, which can be used as a private technology-based tutor in learning math to solve problems; and (d) GeoGebra, which is a mathematical application that can provide illustrations with models and simulations.

GeoGebra software can be used to help mathematics learners from elementary school to college level. At the university level there is a compulsory Calculus course for students in the fields of science and engineering. Usually, this course is given in the initial year of university. It turned out that from several studies it was found that students were still having difficulty understanding the Calculus course. (Pyzdrowski et al, 2012; Zakaria et al, 2015). Various ways are used to improve achievement in the Calculus course. One of them is using GeoGebra software.

GeoGebra is one of the technologies that has become a reliable learning resource in calculus. GeoGebra has become a tool that can help teachers to design effective instructional lessons that enhance teaching and learning process in Calculus (Nobre et al, 2016; Hohenwarter, 2008). It aims to support and enhance the ability of sense-making learners in Calculus, as well as to sharpen reasoning learner skills so that they can be used as problem solvers and communication mathematically. Effective teachers can optimize the potential of GeoGebra to develop students' understanding, stimulate students' interest, and improve students' abilities in Calculus. When the teachers uses technology that is strategically integrated and correct, it means that in a professional manner it has continuously developed technological knowledge and its application to support the learning and teaching process so as to give an impact on students' understanding and use of GeoGebra for Calculus (Gluzman et al, 2018; Thomas et al, 2018; Khalil, 2017).

2. GeoGebra

GeoGebra has been very widely used by academics and researchers as an alternative to learning media of mathematics that is quite reliable based on technology. The use of GeoGebra can be accessed free online and can be downloaded for free for offline purposes. Online GeoGebra can be accessed on this site; https://www.geogebra.org/classic and for offline software, GeoGebra can be accessed through https://www.geogebra.org/download. Based on the site, GeoGebra users have reached 100 million students, while GeoGebra researchers based on Google Scholar have 15,800 published scientific papers.

The GeoGebra software was the result of Markus Hohenwarter's thesis of master program at the University of Salzburg in 2002 (Hohenwarter, 2013). Hohenwarter

designed GeoGebra by combining interactive geometric software features and algebraic systems into an integrated and easy-to-use system for teaching and learning mathematics (Hohenwarter et al,2007). GeoGebra can be used for learning geometry, algebra, calculus and statistics.

To run GeoGebra, Java Runtime Environment (JRE) is required. Devices (Hohenwarter et al, 2007; Ancsin, 2011; Hohenwarter; 2013; Ancsin, 2013) which can support GeoGebra applications include (a) laptops or computers running on the latest Mac, Linux or Windows operating systems; (b) tablets such as iPad, iPad mini, or Android; (c) smartphones running on the latest mobile OS versions such as iOS or Android, and connected to the internet through a web browser; (d) other internet-based devices such as the iPod Touch.

The use of GeoGebra software in the field of academics has been done a lot. This is evidenced by the 28,100 scientific papers regarding GeoGebra produced by students, teachers, lecturers, researchers and practitioners on Google Scholar. The use of GeoGebra in the field of education includes (a) Hussin et al (2018) *Teaching Effectiveness using GeoGebra*; (b) Solvang et al (2018) *Use of GeoGebra for physics education*; (c) Jacinto et al (2017) *Solving mathematical problems using GeoGebra*; (d) Bulut (2016) *Effect of Geogebra on academic achievement of third grade primary school students in solving fraction problems*; (e) Verhoef et al (2015) *Professional development through lesson study by teaching derivatives using GeoGebra*.

Besides using GeoGebra for Mathematics and Calculus, many researchers also conducted research on the Geogebra software itself and its application, including Binterová et al (2013) *Use of Geogebra seen from the content and language used as learning*; Drabekova et al (2015) Solving the Microeconomics Problems by Using GeoGebra. Aktümen et al (2016) *GeoGebra can be considered an Artist's Paintbrush*; Dimitrov et al (2018) *Use of GeoGebra Application for teaching Mechanical Engineering*. Based on these scientific papers, a variety of perspectives and the use of GeoGebra in daily life show a deep interpretation of GeoGebra software.

3. Research Methods

One of the methods that can be used as supporting evidence in a research is through a systematic literature review applied to gather experience from various different studies to answer certain research questions by analyzing the contribution of the research. Systematic literature review is shortened to systematic review. Systematic review (Patten, 2018; Walliman, 2011) is a medium to identify, evaluate and interpret all available

research that is relevant to a particular research question, or topic area, or an interesting phenomenon. Study that forms the basis for systematic review is called primary study and systematic review itself forms of secondary study. Various techniques aim to provide a systematic and rigorous tool for literature analysis. Suggestions are also made on writing analysis of ideas in ways that can provide clarity, coherence and clarity.

4. Discussion

Based on the results of Scopus from 2006 to 2018 there were 373 international scientific papers on GeoGebra. Graphically, from 2006 to 2018 there is always an increase as seen in Figure 1. GeoGebra has also been used in various fields including Social Sciences, Mathematics, Computer Science, Physics, Engineering, Psychology, Art and Humanities, Decision Sciences, Business and Management and Chemistry. Based on the chart in Figure 1, there are 31.5% for Social Sciences, 24% for Mathematics and 21.8% for Computer Sciences.

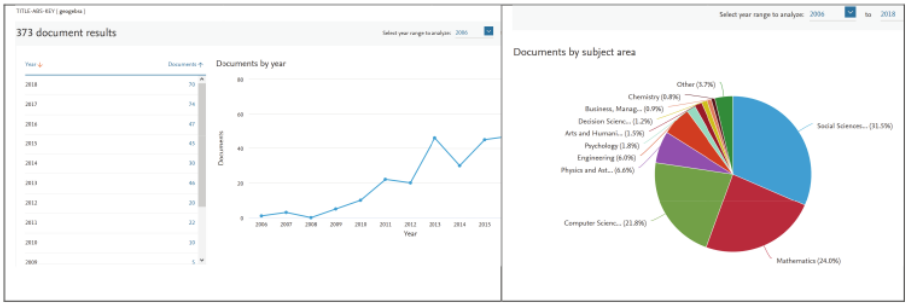

Figure 1: Chart of Scopus GeoGebra.

Figure 2 shows the interest in using GeoGebra based on the Country and its affiliation. Indonesia is one of the countries where the researchers conducted GeoGebra research indexed by Scopus. The number of scientific papers using GeoGebra indexed by Scopus has more than 20 published papers from 2006 to 2018. However, the universities that dominate the scientific papers in GeoGebra are Universidad de Cantabria (Spain) and Universidad de Vigo (Spain).

The use of GeoGebra software is very helpful for learners to provide an overview of function descriptions, to have an overview of visualization, and to be able to represent calculus concepts more realistically. As shown in Figure 3, each represents a function of (a) f(x) = x; (b) f(x) = x^2; (c) f(x) = x^3; (d) f(x) = x^4; (e) f(x) = integral(x^2); (f) f(x) = derivative(x).

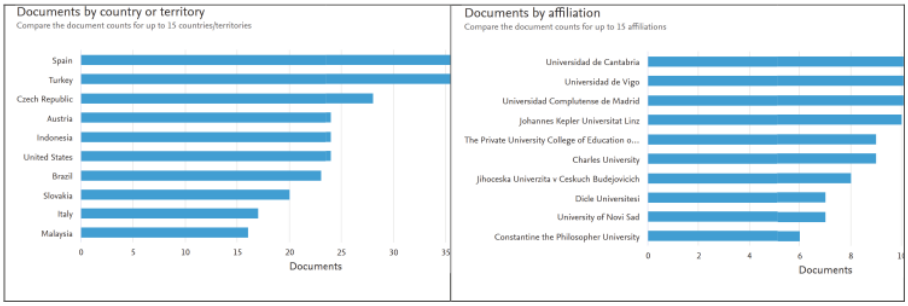

Figure 2: Country-based GeoGebra and its affiliation 2006 - 2018.

Manually describing a function seen in Figures 3b, 3c, 3d, and 3e will be more difficult. By using GeoGebra, learners or tutors will be easier to represent a function visually.

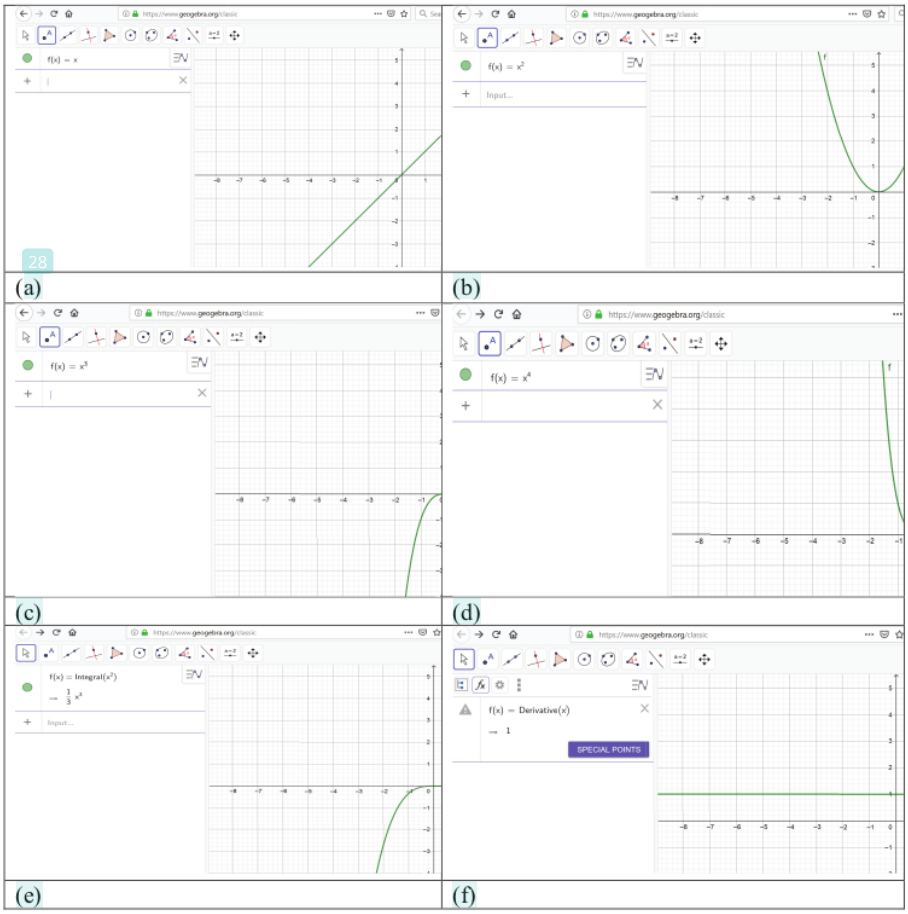

Figure 3: Representation of Functions Using GeoGebra.

5. Conclusion

The application of technology as an alternative to teaching and learning is very important, especially for learning Calculus. GeoGebra is one of the softwares that can facilitate teaching mathematics. The use of GeoGebra software can help students improve understanding of Calculus learning. So that GeoGebra can be a tool that can make it easier for students to master Calculus material. Geogebra is able to help Calculus material students through visualization because GeoGebra is an application of technology that provides an opportunity for learners to visualize their ideas using graphic illustrations. Representing a function in Calculus in graphics is not easy. To be able to describe a function appropriately is not only relying on mathematical abilities but also having skills in art. Therefore, GeoGebra helps lecturers in explaining Calculus concepts easily so Calculus learning becomes more interactive and innovative through creative learning.

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