European Journal of Open Education and E-learning Studies
ISSN: 2501-9120
ISSN-L: 2501-9120
Available on-line at: www.oapub.org/edu

DOI: 10.46827/ejoe.v7i2.4509 Volume 7 | Issue 2 | 2022

STUDENTS' PERCEPTIONS OF USING GEOGEBRA SOFTWARE IN MATHEMATICS LEARNING

Bakri Awaji[i]
University of Bisha,
Bisha, Saudi Arabia

Abstract:
This study adopted a qualitative approach to determine the views of grade eight students concerning mathematics learning with GeoGebra software (GGS). In total, 37 grade eight students (11–14 years old) from two classes participated in the study and 14 students volunteered to participate in focus groups (7 from each class). The data from the two focus groups were analysed using thematic analysis. The results of this study that emerged from the two focus group sessions comprised three main themes: improvements in students' understanding, the amount of time and effort saved, and student engagement. The students believed that GGS enhanced their understanding of mathematics and improved their learning and visualisation. In addition, they found that using GGS required less writing and drawing shapes using the app made learning easier and took less effort. In addition, the students reported that GGS improved their enjoyment in class, fostering a positive attitude toward mathematics and offering them exciting lessons and the ability to create geometric shapes independently.

Keywords: GGS; mathematics learning; using technology

1. Introduction

In recent years, technology has increasingly become integrated in the teaching and learning process within the classroom and is acknowledged as a valuable resource which supports both teachers and students. Technological advances have offered an environment in which critical thinking and social interactions enrich the learning experience and have led to a holistic understanding of how students learn. It is essential to harness technology in the classroom so that students are engaged by and interested in learning mathematics and have the opportunity to use technological tools that are well-suited to this environment. The National Council of Teachers of Mathematics (NCTM, 2000) "Principles and Standards for School Mathematics" singled out technology as one of the main factors in improving the quality of mathematics teaching, arguing that

[i] Correspondence: email bakri39@hotmail.com

teachers should take advantage of technology, designing mathematical tasks such as graphing, visualising and computing. Technology is particularly well suited to addressing these aspects and can thereby improve students' learning opportunities (NCTM, 2000, p. 10). Several researchers (Hatfield & Bitter, 1994; Idris, 2006; Pomerantz, 1997; Rafie, 2002) have highlighted the importance of keeping up to date with technological innovations, which are happening at a fast pace. ICT has many advantages, notably that students can learn at their own level and speed and manage their learning. ICT promotes active rather than passive learning (Kolosick, 1996; Ozerol, 2009), enhances learners' physical and mental abilities and encourages learners to undertake data analysis, thus developing their thinking processes (Zamani, Farahani, Bahamiriyan, & Sadeghi, 2015). Crucially, Dick and Hollebrands (2011) point out that the effective use of technology involves creating a balanced mathematics programme, which can have a positive impact on both teaching and learning. According to the NCTM (2015), teachers and students should have regular access to technologies which support mathematical reasoning, problem solving and communication. Effective teachers encourage their students to expand their understanding and enhance their interest in mathematics, along with developing their mathematical skills by using appropriate and relevant technological resources in the classroom and broadening access to mathematics in the process (NCTM, 2015).

The use of technology in teaching and learning has been found to have a wide range of benefits, from offering students more learning opportunities (Roberts, 2012) to promoting student engagement (White, 2012) and encouraging discovery learning (Benner, 1999). Heid (1997) pointed out that the use of technical resources designed for education is part of a wider movement aimed at changing teaching by embracing children's familiarity with everyday tools, such as tablets and smartphones, and bringing technology into the classroom. Children have no fear of the digital world they live in and are quick to embrace innovations and the products of technology (Chiu & Churchill, 2016; Hohenwarter, Hohenwarter, & Lavicza, 2008).

Earlier studies focused on the effectiveness of existing teaching and learning approaches and highlighted new tools and methods designed to support improvements in both areas. Bwalya (2019) states that integrating technology in education is a positive step and other researchers have found that technology has a key role to play in changing the classroom environment – and indeed entire schools – since it encourages outcome-oriented learning. Thus, school administration and national educational policies have set out to integrate ICT in the learning process (Passey, 2011). In addition, educational transformation hinges on ensuring students are at the heart of the learning process and that schools become immersive learning environments. Teachers have to be able to choose relevant and effective learning technologies and find instructional approaches and techniques that can encourage students to become engaged and interested in learning. As noted by Bwalya (2019), recent studies focused on the process of teaching and learning have highlighted new technological methods that can support teachers and students and allow them to take advantage of useful new techniques.

While it is possible to quantify the benefits of technology in education, recent studies have emphasised the need to undertake additional research to assess all the factors that make up positive, successful technology-enhanced learning (Luo, Zhang, & Qi, 2017; Olkun, Altun, & Smith, 2005). Among the mathematical software packages that have been designed to improve both teaching and learning in this area are GeoGebra, Geometer's Sketchpad and Mathematica. Xistouri and Pitta-Pantazi (2013) consider that dynamic mathematics software (DMS) is an outstanding resource for teaching mathematics and that GeoGebra software (GGS), an open-source DMS focused on geometry, offers an excellent new approach to teaching mathematics that has been acclaimed by both teachers and students. GGS includes the features of DMS, computer algebra systems (CAS) and spreadsheets in one package (Hohenwarter et al., 2009). Students are given a virtual environment in which they can simultaneously view an algebraic component (for example, a coordinate or an equation) and the geometric features of an object (Preiner, 2008). Originally designed by Marcus Hohenwarter, in line with specific mathematical criteria, GGS was then further developed by Florida Atlantic University programmers, who set out to enable students to understand detailed mathematical facts and theories in practice and promote independent learning (Alkhateeb & Al-Duwairi, 2019).

Researchers have recently assessed how students view the effects of using GGS in mathematics learning. A number of studies (Arbain & Shukor, 2015; Radović et al., 2018; Shadaan & Kwan Eu, 2013; Tuba Dikkartın Övez & Kıyıcı, 2018) have found students tend to respond positively to the use of GGS in teaching and learning mathematics. However, other studies (Chua Ling Ling, Amilin Tengah, Shahrill, Tan, & Leong, 2017; Shadaan & Kwan Eu, 2013) have reported negative results. Shadaan and Leong (2013) found that students lacked confidence in using GGS, while Chua et al. (2017) noted some students were not sure how to use it and thus preferred traditional methods of teaching and learning.

2. Methods

This study used a qualitative approach, aimed at determining the students' perceptions of using GGS in their mathematics learning. In total, 37 grade eight students (11–14 years old) in two classes participated in the study and 14 of these volunteered to participate in focus groups (7 from each class). Each class was taught using GGS for one unit (4–5 weeks). Two focus group sessions were conducted after each class taught using GGS. The same teacher taught the two groups. The data from the two focus groups were analysed using thematic analysis, as suggested by Brown and Clark (2006).

3. Results

The results of this study which emerged from the two focus group sessions, were presented in three main themes, namely improvements in students' understanding, the amount of time and effort saved, and student engagement.

3.1 Students' Understanding

This theme presents the views of the grade eight students who participated in the focus groups regarding the effectiveness of using GGS in improving their understanding of mathematics lessons. The students believed that the use of GGS enhances their understanding of mathematics, and that it is better than the previous methods used by their teachers. All students in the two focus groups, who were from different classes, confirmed that their understanding of lessons had been improved by the use of GGS. They found that the use of GGS facilitates their learning, since it makes mathematics topics easier to understand.

Students presented their new experiences of mathematics learning when using GGS. Students emphasised that their learning of mathematics had improved as a result of using the GGS. They mentioned that the new software offers them a better opportunity to learn mathematics compared with the conventional approaches. They indicated that GGS makes learning mathematics easier and makes them feel more comfortable, which enhances their understanding. In addition, GGS helps them to understand lessons faster than before. Furthermore, some students found that the use of the app in the class provides a good opportunity for them to improve their understanding.

The grade eight students tried to present their new experiences of using GGS by comparing it with the whiteboard in terms of comfort and understanding. They stated that the use of GGS makes learning easier than using the whiteboard. For example, Student 2/G2 explained that *"the use of GGS makes the learning easier than the whiteboard*", and Student 3/G2 said that "*GGS makes the learning easier*". In addition, Student 1/G2 emphasised that "*using GGS makes learning easier and we understand more than before*". Moreover, they were of the opinion that learning using GGS makes them feel more comfortable in the classroom and is preferable to the whiteboard. For example, Student 2/G1 said that *"GGS is better than the whiteboard as it is comfortable*".

The students' opinions described above clearly demonstrate that they were happy with the use of GGS in the classroom, and agreed that using this app makes learning easier and more comfortable. Students think that GGS improves their learning because it makes lessons easier and makes them feel more comfortable than when using the whiteboard.

Using GGS helps students understand lessons and the ideas within them more quickly. For example, Student 3/G1 said that *"with the GGS we understand the lesson quickly*", adding that "*we understand the new idea quickly because we can see it by the GGS*". He described an example of how the GGS affected his understanding:

> *"Yes, I understand by the shapes for example, in the comparison between two fractions, the exercise gives us a clear idea about which one is bigger. They have the same shape, but the colour shows the value of each one so it is clear which one is bigger."*

Students gain the ability to understand lessons quickly when using GGS. They attributed the change in their ability to understand lessons to the opportunities for visualisation offered by GGS. The student above indicates that he was able to understand

lessons faster because he could see the differences between the fractions and was therefore able to indicate which fraction is bigger and which one is smaller. In this case, the student attributes his improvement in understanding to the features of GGS and its exercises, which help him to understand faster than when using the normal approach.

The grade eight students found that GGS offers better opportunities for their mathematics learning. For example, Student 1/G1 said that *"by using GGS, I have a chance to learn more than the normal approach*". He explained that:

> *"Yes. It is, my understanding differs from before, for example for the exponents. Using the GGS exercises, we understand the meaning of the powers. We use the button [he means the slide] to see how the value of each number changes when we change the other number [the exponent]. It is easy to see the differences."*

Thus, this student believes that GGS improves his learning because it offers the chance to learn more compared to when using the conventional approach. This was clear in the example described by one student, who described how the GGS exercises help him to understand changes in a number's value when he changed the exponent value. In this example, he found the features of the GGS to be very helpful in enhancing his understanding. In addition, working on the app and engaging with its exercises helps students to improve their understanding. For example, Student 4/G2 said that *"I prefer to do exercises using GGS, it makes me understand better*". The examples described by the students above suggest that the features of GGS mean that it offers more opportunities for students to improve their understanding of mathematics compared to the normal approach.

In summary, the two groups of grade eight students believed that GGS enhanced their understanding of mathematics because of its features. This helps them to learn more effectively than when using the normal approach and makes learning easier and faster. The students believe that GGS improves their learning because they are able to use it in class. In addition, from their examples, it can be clearly seen that the dynamic features and active shapes improve students' visualisation, which in turn improves their learning.

3.2 Time/Effort Saving

This theme presents the views of grade eight students who participated in the focus groups regarding the effectiveness of using GGS on the amount of time and effort required during mathematics lessons. The students believe that the use of GGS reduces the amount of time and effort needed in class and is better than the normal approach.

Students found that using the GGS saves them time in mathematics lessons and found it preferable to the normal approach. They found that the new app helped them to answer questions quickly and allowed them time to think about each question before answering it. Using GGS did not require more time than the normal approach. They found that the use of exercises offered by the GGS app helped them to save time in class. Student 3/G1 said *"now we understand the lesson quickly*". It gives give students a chance to answer questions quickly. For example, Student 3/G1 said *"we have time to think about each exercise,*

and answer questions quickly". The students were of the opinion that doing mathematics exercises using GGS is the main reason for saving time in class. For example, student 1/G2 said that *"the big difference is the time: with the GGS we do not need more time than with the whiteboard; we use the computer now*". He added *"now we do exercises and lessons inside the computer, not on the whiteboard*". Moreover, the use of GGS helps teachers and students to finish their lesson on time. Student 2/G2 said that *"sometimes we run out of time, but we have not finished the lesson*". He added,"*I mean before the use of GGS*".

The students' quotes above clearly demonstrate that students consider GGS to be time-saving in classes since it allows them to understand the lessons quickly, gives them a chance to think and answer questions, and enables them to finish their lessons before the end of the session.

Students are of the opinion that the use of GGS helps them to make less effort compared to the normal approach, and they do not need to write as much as before. In addition, they are able to make many attempts at solving each problem. Student 3/G2 said that *"we do not need to write more, and drawing is easier*"**.** Student 1/G2 added *"we do not need to write more when we are using the app*". Student 3/G1 noted that *"we could try and try and try*". Students therefore consider that GGS reduces the amount of effort they need to make in class, because they do not to have to write more, are comfortable with drawing shapes, and are able to make multiple attempts to answer each question.

To sum up this theme, students consider GGS to be a time- and effort-saving tool, since it helps them to quickly understand the lessons, gives them a chance to think and answer questions, and enables them to finish their lesson on time. In addition, less writing is required, and drawing shapes using the app makes learning easier and requires less effort.

3.3 Student Engagement

This theme presents the views of the grade eight students who participated in the focus groups regarding the effectiveness of using GGS on their engagement in mathematics lessons. The students believe that the use of GGS improves their engagement when they use the app to study mathematics.

Students found that the use of GGS in the classroom makes them feel excited and motivated. They found that the use of GGS improves their eagerness and willingness to learn mathematics. They develop a love for mathematics lessons and prefer to continue to use GGS for studying during the rest of the year. GGS helps to change students' attitudes towards mathematics, leading students to start to like mathematics lessons. For example, Student 5/G2 said, *"I would like to study more mathematics lessons*". Student 1/G1 stated that *"we would like to study more mathematics lessons and stay in the mathematics class for a long time, as we would not want the class to finish*". GGS made it easy to deal with mathematics lessons, helping to change students' attitudes towards the classroom, as GGS enables them to achieve a better understanding of the lessons and actively participate in class. Student 3/G2 explained that *"we start to love mathematics and to find it easy. I can create many types of shapes and change the colour*". Student 2/G2 said, "*I love creating geometry shapes by using GGS; it is easy*". In addition, the use of GGS helps students

to try to explore lessons independently, making them more active in class. Student 4/G1 said "*in each lesson we explore something new in GGS*". Furthermore, when both groups were asked whether they wanted to go back to using the previous approach or continue using the app, all agreed that they wanted to continue using the app for the rest of the year.

The students' opinions described above clearly show that GGS helps students to develop a positive attitude towards mathematics classes by increasing their enjoyment of lessons and motivating them to study more mathematics. They also like using the app to create and change mathematical shapes.

Students thought that the use of GGS provides them with interesting and enjoyable lessons. Some students mentioned some interesting aspects of classroom work. For example, students in both groups mentioned three aspects that make the GGS interesting for them. Student 1/G1 said *"that the most interesting thing for me is when I use GGS in the class*". Students also enjoy answering questions using GGS and discussing work with their peers. For example, Student 2/G1 said that *"the most enjoyable moment for me is answering questions using GGS and discussing them with my colleagues*". The last aspect is the chance to make multiple attempts to solve problems. Student 4/G2 said "*it is interesting to try again easily; we could try and try and try*". Students in the second group, who studied geometry, reported that the ability to move and create shapes using the app was the most interesting feature for them. Student 1/G2 said that *"the interesting thing is moving shapes in the app from one place to another; I like it very much*". Student 5/G2 said *"I like using GGS better than my hands. I love creating geometry shapes using GGS; it is easy*."

The above statements demonstrate that students found GGS to be of interest, since it offers them the chance to work by themselves and answer questions, and to make multiple attempts to answer questions. The app also enables students to easily create dynamic shapes.

To sum up this theme, students are of the opinion that GGS improves their enjoyment in class, since it improves their attitude toward mathematics and offers them interesting lessons when they use the app and create geometric shapes independently.

4. Discussion

The grade eight students in this study had positive attitudes towards the use of technology in their mathematics classes, stating that it had many advantages over traditional methods. These included making it easier for them to understand mathematics, helping them spend less time and effort on grasping topics in class, and enhancing their engagement in class. Several earlier studies reported similar findings (Arbain & Shukor, 2015; Radović et al., 2018; Shadaan & Kwan Eu, 2013; Tuba Dikkartin Övez & Kiyici, 2018), noting that students had positive views of using GGS in the teaching and learning of mathematics. These findings are in contrast to those of Chua et al. (2017) and Shadaan and Kwan Eu (2013), whose studies demonstrated that certain students had a negative view of using GGS in class.

Both groups of grade eight students stated that the features of GGS improved their understanding of mathematics. Their examples also show that the dynamic features and active shapes enhanced their visualisation abilities and this improved their overall learning. A considerable body of research concurs with this view, noting that the multiple representations in GGS play a key part in improving students' understanding of mathematical concepts (for example, Duval, 2006; Elia, Panaoura, Gagatsis, Gravvani, & Spyrou, 2007; McGee & Moore-Russo, 2015; Özgün-Koca, 2001). Elia et al. (2008) found that multiple representations are far more helpful in improving students' understanding of concepts than single representations and Özgün-Koca (2001) determined that using multiple representations improves meaningful mathematical learning. According to Bayazit (2007), multiple representations displayed on a single screen can help students expand their knowledge and the depth of their understanding. Moreover, Duncan (2010) found that multiple representations stimulate students' curiosity and research, as well as improving their learning.

The students in this study maintained that GGS saved them both time and effort, allowing them to understand the lesson quickly, and enabling them to think and respond to questions and to complete their lesson on time. Gono's (2016) findings were very similar and he concluded that DMS gives students the opportunity to use a wide range of techniques to solve mathematical problems. He also pointed out that contrary to the time-consuming methods of pen and paper learning, students of arithmetic and algebraic algorithms who use DMS find that they have extra time to absorb and understand topics, upgrade their reasoning skills and get to grips with the application. Gono (2016) added that DMS gives students the tools they need to organise and manage their own learning.

From the students' perspective, GGS helped them to enjoy lessons, made them feel more positive about learning mathematics and provided them with interesting classes when they used the app and worked independently to create geometric shapes. Earlier studies, such as Doruk, Aktümen, and Aytekin's (2013) work, found that most participants considered GGS a helpful tool for teaching mathematics since it increased student engagement, offered enjoyable learning experiences and removed their fear of learning mathematics. Rosyid and Umbara (2019) carried out a detailed assessment of how students view the implementation of the GGS-assisted Missouri Mathematics Project and found the students had positive views. This reflects the findings of a study carried out by Aydos (2015), which determined that using technology – GGS – improved students' attitudes to being taught and learning mathematics. Aydos (2015) concluded that GGS was a useful tool for teaching calculus to gifted students.

5. Conclusion

This study clearly shows that incorporating GGS in classroom teaching and learning can significantly improve the classroom environment. GGS enhances students' learning and therefore their understanding. It is more effective than the traditional approach to teaching mathematics and makes it easier for students to develop their visualisation skills. The use of GGS saves students both time and effort, makes lessons more engaging

and enjoyable and offers interesting lessons which allow them to create geometric shapes independently through using the app. Research studies have found that GGS-supported learning is more useful and effective than traditional approaches to teaching. These findings can be harnessed to ensure that new teaching materials reflect what has been learned about studying mathematics in the classroom, opening the door to improvements and change.

Conflict interest statement

The author certifies that he has no affiliations with or involvement in any organisation or entity with any financial or non-financial interest in the topic or materials mentioned in **this article.**

About the Author

Professor assistant at the University of Bisha, Bisha, Saudi Arabia, PhD in education, University of Glasgow, Glasgow, UK. https://orcid.org/0000-0001-5831-8482, https://www.researchgate.net/profile/Bakri-Awaji-2/stats

References

Alkhateeb, M. A., & Al-Duwairi, A. M. (2019). The effect of using mobile applications (GeoGebra and Sketchpad) on the students' achievement. *International Electronic Journal of Mathematics Education*, *14*(3), 523–533.

Arbain, N., & Shukor, N. A. (2015). The effects of GeoGebra on students achievement. *Procedia - Social and Behavioral Sciences*, *172*, 208–214.

Aydos, M. (2015). *The impact of teaching mathematics with GeoGebra on the conceptual understanding of limits and continuity: The case of Turkish gifted and talented student*. Bilkent University.

Bayazit, I., & Aksoy, Y. (2007). *Connecting representations and mathematical ideas with the use of GeoGebra: The case of functions and equations.* Erciyes University, Turkey.

Bitter, G. G., & Hatfield, M. M. (1994). Training elementary mathematics teachers using interactive multimedia. *Educational Studies in Mathematics*, *26*(4), 405–409.

Bwalya, D. (2019). Influence of GeoGebra on students' achievement in geometric transformations and attitude towards learning mathematics with technology. *Leong & Noorbaizura*, *10*(13).

Chiu, T. K. F., & Churchill, D. (2016). Design of learning objects for concept learning: effects of multimedia learning principles and an instructional approach. *Interactive Learning Environments*, *24*(6), 1355–1370.

Chua Ling Ling, G., Amilin Tengah, K., Shahrill, M., Tan, A., & Leong, E. (2017). Analysing students' perspectives on geometry learning from the combination of Van Hiele phase-based instructions and GeoGebra. *Proceeding of the 3rd International Conference on Education*, *3*, 205–213.

Dick, T., & Hollebrands, K. (2011). Focus in high school mathematics: Technology to support reasoning and sense making. In *Mathematical and Pedagogical Knowledge* (pp. xi–xvii). National Council of Teachers of Mathematics.

Doruk, B. K., Aktümen, M., Aytekin, C. (2013). Pre-service elementary mathematics teachers' opinions about using GeoGebra in mathematics education with reference to "teaching practices." *Teaching Mathematics and Its Applications*, *32*, 140–157.

Duncan, A. G. (2010). Teachers' views on dynamically linked multiple representations, pedagogical practices and students' understanding of mathematics using TI-Nspire in Scottish secondary schools. *ZDM Mathematics Education*, *42*(7), 763–774.

Duval, R. (2006). A cognitive analysis of problems of comprehension in a learning of mathematics. *Educational Studies in Mathematics*, *61*(1–2), 103–131.

Elia, I., Panaoura, A., Gagatsis, A., Gravvani, K., & Spyrou, P. (2008). Exploring different aspects of the understanding of function: Toward a four-facet model. *Canadian Journal of Science, Mathematics and Technology Education*, *8*(1), 49–69.

Farahani, P., Bahamiriyan, M., & M Sadeghi. (2015). Information and communication technology in education of Iran. *International Journal of Economy, Management and Social Sciences*, *4*(1), 100–104.

Heid, M. K. (1997). The technological revolution and the reform of school mathematics. *American Journal of Education*, *106*(1), 5–61.

Hohenwarter, J. (2008). *Introducing dynamic mathematics software to mathematics teachers: The case of GeoGebra*. University of Salzburg.

Hohenwarter, J., Hohenwarter, M., & Lavicza, Z. (2008). Introducing dynamic mathematics software to secondary school teachers: The case of GeoGebra. *Journal of Computers in Mathematics and Science Teaching*, *18*(2), 135–146.

Idris, N. (2006). *Teaching and learning of mathematics*. Utusan Publications.

Luo, N., Zhang, M., & Qi, D. (2017). Effects of different interactions on students' sense of community in e-learning environment. *Computers & Education*, *115*, 153–160.

McGee, D. L., & Moore-Russo, D. (2015). Impact of explicit presentation of slopes in three dimensions on students' understanding of derivatives in multivariable calculus. *International Journal of Science and Mathematics Education*, *13*(2), 357–384.

National Council of Teachers of Mathematics, (NCTM). (2000). *Principles and standards for school mathematics*. National Council for Teachers of Mathematics.

National Council of Teachers of Mathematics, (NCTM). (2015). *Strategic use of technology in teaching and learning mathematics*. National Council for Teachers of Mathematics.

Nhamo Gono, E. (2016). *The contributions of interactive dynamic mathematics software in probing understanding of mathematical concepts: Case study on the use GeoGebra in learning the concept of modulus functions.* University College London.

Olkun, S., Altun, A., & Smith, G. (2005). Computers and 2D geometric learning of Turkish fourth and fifth graders. *British Journal of Educational Technology*, *36*(2), 317–326.

Özerol, G. (2009). *Perceptions of EFL primary school teachers towards CALL*. Cukurova University, Turkey. library.cu.edu.tr.

Özgün-Koca, S. (2001). *Computer-based representations in mathematics classrooms: The effects of multiple linked and semi-linked representations on students' learning of linear relationships*. The Ohio State University.

Passey, D. (2011). Learning, media and technology implementing learning platforms into schools: An architecture for wider involvement in learning. *Learning, Media and Technology*, *36*(4), 367–397.

Radović, S., Radojičić, M., Veljković, K., & Marić, M. (2018). Interactive learning environments: Examining the effects of GeoGebra applets on mathematics learning using interactive mathematics textbook. *Interactive Learning Environments*, *28*(1), 32–49.

Roberts, G. R. (2012). Technology and learning expectations of the net generation. *Educating the Net Generation*, *3*(1).

Rosyid, A., & Umbara, U. (2019). Analysis of students' attitudes towards implementation of GeoGebra-assisted Missouri mathematics project. *Journal of Physics: Conference Series*, *1265*(1), 1–10.

Shadaan, P., & Kwan Eu, L. (2013). Effectiveness of using GeoGebra on students' understanding in learning circles. *The Malaysian Online Journal of Educational Technology*, *1*(4), 1–11.

Smith, K., & Kolosick, J. (1996). The shift to a learner-centered university: New roles for faculty, students, and technology. *Association of Small Computer Users in Education (ASCUE)*, 146–157.

Tuba Dikkartın Övez, F., & Kıyıcı, O. D. (2018). 6th grade students' views about mathematical teaching based on technology integration. *World Journal of Education*, *8*(5), 160–171.

White, J. (2012). *The impact of technology on student engagement and achievement in mathematics classroom*. Memorial University.

Xistouri, X., & Pitta-Pantazi, D. (2013). Using GeoGebra to develop primary school students' understanding of reflection. *North American GeoGebra Journal*, *2*(1), 19–23.