

## **Effects of Student Self-Assessment and Using GeoGebra™ on Students' Achievements and Self-Directed Learning in Mathematics Lessons in a Junior High Classroom**

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### **Abstract**

This paper demonstrates a teacher-as-researcher intervention study of Student Self-Assessment, utilizing GeoGebra activities on the topic of relationships of geometric figures. The teacher researcher studied students' achievements and self-directed learning by including Student Self-Assessment (SSA) and by teaching procedural knowledge and conceptual knowledge using eleven GeoGebra-based tasks at the same time. The data were collected via questionnaire, interview, as well as two tests which were given after task 6 and task 11 were completed. The teacher researcher oversaw the progress of the 24 Thai male and female junior high mathematics students (13-14 years old), and offered prompt guidance and support using normal classroom techniques. The findings indicated that the utilization of SSA and GeoGebra had a positive impact on these students' academic performance and their ability to take charge of their learning in mathematics classes. Specifically, the intervention led to 1) improved communication between student and teacher; 2) improved students' understanding of what they needed to learn; 3) improved students' confidence to ask for help from the teacher; 4) promoted student achievement; and 5) promoted self-directed learning in mathematics lessons.

**Keywords:** Student self-assessment, GeoGebra, Student achievement, Self-directed learning

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### **Introduction**

The epidemic of the infectious disease COVID-19 has changed the whole world (Moralista & Oducado, 2020), and that includes education. Technology now plays a central role in the educational system, which has been used as a tool to support instruction during the pandemic. Therefore, technology has a role in enhancing the efficiency of the instruction process (Cubukcuoglu, 2013), by addressing various educational challenges, including the flow of knowledge, the assessment processes, the impact of information overload, the growing number of students, and the unique learning differences among individuals (Zulu, 2022).

One example of educational technology is GeoGebra, which serves as dynamic mathematics software that harnesses and integrates the dynamic features of technology. It is commonly employed as an educational tool for teaching and learning mathematics across different levels. It is both a learning and teaching tool for mathematics education across all levels (Hohenwarter & Preiner, 2007), with its main focus on helping students to understand mathematical ideas. While it is intended to support dynamic teaching, it may also be used to emphasize problem-solving, support the creation of mathematical experiments, facilitate the introduction of concepts in both offline and online learning environments (Ziatdinov & Valles, 2022), and provides a number of options for catering to the individual learning needs

of the students. GeoGebra can be downloaded free and used on computers, tablets, and smartphones.

Assessment is important to instruction as it is based on the evidence revealed in student responses. Teachers use this information from assessment in their teaching plans in order to improve student learning. For example, it enables the teachers to differentiate the content through teaching and learning strategies to cater for individual students while in a whole class environment. This type of assessment is called assessment *for* learning (AFL) and is formative in nature. In contrast, summative assessment provides an accumulation of data of mathematical competence or achievement over a long period. This is often called assessment *of* learning, where the teacher uses information to report to parents and others (White, 2018).

Student self-assessment (SSA) serves as a formative assessment tool. It can play a role in enhancing the learning process. SSA has the potential to promote equitable learning opportunities among students. Specifically, it can significantly improve learning outcomes for struggling students by providing them with a clear understanding of their existing knowledge, areas that require improvement, identifying errors, and determining necessary actions for improvement (Mahapoonyanont, 2020).

Through their experience with Thai students in the classroom, the teacher as researcher discovered that 1) students were afraid to ask questions in class, because Thai culture emphasizes respect to teachers and seniors; and 2) there are signs of addiction to online smartphone games, which were very popular among Thai students. These observations raise issues for research.

I decided to collect SSA reports and GeoGebra student responses in written form. The questions I want to investigate is *do SSA reports and GeoGebra enhances communication between students and teachers?* Additionally, I seek to explore whether these tools improve students' comprehension of their learning objectives, boost their confidence in seeking assistance from teachers, contribute to enhanced student achievement, and foster the development of self-directed learning in mathematics lessons. This paper will seek answers to these questions by firstly conducting a brief review of other research papers.

### **Literature Review**

There are a number of questions and issues that this review of literature focuses upon. The first question is the meaning of SSA. The definition by Brown and Harris (2013) involves students engaging in a descriptive and evaluative process regarding their own academic work and abilities. Another one by Mahapoonyanont (2020) enhances the first definition:

*self-assessment is feedback, ... (to) deepen learning and enhance performance; hence the purpose of self-assessment is to generate feedback that promotes learning and improvements in performance. (p. 29)*

In the next section there will be a brief discussion of other papers researching the benefits and problems with SSA.

## Student Self-Assessment

In this section, the papers were selected to present positive and negative claims that SSA, namely (i) provides feedback to teachers for future lesson planning and student assessment; (ii) provides feedback to students in helping them develop skills to notice what they did and did not know; (iii) improves the communication and relationship between the teacher and students, (iv) promotes student achievement and/or creativity, and (v) promotes student self-directed learning in mathematics lessons.

### *Possible Positive Benefits of SSA*

A study by Mahapoonyanont (2020) reported that the benefits of SSA to students were (1) an improved ability to analyze themselves and an improved awareness of whether they understood or not; (2) an improvement in thinking skills; as well as (3) giving opportunity for teachers to provide more feedback to students about their weaknesses and provided suggestions for improvement. These findings resonate with the benefits (ii), (iv), and (iii) mentioned above. The study also listed benefits of SSA for the teacher such as providing real-time feedback from students, as well as facilitating better communication and understanding between teachers and students. These findings resonate with the benefits (i) and (iii) mentioned above.

Thinwiangthong (2018) conducted another quantitative research study with 67 seventh grade students. SSA was utilized as an assessment tool for learning on an hourly basis throughout the entire 5-week experimental period. The behavior of the students was observed and students' opinions were collected on the roles of students and teachers. The study reports that the benefits to students were SSA promoted an increase in student achievement. These findings resonate with benefit (iv) mentioned above.

Zi et al. (2020) carried out a quantitative research study involving 1425 students from 29 schools in Hong Kong. The research aimed to assess students' intentions and actions related to SSA, identifying predictors of these intentions and practices. This was achieved through the utilization of 11 self-report scales grounded in the Theory of Planned Behaviour (Ajzen, 1985). The study reported the benefits to students were SSA fosters essential elements such as attitude, subjective norms, self-efficacy, and perceived controllability, which are pivotal for cultivating self-regulated and lifelong learning. These findings resonate with the benefits (ii) and (v) mentioned above.

The study by Zulkifli and Azman (2021), which used SSA as a tool for learning assessment, reported the benefits to students were enhancing student motivation to help them achieve notable academic success. Through self-assessment, students gained insights into their learning progress and identified the necessary effort required for success. This practice was not only beneficial for students but also played a crucial role in supporting teachers. Teachers too could utilize SSA as a valuable tool, contributing significantly to their teaching effectiveness and overall accomplishment. These findings resonate with the benefits (i), (iii), (iv) and (v) mentioned above.

The researcher Yu (2013) conducted a study in Hong Kong involving 533 students from 16 classes across six schools. The research involved the introduction of various SSA tools by educators, which were subsequently employed by students within mathematics classrooms to

enhance their self-directed learning. The study reported the benefits to students were SSA has the potential to influence students in several ways, including alterations in (a) learning strategies and behaviors, (b) self-assessment skills and self-awareness, (c) motivation, and (d) meta-cognition. These transformations can positively contribute to fostering students' self-directed learning, ultimately enhancing their future learning endeavors and proficiency in self-assessment. These findings resonate with the benefits (ii), (iv) and (v) mentioned above.

The study by Barana et al. (2022), which involves 182 students in 11<sup>th</sup> grade (16 years old) who had to solve 8 real-world mathematical problems using an Advanced Computing Environment, reported that SSA improves students' mathematical problem solving and enhances their proficiency in using technology through mathematical model scenarios and they gained a better understanding of problem situations and engage in constructive discussions with their peers in the classroom.

Rickey et al. (2023) utilized a comprehensive qualitative research design to investigate the integration of SSA by exemplary STEAM teachers. The study reported the benefits to students were that SSA supports learning through active involvement in self-regulatory processes such as goal setting, self-monitoring, and evaluation against objective standards. SSA facilitated student learning by guiding them through crucial self-regulation processes such as goal setting, self-monitoring, and reflection. SSA was connected to enhanced academic achievement and self-regulation skills. These findings resonate with the benefits (ii), (iii), (iv) and (v) mentioned above.

This classroom action research study encompasses two cycles. In the first cycle, the teacher-researcher studied only the SSA. It was found that SSA improved students' instruction experience: improved communication with teachers, improved students' understanding of what they needed to learn, improved students' confidence in seeking teacher help, and provided evidence for the teacher about student progress and issues to improve students' self-learning.

So far SSA has been positively discussed in this section. Now, it is worth noting that SSA can also have a negative impact on students and adults in college, as will be discussed briefly in the next section.

### ***Possible Negative Effects of SSA***

This section discusses the negative effects of SSA, which researchers have noted as follows:

SSA can have positive effects on student learning and performance, but there are also potential negative effects to consider. One possible negative effect is that students may resist or devalue self-assessment if they do not understand its purpose or see it as the teacher's responsibility (Harris & Brown, 2022). Additionally, without a supportive and psychologically safe environment, students may be unwilling to admit their mistakes, hindering the effectiveness of self-assessment (Sintayani & Adnyayanti, 2022). Misappraisal resulting from a lack of knowledge or skills required for SSA can also be problematic and lead to an over or under estimation of one's abilities (Boud, 1995). Additionally, some students may prefer external feedback from their teachers or peers rather than relying solely

on SSA (Nicol, & Macfarlane-Dick, 2006). Finally, SSA may not be appropriate for all types of learning or learning environments, and some students, especially those who consider themselves unique or from a different ethnic background, have difficulties using SSA tools effectively (Black & Wiliam, 1998).

There were other studies uncovered that involved tertiary education and these will be briefly examined in the next section.

### ***Post-secondary school studies***

While the following research uses students from post-secondary contexts, it is worth considering if their findings resonate with this study's results.

The researcher Tashiro et al. (2021) conducted a study on undergraduate students enrolled in the courses of introductory general chemistry designed specifically for science and engineering majors. The objective of the research was to thoroughly investigate the factors associated with alterations in SSA of comprehension following their engagement in a classroom instructional activity. The study reported the benefits to students were SSA encourages students to understand and self-direct their learning. These findings resonate with the benefits (ii) and (v) mentioned above.

Yan and Brown (2017) conducted a qualitative study centered on the self-assessment practices of undergraduate students at a teacher education institute and employed in-depth interviews involving 17 participants to delve into the prevalent self-assessment activities carried out by students. The study reported the benefits to students were SSA promoted self-directed learning, feed-back, and student seeking and self-reflection. These findings resonate with (i) (iii) and (v).

The generalizability of the results, particularly in terms of peer influence, from studies involving undergraduate students to school children, specifically those in junior high school, is uncertain. Junior high school students differ in maturity and experience compared to university students.

In the next section there will be a brief discussion of GeoGebra and its influence on SSA.

### **GeoGebra**

In this section, papers were selected to support or to be critical of the claims that GeoGebra can (i) improve communication between student and teacher; (ii) improve students' understanding of what they need to learn; (iii) improve students' confidence to ask for help from the teacher, (iv) promote student achievement and/or creativity, and (v) promote self-directed learning in mathematics lessons.

Baye et al. (2021) conducted a research study with a sample of 26 first-year university mathematics students with science minor. The study utilized a mixed methods experimental design. Data collection involved both qualitative data gathered through students' reflections and interviews, and quantitative data obtained through pre and post diagnostic tests. The study reported the benefits to students were that GeoGebra software made a positive impact on students' motivation during the learning process. By incorporating diverse teaching

approaches with the technology not only captured students' interest but also enhanced their comprehension and performance in mathematics. These findings resonate with (i) and (ii).

Yohannes and Chen (2021) conducted bibliometric analysis on papers in the Web of Science database published from 2010 to 2020. The focus of the study was on the integration of GeoGebra into mathematics education. The examination included publication trends, research methods, participants, application domains, learning strategies, and research issues. They reported the benefits to students were that GeoGebra facilitated students' comprehension and the establishment of connections among mathematical concepts, thus improving students' cognition. This was achieved through the assessment of students' learning performance, problem-solving skills, cognitive development, reasoning abilities, analytic and holistic thinking, as well as argumentation. These findings resonate with (ii) (i) (iv) and (v).

Ziatdinov and Valles (2022) conducted a study to evaluate the importance of GeoGebra in the context of university-level learners in Korea. The objective was to offer a synthesis of modeling, visualization, and programming (MVP) through the utilization of GeoGebra tools. They reported the benefits to students were that GeoGebra encouraged students to autonomously construct their own models with guidance, assisting a better understanding of motion concepts. It also enhanced motivation and improved mathematical skills, self-awareness, and students' engagement in the learning process. Additionally, GeoGebra strengthened the capability of visualization, recognized as an effective method for enhanced learning. It empowered learners to solve mathematical problems and explore them globally and in detail at their own pace. The use of representations and graphs as problem-solving techniques proved beneficial in obtaining correct and accurate answers. These findings resonate with (v) (iii) (ii) and (v).

Alkhateeb and Al-Duwairi (2019) conducted a quasi-experiment involving a sample of 105 students to study to investigate the impact of GeoGebra and Sketchpad on students' achievement. They developed educational materials, achievement exams, and worksheets in alignment with the university curriculum. The researchers reported the benefits to students were that GeoGebra aided students in comprehending geometry concepts. These findings resonate with (ii).

Merdekawati (2022) conducted a study employing GeoGebra activities for the instruction of arithmetical operations with integers in junior high school classrooms. Data were collected by recording students' worksheets and communications within a virtual classroom. The study reported that GeoGebra provided several advantages to students. It encouraged them to engage in hands-on experimentation with mathematical concepts within an interactive and communicative environment involving both peers and the teacher. Additionally, GeoGebra enabled students to reflect on their work and draw conclusions at the end of the activities. Furthermore, the software assisted students in improving their intuitive understanding and visualization of mathematical processes, particularly in the realm of integer operations. These findings resonate with (i) (iii) and (ii).

Gökçe and Güner (2022) conducted a study utilizing bibliometric analysis for the statistical evaluation of publications, aiming to identify trends in the overall landscape of GeoGebra-related studies from 2009 to 2021. The study reported that GeoGebra offered several benefits to students. The software facilitated students' comprehension of mathematical

procedures and facts through pictorial representation in both two and three dimensions. It also played a role in enhancing the learning of mathematics concepts, contributing to the development of problem-solving skills. Additionally, GeoGebra supported both the teaching and learning of mathematics, fostering the growth of creativity, mathematical knowledge, and skills of students. These findings resonate with (ii) and (iv).

As a result of the discussion above the following research questions were chosen to provide direction to the rest of this study.

### **Research Questions**

The central question of this research is as follows:

Do SSA reports and the use of GeoGebra improve junior secondary school students' experience of mathematics teaching and learning?

The study will be guided by the following supplementary questions:

1. Do SSA reports and the use of GeoGebra improve communication between student and teacher?
2. Do SSA reports and the use of GeoGebra improve students' understanding of what they need to learn?
3. Do SSA reports and the use of GeoGebra improve students' confidence to ask for help from the teacher?
4. Do SSA reports and the use of GeoGebra promote student achievement?
5. Do SSA reports the use of GeoGebra™ promote Self-Directed Learning in Mathematics Lessons?

In the next section, the central research question and the supplementary research questions will guide and influence the methods chosen and the instruments used to obtain answers.

### **Methodology**

This research employed classroom action research with a qualitative and teacher-as-researcher methodology. The teacher in this study is male with over 15 years of secondary mathematics classroom experiences.

The concept of the teacher-as-researcher is claimed to promotes collaboration among teachers in re-evaluating their teaching practices and is rooted in the principles of action research (Kemmis & McTaggart, 1982). Action research is a purposeful and solution-oriented inquiry conducted and owned by teachers. It involves iterative cycles encompassing problem identification, systematic data collection, reflection, analysis, evidence-based action, and the redefinition of the problem. The terms "action" and "research" emphasize the fundamental characteristics of this approach, where ideas are tested in practice to enhance knowledge about and for teaching and learning in the classroom.

In this second cycle, the teacher researcher studied students' achievements and self-directed learning by using SSA and including GeoGebra and by teaching procedural knowledge and conceptual knowledge together. Teaching procedural knowledge sometimes called practical knowledge is concerned with teaching the what and how of doing mathematics (Hurrell, 2021). Conceptual knowledge includes procedural knowledge but is more concerned with why the mathematics works and for what contexts and is also referred

to as connected knowledge and which increases with expertise (DiSessa et al., 2004; Schneider & Stern, 2009).

### Sample

The researcher used purposive sampling of a class of 24 male and female junior high mathematics students (13-14 years old) in the academic year 2022/2023 in the Nakhon Phanom Province of Thailand. In the topic geometric dimensional relationships, eleven geometry tasks were discussed, consisted of 3 two-dimensional geometry tasks; 3 tasks on the relationship between two-dimensional and three-dimensional geometric shapes; 3 tasks on the images obtained by looking at the front, side, and top of a three-dimensional geometric figure; and 2 tasks on the image obtained from the front view side and top using GeoGebra.

In the following figure is a screen shot of the teacher's GeoGebra Classroom page showing the students' work in solving one of the tasks using GeoGebra.

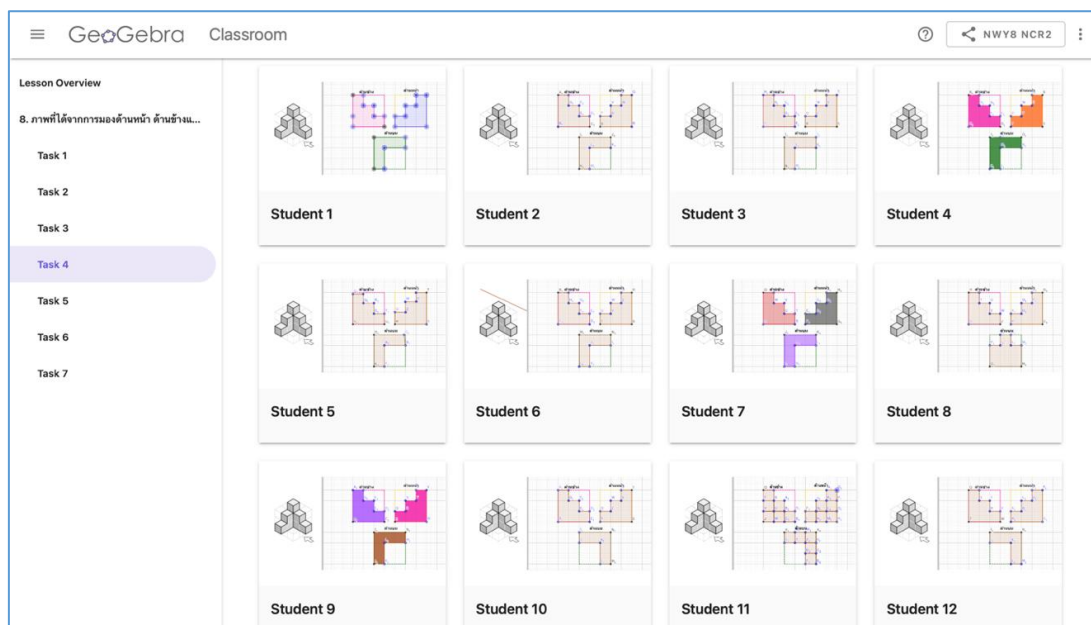


Figure 1. Examples of students' work in solving problems through the use of GeoGebra

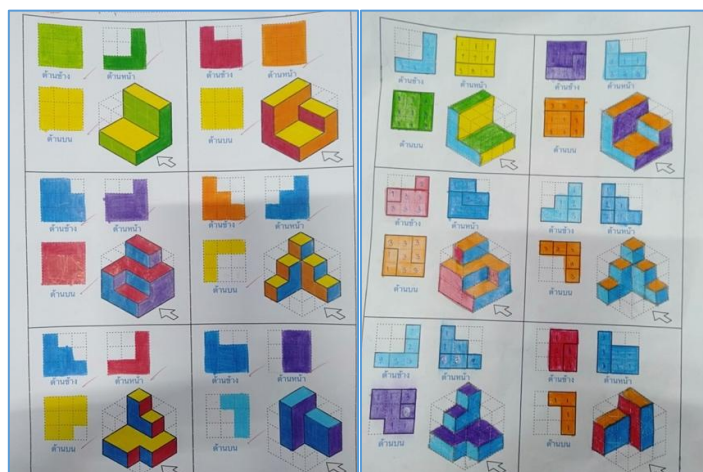


Figure 2. Examples of students' work in solving problems worksheets underneath.



In Figure 3 below, there are two photos showing students learning together, using the GeoGebra application on their mobile phones.



Figure 3. Students learn in the classroom using GeoGebra™ on their mobile phones.

### Data Collection

The teacher researcher developed several instruments such as a questionnaire, an interview protocol, and two tests which were given after task 6 and task 11. The students completed their SSA report after every task and an expert panel checked the translations and analysis to avoid bias by the teacher researcher.

The questionnaire consisted of a scale type of estimation at 5 levels, which are: strongly disagree, disagree, neutral, strongly, strongly agree. 20 items shown in table 1.

Table 1

*The questionnaire level of student's responses*

Scoring	Criteria
4.51-5.00	strongly agree
3.51-4.50	agree
2.51-3.50	neutral
1.51-2.50	disagree
1.00-1.50	strongly disagree

The analysis used in this research included mean, standard deviation, comparison with quality criteria and dependent t-tests that were employed to offer supporting evidence indicating a variance in the mean. A significance level (alpha) of 0.05 was applied to all hypothesis tests. The students' interview instrument consisted of open-ended questions about SSA and using GeoGebra on students' achievements and self-directed learning in mathematics lessons.

### Self-Assessment Data

Initial analysis began simultaneously with data collection of the SSA reports, student interviews and focus groups data as follows.

Table 2

*The table shows the frequency distribution of student self-assessment responses on each cycle (n=24).*

Student Self-Assessment	First cycle			Second cycle		
	Before Lesson	During Lesson	After Lesson	Before Lesson	During Lesson	After Lesson
I totally understand and can teach my peers (4)	2 (8.33%)	2 (8.33%)	6 (25%)	0 (0%)	4 (16.67%)	12 (50%)
I almost have it. But I many need a title more practice (3)	3 (12.5%)	10 (41.67%)	13 (54.17)	0 (0%)	10 (41.67%)	11 (45.83%)
I am a title confused and need some clarification (2)	6 (25%)	12 (50%)	5 (20.83%)	7 (29.17%)	10 (41.67%)	1 (4.17)
I am lost please reteach me (1)	13 (54.17%)	0 (0%)	0 (0%)	17 (70.83%)	0 (0%)	0 (0%)

Table 2 shows the summary of the frequency distribution of SSA responses. The 24 students completed SSA reports before, during and after each cycle by collecting data 3 times. Before learning, it will ask the students to reflect on their prior knowledge. During the cycle, it will ask the students to reflect on their own progress. And after class, it will as the students to reflect on their own learning outcomes and any improvement in understanding from the start of the lesson to the finish. The findings showed that more students had sufficient understanding after the lesson compared to before or during the lesson.

### Results

In the following sections, one questionnaire summary table of student responses to the research questions involving SSA data and t-test results will be presented followed by a comparison of student interview data with this SSA questionnaire summary data. The interview data hopes to better capture the student voice which is often lost in the summary process.

Table 3

*Summary of the questionnaire responses of students (n = 24)*

No	Statements	Mean	S.D.	Interpretation
<b>Positive Responses</b>				
1	My Self-Assessment reports help improve my mathematics learning.	3.96	0.73	Strongly

No	Statements	Mean	S.D.	Interpretation
2	GeoGebra™ helps improve my mathematics learning	4.50	0.58	Strongly
3	GeoGebra™ help me explore mathematics problems.	4.42	0.70	Strongly
4	Students' self-assessment reports helps check my understanding of learning in mathematics.	4.33	0.62	Strongly
5	GeoGebra™ helps check my understanding of mathematics	4.25	0.66	Strongly
6	My Self-Assessment reports help improve my achievement in mathematics tests and examinations.	4.17	0.55	Strongly
7	My Self-Assessment Reports help improve my self-directed learning in mathematics.	4.50	0.58	Strongly
8	GeoGebra™ helps improve my self-directed learning in mathematics.	4.67	0.47	Strongly agree
9	My Self-Assessment Reports help me interact with teachers and friends inside the mathematics classroom.	4.50	0.58	Strongly
10	GeoGebra™ helped me interact with teachers and peers outside of the classroom.	4.63	0.48	Strongly agree
11	My Self Assessment Reports help improve my confidence in answering questions and communicating with the teachers.	4.71	0.45	Strongly agree
12	GeoGebra™ helps improve my confidence in answering questions and communicating with teachers.	4.71	0.45	Strongly agree
<b>Totally</b>		<b>4.45</b>	<b>0.57</b>	<b>Strongly</b>

#### Negative Responses

1	My Self-Assessment reports do not help improve my problem-solving in mathematics.	1.79	0.58	Disagree
2	GeoGebra™ does not help improve my problem-solving in mathematics.	1.50	0.58	Strongly disagree
3	Self Assessment is a waste of time	1.38	0.56	Strongly disagree
4	GeoGebra™ is a waste of time in classroom	1.54	0.71	Disagree
5	Self Assessment reports increase my learning load.	1.67	0.80	Disagree
6	GeoGebra™ adds to my learning burden in the classroom.	1.33	0.47	Strongly disagree

No	Statements	Mean	S.D.	Interpretation
7	My Self Assessment Reports made me anxious to learn.	2.25	0.92	Disagree
8	GeoGebra™ made me anxious to learn.	2.00	0.92	Disagree
<b>Totally</b>		<b>1.68</b>	<b>0.69</b>	<b>Disagree</b>

Table 3 shows the summary of the questionnaire responses of 24 students after the lesson. There are 20 items consisting of 2 parts: 12 positive questions and 8 negative questions. See Table 1 for the questionnaire levels of student's data. The results showed that with the positive questions, there were 4 items (8,10,11,12) where students selected the strongly agree level, besides that the agree level was selected for the other positive items. The negative questions showed there were 3 items (2,3,6) that students selected the strongly disagree level, namely. is the other negative the students selected the disagree level.

### T-test results

The results of the achievements of students after the first cycle and the second cycle are as follows: The data will be presented using Table 4.

Table 4

*T- test Results in the first cycle and second cycle achievements test of students*

Stata	N	Student achievements				
		Means	Std Dev	Mean Difference	T	P
First cycle	24	12.46	4.19	-1.83	-3.0509	0.0057*
Second cycle	24	14.29	3.94			

\*  $p < 0.05$

As can be seen in Table 4, the results of the achievements of 24 students after first cycle (after task 6) and second cycle (after task 11). The statistical t-test results of the achievements of first cycle mean scores of the 24 students was  $12.46 \pm 4.19$  and the second cycle mean score was  $14.29 \pm 3.94$ . When the difference between the achievements the first cycle and second cycle mean scores of students were analyzed with the dependent t-test, it was found that there was no achievements significant difference between the first cycle and second cycle mean scores at the level of  $\alpha = 0.05$  ( $t = -3.0509$ ,  $p < 0.05$ ). Since there is achievements significant difference between the first cycle and second cycle achievements score means of the students.

### Interview Data

Students are labelled as S1, S2, S3, S5 and S6 are female, S4 to S7 are male. In the following discussion the data from table 2 will be compared with the supplementary research questions.

1. *Do student self-assessment reports and the use of GeoGebra improve communication between student and teacher?*

The majority ( $n = 7$ ) of the students clearly mention improvement of communication between student and teacher.

The students highlight the positive impact of both SSA and GeoGebra Classroom on their learning experiences. SSA boosts their confidence in seeking help from teachers and friends

while also encouraging them to teach others. GeoGebra Classroom is praised for its user-friendly interface, providing various tools, and making learning enjoyable by facilitating experimentation and testing. The students appreciate the opportunity to identify areas for improvement and actively engage in collaborative learning. Additionally, both tools contribute to their overall learning progress.

Taking S3 and S4 are examples of clear self-assessment and using GeoGebra actions:

*SSA helps me feel confident in ask my teacher and friends' when don't understand and dare to teach my friends what I understand and can do. And GeoGebra Classroom is a great program that makes learning easier, helps me understand lessons, helps me see many sides, lots of tools to use, have fun learning to do things you've never done. Learn in your spare time, easy to use. But let's have an internet connection. (S3)*

*SSA and GeoGebra Classroom have helped me learn many things, such as understanding where I need to improve my learning by asking friends and teachers for help, and sometimes even teaching my friends. I have also been able to experiment and test if I am doing things correctly in the program. (S4)*

2. Do student self-assessment reports and the use of GeoGebra improve students' understanding of what they need to learn?

The students express varying perspectives on the effectiveness of SSA and GeoGebra Classroom. While SSA aids in self-assessment and understanding lessons, some students worry about time constraints. On the other hand, GeoGebra Classroom is praised for making lessons more comprehensible, providing a three-dimensional perspective, and facilitating flexible learning. However, there are occasional technical issues, such as program resets and the requirement of an internet connection. Overall, the students appreciate the benefits but note some challenges associated with both SSA and GeoGebra Classroom.

Taking S2, S3, S5 and S7 are examples of improvement in students' understanding of what they need to learn:

*SSA helps me know level my working of understand in the lessons. But I am afraid of not being able to keep up with my classmates. And GeoGebra™ Classroom helps me understand the lesson very easy. Because I work in the worksheet, I can see two dimensional. But I work in GeoGebra™ Classroom I can see three dimensional. So, helps me understand more. sometimes the program resets itself, which requires me to redo the work. (S2)*

*SSA helps me feel confident in ask my teacher and friends' when don't understand and dare to teach my friends what I understand and can do. GeoGebra™ Classroom is a great program that makes learning easier, helps me understand lessons, helps me see many sides, lots of tools to use, have fun learning to do things you've never done. Learn in your spare time, easy to use. But let's have an internet connection. (S3)*

*SSA helped me study better, understand lessons, know your own mistakes, and improve myself, but sometimes worries about work because having to do a self-assessment makes me unable to work in time. GeoGebra™ Classroom helps my classroom to be fun and stress free. It made me understand the lesson better and use my smartphone to study. (S5)*

*SSA helps me know if I can do the tasks my teacher gives me. It made me understand what I was doing. But sometimes it makes me lose my mind, get stressed out, and don't work on time. GeoGebra™ Classroom helps me understand lessons and allows you to work anywhere. (S7)*

3. *Do student self-assessment reports and the use of GeoGebra improve students' confidence to ask for help from the teacher?*

The students appreciate the positive impact of SSA and GeoGebra Classroom on their learning experiences. SSA boosts their confidence to seek help from teachers and friends, fostering a willingness to teach others. GeoGebra Classroom is praised for its user-friendly interface, facilitating easier learning, providing various tools, and making the learning process enjoyable. Both tools contribute to their understanding of lessons, with the added benefit of experimentation and testing within the GeoGebra Classroom. The students find value in collaborative learning, seeking assistance when needed, and actively engaging in the improvement of their learning.

Taking S3 and S4 are examples of self-assessment and use of GeoGebra improving students' confidence to ask for help:

*SSA helps me feel confident in ask my teacher and friends' when don't understand and dare to teach my friends what I understand and can do. And GeoGebra™ Classroom is a great program that makes learning easier, helps me understand lessons, helps me see many sides, lots of tools to use, have fun learning to do things you've never done. Learn in your spare time, easy to use. But let's have an internet connection. (S3)*

*SSA and GeoGebra™ Classroom have helped me learn many things, such as understanding where I need to improve my learning by asking friends and teachers for help, and sometimes even teaching my friends. I have also been able to experiment and test if I am doing things correctly in the program. (S4)*

4. *Do student self-assessment reports and the use of GeoGebra promote student achievement?*

The student appreciates the positive impact of both SSA and GeoGebra Classroom on their learning experience. SSA boosts confidence in seeking help and encourages teaching others, leading to better study habits and self-improvement. However, there are concerns about time management due to self-assessment requirements. On the other hand, GeoGebra Classroom is praised for making learning enjoyable, enhancing lesson comprehension, providing diverse perspectives, and offering numerous tools. It contributes to a fun and stress-free classroom environment, facilitating better understanding of lessons and allowing convenient smartphone-based studying.

*SSA helps me feel confident in ask my teacher and friends' when don't understand and dare to teach my friends what I understand and can do. GeoGebra Classroom is a great program that makes learning easier, helps me understand lessons, helps me see many sides, lots of tools to use, have fun learning to do things you've never done. Learn in your spare time, easy to use. But let's have an internet connection. (S3)*

*SSA helped me study better, understand lessons, know your own mistakes, and improve myself, but sometimes worries about work because having to do a self-assessment makes me unable to work in time. GeoGebra Classroom helps my classroom to be fun and stress free. It made me understand the lesson better and use my smartphone to study. (S5)*

5. *Do student self-assessment reports the use of GeoGebra promote Self-Directed Learning in Mathematics Lessons*

The student reflects on the advantages and challenges of both SSA and GeoGebra Classroom. SSA helps in self-assessment, boosting confidence, and aiding memory, but it can be time-consuming and occasionally induces stress. GeoGebra Classroom makes learning enjoyable, fosters creativity, and offers flexibility but may face occasional technical issues due to a weak internet connection. Overall, both tools contribute to improved learning by facilitating self-awareness, collaboration, experimentation, and better understanding of lessons, but they come with their respective drawbacks, such as time constraints and technical glitches. Taking S1, S3, S4, S5, S6 and S7 are examples of self-assessment and use of GeoGebra improving students' confidence to ask for help:

*SSA helps me to know whether I can do it myself or not, and it helps with memory because I must remind myself to evaluate myself every time I work. But it takes a little time to work. GeoGebra helps me enjoy learning and allows me to use my imagination to be creative without having to use notebooks or textbooks, making it convenient and comfortable. I can work anywhere, anytime, which makes learning mathematics less boring. But sometimes It refreshes my work. So, I can't work in time. (S1)*

*SSA helps me feel confident in ask my teacher and friends' when don't understand and dare to teach my friends what I understand and can do. And GeoGebra Classroom is a great program that makes learning easier, helps me understand lessons, helps me see many sides, lots of tools to use, have fun learning to do things you've never done. Learn in your spare time, easy to use. But let's have an internet connection. (S3)*

*SSA and GeoGebra Classroom have helped me learn many things, such as understanding where I need to improve my learning by asking friends and teachers for help, and sometimes even teaching my friends. I have also been able to experiment and test if I am doing things correctly in the program. (S4)*

*SSA helped me study better, understand lessons, know your own mistakes, and improve myself, but sometimes worries about work because having to do a self-assessment makes me unable to work in time. GeoGebra Classroom helps my classroom to be fun and stress free. It made me understand the lesson better and use my smartphone to study. (S5)*

*SSA helps me to know myself. how well done. And the teacher will know if I can do it or not. But it made me nervous and sometimes I couldn't keep up. Studying in GeoGebra Classroom is fun for me. because they do not take notes on the notebook, but instead work on the smartphone and can choose when to work. But sometimes the program has problems due to weak internet. (S6)*

*SSA helps me know if I can do the tasks my teacher gives me. It made me understand what I was doing. But sometimes it makes me lose my mind, get stressed out, and don't work on time. GeoGebra Classroom helps me understand lessons and allows you to work anywhere. (S7)*

## Discussion

The three sources of data presented above were used to answer the main research question which asked if SSA and the use GeoGebra improved their experiences of mathematics teaching and learning. Examining supplementary research question one, we can conclude that most students reported that SSA and the use GeoGebra improved their communication with the teacher and friends'. Examining supplementary question two we can conclude that the majority of students reported that SSA and the use GeoGebra improved students' understanding of what they need to learn. Examining research question three we can conclude

that the majority of students reported that SSA and the use GeoGebra improved their confidence to ask for help from the teacher and friends'. Examining supplementary question four we can conclude that the majority of SSA reports and the use of GeoGebra promoted student achievement.

From the test results of the performance in the first and second cycle of 24 students, it was found that the learning efficiency scores in the first cycle for the students were  $12.46 \pm 4.19$ , and the average scores in the second cycle were  $14.29 \pm 3.94$ . When subjected to a statistical t-test, a significant difference was observed between the mean values of learning efficiency scores for the first and second circuits at a significance level of  $\alpha = 0.05$  ( $t = -3.0509$ ,  $p < 0.05$ ). Therefore, SSA reports and the use of GeoGebra have been found to promote student achievement.

The finding is in line with previous studies where peer and self-assessment are found to contribute to the students' learning through effective feedback, a supportive learning environment, and collaboration among learners (Ndoye, 2017); that the implementation of e-self-assessment activities using information and communication techniques improve students' achievement and increased satisfaction (Martínez et al., 2020); that the traditional scoring system of grades is limited in promoting self-directed learning, while self-assessment allows students to set learning goals, monitor their progress, and reflect on their successes and failures (Ramiz, 2018); and that self-assessed abilities for goal achievement, such as positive self-talk and perceived self-efficacy, have been associated with higher performance levels and aspiration (Stoyanova et al., 2017). However, one study found no significant difference in student learning gains when comparing self-assessment with rubrics to traditional instruction (Hotard, 2010). Overall, student self-assessment and the use of GeoGebra can be effective tools in promoting student achievement, but further research is needed to fully understand their impact.

And examining supplementary question five we can conclude that the majority of students reported that SSA reports and the use of GeoGebra promote Self-Directed Learning in Mathematics Lessons. According to the students' perspective, using GeoGebra for self-assessment helps them to better understand and express their thoughts and opinions to teachers and classmates. By using their own smartphones, students can learn at their own pace and convenience, leading to increased confidence and effectiveness in answering teachers' questions. However, there are still challenges in using smartphones for learning, such as internet connectivity issues, which can result in wasted time and frustration for students. Nonetheless, these challenges can provide opportunities for students to review their learning.

### **Conclusion**

This study found that using SSA and GeoGebra improved the junior high students' experiences of mathematics teaching and learning in the following ways: 1) improved communication between student and teacher; 2) improved students' understanding of what they needed to learn; 3) improved students' confidence to ask for help from the teacher; 4) promoted student achievement; and 5) promoted self-directed learning in mathematics lessons.



However, while acknowledging that as the sample was small and cannot be generalised to other populations, the researcher hopes this article will encourage other teachers to use SSA and GeoGebra in their classrooms. Although mathematics teaching is difficult, it is important for teachers to be creative and innovative and to use evidence-based practices to support teaching and students in achieving education goals and acquiring skills and knowledge that can be used in real life.

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