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# TEACHING GEOMETRY WITHOUT USING CALCULATORS: AN EXPERIMENTAL CASE ON GRADE-9 THAI LEARNERS

# ENSINANDO GEOMETRIA SEM O USO DE CALCULADORES: UM CASO EXPERIMENTAL EM APRENDIZES TAILANDESES DA 9ª SÉRIE

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Abstract: Should we solve geometry problems using calculators? This study identified the effect of using (and not using) calculators during calculations on geometry problems sets, as well as the perceived impact on the use of calculators based on students', parents' and school administrators' perception in a school in Bangkok, Thailand. This study combined both qualitative (survey and interview) and quantitative techniques (experiment) to address the research problem. Findings revealed that the performance of students who used calculators in the experiment did not significantly differ with those who did not which suggests that non-usage of calculators will not affect solving geometry problems, at least in the context of Thai Math education. Further, survey showed that students only used calculators 'sometimes' outside class and gave diverse responses when asked why. Interview with parents, students and administrators showed transcript extracts mostly on their agreement to use calculators in geometry class citing the convenience and speed of doing problems but implied a negative impact on their academic performance in math problems in the real world. This study could provide a baseline information on the use of calculators in the teaching of Math lessons for other nationalities.

Keywords: Mathematics. Geometry. Effect of Usage or Non-usage of Calculator.

Resumo: Devemos resolver problemas de geometria usando calculadoras? Este estudo identificou o efeito do uso (ou não) de calculadoras durante cálculos em conjuntos de problemas de geometria, bem como o impacto percebido no uso de calculadoras com base na percepção de alunos, pais e administradores de escolas em uma escola em Bangkok, Tailândia . Este estudo combinou técnicas qualitativas (pesquisa e entrevista) e quantitativas (experimento) para abordar o problema de pesquisa. Os resultados revelaram que o desempenho dos alunos que usaram calculadoras no experimento não diferiu significativamente daqueles que não o fizeram, o que sugere que o não

uso de calculadoras não afetará a resolução de problemas de geometria, pelo menos no contexto do ensino de matemática tailandês. Além disso, a pesquisa mostrou que os alunos só usavam calculadoras "às vezes" fora da classe e deram diversas respostas quando questionados sobre o motivo. Entrevistas com pais, alunos e administradores mostraram trechos de transcrição principalmente sobre sua concordância em usar calculadoras nas aulas de geometria, citando a conveniência e a velocidade de resolver os problemas, mas implicando um impacto negativo em seu desempenho acadêmico em problemas matemáticos no mundo real. Este estudo pode fornecer informações básicas sobre o uso de calculadoras no ensino de aulas de matemática para outras nacionalidades.

Palavras-chave: Matemática. Geometria. Efeito do Uso ou Não Uso da Calculadora.

## INTRODUCTION

Mathematics is perceived by society as the foundation for scientific and technological knowledge that is cherished by societies worldwide (Hagan et. al. 2020). It cannot be denied that the concept of mathematics can be applied in our everyday lives from simple counting of objects, shopping, or paying our bills, that is why it is being integrated in school curriculums from kindergarten to university level. However, the emphasis placed on mathematics in education and the pervasive nature of mathematics everyday life are not enough to motivate some students to learn, master, and retain its concepts (Miles 2008). As the students advance their educational level, the level of difficulty of Mathematics keeps up and along the way, some students can no longer keep the pace.

With the fast evolution of technology, people constantly innovate and find ways to create and develop a tool or device that will help the society work effectively and efficiently including the students at school to perform basic operations in mathematics without going through the trouble of doing them traditionally thus, it can save them time remembering its fundamental principles and concepts to arrive at a correct answer. The invention of the first digital calculator in 1967 has remarkably changed the course of mathematics. It allows the user to do basic Mathematics operations by merely pressing the buttons based on the computations he wishes the calculator to perform. Nowadays, the constant development of calculators takes its game to the next level. People in the 21st century live in a technology and media-driven environment, marked by various

characteristics, such as access to abundance of information, changes in technology tools, and individual contribution on an unprecedented scale (Narquita et. al. 2013). No wonder it is already a common sight to see digital calculators in people's mobile phones and conveniently take them out from their pocket whenever they need to use them. Current research in technology and mathematics education has found electronic technologies - calculators and computers - are essential tools for teaching, learning, and doing mathematics (National Council of Teachers of Mathematics, 2000).

With all the wonders of this exceptional invention, some mathematics teachers are beginning to ask whether the students' reliance on the calculator has implications for learning the subject. The majority of experts on highschool learning maintain that for students who lack basic number proficiency, calculators may provide only the illusion of progress (Golden, 2005). It leads to the assumption that students may have been overusing the device and underusing their brains. One opinion in the debate states that calculators are good because they allow problems to be completed faster and more accurate while the opposing viewpoint is that calculators become a crutch and students have weak arithmetic skills as a result of having the calculator do the mathematical 'heavy lifting' (Arcena, 2016). Geometry comprises those branches of mathematics that exploit visual intuition (the most dominant of our senses) to remember theorems, understand proof, inspire conjecture, perceive reality, and give global insight (Zeeman, quoted in Royal Society, 2001). Problems in mathematics that involve surface area and volume are not as manageable as doing simple arithmetic operations. Students should at least have the basic foundation on the concepts of the order of operations to arrive at the correct answer. Calculators may provide efficiency and convenience to solve higher-order problems in mathematics such as finding the surface area and volume of three-dimensional figures but still, it requires its basic principles.

The lead researcher observed during his eleven (11) years of teaching mathematics in Thailand, calculators are not perceived as a necessity to Thai students when learning the subject in primary and secondary level because its education system does not encourage the use of the device in these early levels. Nevertheless, some students still opt to use calculators when doing calculations in mathematics for speed and efficiency. For that reason, this study attempts to

determine the implications of calculators on Grade 9 Thai students' in Nawaminthrachinuthit Bodindecha School, Thailand test performance in finding the surface area and volume of three-dimensional figures. The result of this study will determine whether there is a significant difference between the scores of students who take the test with calculators and those who take the test without calculators. Furthermore, the results will also benefit the Mathematics departments and the mathematics teachers in the school to reflect on the importance of emphasizing the basic concepts of the subject as it affects the students' employment of calculators in doing math calculations.

Generally, this study aimed to test the effect of using calculators in solving geometry problem sets in a controlled experiment among Grade 9 Thai learners. Further, it attempted to identify and explain the factors that contribute to the understanding of the usage or non-usage of calculators in geometry online instruction as perceived by the learners themselves, select parents, select Math Thai teachers, and select school managers specialized in Mathematics instruction.

## RESEARCH METHOD

### Sample Population

The forty seven (47) respondents of the data were Grade 9 Lower Secondary Level students enrolled in the English Program at Nawaminthrachinuthit Bodindecha School in Bangkok, Thailand during the School Year 2021 - 2022. Purposive sampling technique was employed in the selection of respondents as there were only two classes out of eleven classes in Grade 9 Lower Secondary Level enrolled in the English Program, hence, the medium of instruction of these two classes in learning mathematics was English during the time of data-collection. Select parents, teachers and school managers were also involved in the study as interviewees during the triangulation.

### Mixed Method Research using Posttest Only Group Design

The study employed Mixed Method - the approach that combines selected data-collection strategies or analysis under both quantitative and qualitative research, and involves triangulation techniques (Camara, 2020). Further, this study adapted the Posttest Only Control Group Design to compare the performance of the sample population in solving problems involving the surface area and volume of three-dimensional figures with or without using a calculator after a lecture-discussion. The researcher prepared a set of problems (in English) and each problem set consisted of ten (10) questions. These questions were taken from two references namely: Mastering Mathematics For Secondary 3A (2020) and Focus Smart Mathematics Textbook For Mathayom 3 (2017). Before administering the research instrument to the respondents, the researcher discussed the purpose of the conducted study via Google meet for them to understand. Then the class was divided into two groups using systematic sampling wherein students with odd student numbers were labeled as 'Group A (without calculators)' and students with even student numbers were labeled as 'Group B (with calculators)'. The researcher delivered a lecture on Surface Volume Calculations via google meet for both groups. After dividing the class, the researcher sent the problem set via Google form. The respondents were requested to turn on their video camera for the whole test duration of fifty (50) minutes. Data were collected via Google sheets. Responses were checked, tallied, summarized and then tabulated. Further, the researchers made sure that all threats to internal validity were controlled including history, maturation, statistical regression, sample selection, testing, instrumentation and design contamination. Data were analyzed using t-Test.

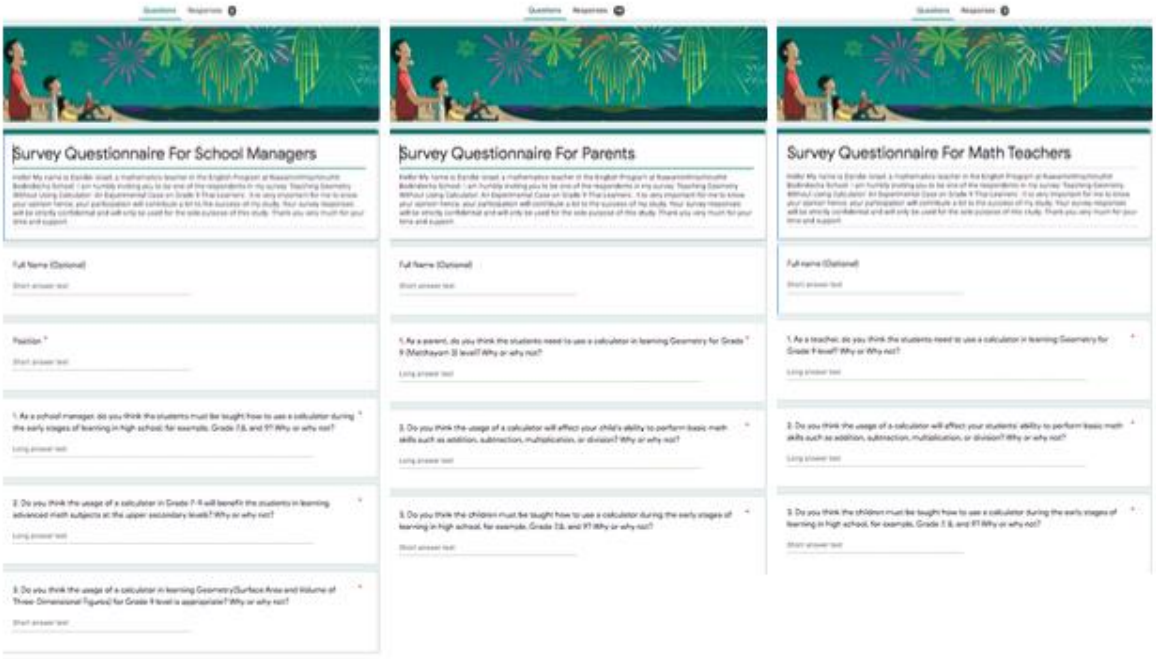
**Checking Students' Attitude Towards the Use/Non-Use of Calculators**

Further, the learners in both groups were sent via google form a survey questionnaire that asked about the usefulness of calculator, their enjoyment about the use of calculator, and the anxiety they feel with the use of calculator in order to quantify their attitude towards the use or non-use of calculators. The survey questionnaire was adapted but modified from the study of Kaino & Salani (2004). The survey questionnaire was divided into 2 parts. Part 1 asked the personal profile of the respondents including their age, gender, preference to use or not

calculators, perceived behavior of their parents on the use of calculators or not. On the other hand, Part 2 is a modification of Kiano & Salani's study, as earlier mentioned. The survey-questionnaire was sent to the respondents after the post-test. Data were analyzed using frequency and percentage.

### Interview to Parents, Teachers and School Managers

Figure 1: Survey Questionnaires (Written Interview) for School Managers, Parents, and Teachers.




The researchers also conducted a written interview to fourteen (14) students, three (3) Thai Math teachers, three (3) school managers, and ten (10) parents (Figure 1) towards their perception on the usage or non-usage of calculators in learning Geometry to identify factors that they think could have affected the result of the experiment. This is to ensure that external threats like unique program features are all considered. The researcher sent a letter (written interview) of invitation to select parents, teachers and school managers after the post test result. Answers were analyzed using Thematic Analysis (Creswell, 2004).

## RESULT AND DISCUSSION

## The Effect of Using Calculator

Table 1 showed the Post-Test results of Group A (Without Calculators) and Group B (With Calculators) Grade 9 Thai learners. Their performance was described by the use of frequency count (number of correct answers), percentage, mean and variance.

| Question No. | Group A (24 students) | Percentage (%) | Group B (23 students) | Percentage (%) |
|---|---|---|---|---|
| 1 | 11 | 45.83 | 7 | 30.43 |
| 2 | 5 | 20.83 | 10 | 43.48 |
| 3 | 20 | 83.33 | 17 | 73.91 |
| 4 | 13 | 54.17 | 18 | 78.26 |
| 5 | 12 | 50.00 | 9 | 39.13 |
| 6 | 13 | 54.17 | 13 | 56.52 |
| 7 | 17 | 70.83 | 15 | 65.22 |
| 8 | 17 | 70.83 | 15 | 65.22 |
| 9 | 6 | 25.00 | 11 | 47.83 |
| 10 | 10 | 41.67 | 14 | 60.87 |
| Mean | x=12.4 | | x=12.9 | |
| Variance | 2=22.71 | | 2=12.77 | |

The data (Table 1) revealed that Group B (With Calculators) with mean score of 12.9 performed slightly better than Group A (Without Calculators) with mean score of 12.4. Zembat (2008) found that technology "gave participants a chance to make conjecture, an opportunity to try that conjecture with the help of dynamic features (GSP,spreadsheets) and to evaluate results". The use of calculator minimizes human errors in computation and helps them solve problems faster.

Table 2: Effectiveness of Using Calculators in Solving Geometry Problems

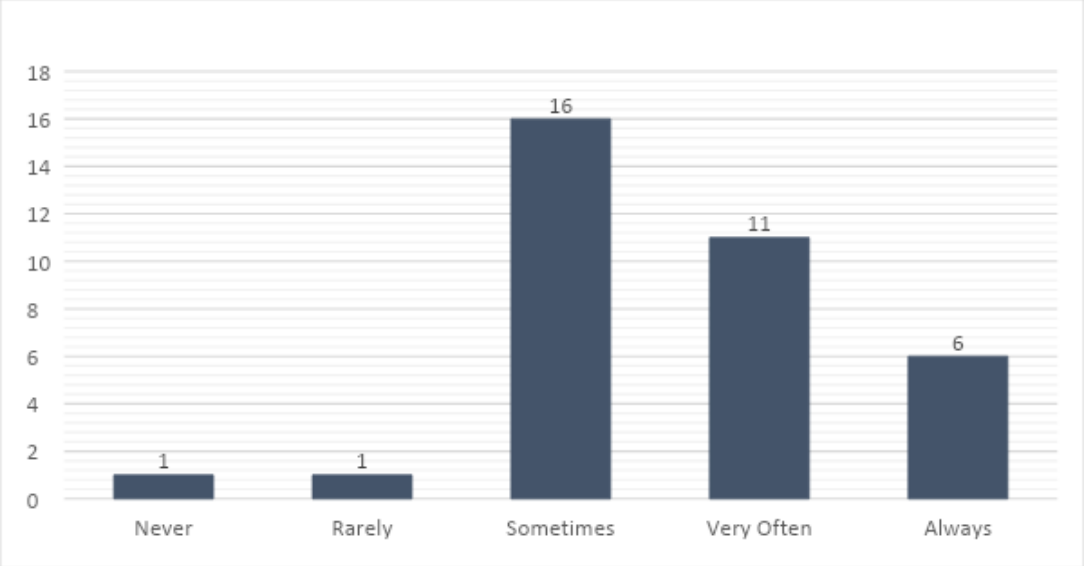
| Test | t-computed value | t-tabular value | | Degree of Freedom | Remark |
|---|---|---|---|---|---|
| | | 0.01 | 0.05 | | |
| Post-Test | 0.4065 | 2.6896 | 2.0141 | 45 | Not Significant |

The result of the findings revealed that there was no significant difference between the performance of the respondents in Group A (without calculators) and Group B (with calculators) in solving problems that involve surface area and volume of three-dimensional figures since the t-computed absolute value of 0.4065 is smaller than the t-tabular value of 2.0141 at 0.05 level of significance, also, smaller than the t-tabular value of 2.6896 at 0.01 level of significance, both with 45 degrees of freedom. This finding favors the Null hypothesis which states that there is no significant difference between the means of the two groups considering that the mean average of Group A (without calculators) is 12.4 and the mean average of Group B (with calculators) is 12.9 (Table 1).

According to the Education World Journal (1997), critics are likely to preach repetition and memorization and view mathematics as a discipline and claim that calculators prevent students from seeing the underlying structure and beauty in math. In a similar study, Clark (2011) indicates that it is vital that students gain proficiency in basic skills before being allowed access to technology which can short-cut their understanding.

**Students' Attitude Towards the Use/Non-Use of Calculators**

Figure 2: Frequency of Using Calculators Outside the Class in Doing Math Problems




The researcher surveyed thirty-five (35) students on how frequently they used calculators outside the class (Grade 9 Thai learners are not allowed to use calculators in math class) when doing math problems (Figure 1). Almost half of the students (45.7 %) responded 'Sometimes' and it only implies that outside the class, most of them use calculators in doing math problems. Calculators need to be used as tools that can help make large calculations easy or as a means of checking work for correctness (Clark, 2011). Eleven students (31.4 %) responded 'Very Often' followed by six students (17.1 %) who responded 'Always', then one student (2.9 %) by 'Rarely' and lastly, one student (2.9 %) who responded 'Never.'

**Survey on the Usage or Non-usage of Calculators in Geometry Class**

Table 3: The table shows the coding of qualitative data extracted from the interview.

| Interview Extract (Common Responses) | Code |
|---|---|
| *'No, because it's basic calculate.'* | Disagree |
| *'Not appropriate…easy-to-understand computation.'* | |
| *'No…it will make student not improve what their learn.'* | |
| *'No because I want he practice to calculate by himself.'* | |
| *'Yes, because it's faster than using a brain.'* | Agree |
| *'Yes because it easier to find answer and corrected.'* | |
| *'Yes because it will make studying easier.'* | |
| *'Calculator just use for complicated calculation… but we still have to use thought.'* | Neutral |
| *'Yes for sometimes…'* | |
| *'For my opinion, depending on the content being taught how difficult it is…'* | |
| *'Can use if necessary and appropriate..'* | |

In this extraction of data, we used the common responses from the respondents and categorized them on three codes, namely; Disagree, Agree and Neutral. Total responses were analyzed using frequency and percentage.

Table 4: The table shows the written interview results from the respondents towards their perception on the usage or non-usage of calculators in Geometry class.

| Respondent | Disagree | P (%) | Neutral | P (%) | Agree | P (%) |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| Students | 6 | 42.86 | 1 | 7.15 | 7 | 50.00 |
| Parents | 2 | 20.00 | 3 | 30.00 | 5 | 50.00 |
| School Managers | 1 | 33.33 | 1 | 33.33 | 1 | 33.33 |
| Math Teachers | 2 | 66.67 | 0 | 0.00 | 1 | 33.33 |
| Total | 11 | 36.67 | 5 | 16.67 | 14 | 46.67 |

The respondents' answers from the written interview revealed that fourteen (14) of them (Table 4) which constituted 46.67 % of the total samples agreed with the usage of calculators in Geometry class citing the convenience and speed of doing problems.

If the true nature of mathematics is understood, then the use of technology in the learning of mathematics will be seen as natural enhancements and extensions (Waits, et. al. 2000). However, eleven (11) respondents disagreed with its usage because of the subject's simplicity and basic concepts. Five (5) respondents were neutral, considering the subject's level of difficulty.

**Survey on the Negative Implications of Using Calculators on Students' Performance in Doing Basic Math Computations**

Table 5: The table shows the coding of qualitative data extracted from the interview.

| Interview Extract (Common Responses) | Code |
|---|---|

| | |
|---|---|
| *'Yes, I do it because students won't improve their math skills, slow down calculations, or think incorrectly due to lack of training.'* | Extremely |
| *'Yes because if we keep using calculator when we don't have calculator it will be hard to solve problem.'* | |
| *'Yes I think so because he doesn't practice skills.'* | |
| *'No because if you're doing the problem with a calculator, it will only help speed up your thinking.'* | Not at all |
| *'I think not affect to much because he have a basic is good enough.'* | |
| *'No because if student understand the formulas well with or without calculator will make no different.'* | |
| *'I think sometime it affects because the skill in math need to do some question without calculator.'* | Moderately |
| *'Some can learn from it to be master at solving hard math, but some just use it for laziness.'* | |
| *'Yes because it has advantage in it but it also has disadvantage.'* | |

In this extraction of data, we used the common responses from the respondents and categorized them on three codes, namely; Extremely, Moderately and Not at all. Total responses were analyzed using frequency and percentage.

Table 6: The table shows the written interview results from the respondents on the negative implications of using calculators on students' performance in doing basic math computations.

| Respondent | Extremely | P (%) | Moderately | P (%) | Not at all | P (%) |
|---|---|---|---|---|---|---|
| Students | 9 | 64.29 | 2 | 14.29 | 3 | 21.43 |
| Parents | 5 | 50.00 | 3 | 30.00 | 2 | 20.00 |
| School Managers | 1 | 33.33 | 1 | 33.33 | 1 | 33.33 |
| Math Teachers | 3 | 100.00 | 0 | 0.00 | 0 | 0.00 |
| Total | 18 | 60.00 | 6 | 20.00 | 6 | 20.00 |

The respondents' answers from the written interview revealed that eighteen (18) of them (Table 6) which constituted 60 % of the total samples responded 'Extremely' which implied a significant negative implication of using calculators on students' performance in doing basic math computations. According to Clark (2011) in his study on effective calculator use in secondary mathematics classrooms, it is vital that students gain proficiency in basic skills before being allowed access to technology which can short-cut their understanding. Most students and parents had emphasized learning the basic computation skills either mentally or hand technique in the lower

secondary since the majority of the examinations in math doesn't allow the use of calculators. Six respondents (20%) responded 'Moderately' and another six (20%) answered 'Not at all' citing that if learners didn't understand the math concept, the usage or non-usage of calculators made no difference.

## CONCLUSIONS

The data gathered from the two groups revealed that the usage or non-usage of calculators didn't affect the respondents' ability in solving problems that involved surface area and volume of three-dimensional figures therefore, there was no significant difference in their performance in learning Geometry.

The practice of Thai teachers in teaching math subjects at the lower secondary level has contributed a great deal to the foundation of these learners' basic mathematical skills by letting them do computations either mentally or through hand technique rather than using calculators. They put emphasis and the importance of building the basic math skills of the learners beforehand at the early stages of learning both in primary and lower secondary levels as this method can help them do more complex and critical problems in mathematics mentally without relying on computing devices such as calculators. This helps the students answer standard examinations that don't allow calculators in computing and solving math problems such as the Ordinary National Educational Test (O-NET) which is administered annually by the National Institute of Educational Testing Service to Grade 6, Grade 9, and Grade 12 both in public and private schools in Thailand. These devices should only facilitate the learning of students in mathematics hence, cannot be deemed a necessity or a requirement.

Advances in technology have improved the use of the calculator and mathematics curricula have been designed to involve this technology (Kaino, 2004). However, most respondents from the written interview strongly emphasized self-regulations when using them. The students must know when to use and when not to use calculators. In a similar study of Thomas (2006) on the use of

calculators in the mathematics classroom, a common concern was that teachers thought that students were not gaining a full understanding of topics, and were instead relying on their calculators to tell them the answers, also mentioned how students were more likely to accept answers without considering how reasonable they were. Therefore, students should learn the basics of calculations first by hand technique or mentally using their brain more and relying on these devices less.

## Limitations

The respondents of this study included Grade 9 students enrolled in the English Program, hence, the medium of instruction in teaching mathematics was English. Findings could be best generalized with Grade 9 students of similar discipline.

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## Conflict of Interest

The authors declare no conflict of interests.

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