Questioning the Unquestioned: How Primary School Teachers in Yogyakarta Perceive Calculator Use in Mathematics Lessons

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Abstract: *The use of calculator in Indonesia is heavily stigmatized due to its allegedly detrimental effect on the students' learning. On the contrary, public education system in many developed countries has embraced calculator as part of educational technology, supported by myriad positive findings regarding its use in mathematics learning. Considering calculator is one of the most affordable and accessible options for educational technology, calculators can be a promising alternative to introduce educational technology in developing country such as Indonesia. Therefore, changing the stigma is necessary, which can be made possible through appropriate intervention. This study investigated teachers' perception regarding the use of calculator in mathematics learning in primary school. Open-ended questionnaire was assigned to 30 primary school teachers' in Yogyakarta, followed by qualitative data analysis. The result suggests that calculator use in primary school mathematics classroom is not a common occurrence in Yogyakarta. Most teachers see calculators simply as calculating device and serve little educational benefit beyond that. The result is hoped to shed light on teachers' perception regarding calculator, in order to devise suitable and fruitful intervention in the future.*

1. Introduction

Calculators started to reach global population in the 1970-s [1]. Calculator first started as an edge-cutting technological device, but just like any other technology, it got cheaper and better. Compared to computers, calculators are less sophisticated and less powerful but it is more accessible alternative for mathematics in developing countries [2]. More people are more capable of having a calculator as its price is more affordable. To date, the calculators used widely in society can be classified into three types: 4-function calculator, scientific calculator, and graphic calculator. The term 'calculator' in this article, from this point onward, will refer to the second one.

The use of calculator, whether in learning activities or in examination, is a common occurrence in public education system in many developed countries. Since 1982, UK education system has foreseen that children will grow up in environments where calculators and computers are readily accessible [3, p. 95]. In Australia, Australian Association of Mathematics Teachers (AAMT) endorsed the use of calculator in year 1-12 and ability to use calculator should be a part of school-leaving qualifications [4]. NCTM in the United States acknowledged technology, including calculators as not only an essential part of mathematics teaching and learning [5], but also enhances the quality of learning and encourages the students' engagement [6]. In Southeast Asia, several countries such as Singapore, Malaysia, Vietnam and Philippines have started to use the calculators in their learning and examinations [7], [8].

In Indonesia, the education system is fairly agreeable on the subject of bringing technology into the classroom. However, there seems to be a boundary when it comes to calculator. Even though official regulation only prohibit calculators in national examination [9], the use of calculator in mathematics classroom remains frowned upon and rarely happens. However, the recent online

national student's competency test (AKSI) utilized students with pop-ups calculators. It should have given a fresh air to teachers to see that calculators can be used in the testing. In addition, one of the big calculator companies has made a memorandum of agreement (MoA) with the ministry of Education and Culture of Indonesia [7].

The effect of calculator in learning has been widely researched. Two meta-analysis conducted a decade apart, each examining more than 50 independent studies, consistently reported similar result; the use of calculator does not have negative effect on the students' acquisition of basic mathematics concepts and skills [10][11]. In fact, the students tend to possess better operational and problem-solving skills. The use of calculator also encourages positive attitude toward mathematics[10][11]. Positive attitude toward computer and calculator also correlates with better overall mathematics performance [12]. Recent studies showed that calculator could help develop critical thinking, mathematics performance, and motivation [13].

The stigma surrounding the use of calculators in mathematics learning generally happen due to its reputation as simply a calculating device. The studies cited above emphasize that the issue is not on the use of calculator per se, but more on how to use it. If it is properly used, calculators offer many educational potentials through its functions. Kissane [14], for example, mentioned four educational functions of calculator, namely calculation, affirmation, representation, and exploration.

Why is this important to discuss? Calculator is relatively more affordable and accessible compared to other means of educational technology. In line with this, Zucker and Light [15] have observed that the computer technology is often more expensive. The price of one unit of calculator is generally cheaper than computer even ones with the lowest specification. Calculator does not have much demand in terms of supporting infrastructure, since it can work without electricity network or internet, with some calculators even boast solar energy as its power. Calculator is also small and durable, meaning it is easy to carry, store, transport, and set up. In Indonesia, the uneven distribution of supporting infrastructure contributes to the difficulty of introducing educational technology in most community. Calculator can be the alternative in such cases.

The previous explanation already covered the role of calculator in public education system in many countries, the positive research findings regarding calculators in mathematics learning, educational function offered by calculators, and the advantage of calculator as an alternative in introducing educational technology. Considering these premises, the stigma surrounding the use of calculator in mathematics learning is no longer relevant. Instead of avoiding calculators, teachers should cultivate its many benefits and creatively explore them to enrich their mathematics lesson.

Challenging the status quo is not easy feat and, in this case, teachers have the central role. While all stakeholders in education has a role in changing any stigma regarding a certain pedagogical approach, teachers are strategically positioned because they can ignite change at a very basic level: their own classroom. Therefore, it is important to investigate the teachers' perception regarding calculators and its use in mathematics classroom, as it may provide necessary insight in envisioning and devising appropriate intervention.

Currently, there has been little research regarding the perspectives of Indonesian teachers regarding calculators. This study aims fill this gap by investigating primary school teachers' perception towards the use of calculator in mathematics teaching and learning. Primary school is chosen because the negative perception of calculator is more frequently associated with this grade, compared to other grades. To provide richer insight, we also sought to study teachers' previous experience with calculators, as we consider it important factor that shapes or be shaped by the teachers' perception. The research question to be answered in this study are 1) *how is calculator used in mathematics teaching and learning in primary schools in Yogyakarta?* and 2) *what is the*

perception of primary school teachers in Yogyakarta towards the use of calculators in mathematics teaching and learning?

2. Method

This study is part of a larger research aimed to investigate how the use of calculators affect the students' critical thinking ability and their attitude. The subject of this study is the participants of a workshop on utilizing scientific calculators in primary school which was conducted by SEAMEO QITEP in Mathematics. The sample was obtained through one of the method of purposeful sampling namely convenience sampling [16]. The participants are the teachers who were interested in this workshop and voluntarily applied to be participants. This method is chosen because it is appropriate for the workshop setting, for which the participants are invited on application basis. Further screening was implemented, through which 29 workshop participants are selected from around 40 applicants according to their academic profile and geographical distribution.

Data collection was conducted through open-ended questionnaire through an online platform Google Form. The questionnaire was in Bahasa Indonesia and comprised of four questions, which are the following (English translation):

1. *Have you ever used calculator in mathematics teaching and learning? Explain your reason.*
2. *What is the positive side of calculator?*
3. *What is the negative side of calculator?*
4. *Is calculator appropriate to be used in mathematics teaching and learning in primary school? Explain your reason.*

Question 1 are related to the teachers' experience concerning calculators use in primary school, while question 2, 3, and 4 are aimed to divulge their perception about it. As the questionnaire was meant to be the pre-test for the workshop, the teachers answered the questionnaire simultaneously prior the first workshop session. The questionnaire was not anonymous, which mean the teachers must provide their name alongside their response. However, this is unlikely to cause bias that affect their response to the question, since the questions in this research are presented as workshop pre-test, which the teachers were used to.

Content analysis was used to analyze the data from the questionnaire. Data analysis was conducted qualitatively by searching, identifying, and categorizing overarching themes in the *quotations* (words or phrases) of data [16], meaning the smallest unit of data containing independent decipherable information. We compare these themes to the research questions to ensure its relevance and ability to answer the questions. Next, we translated the themes into *codes* and then assign the codes to different fragments of data. If a teacher's response can be assigned two codes, we ensured to differentiate whether the two codes are independent or related to each other.

To ensure reliability of data analysis, each author independently assigned the codes to the quotes of data. Difference in opinion regarding the appropriate coding was discussed until consensus was reached. In the case no consensus was possible, the item was deemed invalid and omitted from data analysis process. The assignment of the codes was followed by tallying the frequency of each codes appearing in each question. By comparing the frequency of each codes, we are able to make sense the answer of each question in an orderly and consistent fashion. Aside from that, we also analyzed the co-occurrence between the codes to investigate the relationship between different responses.

3. Results and Discussion

In this part of the paper, the result of data analysis will be outlined in two parts, namely the teachers' experience and the teachers' perception. We will describe how the result of data analysis answer the research question and how the answer of the two questions relate to each other, giving one big picture of the current state of calculator usage affairs by primary school teachers in Yogyakarta.

3.1 Teachers' experience using calculator

Out of 29 teachers, fewer than a half (13 teachers) claimed to have used calculators at one point in their mathematics lessons, while 16 teachers stated that they have never used calculator in mathematics classroom. All 29 responses about the reason behind their experience are broken down further into quotations, resulting in 34 independent quotations. The following (Figure 1) are the common themes identified in teachers' reason behind having used calculator, while Figure 2 depicts the common themes identified in teachers' reason for having never used calculators.

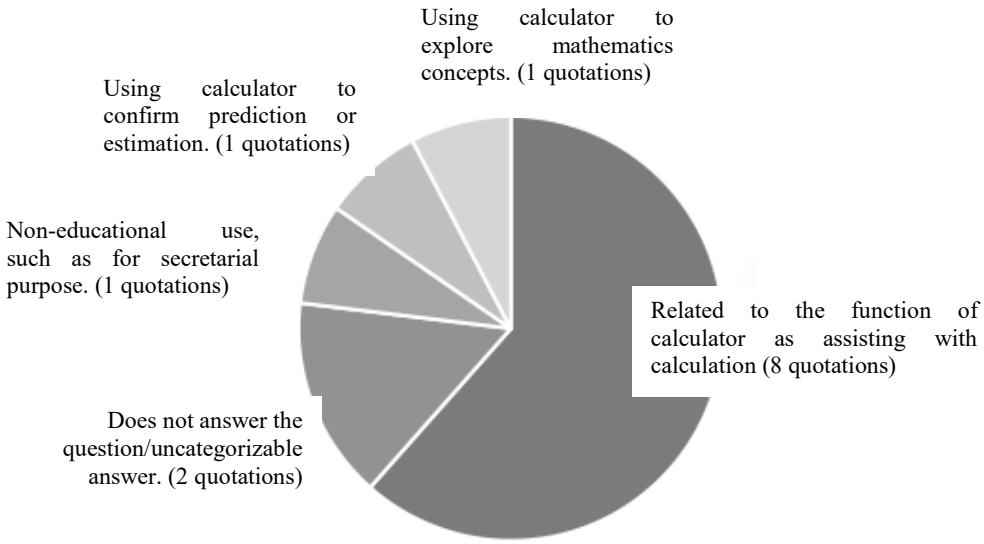

Figure 1. Reason for using calculator (13 quotations)

Teachers who used calculator, the majority of them used it for calculation purposes, especially checking the result of calculation or performing statistical calculation involving large data size. The following are some responses by the teachers.

> I used calculator in lessons where [I have to] check the result of numerical operation involving 3-digit or even 4-digit number.
>
> 4^{th} grade lessons in the topic of calculating mean and addition of large numbers.
>
> I utilized calculators in my lessons. I used it to check the result of calculation done by the students. At first, the students calculate manually, before being proved with calculators.

Out of 13 quotations, only two responses mention educational use of calculator which is not related to assisting with calculation, namely exploration and affirmation. In exploration, the

calculator is used to explore the use of bracket when performing operation involving addition and multiplication. Whereas in affirmation, the calculators are used in problems where the students must make mathematical guess about the answer, such as cube root or repeating decimals.

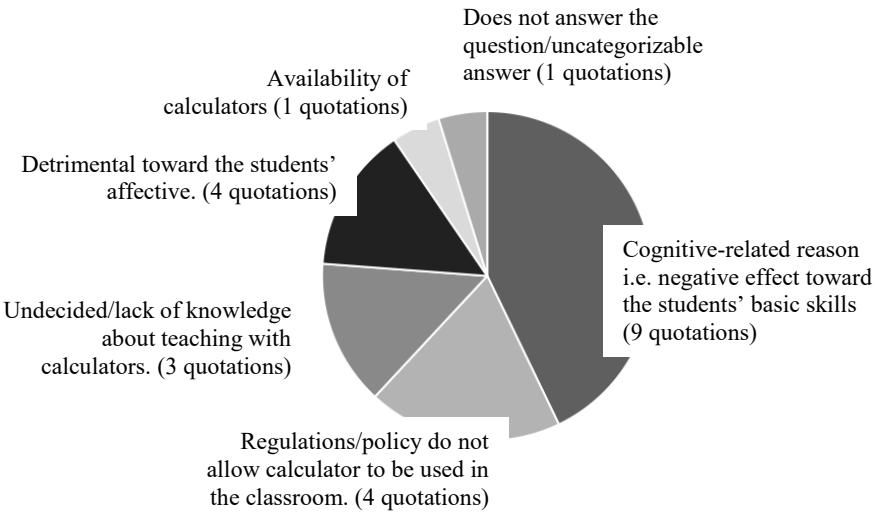

Figure 2. Reason for not using calculator (21 quotations)

For teachers who never used calculator for teaching purpose, half of them cited cognitive-related reason behind their aversion. Among the reasons they mentioned are as follow:

> According to me, calculators make the students to not think creatively, cannot explain basic concept especially multiplication and division, simply pushing buttons and come out the answers. When doing calculation [they] will only rely on calculators and refuse to think by themselves.
>
> So the students will get used to think without technology.
>
> Using calculators in primary school is not allowed so that the students will memorize multiplication

Three quotations cite reasons which revolve around motivation; two of which co-occur with cognitive-related statement. This suggests that according to the teachers, laziness due to calculator and the lack of conceptual understanding are related to each other, even though the causational direction is somewhat mixed. Such responses are detailed as follow.

> [The use of calculator] will disrupt the students' acquisition of basic mathematics concepts and train them to be lazy [to do manual calculation].
>
> Sometimes the student will be too lazy to do the calculation themselves and cause their conceptual understanding to diminish overtime.

Teachers also discuss regulations or policy banning calculator to be used in the classroom, even though none of them specify the regulation in more detail, such as the level of policy making and advocating, or whether it is enforced. Furthermore, some teachers mention unpreparedness and lack of knowledge about teaching calculator, suggesting that they are not opposed to calculator per se,

but simply inexperienced with its educational implementation. Only one quotation mention lack of availability or access to calculators.

From the findings, two state of affairs are evident. First, the use of calculators during mathematics lesson in primary school is not a common occurrence in Yogyakarta. The concern is that the students will be dependent on the computing assistance provided by calculator, which is perceived as harmful for cognitive and affective. Second, in a case where the teachers do utilize calculators, it is limited to simply helping with calculation of large numbers or checking the result. Both situations suggest that the use of calculator to teach mathematics in primary school in Yogyakarta is simply to assist with calculation; the very perspective which also causes teachers to avoid its use.

While no recent studies record calculator usage in primary school, similar situation is documented in study reported by Milou [17], where calculator usage (in this case a graphi calculator) is a controversial subject even in high school. This phenomenon may be explained by the government policy to ban calculator from national examination [9]. As Indonesian curriculum is largely exam-based in practice, teachers are often afraid to try new approach or method that might jeopardize their students' chance in exam.

The teachers' limited view about the educational role of calculator is well recorded in literature [8], [18]. Teachers often cannot see the role for calculator beyond computing device, and while they are eager to adopt newest ICT into their classroom, calculator is often deliberately left out [19]. The teachers' avoidance to use calculator may also be attributed to unfamiliarity and lack of confidence, which is a strong predictor for low enthusiasm to incorporate calculator in teaching [20], [21].

Interestingly, there is only one mention of lack of availability or access to calculator as the reason. While computers are often a more obvious choice when it comes to educational technology, it is not always readily available for everyone. In Indonesia, on average, there is only one computer available for every 16,7 students, and only 25.8% of students have at least one computer at home [22]. As calculators seems to be easily acquired by teachers, it can be a more accessible alternative to computer

3.2 Teachers' perception towards the use of calculators in mathematics teaching and learning

Initial analysis on 29 responses on positive perspective toward calculators yield 44 independent quotations. More than a half (25 quotations) mention assisting with calculation as the reason behind their positive impression. However, a closer look into these 25 quotations reveal a certain trend, which is signified in the following word cloud generated with Atlas.ti.

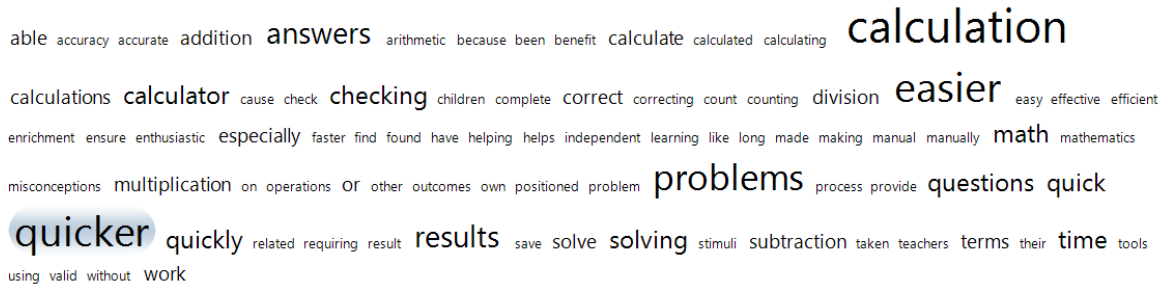

Figure 3. Word cloud of the teachers' perspective in regarding positive sides of calculators

The size of the font signifies the frequency of the word appearing in the quotations; larger means appearing more often, while smaller means appearing less. It is evident that the most frequent words appear in the quotations are "calculation", "quicker", and "easier", which gives a

clear idea about major theme in the teacher's response; the positive side of calculator is to help making calculations *quicker* and *faster*. It is also apparent that, while the words "answer" and "results" occur quite often, words like "process" or "operations" appear in much smaller frequency, suggesting that teachers associate calculators more with acquiring results than tinkering with the process. The following are some examples of the teachers' responses.

> The students will be faster in solving problems related to arithmetic operation (addition, subtraction, multiplication, and division).
>
> Faster calculation, helping the students to be more independent by checking the result of their manual calculation.
>
> For primary school students, calculator makes it faster for the students to find the answer especially addition, subtraction, multiplication, and division without spending a long time for it.

Aside from that, eight quotations cite affective-related explanation, such as the ability of calculator to ignite confidence or make learning more joyful. However, only six out of 44 quotations mention calculator as having positive effect toward the students' cognitive development, such as to foster critical thinking or to develop certain mathematics concepts. The following is the example of such quote.

> … helping the students to develop concepts of average [arithmetic mean], mode, and median.
>
> Deeper and wider understanding of concepts, encourage exploration in problem solving, providing the students the chance to interact with many types of problem.

On the other hand, the analysis on the 29 responses on negative perspective toward calculators yield 30 independent quotations. Common themes identified in these quotations are cognitive-related and affective-related; both occur at almost the same frequency. A closer look into the co-occurrence of these themes reveals that cognitive-related statements appear simultaneously with affective-related statements in about the third of the entire quotations (8 items). This implies that according to the teacher, the damaged conceptual understanding correlates with negative attitude. Both causal directions appear in the teacher's statement. Some examples are as follows.

> In several cases, such as multiplication and addition, the students will be too lazy to calculate by themselves resulting in stunted numerical literacy.
>
> The students will be dependent on calculator and refuse to do calculation manually, whereas the manual calculation contain many thinking processes that can benefit the students.

Out of 29 teachers, an overwhelming majority (21 teachers) claims to support the use of calculator in primary school. When asked about the reason, the frequently appearing themes are the computing assistance provided by calculator, cognitive-related benefit (i.e. to foster critical thinking and to develop mathematics concept) and emphasis on teacher's pedagogy (e.g. calculator can be a powerful tool in the hand of competent teachers). The rest of the responses propose limited use, such as restricting calculators for certain grade and situations, and technological literacy. As for teachers who do not suggest the use of calculators in primary school, frequent themes identified

in their response revolves around the importance of manual calculations in primary school and that using calculator will hinder the acquisition of basic mathematics skills.

Based on these analyses, several key findings can be deduced regarding the teachers' perception toward calculator in primary school. First, calculators can be viewed positively but teachers who do so have limited view about the role of calculators, namely only as computing device. Very few teachers consider calculators as beneficial for the students' conceptual understanding. Second, negative view regarding calculator stems from the concern that calculators may hinder acquisition of basic mathematics concepts and skills which are linked to various attitude problems (such as dependency and lack of confidence). Third, most of the teachers never used calculators yet they think that it is appropriate for primary school use. Fourth, the suggestions not to use calculator in primary school stems from the mindset that mental and manual calculation skills has the utmost importance in primary schools and using calculator might take the focus away from it. Each of these points will be discussed as follow.

The first and second findings can be traced to the stereotype that calculators solely function as computing device. The study by [23], which investigated teachers' belief about calculators across educational stages, found that elementary school teachers are less likely to belief that calculators can enhance mathematics instruction and more focused on computational purpose of calculator. The study explains that this may be linked to mathematics curriculum in primary school which is mostly centered around elementary arithmetic operation. On the contrary, high school teachers are exposed to more advanced mathematics and wide range of problem-solving practice, which provide diverse ways for the students to use calculators.

The second finding also agrees with Banks [24], whose historical analysis about regulation pertaining to calculators and people's reaction against them reveals that the reason most teachers reject calculator is the fear that their students will not learn the basics and be dependent on calculators. Even teachers who endorsed the use of calculators to enhance mathematics instruction strongly emphasis that students need to acquire the basics before start using calculators [23]. These studies also explain the fourth finding. Teachers who refuse the use of calculators in primary school, usually do so because they do not want dependency on calculators to compromise mental and manual calculation skills [18]. This perspective is unfortunate because according to NCTM [25][25], appropriate use of calculator is supposed to support mental and manual calculation, not render them obsolete.

Interestingly, the majority of the teachers never used calculators during their own lesson yet state that it is appropriate to be used in primary school. This finding may be explained by the work of Salani [26] as well as Taley and Adusei [20] in which lack of confidence and technical knowledge about calculator causes low enthusiasm to incorporate calculator in mathematics lessons. Most teachers involved in this study were born in the 1980s and are product of traditional mathematics [27], which may explain their unfamiliarity with calculators aside from its basic four functions. On the other side, this shows a promising stance of the teachers. With sufficient professional training in using calculators to teach mathematics, the teachers might be more enthusiastic to revolutionize their mathematics teaching using calculators [20], [23].

4. Conclusion

Considering the ubiquity of calculator and its research-supported educational benefit, avoiding calculator no longer benefits anyone. Teachers, instead, are supposed to embrace it and exploit calculators to its full potential. Result from the analysis reveal that the use of calculator during mathematics teaching and learning in primary school is not a common occurrence in Yogyakarta. The arguments both and against calculator in primary school are centered around the idea that

calculator is simply a computing device and serving little educational purpose beyond that. However, most teachers agree that calculators can be appropriate tool for primary school mathematics, which is a great indicator that they are open for change and improvement.

The result of this study offers important implication for professional development for teachers in Indonesia. Professional development should encourage teachers to take the advantage of the availability of calculators and turn it into something that will improve their mathematics teaching. Furthermore, professional development should emphasis the educational use of calculators that support the students acquisition of mathematics concepts and skills. The Indonesian mathematics curriculum over the years have started to move toward the direction that prized conceptual understanding more than procedures and memorization. Small but gradual changes like embracing calculators can push the progress further in that direction.

This study was limited to Yogyakarta and surrounding area, and captured the perspectives of only 29 primary school teachers. The small sample, the method of sampling, and the narrow geographic span are the main limitation of this study. The findings here may not be generalizable nationwide or even province-wide, however communities with similar characteristics may yield similar result. We encourage future research to explore wider participant demographic, either based on their educational stages or geography.

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