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How to Enhance Students' Participations in Mathematics Learning Using Calculator?

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Abstract: *One of strategy to improve the quality of mathematics learning is increasing students' participations in learning. During this process, students are guided to find mathematical concepts through exploration, so that concepts can last longer in their minds to be utilized in problem solving. One strategy that can be used to enhance students in mathematics learning is integrating calculator utilization. This study was to describe the strategy to enhance students' participations in mathematics learning in high school and vocational school using a calculator. This research is a narrative qualitative study. Data was collected by observation of 21 teachers from 8 provinces in Indonesia who integrate teaching and learning using calculator and documenting students' responses to worksheets developed by researchers. Data analysis was carried out using Cresswell's steps. The results showed that the teacher's keywords to enhance students in mathematics learning on the topic function was integration the use of a calculator starting from the lessons design, prepared appropriate work sheets and carry out learning, guided students to discover concepts through learning activities, and facilitated students to collaborate and communicate during the process learning. The steps of learning that integrate calculator to explore mathematical concepts in detail are then discussed.*

1. Introduction

Critical thinking and problem solving skills of students are trained in mathematics education. The ability to think critically involves finding patterns, making predictions, finding alternative answers, analyzing, and making decisions [1],[2]. These abilities are used to solve problems [3], both problems during learning and problems that required higher order thinking or problems in everyday life. This is in line with the goals of mathematics learning written in the curriculum in Indonesia.

To facilitate the implementation of learning mathematics in order to achieve these objectives, technological devices can be used [4]. The urgency is strengthened by the availability of technology and makes it easier for students to master the concepts learned and apply them to solve problems [5]. The use of technology in the learning of mathematics needs to pay attention to the affordable prices, easy to access, and easy to operate of these technological devices. The technology devices that fulfill this requirement are calculators. Calculators can be used for various purposes in mathematics learning. The use of calculators in mathematical learning is to help students make representations, calculations, affirmations, and exploration of problem solving [6].

During this active process, students are guided to discover mathematical concepts through exploration, so that concepts can last longer in students' minds to be used in problem solving [5]. One strategy that can be used to enhance students in mathematics learning is to integrate the use of calculators in mathematics learning [7]. At present, there are not many mathematical learning examples that integrate calculators. Examples of integration of calculators in learning mathematics are things that teachers need. With the existence of real examples, can be used as inspiration for teachers to apply it in mathematics learning. In this regard, this study aims to describe the strategy

of enhance students in mathematics learning in high school and vocational school using a calculator.

2. Methods

This research was a qualitative study in narrative type. Data was collected through observation on 21 teachers who conduct teaching and learning from 21 schools of 8 provinces in Indonesia. These provinces were Aceh, West Sumatra, West Java, Yogyakarta, East Java, South Sulawesi, Maluku and West Papua. The researcher designed the lesson plan and student worksheets, then trained the teacher to carry out mathematics learning integrating the calculator utilization. The learning activities were carried out to teach material related to linear functions and quadratic functions. In addition to using students' worksheet that has been prepared, learning activities are carried out using a Classwiz fx-991EX calculator as a learning media. The learning trajectory was designed so that the calculator utilization could make it easier for students to learn topic in mathematics. There were several learning activities designed using the calculator function. The design of the activities were contained in the lesson plan. In the lessons, calculator was used to do calculations, help students match answers, produce examples by applying existing calculation steps, produce data that would be observed by students to be used to make guesses, prove suspicions and obtain new rules or theorems and apply rules for obtain new calculation steps. During the process of implementing learning, the teachers were observed by researchers. The results of the observations were then narrated to obtain a description of how mathematics learning integrated using calculators in the classroom.

3. Results

The students' worksheet was designed to support the implementation of learning activities by utilizing the Classwiz fx-991EX calculator. Five worksheets related to the topic linear function. The students' worksheet related to linear functions and quadratic functions were developed for students to work upon. Of these, Worksheet 1 was related to exploration functions, Worksheet 2 was based on characteristics of linear function graphs, while Worksheet 3 to 5 focused on functions, graphical characteristics of quadratic functions and the application of linear functions and quadratic functions to everyday life. The activities in the worksheet were designed to facilitate students in finding the formula of linear functions and quadratic functions, finding the slope pattern of the line, finding the properties of lines, finding patterns of coefficients in a quadratic function, line graph patterns straight or intersecting parabola and patterns that occur as a result of transformation.

The implementation of learning activities began with an exploration of the function of using Worksheet 1. Through Worksheet 1, students were expected to remember and can explain and determine linear, rational and squared functions correctly. In addition, through this activity students were expected to understand the subject matter related to the domain of function, codomain of function, range of function, and each graph of these functions.

During the implementation of learning activities, most students had been able to identify functions. Not only able to identify, students had also been able to explain the reason correctly. One example of student work that identifies the type of function with the right reasons can be seen in Figure 1. However, there are still some students who had lower ability in rational functions with denominators was in one degree, so that they assumed that the function is a linear function. An example of one incorrect student's answer because identifying rational functions as a linear function can be seen in Figure 2.

$f(x) = 12 - 3x$	Fungsi linier. Karena memenuhi persamaan $f(x) = mx + c$, pangkat tertinggiya satu
$g(x) = \frac{11}{5x+6}$	Tidak keduanya. (Fungsi rasional) $\frac{a}{b} \rightarrow b \neq 0$
$y = x^2 + 2x - 5$	Fungsi kuadrat. Karena memenuhi persamaan $f(x) = y = ax^2 + bx + c$, pangkat tertinggiya dua
$y = 2x - 3$	Fungsi linier. Karena memenuhi persamaan $f(x) = mx + c$, pangkat tertinggiya satu
$2y - 5x = 3$	Fungsi linier. Karena memenuhi persamaan $f(x) = mx + c$, pangkat tertinggiya satu

Figure 1. The Correct students' answers in identifying functions

$f(x) = 12 - 3x$	Fungsi linier
$g(x) = \frac{11}{5x+6}$	Fungsi linier fungsi linier
$y = x^2 + 2x - 5$	Fungsi kuadrat
$y = 2x - 3$	Fungsi linier
$2y - 5x = 3$	Kalau ketemu fungsi linier

Figure 2. The incorrect students' answers in identifying functions

All worksheets compiled always start with various activities that can motivate students to explore. The Worksheet 2 related to the characteristics of the graph of linear functions and in Worksheet 3 related to the relationship and characteristics of graphs of quadratic functions, a problem is presented as the beginning of activities in the worksheet. From these problems, students were directed to carry out exploration related to the material related to the problem. The exploration activities were carried out by using a Classwiz calculator. The Classwiz Calculator was used to facilitate students in determining the values of a given function.

In contrast to the two previous Worksheets, in Worksheet 4 related to the characteristics of quadratic function graphs and Worksheet 5 related to the characteristics of the graphs of transformation and resolution of contextual problems of linear equations and quadratic equations, exploration activities raised in the beginning of activities in Worksheet were designed using one of the functions in a Classwiz calculator, namely *Table*. Students are asked to explore different functions and analyze the output displayed by the Classwiz calculator to answer various questions in the Worksheet related to the material they will be studying. One of the results of exploration of functions carried out by students can be seen in Figure 3.



Figure 3. Student exploration results using a Classwiz calculator

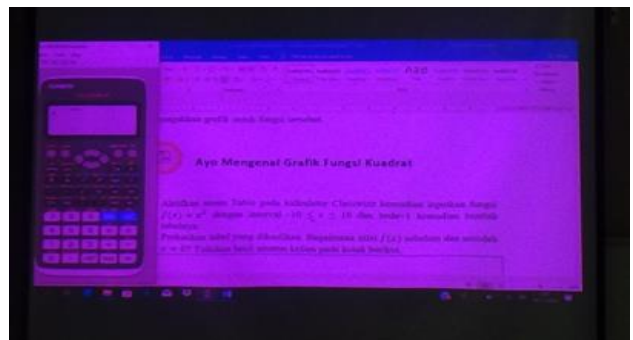


Figure 4. Explanation regarding the use of a Classwiz calculator

Learning activities using the Classwiz Calculator were new to students. Before students start learning activities by referring to the Worksheet, teachers first provides guidance to students regarding the use of a Classwiz calculator in learning activities. Using media in power point,

teacher provided explanations and detailed examples of the use of the calculator. After making sure all students understood the procedures for using the calculator, then they were asked to use a calculator and start completing activities in it.

Some activities were designed to teach students to make guesses about the values of a known function. By observing the pattern formed by the values of x and $f(x)$ of a function, it was expected that students could guess what the function values were for the next value of x . In Worksheet 1, students were first asked to input a function to find out the value of each function of known x on the calculator. This value was used as a reference to determine the function value of some of the next x values. Similar activities were also given by students in Worksheet 2 in determining notation, symbolic expression, domain (area of origin), codomain (friend area) and range (area of outcome) of a function. After students made guesses about the next values of $f(x)$, using the Classwiz calculator students check the accuracy of the alleged function values they have made. Examples of the work results of students in observing the value of a function to predict the value of functions found in Worksheet 1 and Worksheet 2 can be seen in Figure 5.

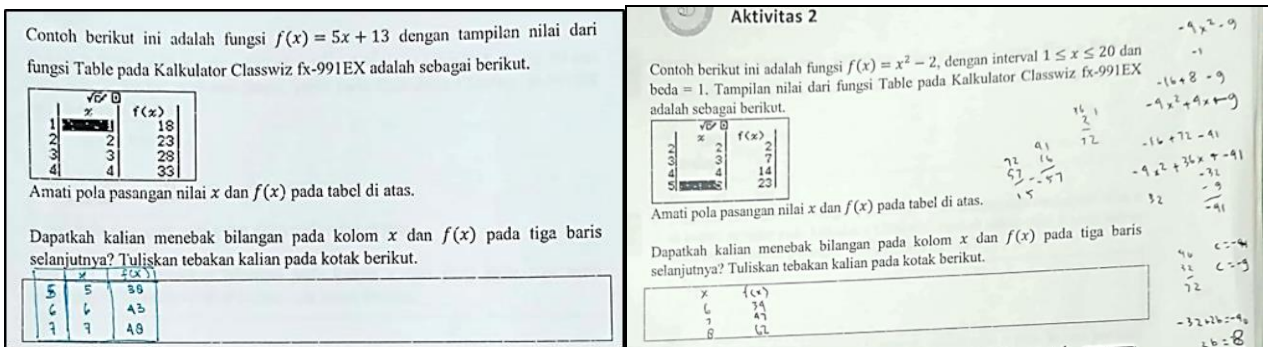


Figure 5. Answers of students in making predictions about the value of a function in Worksheet 1 and Worksheet 2

Some activities were designed in the form of discovery activities for students. Students were given some results or output from the Classwiz Calculator which shows several pairs of values of x and $f(x)$. Learners were asked to guess the function formula of the value pairs. In the process of its discovery, students were guided by the teacher regarding what patterns should be observed so that they could determine the appropriate function formula. Examples of student work can be seen in Figure 6 and Figure 7. Furthermore, to prove the accuracy of the function formula they have set, students were asked to check again the suitability of the values of x and $f(x)$ that have been given with the function formula that had been they specify using the Classwiz calculator.

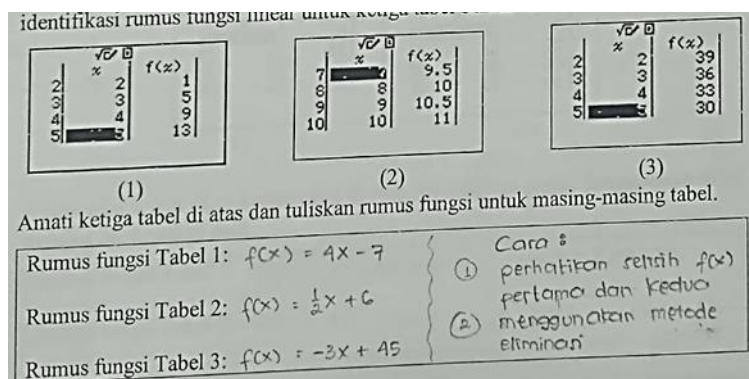


Figure 6. Students' answers in determining the linear function formula

In the implementation of related activities to find formulas from the patterns given, there were still some students who have difficulties. The difficulties experienced by these students were thought to be caused because students were still not accustomed to learning with inductive methods as in the activity. Therefore, during learning activities, in addition to giving emphasis on patterns and which parts should be observed by students, the teacher should also provide motivation so that students do not give up in determining the appropriate function formula.

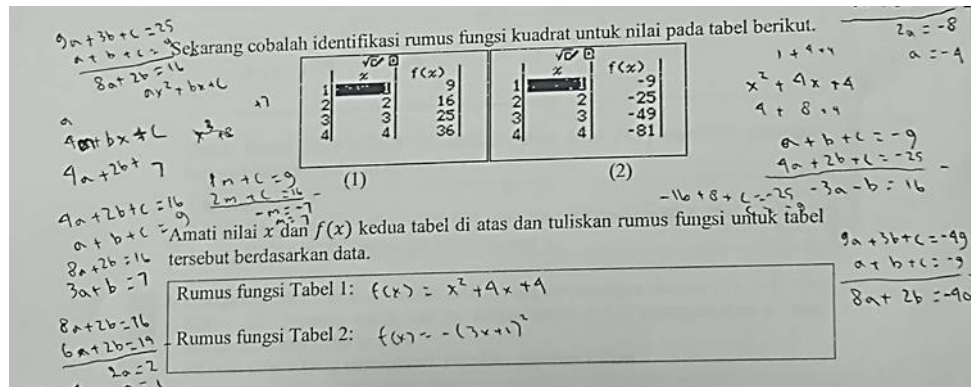


Figure 7. Answers of students in determining the quadratic function formula

In Worksheet 2, students carried out activities related to the graph of a linear function, including determining the image and characteristics of graphs of linear functions to determine the outcome of the transformation. In one activity, students were asked to investigate the gradient of a linear graph. Using a Classwiz calculator, students determined the output of two quadratic functions to determine the gradient value. From the calculator output related to the function values provided, a function graph was also made. Thus, students can observe the relationship between line gradients that were read from the given function and the slope of the graph. Based on these activities, the students were then asked to re-draw graphs of several new function formulas and then create and compare the graphs. Previously, students first calculated function values for each x value by using a Classwiz calculator. In this activity, not all students could draw graphics correctly. Some students still have difficulty in making a straight line graph based on the x and $f(x)$ values that had been obtained. Another difficulty experienced by students was that some students still couldn't find the link between the function graph and the gradient value, so there were still some students who draw graphics with a less precise slope direction. Figure 8 and Figure 9 were examples of student work results.

The use of Classwiz calculators in activities contained in Worksheet 3 and 5 focused more on exploring some of the functions provided using the Table function on the calculator. This activity aimed to direct students to obtain important information from the functions provided in order to identify various characteristics of these functions, both linear and quadratic functions. The output shown on the calculator was expected to be an example for students to identify the characteristics of each function being studied. Examples of student exploration results in Worksheet 3 and 5 could be seen in Figure 10.

Unlike the Worksheet 3 and 5, the output of the *Table* function on the Classwiz calculator on Worksheet 4 was only used as an ingredient for students' exploration of the values of a function for further analysis of the respective characteristics. Based on these outputs, students were expected to be able to explain in detail each characteristic of each function of the specific conditions of the function observed. It could be said that the use of calculators in this activity helps students to apply existing patterns and rules to find more detailed new information. Figure 11 showed one example

of student work related to the analysis of the results of exploration carried out using a Classwiz calculator.

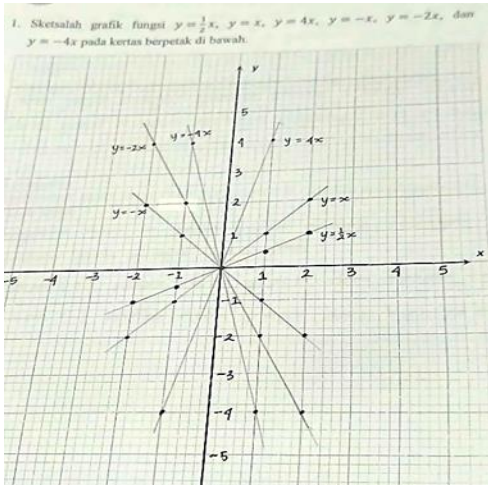


Figure 8. Students' answers related to the gradient and slope of the right line

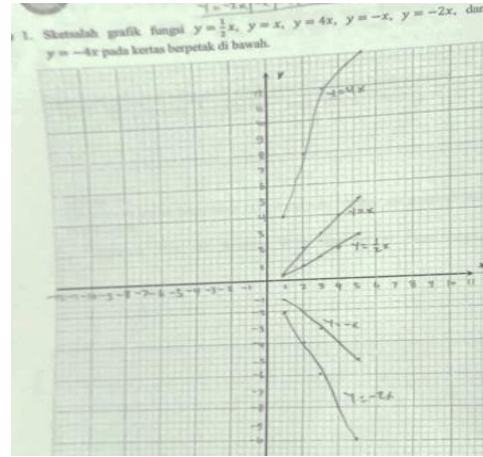


Figure 9. Students' answers related to the gradient and slope of the line that was less precise

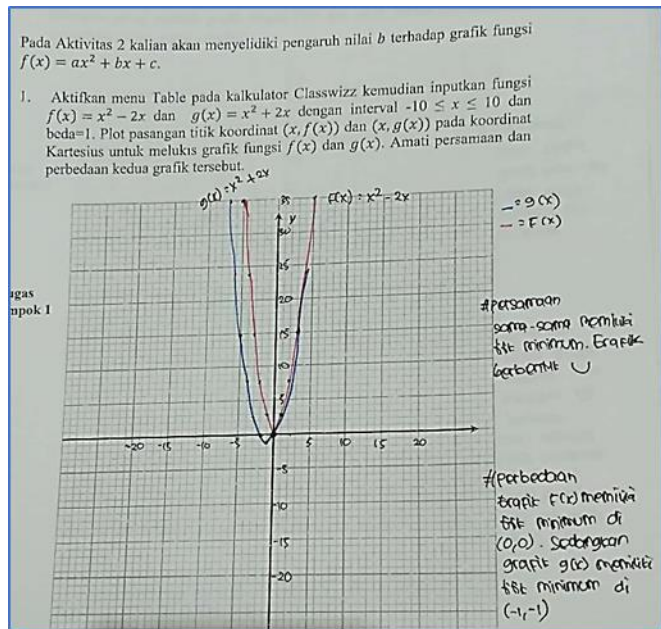
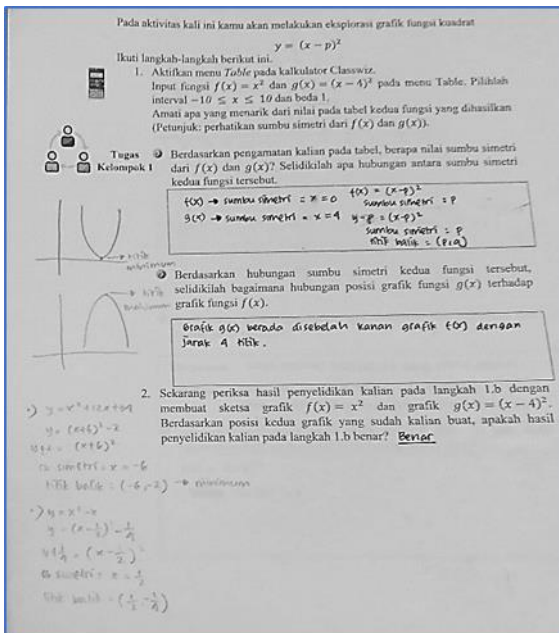


Figure 10. Examples of student exploration results in Worksheet 3 and 5

The use of calculators in learning activities was one of the optimal supporters of the time used in learning activities. By using a calculator, students could easily determine the values of a function so that it could save work time. For example in activities related to the position of two lines. By only being given a function formula, students could quickly determine the points that were the value of the function in accordance with the steps that had been studied previously for the next graphic drawing. Thus, students did not need a long time to find out whether the graphs of the two functions were intersecting or parallel. The work results of students related to the graph of two functions are shown in Figure 11.

1. Amatilah fungsi-fungsi berikut ini. Tentukan titik balik dan sumbu simetrinya.

Fungsi	Titik Balik	Sumbu Simetri	$\frac{b}{a}$	$-\frac{b}{a}$	$\frac{b}{2a}$	$-\frac{b}{2a}$
$f(x) = x^2 - 2x$	(1, -1)	$x = 1$	-2	2	-1	1
$f(x) = x^2 + x - 7$	($-\frac{1}{2}, -\frac{49}{4}$)	$x = -\frac{1}{2}$	1	-1	$\frac{1}{2}$	$-\frac{1}{2}$
$f(x) = -x^2 + 5x + 6$	($\frac{5}{2}, \frac{49}{4}$)	$x = \frac{5}{2}$	-5	5	$-\frac{5}{2}$	$\frac{5}{2}$
$f(x) = 2x^2 + 4x + 5$	(-1, 3)	$x = -1$	2	-2	1	-1
$f(x) = -2x^2 + 6x + 6$	($\frac{3}{2}, \frac{15}{2}$)	$x = \frac{3}{2}$	-3	3	$-\frac{3}{2}$	$\frac{3}{2}$
$f(x) = -x^2 - 4x + 3$	(-2, 7)	$x = -2$	1	-1	2	-2
$f(x) = 4x^2 - 4x - 3$	($\frac{1}{2}, -\frac{13}{4}$)	$x = \frac{1}{2}$	-4	4	$-\frac{1}{2}$	$\frac{1}{2}$

Bandingkan nilai pada kolom sumbu simetri dengan perbandingan pada kolom di sebelahnya. Diskusikan dan temukan hubungan antara nilai sumbu simetri dalam $a, b,$ dan/atau c pada $f(x) = ax^2 + bx + c$. Apa yang dapat kalian simpulkan? Jelaskan jawaban kalian.

Titik balik $(k, f(k)) = (-\frac{b}{2a}, -\frac{D}{4a})$
 Titik balik $(k, f(k)) = (-\frac{b}{2a}, \frac{b^2 - 4ac}{4a})$

2. Titik koordinat $(k, f(k))$ disebut titik balik fungsi dengan k adalah sumbu simetri. Substitusikan nilai x yang kalian peroleh pada langkah 1 di atas ke fungsi $f(x) = ax^2 + bx + c$.

$$k = -\frac{b}{2a}$$

$$f(k) = f(-\frac{b}{2a}) =$$

Apakah nilai $f(k)$ yang kalian peroleh pada langkah 2 mengandung bentuk $b^2 - 4ac$ untuk setiap nilai? Nilai $b^2 - 4ac$ disebut **diskriminan** dan dituliskan sebagai $D = b^2 - 4ac$. Dengan menggunakan D , koordinat titik balik fungsi kuadrat adalah:

$$(-\frac{b}{2a}, -\frac{D}{4a})$$

10

Figure 11. Example of the results of exploration and analysis of students in Worksheet 4

Persamaan Garis | Sketsa Grafik

$y_1 = x$
 $y_2 = -x$

Sketsa Grafik

$y_3 = \frac{1}{2}x + 1$
 $y_4 = -2x + 1$

Sketsa Grafik

Ganti nilai $g(x)$, dengan $g(x) = 2x + 10$, kemudian buatlah tabel dengan kalkulator Classwiz. Ulangi hal yang sama untuk fungsi $g(x)$ yang baru, yaitu $g(x) = 2x - 10$. Amatilah nilai fungsi $f(x)$ dan nilai kedua fungsi $g(x)$ yang baru tersebut. Apa yang dapat kalian simpulkan dari nilai ketiga fungsi tersebut?

7/6(x) berlawanan tanda dengan x bernilai 6

Sketsalah ketiga grafik fungsi tersebut, kemudian amatilah persamaan dan perbedaan ketiga grafik fungsi tersebut.

Figure 12. The results of the work of students related to the position of two function

To optimize the use of calculators, the teachers reminded students to often delete the memory that had been used. This was done so that there was no disruption in the process of using the calculator, one of which is to avoid the performance of the calculator being slow. To strengthen the concept that had been obtained through various activities in the worksheet, each activity in the worksheet always ends with the activities of students making and communicating conclusions related to the material learned by students at the meeting in writing in the worksheet.

The implementation of learning activities did not experience many significant obstacles. The role of the teacher in conditioning the class, both preparing students for learning and conditioning students in the implementation of learning is good enough. This could be seen from the effectiveness of the use of time in the implementation of activities compiled in the worksheet as well as a conducive learning atmosphere, both in individual activities and group activities. Intergroup discussions and class discussions were also well implemented. All students could play an active role in every discussion activity in their group. The teacher as a learning facilitator, also performs his duties well, by going around to control the process of discussion in groups and providing guidance for groups who are experiencing difficulties.

After the group discussion ends, the teachers gave the chances to the students to present the results of their respective group discussions. One or two groups appeared in front of the class to present the answers and conclusions they had made. Other groups that had not had the opportunity

to respond to the results of the work presented in front of the class. At the end of each presentation and class discussion activity, the teacher always emphasizes the conclusions made by the students. Thus, students could check the results of their work and correct their conclusions or findings that were still not appropriate or not appropriate.



Figure 12. Implementation of discussion and mentoring activities by the teacher

One of the obstacles encountered in implementing learning activities using worksheet and Classwiz calculators as supporting media was that some students are not used to learning to use worksheet. This causes them to forget often and not write down the results of the discussions they have done. This had an impact on the next learning phase, namely the presentation stage, class discussion and checking findings. At that stage, students cannot check the answers they had obtained through the activities of individuals or groups with answers and conclusions from the results of class discussions that had been discussed together or the reinforcement that had been delivered by the teacher.

Thus, the use of calculators as one of the learning media contributes positively to help learning process of mathematics conduct easily. Although there were still obstacles in the implementation of learning as mentioned above, mathematics learning could still run smoothly. In closing, learning mathematics with the support of various media in the form of print, as well as media in the form of information technology products was a means to prepare students to face competition in the 21st century in the era.

4. Discussion

One form of ICT media that can be utilized in mathematics learning activities is a calculator. The calculator had various roles in helping students build their knowledge. Based on the research activities that had been carried out, it was known that the use of calculators in mathematics learning activities was one of them as a tool for students in performing calculations and checking answers. Research that had been done and obtained similar results shows that the calculator was an ideal tool for checking student calculation results because the calculator could show accurate results from a calculation [8], [9]. By using the help of a calculator, students could save their learning time so that learning time can be used effectively. The same thing were expressed by [7], [8], and [10] who found that the application of calculators in mathematics learning could reduce the time needed by students to calculate and find a solution to a problem that corresponding.

The learning activities carried out in this study were designed so that students could carry out various discovery activities in the problem solving process related to linear and squared functions. This was in accordance with the recommendations presented by [11] that learning in schools should focus on problem solving activities. The problem solving activities designed in this study present exploration activities to lead students to the discovery of concepts and steps for solving the right problems. To facilitate discovery activities, students used various functions of the

Classwizz calculator. One of the objectives was to facilitate students in conducting exploration based on the information provided in the process of discovering the concepts of functions and graphics. Calculator was an effective technology for developing students' discovery abilities in the problem solving process [9]. In the process, the use of a calculator could facilitate learners in exploring through graph visualization and numbers [12].

Utilization of calculators in learning activities could also be seen in developing conceptual abilities and high-level thinking abilities of students [9]. Exploration activities in the worksheet that had been developed direct students to conduct an analysis of the various information provided and develop hypotheses related to the material they were studying. Students were directed to explore functions that have been studied using calculators to then be analyzed. The results of the analysis were used as the basis for the preparation and verification of hypotheses in the process of finding the next material. With calculators, students could more easily explore with numbers to prove hypotheses or generalize a concept based on a given problem [8]. In this case, the calculator had functions as a medium to facilitate the development of concepts and tools to facilitate discovery and exploration [8].

The use of calculators in learning activities had a positive impact on both teachers and students. In this study, the use of worksheet as a guide for students in learning and the use of calculators as learning support media can facilitate students to learn independently. With various group and individual activities in the worksheet, learning by applying the student-center principle can be facilitated. The role of the teacher in learning activities is only as a facilitator, not as the main subject that transfers knowledge. Research conducted by [8] obtained similar results, namely finding that learning using a calculator as a medium can support the implementation of learning with minimum intervention from teachers so learning with learner-centers could be realized. Because understanding is built by students, this certainly had an impact on understanding good student concepts.

Various advantages of learning by integrating the use of ICT media in it provide a variety of positive impacts for students. As in this study, the use of calculators had contributed to helping students learn. In addition to facilitating activities related to calculations and graphics, calculators can indirectly stimulate the development of high-level thinking skills of students. Through exploration activities carried out using calculators, students could focus on the question "why" rather than "how" related to the things being explored [13]. But still, the role of calculators in learning activities was only as a medium that makes it easy for students to learn. For example in problem solving activities, the calculator only acts as a counting aid or exploration aid. Without a good understanding of the problem given, students will certainly still had difficulty developing their knowledge and finding solutions to the problems given [13], [14].

5. Conclusion

The results showed that activating students in mathematics learning on the topic function starts with planning learning that enhances students through exploration of function concepts integrating the use of calculators, preparing work sheets in accordance with the lesson plan, carrying out learning that guides students to discover concepts through learning activities, facilitating students to collaborate and communicate during the learning process. The stages of learning that integrate calculator utilization for exploring mathematical concepts on topic function include function formulas, characteristics of linear function graphs, and graphical transformation functions and solving contextual problems of linear equations and quadratic equations. On this topic, the dominant *Table* and *QR-code* features were used during the integration of mathematics learning using a calculator.

In this research, the role of students in mathematics learning was enhanced by using a calculator. Research on other mathematical topics is also needed, so that it can be a guide for teachers in integrating the use of calculators in learning. Identifying topics in mathematics that can utilize calculators during learning also needs to be identified, for example with curriculum mapping. The development of teaching materials related to the use of calculators is also needed to support the integration of the use of calculators in mathematics learning.

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