PAPER • OPEN ACCESS

Mapping of mathematics topics that can be integrated their learning utilizing calculator

To cite this article: H Retnawati *et al* 2020 *J. Phys.: Conf. Ser.* **1581** 012061

Mapping of mathematics topics that can be integrated their learning utilizing calculator

H Retnawati[1], A Wijaya[1], W Yunianto[2], P A Laksmiwati[2], M Meilina[3], P G Amanti[3] and R Irawan[3]

[1] Universitas Negeri Yogyakarta
[2] SEAMEO Regional Centre for QITEP in Mathematics
[3] Casio Singapore LTD

E-mail: heri_retnawati@uny.ac.id

Abstract. Calculator is one of technology product that can be integrated with mathematics learning. However, mathematics topics that require calculator in teaching and learning process haven't been identified. This research was revealed to map the school mathematics topics that can be integrated into learning using calculator. This research was a qualitative study, with a content analysis approach. Initially, a focus group discussion (FGD) was held regarding the format of mapping mathematical material. The FGD participants were officials from the education office at the Ministry of Education and Culture, staff from Casio Education Singapore, and reviewers from various universities that had mathematics education study program in Yogyakarta Indonesia. The mathematics topics from elementary school, junior high school, high school and vocational school were mapped, which basic competencies can use a calculator in learning. The results showed that most of the basic competencies in elementary, junior high, high school, and vocational school could integrate their learning using calculator. These uses were categorized into exploration, representation, computation and affirmation. The dominant features of scientific calculator were also mapped at each school level.

1. Introduction

The rapid development of technology needs to be followed by efforts to improve the quality of education, and also in mathematics education as well. With technology, the quality of mathematics learning can be improved [1], because the use of technology in learning can facilitate students in learning [2]. In addition, technology had enhanced students more interested in learning mathematics [3] [4], so the learning process become more fun. Technology also makes it easier for teachers to carry out mathematics learning [5] and conduct assessments [6]. Various technology products can be used by teachers to help the implementation of learning. The technological products in the form of computers and software, the internet, and also calculators [7].

As one of technology product, calculator is relatively inexpensive thing. This calculator can stand alone without the internet or supporting software. For power supply, some types of calculators use solar cells, so they don't depend on electricity or battery connections. Besides being cheap, the calculator has complete features, even more in a scientific calculator [8]. This calculator can be used for various functions, including exploration, representation, affirmations, and confirmations [9]. Using calculator, teachers can present mathematical concepts (representation functions). Utilizing the activity of assisted calculators prepared, students are guided to find mathematical concepts (exploration functions). Using a calculator, students can calculate complex number problems (function of compensation). Utilizing a calculator, students can use it to check answers (affirmation functions). The calculator functions can be elaborated in learning mathematics. Even though the calculator has many functions that can be utilized, not all teachers have used the calculator in learning mathematics.

Various challenges that cause teachers haven't used a calculator. Not all teachers have understood the importance of using technology in the classroom in learning mathematics. People claimed that calculators make students lazy to think and compute. Not all teachers have sufficient skills to use a calculator [10]. In addition, schools also have limited facilities and infrastructure. There are also no books or teaching materials that provide examples of calculator utilization. If teachers are asked to develop their own lesson plans or carry out learning that uses a calculator, there aren't map of mathematics topics for calculator integration in classroom.

The availability of material maps and examples of using a calculator can help teachers develop lesson plans. Moreover, this material map was developed based on the curriculum currently being implemented, namely the 2013 curriculum. This material map can be a guide for teachers to carry out learning, and also prepare themselves to carry out learning in class. The existence of good examples that are in accordance with the standards of the learning process in accordance with the curriculum being implemented will also be an inspiration for teachers to carry out learning utilizing technology, especially calculators to improve the quality of learning. Related to this, a research that aims to map school mathematics topics that can be integrated in learning utilizing calculator.

2. Methods

This research was a qualitative study, with a content analysis approach. In the beginning, a focus group discussion (FGD) was held related to the format of mapping for mathematics topics in integrating the calculator in learning. The FGD participants were two officials of the Ministry of Education and Culture Office from the curriculum and learning center, three staff from Casio Education Singapore related to the use of calculators, and 12 reviewers from various universities that had mathematics education study programs in Yogyakarta Indonesia. After that the mathematics material from elementary, middle, high school and vocational school were mapped, which basic competencies can be integrated calculator utilization in learning.

Furthermore, reviewers were divided into four small groups, each consisting of 3 members to examine and distribute mathematical material that requires a calculator through content analysis. After mapping which material requires a calculator, then an example of its use is made, and also which features of the calculator are identified. Mapping results were reviewed 3 times in large groups involving all reviewers, and two curriculum and learning center staff, two researchers from the Ministry of National Education Research and Development, and 2 collaborators from mathematicians and SEAMEO QITEP staffs. This review aimed to determine the accuracy of using a calculator, the accuracy of calculator features, and the accuracy of examples to integrate calculator in mathematics learning.

The analysis in this study was carried out qualitatively and quantitatively. The qualitative analysis was done by utilizing the comments from reviewers to capture input for map of mathematics topics and then to reflect the improvement. The quantitative analysis was used to calculate the percentage of calculator utilization and dominant features at each school level.

3. Result

3.1 Material map in the curriculum for elementary school, junior high school, senior high school and vocational school that require calculator assistance

As mentioned earlier, material mapping through a review process carried out by education experts would produce information regarding the number of basic competencies that could be integrated with a calculator. More than a half the number of basic competencies mathematics subjects at each school level could be integrated with a calculator (see Figure 1). It means that the existed Curriculum 2013 had actually provided opportunities for students to utilize technology, especially calculator, in their learning process.

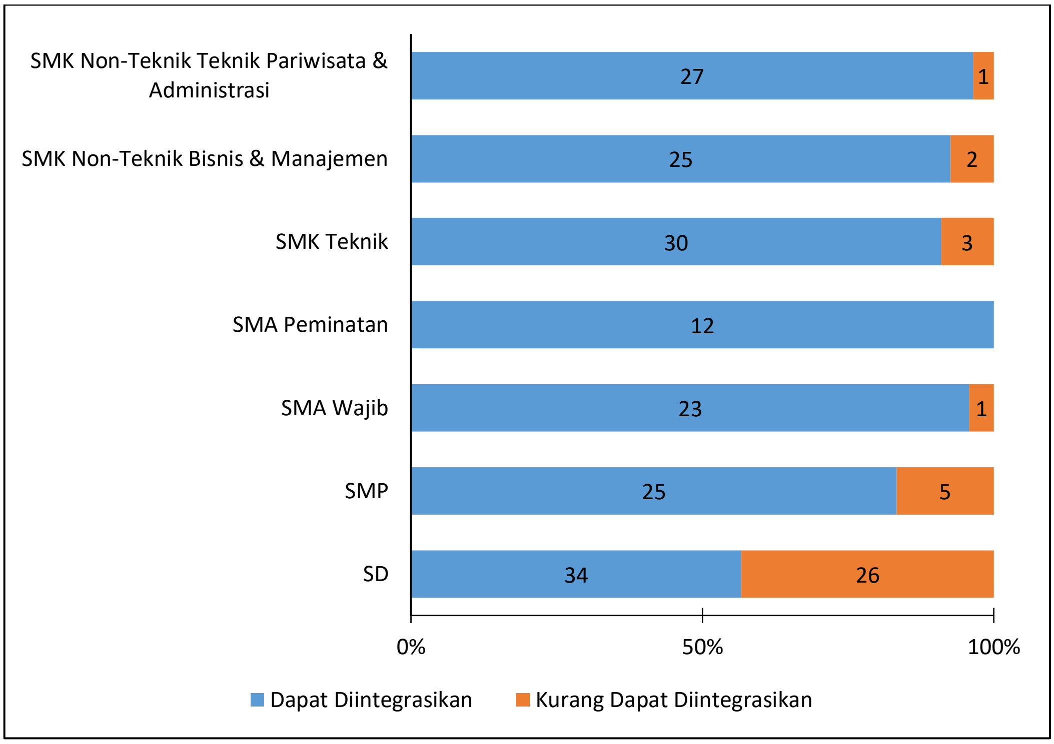


Figure 1. Mapping of basic competencies in mathematics subjects at each school level that could be integrated with calculator

Furthermore, the number of basic competencies for elementary school that could be integrated with calculator had reached greater than or equal to 50%, except for basic competencies in class 3 which only reached 30.77% (see Table 1). At the level of Junior High School, the number of basic competencies that could be integrated with the calculator in each class had reached greater than or equal to 75%. All of the existed basic competencies at the level of Senior High School for each class and group (compulsory and specialization) could be integrated with a calculator, except for the 12th grade (compulsory) in which just 75% of the existed basic competencies that could be integrated with a calculator. Finally, at the Vocational High School level, the percentage of basic competencies that could be integrated with a calculator had reached more than 90%. Thus, almost all of the existed basic competencies at every level of school could be integrated with a calculator. To determine and justify certain basic competencies can be integrated using calculator, a small group of reviewers discussed. The topics for discussion were how to teach the basic competencies in the class using scientific approach, how to construct mathematical concepts trough discover pattern, when students discover pattern if they need complex calculation and need calculator to reduce cognitive load. Basic on the discussion results, reviewers justified the integration of calculator in teaching and learning process in these basic competencies.

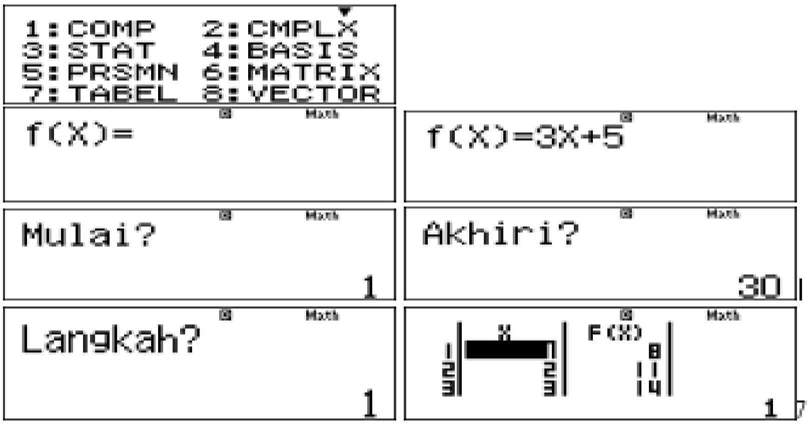
Table 1. Percentage of basic competencies in mathematics subjects at each school level that could be integrated with calculator

Level	Class/Grade	Total of basic competence pairs that could be integrated with calculator	Basic competence pairs in Total (Permendikbud number 24 year 2016)	Percentage of competencies that could be integrated with a calculator
Elementary School (SD)	1	6	9	66.67%
	2	6	10	60.00%
	3	4	13	30.77%
	4	6	12	50.00%
	5	5	8	62.50%
	6	7	8	87.50%
Junior High School (SMP)	7	9	12	75.00%
	8	10	11	90.91%
	9	6	7	85.71%
Senior High School (SMA)	10 compulsory	10	10	100.00%
	10specialization /uncompulsory	2	2	100.00%
	11 compulsory	10	10	100.00%
	11 specialization	4	4	100.00%
	12 compulsory	4	3	75.00%
	12 specialization	6	6	100.00%
Vocational School	Engineering	30	33	90.91%
	Business and management	25	27	92.59%
	Tourism and administration	27	28	96.43%

After mapping the material of learning that could be integrated with the calculator, then reviewer gave the examples of material or learning activity which could be integrated with calculator. For elementary school level, the type of calculator that could be used was Casio ID Plus. This activity was then classified whether it could be used to train students' HOTS or not. This activity was then classified based on the function of the calculator (exploration, representation, affirmation, computation) and the calculator features that could be utilized in that activity. For example, the calculator integration in the mathematics classroom at the junior high school level is presented in Figure 2.

Kompetensi Dasar	Indikator Pencapaian Kompetensi	Fungsi Kalkulator	Fitur Kalkulator
3.4 Menganalisis fungsi linear (sebagai persamaan garis lurus) dan menginterpretasikan grafiknya yang dihubungkan dengan masalah kontekstual	1. Menjelaskan makna nilai gradien dalam konteks perubahan nilai x dan y dari suatu fungsi linear	Eksplorasi Representasi	Tabel

Keterangan/ Contoh	Level Berpikir
Melalui kegiatan eksplorasi, siswa dapat menjelaskan makna nilai gradien dalam konteks perubahan nilai x dan y dari suatu fungsi linear. Pilihlah satu fungsi linear dan nyatakan dalam bentuk $f(x) = mx + c$ dengan m bilangan bulat selain 0 dan c bilangan bulat. Buatlah tabel menggunakan bantuan menu tabel di kalkulator **Casio fx-991 ID PLUS** dengan nilai mulai: 1, nilai akhir: 30, dan langkah: 1. [Berikut adalah contoh hasil yang mungkin didapatkan siswa di kalkulator.]	HOTS



Perhatikan tabel tersebut dari awal sampai akhir terutama pada hubungan nilai perubahan nilai x dan $f(x)$ serta hubungannya dengan nilai m. Cobalah untuk beberapa nilai m dan c yang berbeda dan catatlah hasil pengamatanmu.

Kemudian, tentukan apakah pernyataan yang melibatkan fungsi linear $f(x) = mx + c$ berikut: selalu benar, kadang benar, atau tidak pernah benar, dengan menyertakan penjelasan secukupnya.

1. Jika x bertambah 5, maka $f(x)$ juga bertambah 5.
2. Jika $f(x)$ berkurang 4, maka x berkurang $4m$.
3. Jika x diubah menjadi 3 kali lipat, maka $f(x)$ akan bertambah $3m$.

Tuliskan simpulan tentang bagaimana m berdampak pada perubahan nilai x dan $f(x)$ dari satu baris ke baris berikutnya.

Figure 2. Example of calculator integration in the classroom at the junior high school level

Figure 2 shows that from the basic competencies mapping that had been done, the integration of calculator in elementary mathematics learning allowed students to take advantages of calculator functions in terms of exploration, representation, affirmation, and calculation. The function of the calculator that had the most opportunities to be used in mathematics learning was the exploration function and followed by affirmation, representation, and calculation respectively. In the junior high school level, the function of integrating calculator in learning was more likely to be dominant in exploration function (see Figure 4) then affirmation, calculation, and representation respectively, which was not much different from the functions of the calculator in mathematics learning at the elementary school level.

At the senior high school level, based on Figure 5, the most functions to be used when integrating calculator in learning mathematics were exploration, affirmation, calculation, and representation respectively. As for the vocational high school level, as presented in Figure 6, the most functions to be used when integrating calculator in learning mathematics were exploration, calculation, representation, and affirmation respectively.

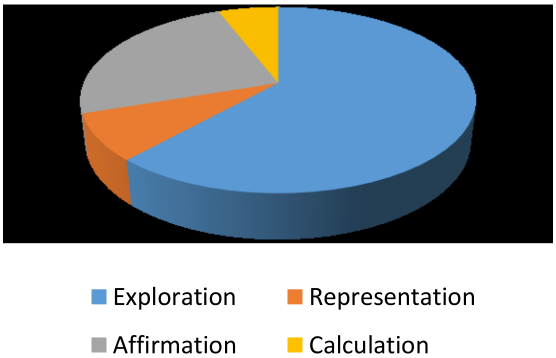


Figure 3. Integration of calculators in elementary mathematics learning in terms of calculator functions

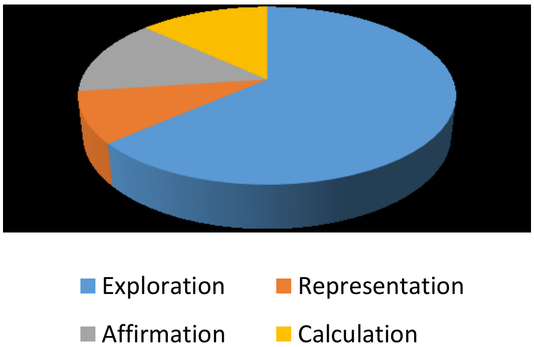


Figure 4. Integration of calculator in junior high school mathematics learning in terms of calculator functions

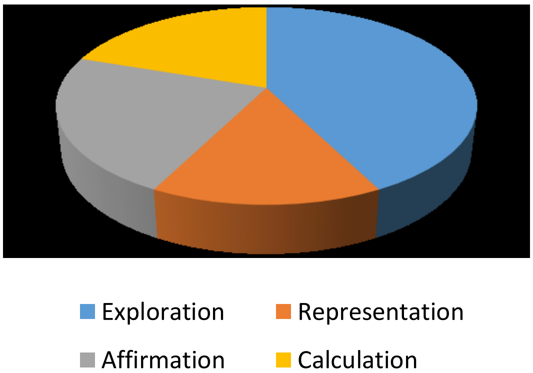


Figure 5. Integration of calculator in high school mathematics learning in terms of calculator functions

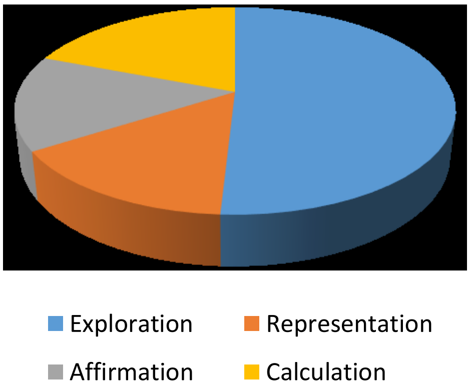


Figure 6. Integration of calculator in vocational school mathematics learning in terms of calculator functions

The mapping of basic competencies for mathematics subject in each class and school level that could be integrated with calculators in terms of calculator functions is presented in Table 2. Based on Table 2, the most function of calculator that could be integrated into mathematics learning for each class and every school level was the exploration function.

3.2 Calculator features that could be utilized at every school level

Previously we discussed the mapping of Core Competencies /Basic Competencies in terms of calculator functions. As for this section, we discuss the mapping of basic competencies based on the calculator feature. At the elementary school (see Figure 7), the Casio ID Plus calculator features that could be integrated with the existed basic competencies consisted of Comp, Check, Stat, S↔D, Random Integer, and Table features, with Comp, Check, and Stat as the top three dominant features.

Table 2. Mapping of core competency/basic competency of mathematics subjects in each class and school level that could be integrated with a calculator

Level	Class	Form of Calculator Usage in Learning			
		Exploration	Representation	Affirmation	Calculation
Elementary School (SD)	1	20/34 (58,82%)	5/34 (14,71%)	9/34 (26,47%)	0/34 (0,00%)
	2	25/30 (83,33%)	0/30 (0,00%)	4/30 (13,33)	1/30 (3,33%)
	3	18/28 (64,28)	1/28 (3,57%)	6/28 (21,42%)	3/28 (10,71%)
	4	16/35 (45,71%)	5/35 (14,29)	11/35 (31,43)	3/35 (8,57%)
	5	31/44 (70,45%)	1/44 (2,27%)	10/44 (22,73%)	2/44 (4,55%)
	6	27/51 (52,94%)	6/51 (11,76%)	14/51 (27,45%)	4/51 (7,84%)
Junior High School (SMP)	7	19/40 (47,5%)	7/40 (17,50%)	8/40 (20,00%)	6/40 (15,00%)
	8	31/37 (83,78%)	1/37 (2,70%)	4/37 (10,81%)	1/37 (2,70%)
	9	32/52 (61,54%)	4/52 (7,69%)	6/52 (11,54%)	10/52 (19,23%)
Senior High School (SMA)	10 compulsory	20/38 ((52,63%)	7/38 (18,42%)	6/38 (15,79%)	5/38 (13,16%)
	10 specialization	38/91 (41,76%)	24/91 (26,37%)	22/91 (24,18%)	7/91 (7,69%)
	11 compulsory	23/64 (35,94%)	1/64 (1,56%)	22/64 (34,38)	18/64 (28,13%)
	11 specialization	13/39 (33,33%)	6/39 (15,38%)	11/39 (28,21%)	9/39 (23,08%)
	12 compulsory	20/42 (47,62%)	4/42 (9,52%)	5/42 (11,90%)	13/42 (30,95%)
	12 specialization	19/39 (48,72%)	5/39 (12,82%)	5/39 (12,82%)	10/39 (25,64%)
Vocational School (SMK)	Engineering	67/136 (49,27%)	19/136 (13,97%)	25/136 (18,38%)	25/136 (18,38%)
	Business and management	81/157 (51,59%)	29/157 (18,47%)	26/157 (16,56%)	21/157 (13,38%)
	Tourism and administration	112/218 (51,38%)	29/218 (13,30%)	25/218 (11,47%)	52/218 (23,85%)

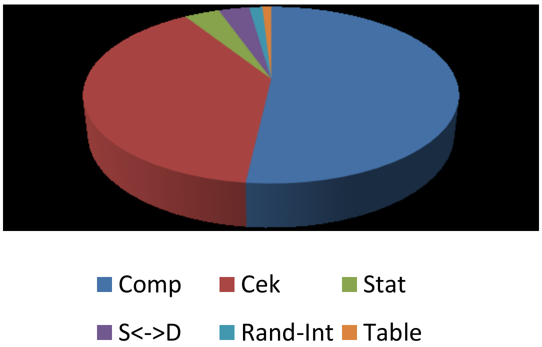


Figure 7. Features of a calculator that can be used in learning at the elementary school level

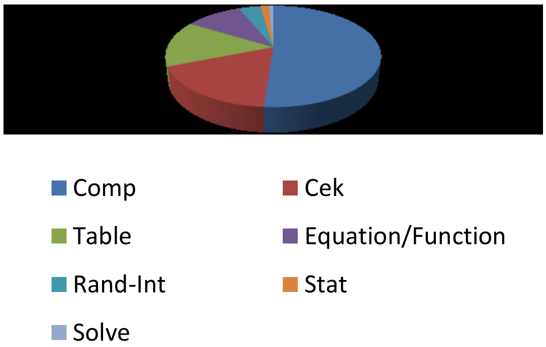


Figure 8. Features of a calculator that could be used in learning at the junior high school level

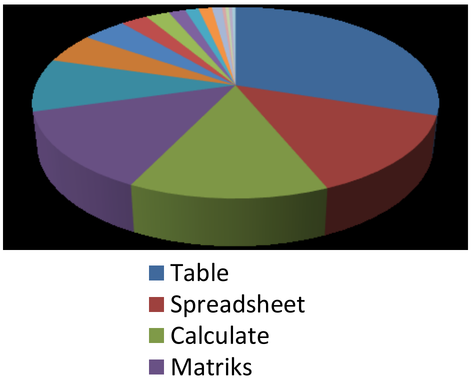


Figure 9. Features of a calculator that can be utilized in learning at the senior high school level

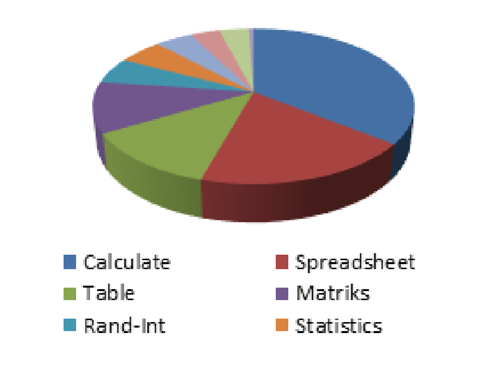


Figure 10. Calculator features that can be used in learning at the vocational school level

In accordance with what was presented in Figure 8, at the junior high school level, there were as many as seven calculator features that could be integrated with the existed basic competencies. Of the seven calculator features, the three dominant features were Comp, Check, and Table.

The calculator that could be integrated into mathematics learning for senior high school and vocational school was Casio Classwiz. Based on Figure 9, at the senior high school level there were 17 calculator features that could be integrated with the existed basic competencies. From these 17 features, the top four dominant features were the Table, Spreadsheet, Calculate, and Matrix. While at the vocational school level, there were as many as 10 calculator features that could be integrated with the existed basic competencies (see Figure 10). Of these ten calculator features; the Calculate, Spreadsheet, Table, and Matrix feature were the top four dominant features that could be used in integrating calculator in mathematics learning.

In the review curriculum, which basic competencies have been identified which can be integrated with calculator. The results of identification of each competency were basic competencies that could utilize one of various functions of calculator, including exploration, representation, affirmations, and confirmations [9]. The results of this research help teachers to improve their skills in integrating calculators in teaching, because according to the results of previous studies that not all teachers have sufficient skills to use a calculator [10]. These results also support the results of research [11] that mapping the content of mathematics that can be integrated with the learning calculator, it can make implementation in the classroom easier for teachers.

Based on the results of the curriculum review, not all material could be integrated with a calculator. These results showed that further research needs, what technological devices could be integrated in classroom with calculators. Other further research needs to be done also related to the development of worksheets for classroom learning using calculators, as well as the development of test instruments for assessment in learning using calculators [11]. Research on learning trajectory on the integration of learning with the use of technology is also needed, because good learning trajectory could help students easier to construct students' understanding of mathematical concepts [12].

4. Conclusion

The results showed that most of the basic competencies in elementary, junior high, high school, and vocational school could integrate their learning using calculator. These uses were categorized into exploration, representation, computation and affirmation. The dominant features of scientific calculator were also mapped at each school level.

The next research can be done related to the research results. Teaching materials to support calculator integration in learning were also needed. Teaching materials could be in the form of books, student's worksheet, and student's worksheet for enrichment which were integrated with calculator. This teaching material was developed based on the curriculum map of calculator utilization in mathematics learning. This research had produced an integrated curriculum map related to the use of technology, especially in learning, which still needs to be followed up to become teaching material that could be used by teachers and students.

Acknowledgments
Authors wishing to acknowledge Casio Singapore PTE LTd Jakarta representative Office that had supported this research.

5. References

[1] Umar K I, Basheer M M, Isa, R, Watsilla H 2017 *International Journal of Engineering Technology Research & Management (IJETRM)*, **1** 03
[2] Montrieux H, Vanderlinde R, Schellens T, De Marez L 2015 *PLoS One,* **10** 12 e0144008.
[3] Yeh C Y C, Cheng H N H, Chen Z H, Liao C C Y, Chan T W 2019 *Research and Practice in Technology Enhanced Learning* **14** 5.
[4] Khayati S. & Payan A 2014 World Academy of Science, Engineering and Technology, *International Journal of Educational and Pedagogical Science*, **8** 9.
[5] Radović S, Marić M, Passey D 2019 *Education and Information Technologies,* **24** 1.
[6] Retnawati H 2015 *The Turkish Online Journal of Educational Technology*, **14** 4.
[7] Salani E 2013 *European Educational Research Journal*, **2** 4.
[8] Kissane B n.d. The Algebraic Calculator and Mathematics Education. *ATCM99*. http://wwwstaff.murdoch.edu.au/~kissane/papers/ATCM99.pdf
[9] Kissane B & Kemp M 2012 *Journal of Science and Mathematics Education in Southeast Asia* **35** 2.
[10] Jairus P, Ochanda J P & Indoshi F C 2011 *Journal of Media and Communication Studies* **3** 3.
[11] Kissane B, McConney A, & Ho K F 2015 Review of the use of technology in Mathematics education and the related use of CAS calculators in external examinations and in post school tertiary education settings (Perth, WA: School Curriculum and Standards Authority).
[12] Retnawati H 2017 Olympiads in Informatics **11**.