What Does Research Say on The Use of Calculator to Improve Indonesian Students' Mathematics Achievement?

Pasttita Ayu Laksmiwati
pasttitalaks@gmail.com
SEAMEO Regional Centre for Qitep in Mathematics
Indonesia

Ariyadi Wijaya
a.wijaya@uny.ac.id
Yogyakarta State University
Indonesia

Heri Retnawati
retnawati.heriuny1@gmail.com
Yogyakarta State University
Indonesia

Wahid Yunianto
yunianto_wahid@yahoo.co.id
SEAMEO Regional Centre for Qitep in Mathematics
Indonesia

Pientha Glenys Amanti
pienthaglenys@gmail.com
Casio Singapore Pte Ltd, Jakarta Rep Office
Indonesia

Abstract: *Technology has essential roles in mathematics teaching and learning. So, it is crucial to facilitate students with access to technology, such as the use of calculators in their learning process. This study was aimed to investigate the effectiveness of the Classwiz scientific calculator on the improvement of students' mathematics achievement. This study was conducted in nine provinces of Indonesia, involving eleven senior high schools. The researchers employed a quasi-experimental research study with pretest-posttest control-group design with both qualitative and quantitative data collected and analyzed. Five lessons with context-based activities as interventions in the experimental group were designed to offer students OTL. The qualitative data were collected by using a mathematics test involving pre-test and post-test. Moreover, the study used classroom observation and field notes to collect qualitative data. The main focus of the research was students' mathematics achievement. The students' mathematics achievement was also analyzed based on the perspective of gender and school location (western, central, and eastern Indonesia). The investigation showed that the use of the calculator gave a significant impact on the students' mathematics achievement. In conclusion, the finding of the study suggests that the use of calculators in mathematics learning could improve students' mathematics achievement.*

1. Introduction

To survive in this era, every individual demand different competency that are more than content knowledge. One of the competencies in the 21st-century era is technology and media literacy skills. Technology development and innovation have become one of the primary themes in educational issues and policies in this decade. In the teaching and learning process where students have become the center, technology integration in the learning activities developed by the teachers becomes crucial. In Indonesia, technology development also becomes one of the main focuses; as in 2018 the document called Making Indonesia 4.0 was released by the Indonesian Ministry of Industry. The importance of technology can be seen in [16], where technology becomes one of the school mathematics principles. According to [9], with the integration of technology in a daily mathematics lesson, students' competencies can be improved. In the same vein, technology gives students a chance to be engaged in mathematics learning (see [10] and [20]).

The integration of technology in mathematics learning can be done by using calculators. Many studies prove that calculators give positive impacts on mathematics teaching and learning (see [3], [13], [21], and [18]). Thus, it is important to integrate calculators in mathematics teaching and to consider its benefit. However, the purpose of this study was to examine the effect of Classwiz scientific calculators seen from the viewpoint of students' mathematics achievement. Therefore, this research examined two research questions. The first question was whether there were any effects on students' mathematics achievement by the integration of Classwiz scientific calculators in mathematics learning. The second question was how the learning environment had an impact on students' mathematics achievement.

2. Students' Mathematics Achievement and the Use of Calculators in Mathematics Teaching and Learning

It is believed that students' achievement becomes an important factor in classroom teaching practice (see [2], [7], [8], and [23]). Many studies suggest that students' achievement is considered the primary goal of learning (see [22]). Students' achievement is defined as students' learning progression, students' understanding of subject matter knowledge and is measured by a standardized test (see [19], [1], and [17]). Then, in [12], students' achievement is closer to skills of communication, collaboration, and solving complex problems. It can be concluded that students' achievement is development processes through the learning process. Students' achievement is an illustration of students' understanding, subject matter knowledge, and skills.

In general, the use of an achievement test is intended to measure the personal knowledge and cognitive proficiency (see [24] and [6]). Also, the achievement test is given in a specific time to measure students' performance in a particular topic to measure the degree of learning successfulness (see [15] and [11]). In the same way, it is described that an achievement test is used to give appreciation and acknowledgment of students' successfulness (see [4]). In sum, the use of achievement tests in this study was to provide evidence of the students' achievement to measure the effect of the learning process. Lastly, it offered a clear understanding and suggestions of the students' learning results.

Regarding the positive impact of calculator usage on mathematics achievement, can be seen from a meta-analysis study of calculator effects on students' mathematics achievement and attitude (see [5]). After analyzing 54 research studies, she found the use of calculators in the learning process and assessment developed students' operational skills and problem-solving skills. Additionally, the use of calculators encouraged students to have better attitudes toward mathematics than the others who did not use them.

3. Methods

This study was aimed to investigate the effects of the use of *Classwiz* scientific calculators on the students' mathematics achievement. Moreover, the effects from the perspective of gender were also analyzed. This research study used a quasi-experimental research study with a pretest-posttest control-group design. There were two classes namely an experimental group and a control group. In the experimental group, the intervention was used to allow the students to learn (OTL) by giving some exploration activities and context-based solving activities, in terms of the integration of *Classwiz* scientific calculators. In contrast, in the control group, the students engaged in the daily classroom activities with no use of calculators in the learning process. Mathematics test that consisted of pre-test and post-test were used in this study to collect quantitative data, whereas classroom observation and field notes were used to collect qualitative data.

Indonesian tenth graders from eleven senior high schools from the nine provinces of Indonesia participated in this study were selected by the Senior High School Development Directorate *(Direktorat PSMA).* The experimental group and the control group were randomly selected from those schools. Thus, there were around five hundred students for both the experimental group and the control group.

The research framework used in this research was developed by Kutzler (see [14]). The experimentation in the integration of the *Classwiz* calculators in this research is as follows.

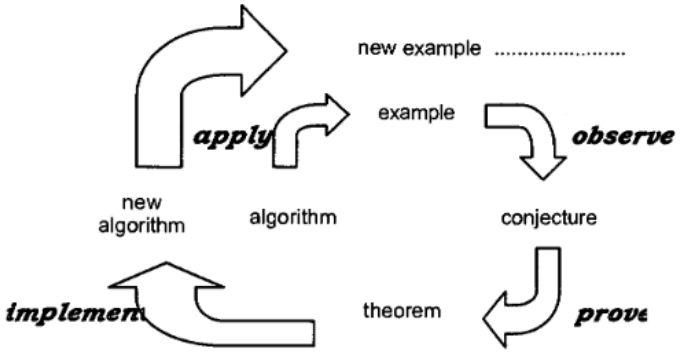


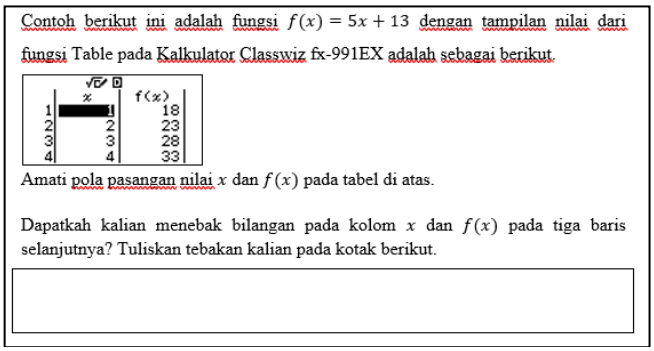
Figure 3.1 Experimentation process in the use of the *Classwiz* scientific calculators in mathematics learning (see [14]).

The experimentation process illustrated by the above picture consists of *apply, observe, prove,* and *implement* as the four main components. Those processes were included in the learning activities and the students' worksheet, which was used in the experimental group as a treatment. To collect the qualitative data, mathematics tests consisting of pre-test and post-test were given before and after the treatment. The tests were taken by the students in both the experimental and control groups. The tests were paper-based and referred to the basic competencies of Indonesian Curriculum which included determining and explaining function-linear, quadratic, and rational functions –that include mathematical notation of a function, domain and range, symbolical expression, and graph of a function. There were 24 developed items of the tests.

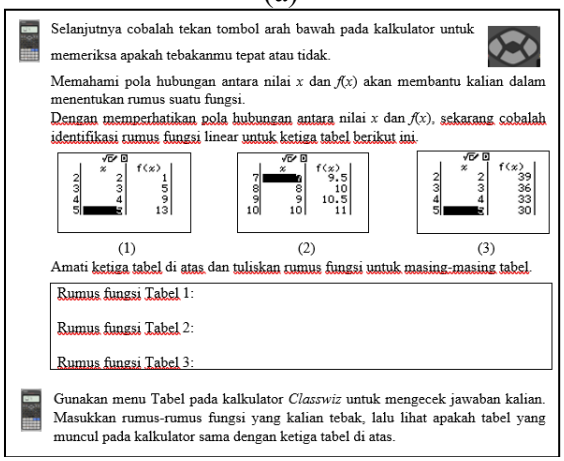
Regarding the research questions, the quantitative data were analyzed to answer the questions and to describe the mathematics achievement in both experimental and control groups. Furthermore, the qualitative data were analyzed to describe the use of the *Classwiz* scientific calculator in mathematics learning. Both descriptive and inferential statistics were used in the analysis process. Analysis of variance (ANOVA) and univariate analysis of covariance (ANCOVA) were used to find the effect of the variables.

4. Results

The worksheet developed in this research consist of five worksheets and is called *Lembar Kerja Peserta Didik* (LKPD) 1, 2, 3, 4, and 5. Each LKPD focuses on specific materials based on the indicators which were developed from the basic competencies. The topics are exploring fractions, graphs of linear equations, quadratic functions and its graph, and the applications of a linear and quadratic function. The learning activities were assisted by the worksheet, and most of the activities were focused on exploration and investigation. Based on the observation, the students' responds toward the learning process were positive. The students actively participated in the learning process. They were facilitated by the teacher to discuss and present their investigation results. Through the integration of the *Classwiz* scientific calculators, the investigation process was conducted efficiently. One of the reasons was the students focused more on the observation, investigation, and exploration than on the procedural part. The use of the *Classwiz* scientific calculators helped the students when they were dealing with big data and big numbers. The following figure presents the examples of the students' activities in the worksheet. The activities facilitated students to make predictions of a problem.



(a)



(b)

Figure 4.1 The examples of students' activity that facilitate students to predict

After they made their prediction, they observed the patterns and the functions of the provided data. The use of *Classwiz* scientific calculators was to confirm whether the students' prediction was correct or not. The basic idea of domain, codomain, and range of a function was served by the activities as shown in the following picture. The investigation process was also conducted in quadratic function, for example in the investigation of their graph properties based on the values of a, b, and c of quadratic function $f(x) = ax^2 + bx + c$. In the investigation process, the students

were asked to observe from the calculator and drawing before concluding. The example of the activities is shown in Figure 4.2.

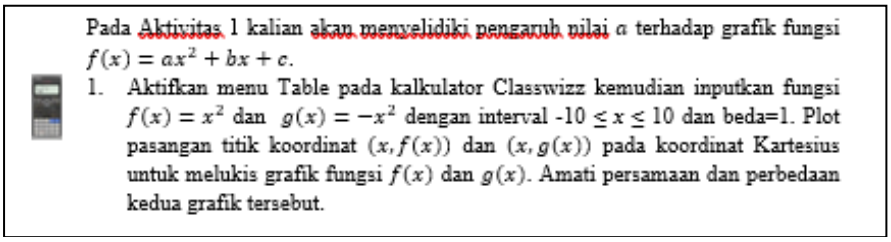


Figure 4.2 An example of students' activity that facilitates students to observe

In the next activity, the students observed from the use of the QR code to help them construct the graphs. The students got difficulties to use this feature. It can be seen from the following figure that the graph has inaccurate drawing, indicating they could not conclude the problem.

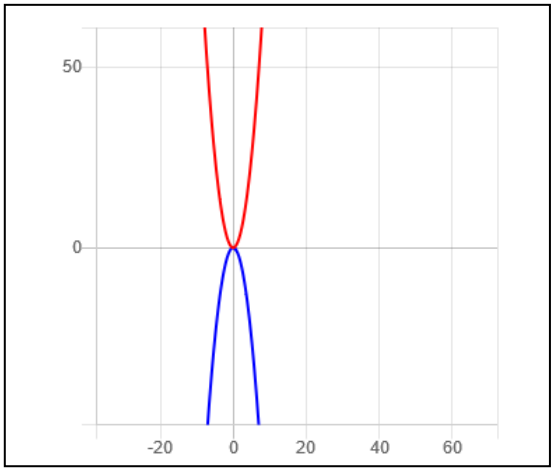


Figure 4.3 An example of student's exploration using QR Code feature in the *Classwiz* scientific calculators

In this study, the students learned linear and quadratic functions. The experimental group had a mathematics lesson that was integrated with the use of the *Classwiz* scientific calculators, while the control group had a regular mathematics lesson. The quantitative data were analyzed from the mathematics achievement test. The following table illustrates the descriptive statistics of the pre-test and post-test to measure the mathematics achievement.

Table 4.1. Descriptive statistics of the experimental group and the control group

Group		Statistics				
	Math. achievement	N	Minimum	Maximum	Mean	Std. Deviation
Experimental	Pre-Test	508	4	92	27.06	17.169
Group	Post-Test	508	4	92	46.41	19.009
Control	Pre-Test	508	4	60	22.34	12.561
Group	Post-Test	508	4	84	36.72	18.828

Table 4.1 shows the results of the pre-test and post-test for the mathematics achievement of the experimental group and the control group. The gain score of the pre-test to post-test for

mathematics achievement of the experimental group was 19.35 points, while the gain score for the control group was 14.38 points. Based on this result, the gain score of the experimental group was higher than that of the control group. Thus, it can be concluded that the use of calculators in the experimental group gave a positive contribution to the students' mathematics achievement.

The following figure represents the comparison of the mathematics achievement between those two groups. It can be observed that there was an increasing gain score in both groups after the treatment. The gain score of the experimental group was 3.97 higher than that of the control group. Thus, from the result, the use of it gave a positive impact on the students' mathematics achievement compared to the regular mathematics classrooms.

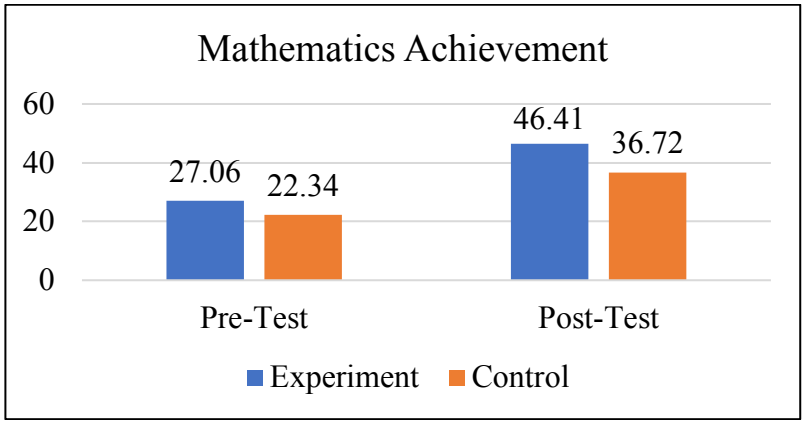


Figure 4.4 Comparison of students' mathematics achievement

In this study, the inferential statistics were used to confirm the result of the effects. The further investigation done was comparing the mathematics achievement of the experimental and control groups. To get a simultaneous comparison of the mathematics achievement, the univariate analysis of variance (ANOVA) was used. In the analysis, the following hypothesis was tested.

H_0 : $\mu_{11} = \mu_{12}$ (there is no significant difference between the mean scores of mathematics achievement of the two groups)

H_1 : $\mu_{11} \neq \mu_{12}$ (there is a significant difference between the mean scores of mathematics achievement of the two groups)

Table 4.2. The effect of the *Classwiz* scientific calculator usage on mathematics achievement

Effect		Value	F	Hypothesis df	Error df	Sig.
intercept	Pillai's Trace	.459	860.192[b]	1.000	1014.000	.000
	Wilks' Lambda	.541	860.192[b]	1.000	1014.000	.000
	Hotelling's Trace	.848	860.192[b]	1.000	1014.000	.000
	Roy's Largest Root	.848	860.192[b]	1.000	1014.000	.000
GROUP	Pillai's Trace	.018	18.452[b]	1.000	1014.000	.000
	Wilks' Lambda	.982	18.452[b]	1.000	1014.000	.000
	Hotelling's Trace	.018	18.452[b]	1.000	1014.000	.000
	Roy's Largest Root	.018	18.452[b]	1.000	1014.000	.000

The above analysis result shows a significant difference of the mathematics achievement between the experimental group and the control group because sig < .000; Wilk's Λ = 0.982. It can be

observed that the use of the *Classwiz* scientific calculators could simultaneously give a positive contribution to the improvement of students' mathematics achievement. The next analysis identified a significant difference in the mathematics achievement between the experimental group (M = 46.41, SD = 19.009) and the control group (M = 36.72, SD = 18.828).

Table 4.3. The effect of the *Classwiz* scientific calculator usage on mathematics achievement

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Exp	Exp	7.071*	1.082	.000	4.949	9.194
Cont.	Cont.	-7.071*	1.082	.000	-9.194	-4.949

Further analysis was done to comprehend the different effect of prior knowledge on mathematics achievement of those groups. The following table indicates that there was a significant difference ($p < .0005$), thus the result shows that there was an effect of students' prior knowledge and ability on mathematics achievement.

Table 4.4. The effect of students' prior knowledge and ability on mathematics achievement

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	93107.083[a]	2	46553.542	160.564	.000	.241
Intercept	214749.507	1	214749.507	740.675	.000	.422
PRE_TEST	69320.611	1	69320.611	239.088	.000	.191
GROUP	12393.016	1	12393.016	42.744	.000	.040
Error	293706.886	1013	289.938			
Total	2141936.000	1016				
Corrected Total	386813.969	1015				

Moreover, gender became an interesting point of this study, so a comparison between boys and girls in their mathematics achievement was analyzed.

Table 4.5. Descriptive statistics of the experimental group and the control group

Group		Statistics				
	Math. achievement	N	Minimum	Maximum	Mean	Std. Deviation
Girls	Pre-Test	230	4	92	27.23	18.293
	Post-Test	230	4	92	46.71	18.829
Boys	Pre-Test	270	4	84	26.87	15.731
	Post-Test	270	4	88	48.40	18.342

Table 4.5 shows the results of pre-test and post-test for the mathematics achievement of boys and girls. The gain score from the pre-test to post-test for mathematics achievement of the girls' group was 19.48 points, while the gain score for the boys' group was 21.53 points. Based on this result, the gain score of the boys was higher than that of the girls. Thus, it was proved that the use of calculators in the experimental group gave more contribution to the boys.

The following figure represents the comparison of mathematics achievement between those two groups. It can be observed that there was increasing gain score in both groups after the treatment. The gain score of the boys' group was 3.05 higher than that of the girls' group. Thus, from the result, the use of the *Classwiz* scientific calculators gave a greater impact on boys' mathematics achievement than that of the girls.

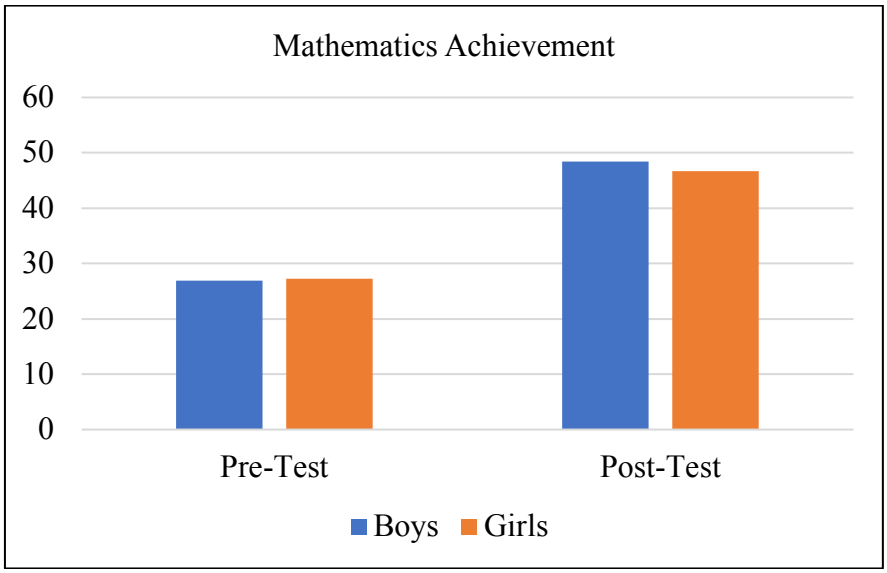


Figure 4.5 Comparison of boys' and girls' mathematics achievement

In addition, inferential statistics were used to investigate the significant differences of the mathematics achievement between boys and girls. Based on the following table, it can be concluded that there was no significant difference between that of boys and girls ($F = 2.722$, $p = .100$).

Table 4.6. The effect of students' prior knowledge and ability on mathematics achievement seen from gender perspective

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	50755.415[a]	2	25377.708	103.992	.000	.295
Intercept	139446.786	1	139446.786	571.419	.000	.535
PRE_TEST	50239.782	1	50239.782	205.870	.000	.293
GENDER	664.306	1	664.306	2.722	.100	.005
Error	121285.897	497	244.036			
Total	1306064.000	500				
Corrected Total	172041.312	499				

5. Conclusion

Returning to the first research questions posed at the beginning of this study, it can be concluded that there were impacts on students' mathematics achievement by the integration of the *Classwiz* scientific calculators in the mathematics class. Secondly, regarding the next question of how the learning impacts on the students' mathematics achievement. From the data analysis, the intervention gave a significant impact on mathematics achievement. Students who used the calculators in the experimental group achieved a higher score than those of the control group who had regular lessons. Meanwhile, seen from the gender perspective, the analysis showed there was no significant difference between the mathematics achievement of the boys and girls. Also, based on the observation, the students gave a positive response to the use of the calculators in their learning.

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References

[1] Black-Hawkins, K., Florian, L., & Rouse, M. (2007). *Achievement and inclusion in schools*. New York, NY: Routledge.

[2] Brewer, D. J., & Stasz, C. (1996). Enhancing opportunity to learn measures in NCES data. In G. Hoachlander, J. E. Griffith, & J. H. Ralph (Eds.), *From data to information: New directions for the National Center for Education Statistics* (p. 3.1-3.28). Washington, D.C.: U.S. Department of Education.Cohen, Manion, & Morrison, 2002

[3] Demana, F., & Waits, B. K. (1992). A computer for all students. *Mathematics Teacher*, *85*, 94–95.

[4] Ebel, R.L., & Frisbie, D.A. (1991). *Essential of educational measurement.* Englewood Cliffs, NJ: Prentice-Hall Inc.

[5] Ellington, A. J. (2003). A Meta-Analysis of the Effects of Calculators on Students' Achievement and Attitude Levels in Precollege Mathematics Classes. *Journal for Research in Mathematics Education*. https://doi.org/10.2307/30034795

[6] Elliot, S.N., Kratochwill, T.R., Cook, J.L., & Travers, J.F. (2000). *Educational psychology: effective teaching, effective learning*. New York, NYL: McGrawHill

[7] Grouws, D. A., & Cebulla, K. J. (2000). *Improving student achievement in mathematics*. Brussels: International Academy of Education.

[8] Hiebert, J., & Grouws, D. (2009). Which instructional methods are most effective for math? *Better: Evidence-Based Education*, *2*(1), 10–11.

[9] Hohenwarter, J., Hohenwarter, M., & Lavicza, Z. (2008). Introducing Dynamic Mathematics Software to Secondary School Teachers: The Case of GeoGebra, *Journal of Computers in Mathematics & Science Teaching, 28*(2), 135-146. Retrieved from https://archive.geogebra.org/static/publications/2009-Hohenwarter_Lavicza _IntroducingDynMath Soft- GeoGebra.pdf.

[10] Hollebrands, K. F. (2007). The role of a dynamic software program for geometry in the strategies high school mathematics students employ. *Journal for Research in Mathematics Education*, *38*(2), 164 - 192.

[11] Johnson, B. & Christensen, L. (2012). *Educational research: quantitative, qualitative, and mixed approaches.* Thousand Oaks, CA: Sage.

[12] Johnson, D.W. & Johnson, R.T. (2002). *Meaningful assesment.* New York, NY: Allyn and Bacon.
[13] Kastberg, S., & Leatham, K. (2005). Research On Graphing Calculators at the Secondary Level: Implications for Mathematics Teacher Education. *Contemporary Issues in Technology and Teacher Education*.
[14] Kutzler, B. (2000). The algebraic calculator as a pedagogical tool for teaching mathematics. In *The T3 World-Wide Conference*. Retreived from https://files.eric.ed.gov/fulltext/ED444858.pdf.
[15] Muijs, D. & Reynolds, D. (2011). *Effective teaching: Evidence and practice*. London: Sage
[16] NCTM. (2000). Principles *and standards for school mathematics*. Virginia, VA: NCTM Inc.
[17] Nitko, A.J., & Brookhart, S. M. (2011). *Educational asessment of students*. Boston, MA: Pearson.
[18] Ochanda, J. P., & Indoshi, F. C. (2011). Challenges and benefits of using scientific calculators in the teaching and learning of Mathematics in secondary school education. Journal of Media and Communication Studies, 3(3), 102–111.
[19] Robert, L. & Chair, L. (2009). *Student learning, students achievement: How do teachers measure up?*. American: National board for profesional teaching standards (NBPTS).
[20] Saha, R. A., Ayub, A. F. M., & Tarmizi, R. A. (2010). The effects of GeoGebra on mathematics achievement: Enlightening coordinate geometry learning. *Procedia-Social and Behavioral Sciences*, *8*, 686-693.
[21] Salani, E. (2013). Teachers' beliefs and technology : Calculator use in mathematics instruction in junior secondary schools in botswana. European Educational Research Journal, 2(4), 151–166. https://doi.org/10.12973/eu-jer.2.4.151.
[22] Westwood, P., S. (2008). *What teachers need to know about teaching methods*. Camberwell,Victoria: ACER Press Woods, P.A., & Woods, G.J. (2009). *Alternative education for 21st century*. New York, NY: Palgrave Macmillan
[23] Wijaya, A., van den Heuvel-Panhuizen, M., & Doorman, M. (2015). Teachers' teaching practices and beliefs regarding context-based tasks and their relation with students' difficulties in solving these tasks. *Mathematics Education Research Journal*, *27*(4), 637–662.
[24] Wright, R. J. (2008). *Educational assesment: tests and measurements in the age of accountability.* Thousands Oaks, CA: Sage