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EFFECT OF SMARTPHONE-ASSISTED JIGSAW COOPERATIVE LEARNING ON SENIOR SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN MATHEMATICS WITHIN EDUCATION DISTRICT IV, LAGOS STATE

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ABSTRACT

This study investigated the effect of smartphone-assisted Jigsaw cooperative learning on senior secondary school students' achievement in mathematics in addition to determining how gender and smartphone efficacy as moderating variables influenced students' achievement in mathematics. The study was guided by three research questions and six hypotheses. Purposive sampling was used to select two (2) schools from Educational District IV of Lagos State. Five hundred and thirty-four students from intact classes were assigned into experimental and control groups. The Smartphone Assisted Learning Package was the treatment while Mathematics Achievement Test served as the data collection instrument. Descriptive and inferential statistics employed include mean, standard deviation, and Analysis of Covariance (ANCOVA). Findings indicated that students who were taught mathematics using a smartphone-assisted Jigsaw strategy performed significantly better than those exposed to the traditional method of teaching. Smartphone efficacy and gender had no significant consequence on students' achievement in mathematics. Findings led to recommendations including that teachers should expose mathematics students to smartphone-assisted Jigsaw cooperative learning strategy to promote active learning and interaction leading to a significant gain in students' mathematics achievement.

KEYWORDS

Smartphone-assisted Jigsaw cooperative learning; Smartphone-Efficacy;
Mathematics achievement; Gender.

INTRODUCTION

The availability and ubiquity of smartphones have greatly changed the way individuals communicate, work and study in the 21st century. Smartphones today are taking on greater prominence in educational institutions (Jin & Zhirui, 2017) and this proliferation is constantly changing the way we interact and learn. Studies have found that smartphones and tablets when used appropriately, may assist students in improving academic achievement (Ivic & Jakopec, 2016; Liu & Yang, 2018) while studies like Froese, Carpenter, Inman, Schooley, Barnes, Brecht, and Chacon (2012) consider the use of smartphone in educational settings as a distraction. However, simply integrating smartphones into the teaching and learning process does not guarantee better or improved learning outcomes. Empirical evidence on the use of the Jigsaw cooperative learning strategy has revealed that students enjoy using the Jigsaw method and performed significantly better after the intervention (Azmin, 2016; Nduji, Nwandikor, Keziah & Elejere, 2020). Therefore, integrating smartphones with effective teaching and learning strategies is necessary for better learning achievement (Sung, Chang & Yang, 2015). One of such teaching and learning strategies is cooperative learning which has been acclaimed by numerous researchers to be of great help in improving students' academic achievement (Aziz & Ghulam, 2013, Lawal & Awofala, 2021).

Gender and smartphone efficacy are included in this study as moderator variables. Gender has been identified as one of the factors influencing students' achievement (Gambari, Yusuf & Thomas, 2015) but research outcomes on the influence of gender on academic achievement have been inconclusive. Studies such as Dada, Johnson, and Lawal (2019); Mobark (2014) found no significant difference in the academic achievement of male and female students. Mailani (2014) on one hand found female students' achievement to be significantly higher than that of their male counterparts while Oribhabor (2019) observed male students excelled more in mathematics than their female colleagues.

These contradictory findings call for the inclusion of gender as a moderator variable in this study. The other variable moderating in the study is smartphone efficacy which refers to the judgment of one's capability to use a smartphone or the level of confidence a user has when confronted with the use of a smartphone. Smartphone efficacy is included in this study as a moderator variable because as stated by Mahat, Ayub, and Wong (2012), students must have a high level of confidence in using mobile technology as part of the teaching and learning process before the use of mobile technology in teaching and learning can be successful. Studies on smartphone efficacy though limited have yielded varying results. Yang (2012) found that students experience high self-efficacy in mobile learning but found no significant difference in male and female students' mobile efficacy while Mahat et al (2012) found that students have a moderate level of self-efficacy in using mobile technology.

Smartphones are fast becoming learning tools with great potential for use due to their increased availability, accessibility, and application to daily living in the community such as social networks (Lawal & Faleye, 2015). Despite the increased availability of smartphones, studies on their effect on students learning outcomes are quite few and debatable. Nonetheless, the increased availability of smartphones amongst senior secondary school learners has become a concern to educational stakeholders who continually seek ways of making the teaching and learning environment interesting and adaptable to 21st-century learners who are technology-driven. The smartphone in itself does not guarantee improved achievement; hence, there is a need for its integration with other effective teaching and learning strategies. This study, therefore, considers the integration of a jigsaw cooperative learning strategy in a smartphone-assisted learning environment to determine the effect of a smartphone-assisted jigsaw cooperative learning environment on senior secondary school students' achievement in mathematics.

Research questions

The following research questions were raised to guide the study

1. What is the difference in the achievement of secondary school students taught mathematics in a smartphone-assisted jigsaw cooperative learning environment and those taught in a traditional setting?
2. What is the difference in the mathematics achievement score of male and female students taught mathematics in a smartphone-assisted Jigsaw cooperative learning environment?

3. Is there any difference in the mathematics achievement score of students with high and low smartphone efficacy taught mathematics in a smartphone-assisted jigsaw cooperative learning environment?

Hypotheses

The following null hypotheses were tested in the study

1. There is no significant effect of treatment on the mathematics achievement of students.
2. There is no significant effect of gender on students' mathematics achievement.
3. There is no significant effect of smartphone efficacy on the mathematics achievement score of students.
4. There is no significant interaction of treatment and gender on students' mathematics achievement.
5. There is no significant interaction of treatment and smartphone efficacy on students' mathematics achievement.
6. There is no significant interaction of treatment, gender, and smartphone efficacy on students' mathematics achievement.

Materials and Methods

Research design

The study is a quasi-experimental design of non-equivalent, pretest, posttest type. Participants were five hundred and thirty-four (534) SS2 mathematics students drawn from eight intact classes from two (2) different senior secondary schools in Lagos Educational District IV, Lagos State. The schools were purposively selected based on the following criteria:

- School ownership (government-owned schools)
- Gender composition (co-educational enrolment)
- Availability of smartphones to students (selected schools within the district whose students were provided with smartphones by the government.)

The schools were randomly assigned to the experimental (smartphone-assisted jigsaw) and control group (traditional method) using the simple random sampling technique. The experimental group (n = 256) was taught using a smartphone-assisted jigsaw cooperative learning strategy while the control group (n = 278) was exposed to the traditional chalk and talk method for 8 weeks. Data were collected through mathematics achievement test while Smartphone-Assisted Learning Package (SALP) or the Roducate Educational App served as the treatment.

Instrument

Mathematics Achievement Test (MAT): consists of 50 multiple choice questions adopted from past examinations of the West African Examination Council (WAEC, May/June 2010 – 2019). The questions in the test were based on the content of the algebra section of the S.S.2 mathematics curriculum. Each of the stems of the MAT had 4 options (A – D) as possible answers to the questions and each carried one point making a total of 50 points score. The instrument MAT was administered to the experimental and control groups as pre-test and post-test. The test was validated by three experts and pilot tested on 240 S.S.2 students who were not involved in the study. A reliability coefficient of 0.76 was obtained using Kuder Richardson (KR – 21).

Smartphone Efficacy Questionnaire (SEQ)

A 9-item Likert-type instrument designed to measure students' self-efficacy in using mobile devices. The instrument was adopted from the 25 items questionnaire on "pupil's attitude and self-efficacy of using mobile devices" adapted by Nikolopoulou and Gialamas (2017) from Tsai, Tsai, and Hwang (2010) (the developer) by rewriting the term "PDA" as "mobile devices". The 9 items were adopted from items 17 - 25 of the "pupil's attitude and self-efficacy of using mobile devices" questionnaire. Each item of the SEQ is rated on a four-point Likert scale ranging from strongly disagree = 1, disagree= 2, agree = 3, to strongly agree = 4. The instrument was also validated by experts and pilot tested on 240 S.S. 2 students who were not involved in the study. A reliability coefficient of 0.84 was obtained using Cronbach's alpha analysis.

Smartphone Assisted Learning Package (SALP)

This is also known as the Roducate Educational App was the treatment instrument used in the smartphone-assisted jigsaw experimental group.

Experimental procedure:

Students who participated in the study were trained by an officer from the district on how to make use of the Roducate App which was used in the experimental group. The teacher and the research assistant who participated in the study were trained in combining the smartphone-assisted learning package (SALP or Roducate App) with a cooperative learning strategy (Jigsaw). The treatment period for both groups lasted 10 weeks. Students in the experimental group were heterogeneously divided into groups. At the beginning of the study, the mathematics achievement test was administered to students in the sampled schools as a pretest during the first week to ascertain the cognitive achievement of the students before the treatment. During the 8 weeks of the treatment, students in the experimental group were exposed to the use of a smartphone-assisted cooperative learning strategy (jigsaw) as treatment while students in the control group were exposed to the traditional method. After the treatment, MAT was again administered as a posttest with a reshuffling of the items to prevent the halo effect.

Procedure

The Smartphone-Assisted Jigsaw Cooperative Learning Strategy

Students were divided into small heterogeneous groups called home groups with 3 members in each group. Each member was assigned different responsibilities. Initially, all the students were made to recall and understand the prior knowledge of the basic concepts of the topic at hand. After this process, the content of the lesson was divided into three (based on the objectives to be achieved for the lesson) and assigned to each member of the homegroup. Students then met in their home groups and studied the assigned task using the smartphone-assisted learning package. Each member in the home group attempted to learn the assigned task by referring to the smartphone-assisted package.

Upon completion of the task, each member moves into expert groups consisting of members from other home groups who had been assigned the same portion of the lesson. In the expert group, participants discussed and shared their materials with other members of the group and discussed how to teach them to their members in the homegroup. The teammates returned to their home groups where they taught what they learned from the jigsaw group to other members of their group. The homegroup then worked on specific exercises and submits as a group. High-scoring teams were recognized and rewarded in the class. At the end of each week, learners take a test to determine their progress.

Traditional Method

The teacher solves the theoretical or numerical problems on the board while the students learn by listening and copying the solved problems. Students are thereafter given a similar problem to solve.

Data Analysis

The data collected from the study were coded using the Statistical Package for Social Sciences (SPSS) software and analyzed using mean standard deviation, and Analysis of Covariance (ANCOVA) at 0.05 alpha level.

Results and Discussion

The results are presented based on the research questions and hypotheses.

Research Question One: What is the difference in the achievement of secondary school students taught mathematics in a smartphone-assisted jigsaw cooperative learning environment and those taught in a traditional setting?

Table 1: Mean Gain in achievement Scores of Students taught Mathematics using Smartphone Assisted Jigsaw and Traditional Method

		Pretest		Posttest			
Treatment	N	Mean	Std. Deviation	Mean	Std. Deviation	Mean Difference	% gain
Traditional	278	12.48	5.55	16.42	6.57	3.94	31.57
Smartphone jigsaw	256	17.43	8.44	32.66	5.56	15.23	87.38
Total	534	14.85	7.50	24.20	10.16		

From table 1 above, it is observed that both groups had improved achievement in the posttest but students exposed to smartphone-assisted jigsaw had a higher mean gain score of 15.23 while the traditional method had a mean gain score of 3.94. This indicates that both groups benefitted from their treatment but the smartphone-assisted Jigsaw group had a far better achievement gain of 87.38% as compared to the traditional group with 31.57%.

Research Question Two: What is the difference in the mathematics achievement score of male and female students taught mathematics in a smartphone-assisted Jigsaw cooperative learning environment?

Table 2: Descriptive Statistics of Achievement Male and Female Students exposed to Smartphone Assisted Jigsaw instruction in Mathematics.

		Pretest		Posttest		
Gender	N	Mean	Std. Deviation	Mean	Std. Deviation	Mean Difference
Male	343	14.75	7.49	24.74	10.29	9.99
Female	191	15.04	7.52	23.24	9.88	8.20
Total	534	14.85	7.50	24.20	10.16	

Table 2 indicates that there exist differences in the mean achievement scores of male and female students before the treatment with the females having a higher mean score. However, after the treatment male students had a higher mean score of 24.74 which implies a gain of 9.99 while their female counterparts had a mean achievement score of 23.24 translating to an achievement gain of 8.20 after exposure to treatment.

Research Question Three: Is there any difference in the mathematics achievement score of students with high and low smartphone efficacy taught mathematics in a smartphone-assisted jigsaw cooperative learning environment?

Table 3: Achievement Gain of Students by Smartphone efficacy taught Mathematics using Smartphone-Assisted Jigsaw and Traditional Method.

		Pretest		Posttest		
Phone Efficacy	N	Mean	Std. Deviation	Mean	Std. Deviation	Mean Difference
Low	206	15.10	8.19	23.33	10.05	8.23
High	328	14.70	7.04	24.75	10.20	10.05
Total	534	14.85	7.50	24.20	10.16	

Table 3 above indicates that students with high smartphone efficacy had higher mean achievement gain than their counterparts with low smartphone efficacy when exposed to the treatment.

Hypothesis One: There is no significant effect of treatment on the mathematics achievement of students.

Table 4: ANCOVA Summary of mathematics achievement by treatment, gender, and smartphone efficacy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	35312.312[a]	8	4414.039	117.678	.000	.642
Intercept	53003.785	1	53003.785	1413.080	.000	.729
Covariate	2.676	1	2.676	.071	.790	.000
Treatment	25220.606	1	25220.606	672.381	.000	.562
Gender	34.074	1	34.074	.908	.341	.002
Phone efficacy	29.356	1	29.356	.783	.377	.001
Treatment*Gender	.309	1	.309	.008	.928	.000
Treatment*Phone efficacy	.022	1	.022	.001	.981	.000
Gender*Phone efficacy	65.178	1	65.178	1.738	.188	.003
Treatment*Gender*Phone efficacy	1.783	1	1.783	.048	.827	.000
Error	19692.439	525	37.509			
Total	367843.000	534				
Corrected Total	55004.751	533				

a. R Squared = .642 (Adjusted R Squared = .637)

Table 4 above shows that the main effect of treatment on students' achievement in mathematics $F_{(1, 525)} = 672.381$, $p = 0.000$. With $p<0.05$, the main effect of the treatment was significant. This indicates that the smartphone-assisted Jigsaw strategy produced a significant effect on students' achievement scores after the effect of the pretest was controlled. Partial eta squared specifies the effect size of the treatment as 56.2% accounting for more than 50%.

Hypothesis Two: There is no significant effect of gender on students' mathematics achievement.

ANCOVA analysis as presented in Table 4 specifies the effect of gender on mathematics achievement as $F_{(1, 525)} = 0.908$, $p = 0.341$ which is statistically insignificant at 0.05 we, therefore, accept the null hypothesis that gender does not account for a significant effect on mathematics achievement. The effect size of gender as quantified is also very paltry as put at 0.2% by partial eta squared.

Hypothesis three: There is no significant effect of smartphone efficacy on the mathematics achievement score of students.

Table 4 revealed $F_{(1, 525)} = 0.783$, $p = 0.377 > 0.05$ as the effect of smartphone efficacy on the mathematics achievement of students. The p-value depicts a non-momentous effect of smartphone efficacy on students' achievement in mathematics. The effect size was near zero as $\eta^2 = 0.1\%$. Hence, the null hypothesis that there is no significant effect of smartphone efficacy on mathematics achievement students is upheld.

Hypothesis four: There is no significant interaction of treatment and gender on students' mathematics achievement.

On the interaction effect of treatment and gender on mathematics achievement of students, Table 4 showed that $F_{(1, 525)} = 0.008$, $p = 0.928$ which was not significant since the $p > 0.05$. An expression of the fact that the treatment practically had the same effect whether a student was male or female thereby eradicating gender influence. Partial eta squared expressly specified a zero effect for the interaction of treatment and gender in the study.

Hypothesis five: There is no significant interaction of treatment and smartphone efficacy on students' mathematics achievement.

ANCOVA analysis of treatment phone efficacy interaction in Table 4 exhibited that $F_{(1, 525)} = 0.001$, $p = 0.981$. With $p > 0.05$, students' mathematics achievement did not respond to the treatment based on learners' efficacy on smartphones whether high or low. The treatment, therefore, does not favour students with better phone efficacy over their counterparts who have a drawback in that regard. The null hypothesis is therefore accepted.

Hypothesis six: There is no significant interaction of treatment, gender, and smartphone efficacy on students' mathematics achievement.

On the three-way interaction effect of treatment, gender and smartphone efficacy on students' mathematics achievement, Table 4 displayed that $F_{(1, 525)} = 0.048$, $p = 0.827$. At $\alpha = 0.05$, this effect is not statistically significant and $\eta^2 = 0\%$. Again, the null hypothesis is not rejected.

Discussion

The result of the analyses related to hypothesis one indicated a significant difference in mathematics achievement of students in favour of those in the experimental group. A significant difference was found between the mathematics achievement of students exposed to the smartphone-assisted jigsaw and those exposed to the traditional method. The findings concerning the better achievement of students within the smartphone-assisted jigsaw experimental group agree with earlier findings of Fakomogbon and Bolaji (2017), Jena and Pohkrel (2017), Ozer and Kilic (2018) who found that cooperative or collaborative learning in a mobile learning environment improves students learning outcomes. This could be due to the technologically-driven society which has made teenagers very device-friendly (Lawal & Faleye, 2015) and could serve as a bait to more devotion and love for mathematics instruction.

The second hypothesis indicated no significant difference in the achievement of males and females taught mathematics using the smartphone-assisted jigsaw and those in the control group. The finding is in agreement with Ajai and Imoko (2015) in addition to Lawal and Awofala (2021) who found that gender does not significantly predict mathematics achievement which is quite common in recent research results as the gender gap in mathematics achievement is adjudged to be waning. The finding however is in contradiction with Contini et al (2017), and Ojaleye and Awofala (2018) who all found gender differences in students' achievement in mathematics. A closer look at the mean values from the study however showed that male students had a higher post-test mean achievement when compared to their female counterparts although the difference is not significant. This finding aligns with Oribhabor (2019) who found male students excelling more in mathematics than their female counterparts. Effects sizes of the moderator variables, gender, and smartphone efficacy were both found to be very small. Further inferential statistics revealed no significant difference in the mathematics achievement of students with high and low smartphone efficacy which may induce the inherent advantage of serving as a leveler between socio-economically comfortable and disadvantaged learners.

Overall, smartphone-assisted jigsaw cooperative learning strategy, gender, and phone efficacy all accounted for a total of 56.2% of the variation observed in students' mathematics achievement. This established the far-reaching effect of the technology-based treatment on students' achievement in the subject.

Conclusion

The findings of this study emphasized that the teaching and learning of mathematics in senior secondary schools in Nigeria using a smartphone-assisted jigsaw cooperative learning strategy is worthwhile as it produced a significant effect on mathematics achievement. Smartphone-assisted instruction within a cooperative learning environment narrowed the gender gap in achievement and does not appear to favour better-privileged students over their less privileged colleagues.

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Recommendations

Based on the findings of this study, the following recommendations are offered:

1. Teachers should expose mathematics students to smartphone-assisted jigsaw cooperative learning strategy to promote active learning and social interaction, eventually leading to a significant gain in students' mathematics achievement.
2. Government and non-governmental stakeholders should support students through the provision of smartphones to enhance smartphone-assisted mathematics instruction.
3. A more interactive mathematics app could be designed for smartphones to further improve on the gains of smartphone-assisted instruction.

References

Ajai, J. T. &Imoko, I. I. (2015). Gender differences in mathematics achievement and retention scores: a case of problem-based learning method. *International Journal of Research in Education and Science (IJRES),1*(1), 45 – 50

Aziz, J. &Ghulam, M. K. (2013). The study of the effectiveness of cooperative learning approach in learning mathematics at secondary level in Pakistan. *Mathematical Theory and Modeling,3*(10), 24-32.

Azmin, N. H. (2016). Effect of the jigsaw based cooperative learning method on students' performance in general certificate education advanced level psychology; An exploratory Brunei case study. International education studies, *9*(1), 91 – 96. Doi:10.5539/ies.v9n1p91

Contini, D., Di Tomasso, M. L. &Mendolia, S. (2017). The gender gap in mathematics achievement: Evidence from Italian data. *Economics of Education Review*, *58*, 32-42.

Crampton, H. & Burke, D. (2015). Research trends in the use of mobile learning in mathematics. *International Journal of Mobile and Blended Learning, 7*(4), 1-5. Doi:10.4018/IJMBL.2015100101

Dada, F. H., Johnson, F. O. &Lawal, R. F. (2019). The efficacy of 4-stage proficiency approach in eradicating gender related mathematical proficiency differences among senior secondary students in Lagos State. *ABACUS: Journal of the Mathematical Association of Nigeria, 42* (1), 434-443.

Fakomogbon, M. A., &Bolaji, H. A. (2017). Effects of collaborative learning styles on performance of students in a ubiquitous collaborative mobile learning environment. *Contemporary Educational Technology*, *8*(3), 268 -279.

Froese, A. D., Carpenter, C. N., Inman, D. A., Schooley, J. R., Barnes, R. B., Brecht, P. W. & Chacon, J. D. (2012). Effects of classroom cellphone use on expected and actual learning. *College Student Journal*, *46*(2), 323 – 332.

Gambari, A. I., Yusuf, M. O. & Thomas, D. A. (2015). Effects of Computer-Assisted STAD, LTM and ICI cooperative learning strategies on Nigerian secondary school students' achievement, gender and motivation in physics. *The Malaysian Online Journal of Educational Sciences*, *3*(4), 11-26.

Ivic, V. &Jakopec, T. (2016). Using mobile application in foreign language learning: a case study. *Libellarium,9*(2), 217 – 230. https://doi.org/10.15291/libellariumv9i2.288

Jena, A. K. &Pokhrel, K. (2017). Effects of collaborative m-learning and individual e-learning on the academic performance, attention benefit & consistency of learning. *The Online Journal of Distance Education and E-Learning, 5*(1), 35 – 46.

Jin, W. &Zhirui, D. (2017). Research on mobile learning model of college English based on WeChat platform. *EURASIA: Journal of Mathematics Science and Technology Education*, *13*(8), 5847-5853. https://doi.org/10.12973/eurasia.2017.01034a

Lawal, R. F. &Awofala, A. O. A. (2021). Effect of Team Assisted Individualisation strategy on senior secondary school students' motivation to learn Mathematics. *Nigerian Online Journal of Educational Sciences and Technology*, *3*(1), 36-46.

Lawal, R. F. &Faleye, D. (2015). Usage of social networks and parents' marital status as predictors of students' attitude to Mathematics. Paper presented at the 7th School of Science Education Conference, Federal College of Education (Technical), Akoka, Lagos, 12th – 14th May, 2015.

Liu, T. & Yang, X. (2018) effects of the visual/verbal learning style on concentration and achievement in mobile learning. *EURASIA: Journal of Mathematics Science and Technology Education*, *14*(5), 1719 -1729. https://doi.org/10.29333/ejmste/85110

Mahat, J. Ayub, A. F. M. & Wong, S. L. (2012). An assessment of students' mobile self-efficacy, readiness & personal innovativeness towards mobile learning in higher education in Malaysia". *Proceedia-Social and Behavioural Sciences64,* 284 – 290.

Mainali, B. R. (2014). Investigating the relationships between preferences, gender and high school students' geometry performance. A Dissertation Submitted In Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Education in the College of Education and Human Performance at the University of Central Florida Orlando, Florida.

Mobark, W. M. (2014). The effect of using cooperative learning strategy on graduate students' academic performance and gender differences. *Journal of Education and Practice,5*(11), 64 – 71.

Nduji, C.C., Nwandikor, C., Keziah, B. C. &Elejere, U. C. (2020). Effect of Jigsaw Based Cooperative Learning Strategy (JBCLS) on senior secondary school students' interest and achievement in physics. *International Journal of Studies in Education*, *16*(1), 164 – 168.

Ojaleye, O. &Awofala, A. O. A. (2018). Blended learning and problem-based learning instructional strategies as determinants of senior secondary school students' achievement in algebra. *International Journal of Research in Education and Science (IJRES)*,*4*(2), 486 – 501. https://doi.org/10.21890/Ijres.428286

Oribhabhor, C. B. (2019). The influence of gender on mathematics achievement of secondary school students in Bayelsa State. *African Journal of Studies in Education*, *14*(2), 196-206.

Ozer, O. &Kilic, F. (2018). The effect of mobile assisted language learning environment on EFL students' academic achievement, cognitive load and acceptance of mobile learning tools. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(7), 2915–2928. https://doi.org/10.29333/ejmste/90992

Perry, D. R. &Stecks, A. K. (2015). Increasing student's engagement, self-efficacy, and meta-cognitive self-regulation in the high school geometry classroom: Do Ipads help? *Computers in School*, 32(2), 122 – 143.https://doi.org/10.1080/07380569.2015.1036650

Picha, G. (2018). *Effective technology use in mathematics class*. Edutopia

Sitrava, R. T. (2017). The 7th grade students' perception of the letters in an algebraic expression. *Proceedings of ISER International Conference, Moscow, Russia. 9th -10th, March, 2017.*

Sung, Y. T., Chang, K. E & Yang, J. M. (2015) how effective are mobile devices for language learning? A meta-analysis. *Educational Research Review*, *16*, 68 – 84. https://doi.org/10.1016/j.edurev2015.09.001

Yang, S. (2012). Exploring college students' attitude and self-efficacy of mobile learning. *TOJET: The Turkish Online Journal of Educational Technology*, *11*(4), 148-153.