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EFFECT OF SMARTPHONE-ASSISTED JIGSAW COOPERATIVE LEARNING ON STUDENTS' MATHEMATICS SELF-EFFICACY

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Abstract

Smartphones have become handy tools in the hands of 21st-century teenagers owing to their necessity for communication and socialization. These devices could therefore possess underlying benefits for mathematics education. This quasi-experimental study probed the consequence of smartphone-assisted Jigsaw cooperative learning on senior secondary school students' mathematics self-efficacy with recourse to how gender and smartphone efficacy could moderate this effect. The study involved five research questions and hypotheses. Two schools from the Educational District IV, Lagos State were selected by purposive sampling technique from which five hundred and thirty four (534) students drawn from intact classes were assigned into experimental and control groups. Smartphone Assisted Learning Package (SALP) served as the intervention while a valid and reliable Mathematics Self-Efficacy Questionnaire (r=0.90) was employed for data collection. Statistical tools deployed for descriptive and inferential analysis include mean, standard deviation and Analysis of covariance (ANCOVA). Outcome of data analysis portrayed a momentous effect of treatment on students' mathematics self-efficacy. Smartphone efficacy and gender were found to possess substantial influence on participants' mathematics self-efficacy. These findings led to the recommendation that teachers should expose mathematics students to smartphone-assisted Jigsaw cooperative learning strategy to promote active learning and improve students' mathematics self-efficacy.

Keywords: Gender, Mathematics self-efficacy, Smartphone-assisted jigsaw cooperative learning.

Abstrak

Ponsel pintar telah menjadi alat yang berguna bagi remaja abad ke-21 dalam komunikasi dan sosialisasi. Perangkat ini dapat memberikan manfaat yang mendasar bagi pendidikan matematika. Penelitian quasi-eksperimen ini mempelajari pengaruh pembelajaran kooperatif Jigsaw berbantuan ponsel pintar terhadap efikasi diri matematika siswa sekolah menengah atas, dengan mempertimbangkan bagaimana gender dan efikasi ponsel pintar dapat memoderasi efek tersebut. Penelitian ini melibatkan lima pertanyaan penelitian dan hipotesis. Dua sekolah dari Distrik Pendidikan IV, Negara Bagian Lagos, dipilih dengan teknik pengambilan sampel purposif, di mana lima ratus tiga puluh empat (534) siswa diambil dari kelas-kelas utuh ditugaskan ke dalam kelompok eksperimen dan kontrol. Paket Pembelajaran berbantuan ponsel pintar digunakan sebagai intervensi, sementara Kuesioner Efikasi Diri Matematika yang valid dan reliabel (r=0.90) digunakan untuk pengumpulan data. Alat statistik yang digunakan untuk analisis deskriptif dan inferensial meliputi mean, deviasi standar, dan Analisis kovarian (ANCOVA). Hasil analisis data menunjukkan pengaruh perlakuan signifikan terhadap efikasi diri matematika siswa. Efikasi ponsel pintar dan gender terbukti memiliki pengaruh besar terhadap efikasi diri matematika siswa. Temuan ini mengarah pada rekomendasi agar guru memperkenalkan strategi pembelajaran kooperatif jigsaw berbantuan ponsel pintar kepada siswa untuk mendorong pembelajaran aktif dan meningkatkan efikasi diri matematika siswa.

Kata kunci: *Efikasi diri matematika, Gender, Pembelajaran kooperatif Jigsaw berbantuan ponsel pintar*.

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INTRODUCTION

Self-efficacy is an important concept in social cognitive theory and has been widely recognized as one of the most important theories about human learning. Butler-Bowdon (2017) admitted that self-efficacy is a concept introduced by Albert Bandura (1977), stating that people's convictions in regard to their capacity to achieve a certain purpose influence their success in relation to the planned activity. The concept is a multi-dimensional construct that indicates the way people feel, think and behave in specific situations as well as an individual's belief in his/her ability to perform a specific task in a given situation or context (Bandura, 1977). Kenny, Van Neste-Kenny, Burton and Park (2011) noted that students' perception of self-efficacy has been found to influence their decisions about the choice of activities in which they engage their emotional responses when performing the behaviors and their perspective in carrying out these actions. In fact, a strong feeling of personal self-efficacy improves an individual's personal wellbeing and achievement; as such self-efficacy is a key predictor of students' success in academic performance over the years (Santi, Gorghiu, & Pribeau, 2020). Komarraju and Nadler (2013) reported that students who are more confident and self-assured are more likely to report high levels of academic performance. Studies (Huang, 2013; Shaine, 2015, Tizazu & Ambaye, 2017) revealed that students with high self-efficacy outperform students with low self-efficacy.

Mathematics self-efficacy has been operationally defined by researchers (Toland & Usher, 2016; Bonne & Lawes, 2016) as learner's self-efficacy related to the learning area of mathematics. Laranang and Bondoc (2020) described mathematics self-efficacy as the belief in one's ability to learn and succeed in school mathematics while Getachew and Birhane (2016) refer to mathematics self-efficacy as a belief of competency in engaging in mathematical problems. Mathematics self-efficacy can therefore be described as an individual's belief/perception of their abilities in mathematics or students' confidence in their ability to master mathematics concepts, tasks and activities. It can also be described as an individual's judgment of his/her capabilities to solve specific mathematics problems, perform mathematics related tasks and succeed in mathematics related courses.

Mathematics self-efficacy is essential because of its well established association with students' learning outcomes in mathematics. Studies (e.g. Skaalvik, Federici, &

Klassen, 2015, Recber, Isiksal, & Koç, 2018; Rodriguez, Regueiro, Pineiro, Valle, Sanchez, Viertes, 2020; Norbu & Dukpa, 2021) reported that students' mathematics self-efficacy predicts their achievement and grades. Roick and kingeisen (2017) proved that students who have better disposition set themselves higher performance targets and get better outcomes in mathematics. Arifin, Wahyudin and Herman (2021) stated that students with high mathematics self-efficacy solve mathematics problems more accurately and efficiently than students with low mathematics self-efficacy. Studies (Woke, Agu & Joy, 2021; Negara, Wahyudin, Herman & Tanner, 2021; Odiri, 2020; Evans, 2015) have also shown that mathematics self-efficacy has a high positive significant relationship with students' achievement in mathematics and that it is a good predictor of mathematics achievement. Therefore, there is a need to consider instructional strategies that will enhance students' mathematics self-efficacy which will bring about improvement in students' achievement in mathematics that has been a major concern of teachers and researchers over the years. Greensfeld and Deutsch (2020) noted that teachers need to develop and monitor students' mathematics self-efficacy during the mathematics learning process by making use of strategies that create a positive climate in teaching and learning mathematics.

For academic progression and efficient learning of students, the method of instruction or teaching strategy is usually an important factor. The method of instruction should be flexible to match the learning needs of individuals incorporating cooperation and interaction between students (Golshah, Dehdar, Imani & Nikkerdar, 2020). One of such strategies is the cooperative learning strategy. Sathyprakasha, Nandini and Kalyani (2014) described cooperative learning as a classroom learning environment in which students work together in small mixed ability or heterogeneous groups to achieve academic tasks. Cooperative learning strategies are found to enhance learners' self-efficacy (Mari & Gumel, 2015; Ahmadian, 2015). There are dozens of strategies that can be used by the teacher under the umbrella of cooperative learning, however, the jigsaw cooperative learning is considered in this study.

The advent of technology over the past decades has displayed the importance of technology to learning processes which has been widely established by researchers such as Obi, Obiakor and Graves (2016); Plough (2017). The National Council of Teachers of Mathematics (NCTM) also recommended the integration of technology in the teaching and learning of the subject stating that technology is essential in teaching and learning mathematics as it influences the mathematics that is taught and enhances students' learning. In contemporary times, the availability and globalization of smartphones have made these gadgets ideal for educational purposes as a number of benefits have resulted from the usage of technologies in classroom contexts.

Studies like Fakomogbon and Bolaji (2017) and Each and Suppasetseree (2021) which examined the integration of smartphones with cooperative learning in classroom contexts revealed improvement in students' academic performance. Similarly, Dada and Nwoke (2023) revealed that students generally have sustained interest when working with phones and laptops because students have an excitingly fun-filled view of phone and laptop based activities. Furthermore, a high self efficacy in the ability to operate phones and laptops was reported as a result of students' high proficiency level in operating phones and laptops. It is logically important that students' smartphone self efficacy be considered before integrating smartphone usage into classes. Choi, Lim and Xiong (2012) and Celik and Yesilyurt (2013) agree that technology self-efficacy is a key component that needs to be considered when addressing the integration of technology in the classroom and Mahat, Ayub and Luan (2012) asserted that students must have a high level of confidence in using mobile technology before the use of mobile technology in teaching and learning can be successful. Technology self-efficacy such as computer self-efficacy (Yang, 2012) referred to the belief one possesses in their competence for using computers. Thus, smartphone efficacy is defined as the level of confidence a user expresses of his/her capabilities at/when confronted with the use of a smartphone. A few studies showing inconsistent findings exist for smartphone efficacy related studies. For instance, Mahat, Ayub and Luan (2012) found that students have a moderate level of self-efficacy in using mobile technology while Yang (2012) found that students experience high self-efficacy in mobile learning but found no significant difference in male and female students' mobile self-efficacy.

It can be pictured from the foregone conclusion that integrating technologies in cooperatively taught mathematics lessons could possess the capacity to improve students' mathematics self-efficacy, a key factor for success in mathematics learning. The integration of smartphones with jigsaw cooperative learning is what the researchers define as smartphone-assisted jigsaw cooperative learning in this study. In view of integrating smartphones with cooperative learning, improved students' achievement have been documented (Fakomogbon & Bolaji, 2017; Each & Suppasetseree, 2021). However, there was no record within the researchers' scope of literature search as to the effect of smartphone-assisted cooperative learning on students' mathematics self efficacy. This gap necessitates that the effect of smartphone-assisted jigsaw cooperative learning on students' mathematics self efficacy be studied. Also, the limited and no consensus results obtained for students' phone efficacy necessitated the inclusion of smartphone efficacy as a moderating variable in this study.

While probing the effect of smartphone-assisted cooperative learning on students' mathematics self-efficacy, gender was also included as a moderator variable as it could lend an intravenous influence on the outcome of the strategy on students' mathematics self-efficacy. Gender differences in mathematics self-efficacy beliefs are an interesting area to explore although research outcomes on the influence of gender on student's mathematics self-efficacy have been inconclusive. Studies such as Cakiroglu and Isiksal (2009) found a significant main effect of gender on self-efficacy in favor of boys. Mozahem, Boulad and Ghanem (2020) on the other hand found that gender difference is not statistically significant though there existed a difference in means for boys and girls in a trivial magnitude. In a similar vein, Dada (2021) found that there was no significant interaction effect of treatment and gender for students who were exposed to a 4-stage proficiency approach to instruction involving Tutorial, Terms, Operations and Problem solving stages. These contradictory findings call for the inclusion of gender as a moderator variable in this study. Therefore, this study considers the integration of a Jigsaw cooperative learning strategy in a smartphone assisted learning environment to determine the effect of smartphone assisted jigsaw cooperative learning on senior secondary school students' mathematics self-efficacy.

Research questions

The following research questions were raised to guide the study: (RQ1) What is the difference in the mathematics self-efficacy of secondary school students taught mathematics in smartphone-assisted Jigsaw cooperative learning environment and those taught in traditional settings?; (RQ2) What is the influence of treatment and gender interaction on the mathematics self-efficacy of students?; (RQ3) What is the influence of treatment on the mathematics self-efficacy of students with high and low smartphone efficacy?; (RQ4) What is the difference in the mathematics self-efficacy of male and female students with high and low smartphone efficacy?; (RQ5) What is the influence of the three-way interaction effect on the mathematics self-efficacy of students?

Research hypotheses

The following null hypotheses were tested in the study: ($H_0$1) There is no significant effect of treatment on students' mathematics self-efficacy; ($H_0$2) There is no significant interaction effect of treatment and gender on the students' mathematics self-efficacy; ($H_0$3) There is no significant interaction effect of treatment and phone-efficacy on the students' mathematics self-efficacy; ($H_0$4) There is no significant interaction effect of gender and phone-efficacy on the students' mathematics self-efficacy; ($H_0$5) There is no significant three-way interaction effect of treatment, gender and phone-efficacy on students' mathematics self-efficacy.

RESEARCH METHODS

Research design

The design is a quasi-experimental study of non-equivalent, pretest, posttest and control group type. Participants were five hundred and thirty-four (534) second year mathematics students from intact classes of two (2) senior secondary schools in Lagos Educational District IV, Yaba, Lagos State, Nigeria. The schools were purposely selected based on the following criteria: (1) School ownership (Government), (2) Gender composition (Co-educational), (3) Availability of smartphone to students (students of selected schools within the district provided with smartphone by the government).

The schools were assigned to the experimental group (smartphone-assisted Jigsaw) and control group (lecture method) using simple random sampling technique. The experimental group (N=256) was taught through smartphone-assisted Jigsaw cooperative learning strategy whereas the control group (N=278) was taught using the lecture method for 8 weeks. Data were collected through the mathematics achievement test while SALP also known as the Roducate Educational App was used as the treatment instrument.

Instruments

Mathematics Self-Efficacy Questionnaire (MSEQ): The MSEQ is a 13-item Likert type instrument designed to measure student's mathematics self-efficacy. The instrument was adopted from the Mathematics Self Efficacy and Anxiety Questionnaire (MSEAQ) developed by May (2009). The 13 items were adopted from items 1,4,7,9,10,12,13,16,19,20,21,23, and 28 of the MSEAQ. The MSEQ is made up of two parts. Part A consists of a student's profile such as name of student, name of school, class, sex, and age. Part B is made up of the adopted 13 items from the MSEAQ. Each item of the MSEQ is rated on a five-point modified Likert scale ranging from Never (1 point), Seldom (2 points), Sometimes (3 points), Often (4 points) to Usually (5 points).

Smartphone Efficacy Questionnaire (SEQ): The smartphone efficacy questionnaire (SEQ) is a 9-item Likert type instrument designed to measure student's self-efficacy on mobile devices. The instrument was adopted from the 25 items questionnaire on "pupil's attitude and self-efficacy of using mobile devices" as adapted by Nikolopoulou and Gialamas (2017) from Tsai, Tsai & Hwang (2010) (the developer) by rewriting the term "PDA" as "mobile device". The 9 items were adopted from items 17-25 of the "pupils' attitude & 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 point), Disagree (2 points), Agree (3 points), to Strongly Agree (4 points).

SALP or the Roducate Educational App was the treatment instrument used in the smartphone-assisted Jigsaw experimental group. The package contains subjects or topics which students encounter at the senior secondary school level.The main menu of the package consists of lectures, mock exams, tasks, tutorial videos.

Experimental procedures

Students who participated in the study were trained by an officer from the district on how to use the smartphone and more importantly how to make use of the Roducate App which was used in the experimental group. The teacher and research assistant who participated in the study (especially in the treatment group) were trained in combining the SALP (the Roducate App) with Jigsaw cooperative learning. The treatment period for all groups covered 10 weeks. Students in the experimental group were heterogeneously divided into groups. At the beginning of the study, the mathematics achievement test was administered on students in the sampled schools as a pretest during the first week of the treatment to ascertain their cognitive achievement before commencement of treatment. During the 8 weeks of the treatment, students in the experimental group were exposed to the use of smartphone-assisted cooperative learning as treatment while students in the control group were exposed to the lecture method. Immediately after the treatment, MAT was again administered as a posttest.

Instructional procedure for the smartphone assisted jigsaw

In its implementation, smartphone-assisted jigsaw cooperative learning applies the following 7 steps.

Step 1, students were divided into small heterogeneous groups called home groups with 3 members in each group. Each member is then assigned a number/alphabet (say 1, 2, 3 or a, b, c) based on their ability level.

Step 2, teacher introduces the topic for the lesson and state the objectives (3) to be achieved by the end of the 80 minute lesson.

Step 3, students are assigned a specific objective ,or segment of the lesson according to the number given to them in step 1. Step 3, students assigned to the same objective or segment of the lesson come together to form an “expert group”where they learn and solve 1 or 2 exercises on the segment assigned (using the SALP/ Roducate App) while the teacher and research assistant move round to ensure that students are on track with what is being learnt and also ensure class decorum.

Step 4, students return to their home groups and discuss/explain (using the lessons or videos on the SALP/ Roducate App as directed by the teacher) what is learnt in the “expert group” to the other members of their home groups in a bid to ensure that all members master the content of the lesson.

Step 5, students as a group attempted class exercise and submit only one sheet after reaching a consensus.

Step 6, students take individual tests at the end of a topic which is marked by the teacher/ research assistant. This also contributes towards the group, since groups where every member scored very well in the individual test are recognized and rewarded in class.

Step 7, the instruments were re-administered on the 10^{th} week.

Traditional method

This strategy was characterized by the teacher solving all the theoretical or numerical problems on the board while the students learn by listening and copying the solved problems in their notebooks.

Data analysis

The MSEQ was administered twice as a pretest and posttest. Data collected were analyzed using Analysis of Covariance (ANCOVA) at 0.05 alpha level.

RESULTS AND DISCUSSION

Research questions 1 (RQ1)

What is the difference in the mathematics self-efficacy of secondary school students taught mathematics in Smartphone-assisted Jigsaw cooperative learning environment and those taught in traditional settings?

Table 1. Descriptive Statistics of Mathematics Self-Efficacy Scores of Students' in Treatment Group

Treatment	*N*	Pretest		Posttest		Mean diff	% gain
		Mean	StDev	Mean	StDev		
Traditional	278	45.95	10.09	46.96	8.75	1.01	2.20
Smartphone Jigsaw	256	45.80	8.50	47.55	9.06	1.75	3.82
Total	534	45.88	9.36	47.24	8.90		

Table 1 indicates that students in the Smartphone Assisted Jigsaw experimental group had higher post-treatment mathematics self-efficacy mean score showing a progress from a mean of 45.80 to 47.55 (mean difference=1.75) while students in the traditional group progressed from 45.95 to 46.96. It suggests that students exposed to the Smartphone Assisted Jigsaw experimental group had a higher self-efficacy gain of 3.82% while their colleagues in the Traditional group had a self-efficacy gain of 2.20%.

Research questions 2 (RQ2)

What is the influence of treatment and gender interaction on the mathematics self-efficacy of students?

The interaction of treatment and gender under the lecture group as presented in Table 2 resulted in a marginal gain of 0.98 among male students signifying 2.14% gain in students' self-efficacy whereas female students appreciated by 1.07 (2.31%). In the Smartphone Assisted Jigsaw group, male students recorded a mean gain of 2.31 (4.98%) but their female colleagues featured a 0.37 (0.84%) increase in mean self-efficacy.

Table 2. Descriptive Statistics of Treatment and Gender Interaction on Mathematics Self-Efficacy of Students

Treatment	Gender	*N*	Pretest		Posttest		Mean diff	% gain or loss
			Mean	StDev	Mean	StDev		
Lecture	Male	162	45.69	10.31	46.67	9.22	0.98	2.14.
	Female	116	46.30	9.811	47.37	8.08	1.07	2.31
Smartphone assisted Jigsaw	Male	181	46.42	8.329	48.73	8.783	2.31	4.98
	Female	75	44.31	8.776	44.68	9.134	0.37	0.84

Clearly, the appreciation in students' self-efficacy observed as a result of treatment and gender interaction was highest among male students exposed to the Smartphone Assisted Jigsaw strategy followed by Lecture method-exposed female students after which comes their male counterparts while Smartphone Assisted Jigsaw strategy female had the least mean self-efficacy gain of 0.37 implying a 0.84% gain.

Research questions 3 (RQ3)

What is the influence of treatment on the mathematics self-efficacy of students with high and low smartphone efficacy?

Table 3. Descriptive Statistics of Treatment and Phone Efficacy Interaction on Students' Mathematics Self-Efficacy

Treatment	Phone Efficacy	*N*	Pretest		Posttest		Mean diff	% gain or loss
			Mean	StDev	Mean	StdDev		
Lecture	Low	116	45.28	10.320	44.16	7.988	1.12	2.47
	High	162	46.42	9.932	48.96	8.750	2.54	5.47
Smartphone assisted Jigsaw	Low	90	45.13	7.937	45.37	8.351	0.23	0.51
	High	166	46.16	8.793	48.73	9.233	2.57	5.57

Considering the distribution of points on the self-efficacy scale, the highest gain in self-efficacy was recorded under the experimental group of students with high phone efficacy and this is closely followed by lecture group participants with high phone efficacy. It appears that phone efficacy wield a great influence on students' self-efficacy regardless of their affiliation with either the control or the experimental group. Interestingly, subjects of the Lecture group with low phone efficacy recorded a decrease in mean self-efficacy while Smartphone Assisted Jigsaw group participants with low phone efficacy had a slight increase of 0.23 in mathematics self-efficacy.

Research questions 4 (RQ4)

What is the difference in the mathematics self-efficacy of male and female students with high and low smartphone efficacy?

Table 4. Descriptive Statistics of Gender and Phone Efficacy Interaction on Mathematics Self-Efficacy of Students

Gender	Phone Efficacy	*N*	Pretest		Posttest		Mean diff	% gain or loss
			Mean	StdDev	Mean	StdDev		
Male	Low	125	45.14	9.568	45.42	8.743	0.27	0.60
	High	218	46.61	9.141	49.10	8.949	2.49	5.34
Female	Low	81	45.33	9.015	43.57	7.046	1.77	3.90
	High	110	45.65	9.788	48.34	9.074	2.68	5.87

Table 4 presents the analysis of the influence of gender and phone efficacy interaction on students' mathematics self-efficacy. Males regardless of their level of phone efficacy recorded a gain in mean self-efficacy while female students with low phone efficacy had a reduced self-efficacy despite the treatment received. High leveled phone efficacy females had a gain of 2.68 in mean self-efficacy indicating the highest mean gain resulting from gender phone efficacy interaction.

Research questions 5 (RQ5)

What is the influence of the three-way interaction effect on the mathematics self-efficacy of students?

Table 5. Three-Way Interaction of Treatment, Gender and Phone Efficacy on Students' Mathematics Efficacy

Treatment	Gender	Phone Efficacy	*N*	Pretest		Posttest		Mean diff	% gain or loss
				Mean	StdDev	Mean	StdDev		
Lecture	Male	Low	59	44.05	11.054	43.66	9.400	0.39	0.89
		High	103	46.63	9.795	48.39	8.701	1.76	3.77
	Female	Low	57	46.56	9.428	44.68	6.243	1.88	4.04
		High	59	46.05	10.241	49.97	8.820	3.92	8.51
Smartphone Assisted Jigsaw	Male	Low	66	46.12	7.972	46.98	7.853	0.86	1.86
		High	115	46.59	8.557	49.74	9.157	3.15	6.77
	Female	Low	24	42.42	7.324	40.92	8.209	1.50	3.54
		High	51	45.20	9.317	46.45	9.083	1.25	2.77

The three-way interaction effect of treatment, gender and phone efficacy on students' self-efficacy is presented in Table 5. Analysis reveals highest mean self-efficacy gain amidst high level phone efficacy female students exposed to the lecture method of teaching. This is followed by high level phone efficacy males subjected to the Smartphone Assisted Jigsaw treatment (3.15).

Null hypotheses test

The results of data analysis for all null hypotheses (H_01-H_05) in this study are presented in Table 6.

Table 6. Results of Data Analysis about Effect of Treatment, Gender and Phone Efficacy on Students' Mathematics Self-Efficacy

Source	Type III Sum of Squares	*Df*	Mean Square	*F*	*Sig.*	Partial Eta Squared
Corrected Model	4287.649[a]	8	535.956	7.422	.000	.102
Intercept	34047.514	1	34047.514	471.483	.000	.473
Covariate	871.366	1	871.366	12.066	.001	.022
Treatment	33.027	1	33.027	.457	.499	.001
Gender	272.584	1	272.584	3.775	.053	.007
Phone Efficacy	2100.589	1	2100.589	29.089	.000	.052
Treatment × Gender	819.631	1	819.631	11.350	.001	.021
Treatment × Phone Efficacy	24.236	1	24.236	.336	.563	.001
Gender × Phone Efficacy	80.995	1	80.995	1.122	.290	.002
Treatment × Gender × Phone Efficacy	14.953	1	14.953	.207	.649	.000
Error	37912.188	525	72.214			
Total	1233963.000	534				
Corrected Total	42199.837	533				

a. R Squared = .102 (Adjusted R Squared = .088)

Table 6 shows that for treatment (H_01), the *F*- and *p*-values were 0.457 and 0.499 respectively. Hence at $p<0.05$ level of significance, there was no significant main effect of treatment on students' mathematics self efficacy. This simply indicates that students' mathematics self efficacy was not affected by the type of treatment that students received. In other words, whether or not the students were taught using the smartphone assisted Jigsaw cooperative strategy or the conventional strategy did not matter on the students' mathematics self efficacy. This result goes in the opposite direction to the findings of many previous studies in this line which affirmed that technology enhanced methodologies positively influenced students' learning outcomes. Such studies include Obi, Obiakor, & Graves (2016) and Plough (2017).

In Table 6 also shows that for the interaction effect of treatment and gender ($H_0 2$), the *F*- and *p*-values were 11.350 and .001 respectively. Hence at $p<0.05$ level of significance, there was a significant interaction effect of treatment and gender on the students' mathematics self-efficacy. While treatment and gender did not have any significant effect on students' mathematics self efficacy, the interaction of treatment and gender had a significant influence on students' mathematics self efficacy. Interaction effects of factors present in classroom instructions should not be ignored as they have the capacity to produce desirable or sometimes undesirable effects on some learning outcomes. Regarding the interaction effect of a treatment and gender, the significant effect found in this study contradicts the finding of Dada (2021) which showed that there was no significant interaction effect of treatment and gender.

Table 6 further shows that for the interaction effect of treatment and phone-efficacy ($H_0 3$), the *F*- and *p*-values were 0.336 and 0.563 respectively. Hence at $p<0.05$ level of significance, there was no significant interaction effect of treatment and phone-efficacy on students' mathematics self efficacy.

Table 6 also shows that for the interaction effect of gender and phone-efficacy ($H_0 4$), the *F*- and *p*-values were 1.122 and 0.290 respectively. Hence at $p<0.05$ level of significance, there was no significant interaction effect of gender and phone-efficacy on students' mathematics self- efficacy. This also indicates that students' mathematics self-efficacy was not affected by gender. This implies that students' mathematics self-efficacy was not influenced by the student being either male or female, i.e., both male and female mathematics self-efficacy were at par.

Table 6 also shows that for the three-way interaction effect of treatment, gender and phone-efficacy ($H_0 5$), the *F*- and *p*-values were 0.207 and 0.649 respectively. Hence at $p<0.05$ level of significance there was no significant three-way interaction effect of treatment, gender and phone-efficacy on students' mathematics self-efficacy.

CONCLUSION

The findings of this study are of immense value to the educational sector as they showed that exposing students to learning mathematics in a smartphone assisted jigsaw learning environment resulted in an increase in students' mathematics self-efficacy though the increase was not statistically significant. More importantly, the study revealed that smartphone efficacy had a significant effect on students' mathematics self-efficacy in a smartphone assisted learning environment and this can indirectly affect students' achievement. Students' smartphone proficiency is an advantage for teachers to key into and raise students' fallen mathematics self-efficacy as this will in the long run produce students who have a high and positive view of their mathematics abilities.

Based on the findings of this study, the following recommendations are made: (1) students should be exposed to smartphone assisted jigsaw cooperative learning strategy as it will lead to an increase in their mathematics self-efficacy which is one of the major factors influencing students' mathematics achievement; (2) a more comprehensive study on the effect of smartphone assisted learning strategy on mathematics self-efficacy should be carried out to either buttress or negate the findings of this study; (3) smartphone assisted instruction as a new paradigm in teaching and learning process should be further explored for its effect on other learning outcomes.

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