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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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EXPLORATION OF GEOMETRY CONCEPTS AT THE TRADITIONAL HOUSE OF TAFATIK MAROMAK OAN MALAKA

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Abstract

Ethnomatematics is an intersection between mathematics and culture, making it a study of mathematical concepts within a specific cultural context. In line with this, the present research aimed to explore the mathematical concepts present in the Tafatik Maromak Oan traditional house. This research is qualitative research with an ethnographic approach. This research was conducted in August 2022 in Wehali Village, Central Malaka District, Malaka Regency. The instruments used are observation guidelines, interview guidelines, and documentation. Participants in this study consisted of 4 people with details of 1 King *(Nain*), 1 traditional housekeeper (*fukun),* 1 craftsman and 1 community member. The stages in this study consisted of domain analysis, taxation analysis, componential analysis, analysis of cultural themes, and drawing conclusions. The results of this study indicate that the mathematical concepts contained in the Tafatik Maromak Oan Malaka traditional house are geometric concepts including rectangles, squares, triangles, circles, lines, cylinders and trapezoids.

Keywords: Ethnomatematics, Exploration, Traditional house of tafatik maromak oan malaka.

Abstrak

Etnomatematika merupakan ruang irisan antara matematika dan budaya, menjadikannya studi tentang konsep matematika dalam konteks budaya tertentu. Sejalan dengan itu, penelitian ini bertujuan untuk menggali konsep matematika yang ada pada rumah adat Tafatik Maromak Oan. Penelitian ini merupakan penelitian kualitatif dengan pendekatan etnografi. Penelitian ini dilaksanakan pada bulan Agustus 2022 di Desa Wehali, Kecamatan Malaka Tengah Kabupaten Malaka.Instrumen yang digunakan adalah pedoman observasi, pedoman wawancara, dan dokumentasi. Partisipan dalam penelitian ini terdiri dari 4 orang dengan perincian 1 orang Raja (Nain), 1 orang penjaga rumah adat (fukun),1 orang tukang dan 1 orang anggota masyarakat. Tahapan dalam penelitian ini terdiri dari analisis domain, analisis taksionamianalisis komponensial, analisis tema budaya, dan penarik kesimpulan. Hasil penelitian ini menunjukan bahwa konsep geometri yang terdapat pada rumah adat Tafatik Maromak Oan Malaka adalah konsep geometri diantaranya, persegi panjang, persegi, segitiga, lingkaran, garis, slinders dan trapisium.

Kata Kunci: *Eksplorasi, Etnomatematika, Rumah adat tafatik maromak oan malaka*.

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INTRODUCTION

Mathematics is actually used by everyone in everyday life. However, many people often fail to realize the practical applications of mathematics in their daily routines. They often perceive mathematics solely as a subject studied in school. In reality, mathematics is an integral part of culture that has existed since ancient times and can be utilized to analyze innovative ideas and embody the values inherent in human culture. Its aesthetic sense and human creativity demonstrate its strength. Human activities in everyday life extensively employ mathematical concepts, including calculation, analysis, and data management (Nuh & Dardiri, 2016).

Mathematics and culture are interrelated and cannot be separated from human life. The relationship between mathematics and culture that underlies human activity is called ethnomathematics (Sari et al., 2021; Alghadari & Son, 2018; Ditasona, 2018; Ditasona, Turmudi, & Rosjanuardi, 2021). The idea of incorporating sociocultural elements into mathematics was initiated in 1977 by a Brazilian mathematician named Ubiratan D'Ambrosio. He coined the term "ethnomathematics" to refer to mathematics practiced by cultural groups or indigenous peoples, which is considered a lens for viewing and understanding mathematics as a cultural product (D'Ambrosio, 2016). Mathematics is a science that helps us understand how ethnomathematics is derived from culture, revealing the relationship between culture and mathematics (Prawati, 2016). According to Wahyuni, Tias, and Sani (2013) ethnomathematics serves as a bridge between education and culture, particularly in mathematics education.

Furthermore, D'Ambrosio (2016) states that the aim of ethnomathematics is to recognize that there are different ways of engaging with mathematics, taking into account the academic mathematical knowledge developed by different sectors of society and considering the various modes through which different cultures negotiate their mathematical practices, such as classification, counting, measuring, designing buildings or tools, and playing. Ethnomathematics is a study that bridges mathematics and culture (Jayanti & Puspasari, 2020).

Various studies on ethnomathematics, such as the ones conducted by Amsikan and Nahak (2017) have found that the concept of space and symbolic systems are integral parts of geometry, closely related to architecture, traditional structures, and modern buildings. The concept of space represents the outcomes of systematic human thinking about existing objects, while the representation results in traditional or modern symbols (Richardo, 2017).

Based on the aforementioned research findings, it becomes evident that traditional houses encompass rich mathematical concepts. This realization has motivated researchers to conduct ethnomathematics research on the Tafatik Maromak oan Malaka traditional house. The Maromak Oan traditional house is located in Laran, Wehali Village, Central Malaka District. It features a thatched roof with gewang ropes, and the walls are constructed using wood and planks. Due to its distinctive characteristics and deeply rooted traditional nature, conducting research on this traditional house is considered important. The aim is to explore the geometry concepts embedded within the Tafatik Maromak Oan Malaka traditional house.

RESEARCH METHOD

This study is an exploratory qualitative research with ethnographic approach . Qualitative research is research that intends to understand phenomena about what is experienced by research subjects, for example behavior, perceptions, motivations, actions and so on, holistically and through descriptions in the form of words and language, in a special natural context. and, by utilizing various scientific methods (Aulia & Rista, 2019).

The approach used in this research is ethnography. This approach focuses on efforts to discover how humans organize their culture in their minds and then use this culture in everyday life, this culture exists in the human mind. The task of ethnography is to find and describe the organization of thought.

This study was carried out at the Tafatik Maromak Oan Malaka traditional house in Wehali Village, Malaka Regency throughout August 2022. Actually, there are many traditional houses in Malaka because each custom has its own traditional house. However, this study focuses only on one particular traditional house, namely the Tafatik Maromak Oan traditional house. The interesting aspect of this traditional house, especially in terms of its name, is that "Maromak Oan" translates to "Child of God" in English. The subjects in this study consisted of 4 people with details of 1 king, 1 traditional house guard or commonly called fukun, 1 builder, and 1 community member from the Maromak Oan Malaka tribe who can provide information about the concept of the Tafatik Maromak Oan Malaka traditional house.

Data collection techniques used in this study are observation, interviews, and documentation. In this study the research instruments used were researchers (human instruments), observation guidelines, interview guidelines, documentation. The data analysis technique adopted a techniques in qualitative research with an ethnographic approach according to Sugiyono (2011), namely domain analysis, taxonomic analysis, componential analysis, and analysis of cultural themes and drawing conclusions.

Data analysis techniques in qualitative research for ethnography consist of domain analysis, taxonomic analysis, component analysis, and analysis of cultural themes. Each of the stages of data analysis carried out in this study, in domain analysis, the researcher conducted a small analysis related to the research and found several domains of ethnomathematics activity that would be used as research centers. Taxonomic analysis is the stage for describing the selected domains in more detail to obtain their internal structure, from the domains or activities that have been determined by the researcher, namely grouping and counting domains/activities, the researcher will focus more on the research carried out. After carrying out a taxonomic analysis, a componential analysis is carried out which aims to organize data that selects differences based on data collection, so the results of the taxonomic analysis will develop into more specific components.

Analysis of cultural themes is the final stage in the data analysis process. Based on the components that have been determined in the componential analysis, the research results will be obtained in the form of cultural findings (ethnomatematic findings). by removing unnecessary data. After the data reduction process, the data presentation will be carried out to continue the data analysis stage. Observations made in this study were direct observations, namely direct observations on Tafatik Maromak Oan. Observations made in this study were direct observations, namely direct observations on Tafatik Maromak Oan. Also in this study, documentation in the form of photos, videos, and interview audio data will be used as supporting data for the results of the observations and interviews.

RESULTS AND DISCUSSION

The parts that are the object of this research are the shape of the roof, *kakuluk mane*, *kakuluk feto*, walls, floors, pillars, doors, musical instruments, betel nut, brooms, *kelewang*, each of which is explained as follows.

The shape of the roof of a traditional house

The shape of the roof of the Tafatik Maromak Oan traditional house is different when viewed from the front and side, as shown in Figure 1.

(a) front view (b) side view

Figure 1. The Shape of the Roof

The roof of the Maromak Oan Tafatik traditional house uses gewang leaves. This traditional house has a different size from traditional houses in general in Malaka. The size of the traditional house is 9×7 meters. When viewed from the front (Figure 1a), the roof of this traditional house is triangular. The shape is said to be a triangle because it is a flat shape bounded by three sides and three vertices. This is in accordance with the notion of a triangle according to Suharjana, Markaban, and Sasongko (2009) that a triangle is a plane figure consisting of three-line segments and all two-line segments meet at the ends. Each line segment that forms a triangle is called a side and the ends where the line segments meet is called vertices.

Figure 1(b) is the roof of a traditional house when viewed from the side. The shape resembles a trapezoid because it is done with accurate calculations. A roof shaped like this has a connection between the pillars of the house in the form of a trapezoidal triangle. It is called a trapezoid because it has four sides that are parallel but not the same length and has vertices, sides and angles. This is in accordance with the definition of Nuharini and Wayuni (2008) that a trapezoid is a quadrilateral that has a pair of parallel opposite sides. The parallel sides are called the base and top sides, while the other sides are called the legs of the trapezoid.

Kakuluk

Kakuluk in the Tafatik Maromak Oan traditional house consist of *Kakuluk mane* and *Kakuluk feto*. The basic material for kakulukmane is round wood with a height of 7 meters and a diameter of 35-40 cm. *Kakuluk mane* is bigger than Kakuluk feto. This differentiates men and women based on the degree in their tribe, that the degree of men is higher than that of women. In *Kakuluk mane* there is a place used to hang betel nut bags, spears (riman) and under *Kakuluk mane* there is a place to store offerings for people who die during traditional ceremonies, while in Kaluk Feto there is Hadak leten as a place to store baskets, barfai (nyiru), dishes (bikan) and other cooking utensils, as well as under Kakuluk. feto also has a stove (lalian) which is used for cooking during traditional ceremonies. The forms of kalukuk mane and feto are shown in Figure 2.

(a) *Kakuluk mane* (b) *Kakuluk feto*

Figure 2. *Kakuluk mane* dan feto

It can be seen in Figure 2 that the mane and feto kakuluk are in the shape of a right triangle. The shape is said to be triangular because it is a flat shape bounded by the presence of three vertices, so it is called a triangular shape. This is in accordance with the notion of a triangle according to Suharjana et al. (2009), a triangle is a flat figure consisting of three-line segments and two-line segments meeting at the ends. Each line segment that forms a triangle is called a side, and the points where the ends of the line segments meet are called vertices. While the center pillar is cylindrical.

Wall

On the wall of Tafatik Maromak aon there are sub-Tafatik which are studied one by one based on their relation to the concept of geometry. For the walls, the material used is a board with a height of two meters, installed virtually around Tafatik Maromak Oan, each wall is limited by 2 (two) small pillars. The geometry concept on the walls and boards is a rectangular flat shape, as shown in Figure 3.

Figure 3. Walls and boards

A wall is called a rectangle because it has the same side lengths and has four angles. The wall is a flat shape formed by two pairs of ribs that are the same length. This is in accordance with the definition developed by Sujatmiko (2005), that a rectangle is a rectangular flat shape that has two pairs of parallel and equal sides and has four right angles where the two sides face each other with the same length and parallel and have two diagonals (crosses) that intersect into two equal parts.

Floor (*Labis*)

Shape of the *labis* after it is made with a height of 1 meter above the ground. Judging from its shape, the geometric concept contained in the Tafatik Maromak Oan *labis* is a rectangle, as shown in Figure 4.

Figure 4. The shape of the floor (*labis*)

It is said to be a rectangle because it is seen from the shape of the *labis* which has the same side lengths and has four angles. *Labis* is a flat shape formed by two pairs of ribs that are the same length. This is in accordance with the definition developed by Sujatmiko (2005), that a rectangle is a rectangular flat shape that has two pairs of parallel sides and the same length and has four equal right angles, namely 90 degrees and has two axes symmetry.

Pole shape

At Tafatik Maromak Oan there are 12 pillars with a height of 3 meters and 28 pillars, each pillar is a circle resembling a tube. This traditional house is different from traditional houses in Malaka Regency as a whole because it has more poles compared to others. This pole has a geometry concept of a tube, as shown in Figure 5.

Figure 5. The shape of the pole

The pole has a tube-like shape. This can be seen from its shape which resembles a circle that is maintained and parallel and has a line that surrounds the two circles.

According to Draja, Peni, and Wondo (2021), a tube is a space in the form of a regular upright prism with a circular base. A tube is a space bounded by two parallel circles of the same shape and size) and a blanket.

Door shape

The door of the Tafatik Maromak Oan Malaka traditional house has 4 doors. Each door has a different meaning, namely the door of the rising sun (omat lasaen). The door is always closed every day, the door is only opened when there is a traditional ceremony. Sunset door (Odamatnrae) This door has the same size as the other doors but has a different meaning. This door is used When the female traditional house guard performs traditional rituals, the door at the front is called (omattlor) as access in and out of the male traditional house -men (fukun mane) and omatsae function as access to and from the women's traditional house (fukun feto) when performing traditional rituals as shown in Figure 6.

Figure 6. The shape of the door (*omatrae)*

It is said to be a square because it has four corners that are the same length and the corners are the same. The door is said to be square because it has a size of one meter square. This is in accordance with the definition of a square according to Nuharini and Wayuni (2008), a square is a rectangular flat shape that has four sides of the same length and has four right angles of 90 degrees and has four axes of folding and rotating symmetry.

Musical instruments

The musical instrument at the Tafatik Maromak Oan Malaka traditional house is the bibiliku or commonly called a drum or likurai which is made of teak or mahogany trees at the bottom, also affixed with goat skin or cow skin at the top, this drum is in the form of a tube where the top diameter is large, and at the bottom in the form of a circle with a small diameter as shown in Figure 7.

Figure 7. The shape of the drum (*my lips)*

If you make a line according to the shape of my aunt, it looks like a tube. Based on its formation, through a circle that is maintained and long and has a line that surrounds the two circles. According to Draja et al (2021), a tube is a space in the form of a regular upright prism with a circular base. A cylinder is a space bounded by two parallel circles of the same shape and size and a blanket.

Betel nut holder (*Kabir feto*)

The place for betel nut is used to put betel nut, lime, good for welcoming guests, traditional ceremonies and this *kabir* has a flat shape when the outline is made like a square, this *kabir* is stored in Tafatik Maromak Oan so it is used for offering areca nut to ancestors who are grave as seen in Figure 8.

Figure 8. Female betel nut (*Kabir feto)*

Judging from the shape of the *kabir*, feto has four corners that are the same length and the same angles, so *kabir* is called a square. *Kabir feto* is made square to store betel nuts. This is in accordance with the definition of a square according to Nuharini and Wayuni (2008), a square is a rectangular flat shape that has four sides of the same length and has four right angles of 90 degrees and has four axes of folding and rotating symmetry.

Men's bag (*Kakaluk mane*)

Kakaluk mane or commonly called this bag is hung right above the *Kakuluk mane*. This bag has a shape or carving like a motif on the bottom with a rhombus-like shape and has a straight-line border in the middle as shown in Figure 9.

Figure 9. Bag (*Kakaluk mane*)

Kakaluk mane is called a rhombus because the shape or image on the *kakaluk mane* stored in the Tafatik Maromak Oan traditional house is rectangular and has an isosceles triangle. This is in accordance with the definition of Sujatmiko (2005) which states that a rhombus is a rectangular flat shape formed from an isosceles triangle and its reflection after being reflected from its base and has two angles that are side by side 180 degrees and have sides that face each other not perpendicular.

Male betel nut holder (*Kabir mane*)

Kabir mane has two models, one is made of woven rope and the other is made of woven cloth, but has the same function, namely to store betel and areca nut. *Kakaluk mane* made of woven has a rectangular shape and each woven is in the form of a parallelogram as shown in Figure 10.

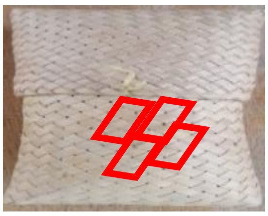


Figure 10. The male betel nut

Kabir mane is called a rectangle because it has the same length of sides and four angles. One of the flat shapes is formed by two pairs of ribs of the same length. This is in accordance with the definition developed by Sujatmiko (2005). *Kabir mane* is woven using a rope and each plait is in the form of a parallelogram, where the two sides face each other with the same length and are parallel and have two diagonals (cross lines) that intersect into two equal parts.

Sweep (right)

This broom has a shape like a line broom which is only used to sweep the Tafatik Maromak Oan traditional house as shown in Figure 11.

Figure 11. Broom (*Knar*)

A broom is called a line because it has one dimension, namely length. As defined by Gulendra (2010), a line is a geometric shape that is described by a moving point, a line has only one dimension, namely the length of the line, it also has three types, namely a straight line, the shortest connecting line between two points that do not coincide and have no end, or base, and the thickness of the diameter cannot be measured.

***Kalewang* (*Surik naruk*)**

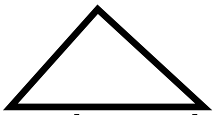
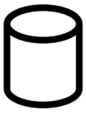
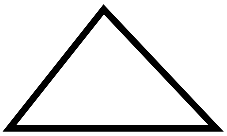
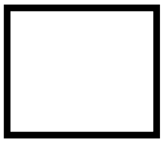
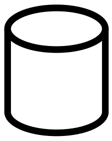
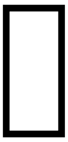
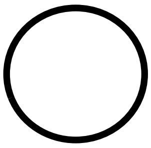
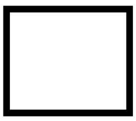
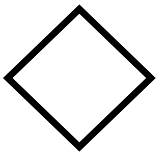
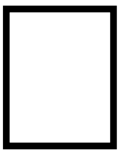
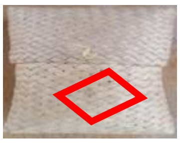
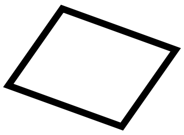
Surik naruk or *Kalewang* is a traditional weapon of the Malaka people which has a shape like a line, *Kalewang* has a long and slender shape with a pointed tip, the *Kalewang* is equipped with a sheath made of wood with carved motifs typical of the Malaka tribe. Wehali community. *Kalewang* is believed by the people, especially in the traditional royal house of Tafatik Maromak Oan Malaka as a means of war in ancient times as shown in Figure 12.

Figure 12. *Kalewang* (*Surik naruk*)

Kelewang is called a line because it has one dimension, namely length. As defined by Gulendra (2010) that a line is a geometric shape that is described by a moving point, a line has only one dimension, namely the length of the line also has three types, namely a straight line, the shortest connecting line between two points that do not coincide and have no end or base, and the thickness of the diameter cannot be measured.

Based on the results of research on the Tafatik Maromak Oan Malaka traditional house, geometry concepts are presented in Table 1.

Table 1. The concept of geometry in the Tafatik Maromak Oan Malaka House

Forming	Geometry Concept	Forming Mathematics	Geometry Concept
 Front look	 Isosceles triangle	 Post	 Cylinder
 Kakuluk	 Triangle	 Door	 Rectangle
 Side view	 Trapezoid	 Drum (my aunt)	 Cylinder
 Wall	 Rectangle	 Circle	 Circle
 Floor (*Labis*)	 Rectangle	 *Surik naruk* (*Klewang*)	Line
 Areca nut holder (*Kabir*)	 rectangle	 Men's bag (*Kakaluk mane*)	 Cut the rice cake
 Areca nut holder (*Kabir mane*)	 Rectangle	 Areca nut holder (*Kabir mane*)	 Parallelogram

CONCLUSION

Based on the results and discussion, it can be concluded that the Tafatik Maromak Oan Malaka traditional house encompasses numerous geometry concepts, including flat shapes and geometric shapes, particularly within the realm of geometry. The geometry concepts are evident in various aspects of the traditional house's construction. For instance, square patterns are displayed on the walls, *labis*, *kabir mane*, and *kabir feto*, while triangles are found on the front and back roofs, trapezoids on the side roofs, circles on the bibiliki, lines on the scallions, and rhombuses on kakaluk mane.

Considering these findings, the researchers recommend that mathematics teachers utilize the outcomes of this study as a valuable resource for teaching mathematics at the school level. Furthermore, it is suggested that future researchers employ the findings of this study as a reference when conducting further research in the field of ethnomathematics, exploring not only traditional houses but also other cultural manifestations.

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SECONDARY SCHOOL STUDENTS SELF-REGULATED LEARNING SKILL AS PREDICTOR OF MATHEMATICS ACHIEVEMENT IN IMO STATE NIGERIA: FOCUS ON GENDER

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Abstract

Mathematics as an abstract subject, requires the application of cognitive strategies such as self-regulated learning skill to predict students' achievement. This paper was designed to investigate the secondary school students self-regulated learning skill as a predictor of mathematics achievement with respect to gender. A correlational survey research design was employed. The sample size consisted of 882 senior secondary students class two (SSII) randomly selected from 14 out of 124 public senior secondary schools in Owerri Education Zone of Imo State. Two different instruments were used for data collection. They are Questionnaire on Self-Regulated Learning (QSRL) and Mathematics Achievement Proforma (MAP). Three experts validated the instrument. The Cronbach Alpha calculated yielded a reliability coefficient of 0.89 for QSRL. The data collected were analyzed using Pearson Product-moment correlation coefficient and regression analysis with the aid of Statistical Package for Social Sciences (SPSS) version 20. The findings revealed that self-regulated learning skills significantly predict male students' achievement in mathematics. The findings also showed that self-regulated learning skill does not significantly predict female students' achievement in mathematics. It was recommended among others that secondary school students should regulate their learning to increase their mathematics achievement.

Keywords: Academic achievement, Gender, Mathematics, Self-regulated learning skill.

Abstrak

Matematika sebagai subjek abstrak membutuhkan penerapan strategi kognitif seperti keterampilan pembelajaran mandiri untuk memprediksi prestasi siswa. Makalah ini dirancang untuk menyelidiki keterampilan pembelajaran mandiri siswa sekolah menengah sebagai prediktor prestasi matematika dengan memperhatikan gender. Desain penelitian survei korelasional digunakan. Sampel terdiri dari 882 siswa sekolah menengah atas kelas dua (SSII) yang dipilih secara acak dari 14 dari 124 sekolah menengah negeri di Owerri Education Zone, Imo State. Dua instrumen berbeda digunakan untuk pengumpulan data, yaitu Kuesioner Pembelajaran Mandiri (QSRL) dan Proforma Prestasi Matematika (MAP). Tiga ahli telah memvalidasi instrumen tersebut. Alpha Cronbach yang dihitung menghasilkan koefisien reliabilitas sebesar 0,89 untuk QSRL. Data yang dikumpulkan dianalisis menggunakan koefisien korelasi Pearson Product-moment dan analisis regresi dengan bantuan Statistical Package for Social Sciences (SPSS) versi 20. Temuan penelitian menunjukkan bahwa keterampilan pembelajaran mandiri secara signifikan memprediksi prestasi siswa laki-laki dalam matematika. Temuan juga menunjukkan bahwa keterampilan pembelajaran mandiri tidak secara signifikan memprediksi prestasi siswa perempuan dalam matematika. Diantara rekomendasi lainnya adalah siswa sekolah menengah harus mengatur pembelajaran mereka untuk meningkatkan prestasi matematika mereka.

Kata kunci: *Gender, Matematika, Prestasi akademik, Self-regulated learning skill.*

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INTRODUCTION

Mathematics is a crucial subject for developing analytical and critical thinking skills in secondary school students in Nigeria. It is a foundational subject for many fields of study and future careers such as medicine, economics, business, finance, science, technology, engineering, and mathematics (STEM), as well as a vital tool for development across all spheres of life (Nigerian Mathematical Society, 2017). According to the Nigerian National Policy on Education, mathematics is one of the core subjects in the secondary school curriculum and is a prerequisite for admission to higher education institutions (Federal Ministry of Education, 2013). Also, a survey by the Chartered Institute of Personnel Management of Nigeria (2019), revealed that employers in Nigeria have deemed mathematics to be one of the top five qualifications that candidates must possess in order to be ready for employment. A study by the National Bureau of Statistics found that mathematics was one of the most important subjects for students in Nigeria, with over 75% of students reporting that mathematics was either "very important" or "extremely important" for their future careers (National Bureau of Statistics, 2018). A number of stakeholders, including the government, educational institutions, and employers, have acknowledged the significance of mathematics in secondary school. Despite the importance of mathematics, students' academic achievement worsens as years go by.

Numerous studies have been conducted regarding the poor mathematics performance of secondary school students in Nigeria both in internal and external examinations (Awofala et al., 2022; Ugwuanyi, Okeke, & Asomugha, 2020; Ndidi & Effiong, 2020; Salami & Ibijola, 2021), particularly on national (external) examinations such as the West African Examination Council (WAEC), National Examination Council (NECO). Reports from Chief Examiners of West African Examinations Council (WAEC) and the National Examinations Council (NECO), showed that poor performance in mathematics continues to be a problem among secondary school students in Nigeria. in 2019, only 54.59% of the students who sat for the WAEC Senior School Certificate Examination (SSCE) in Nigeria obtained a credit pass in mathematics, while 45.41% failed. In 2020, the performance was slightly better, with 65.24% obtaining a credit pass and 34.76% failing. However, the percentage of students who obtained an A1-C6 grade in mathematics decreased from 13.79% in 2019 to 8.94% in 2020. In 2020 there was a significant gender gap in mathematics performance among secondary school students in Nigeria. Out of the 1,538,445 candidates who sat for the examination, only 38.8% of females obtained a credit pass in mathematics compared to 55.9% of males. These figures suggest that there is still a significant gap in mathematics performance among secondary school students in Nigeria. Similarly, in the 2020 NECO examination, only 33.34% of the candidates who sat for the examination obtained credit passes (grades A1-C6) in mathematics, while 31.41% failed the subject. The results also showed a gender gap in mathematics performance, with 36.6% of females obtaining a credit pass compared to 53.4% of males. These numbers show that a sizable portion of Nigerian secondary school students fall short of the basic standards for mathematics proficiency.

Gender disparities in mathematics achievement and self-regulated learning have been identified as significant challenges in the Nigerian educational system (Odeleye & Adeyemo, 2016; Adetula & Akinbobola, 2017). Research has also indicated that there are gender differences in the performance of mathematics and self-regulated learning in secondary school students in Nigeria, with boys generally outperforming girls. Adegoke and Adeneye (2020) found that boys performed better than girls in mathematics, while Odinko and Uzorh (2018) found that boys reported higher levels of self-regulated learning compared to girls. These findings suggest that there is a need to address the gender disparities in mathematics performance and self-regulated learning in Nigerian secondary schools.

The issue of poor academic performance, particularly in mathematics, is a concern that needs to be addressed in line with the goals of the 2030 Agenda for Sustainable Development. To achieve scientific and technological advancement, it is crucial to understand the relative contribution of secondary students' self-regulated learning skills as predictors of mathematics achievement, while considering potential gender differences. The neglect of self-regulated learning skills and the presence of gender disparities in education make it necessary to focus on improving students' abilities to regulate their own learning processes. By addressing this issue, educators and policymakers can work towards narrowing the academic performance gap and promoting equal opportunities for all students in pursuit of scientific and technological progress.

Self-regulated learning refers to the process by which students guide their own learning through metacognition, strategic action, and motivation. Perry, Phillips, and

Hutchinson (2006) described self-regulated learning skill as a combination of these elements, while Zimmerman (2002) defined it as the degree to which students actively participate in their own learning process. Self-regulated learning can be applied in various subject areas, but according to Metallodou and Vlachou (2007), Mathematics is an area where cognitive strategies are particularly important. Dawn (2012) argued that teaching self-regulatory skills is crucial to encourage the use of effective study habits and to build students' self-efficacy and motivation in Mathematics.

Self-regulated learning in mathematics refers to a process whereby students take an active role in their learning by employing cognitive, metacognitive, and behavioral strategies to plan, monitor, and evaluate their learning. In the context of mathematics, self-regulated learners set goals, develop strategies to solve problems, monitor their progress, and adjust their strategies as needed. For instance, a self-regulated learner in mathematics may set a goal to solve a certain number of practice problems each day, develop a strategy for solving complex problems, monitor their progress by checking their solutions against the correct answers, and adjust their approach if they encounter difficulties. By engaging in self-regulated learning in mathematics, students can improve their understanding of mathematical concepts, develop problem-solving skills, and build confidence in their ability to succeed in the subject. This can have a positive impact on their academic achievement in mathematics and beyond.

Mathematics is the study of numbers, numbers, shapes, patterns, and relationships (Kilpatrick, Swafford, & Findell 2001). It encompasses problem-solving, logical reasoning, critical thinking, and analytical skills. Mathematics is a subject that requires the application of self-regulatory processes, such as goal-setting, planning, monitoring, and evaluating one's learning progress. Students engage in self-regulated learning in mathematics by actively managing their own cognitive processes, using appropriate strategies, and maintaining motivation and engagement to achieve mathematical understanding and proficiency. Students, regardless of gender, engage in self-regulated learning in mathematics.

Gender, as defined by the World Health Organization (2022), refers to the societal and cultural expectations, roles, behaviors, and activities that are attributed to individuals based on their perceived identity as male or female. It encompasses the social, psychological, and cultural dimensions of being a man or a woman, as well as the relationships and interactions between individuals in a given society. It is important to note that gender is distinct from biological sex, which pertains to the anatomical and physiological characteristics that distinguish males from females. In the context of mathematics and self-regulated learning skill, gender can play a role in how students engage in the learning process.

Gender, mathematics, and self-regulated learning skills are interconnected in educational settings. Research suggests that there may be gender differences in mathematics achievement and the utilization of self-regulated learning strategies. Studies have shown that girls often report lower levels of self-confidence and self-efficacy in mathematics (Stoet & Geary, 2018). This can lead to decreased engagement, motivation, and persistence in learning the subject. On the other hand, boys may exhibit higher levels of confidence and interest in mathematics, which can positively influence their self-regulated learning behaviors. For instance, a study by Bong (2008) found that girls tend to engage in more self-regulated learning strategies in mathematics when they have higher self-efficacy beliefs. This indicates that girls' self-regulated learning skills in mathematics may be influenced by their perceptions of their own capabilities.

Furthermore, gender stereotypes and societal expectations can play a role in shaping students' attitudes towards mathematics and their self-regulated learning behaviors. Girls may face stereotype threat, where negative stereotypes about their mathematical abilities can affect their self-regulation and performance (Spencer, Steele, & Quinn, 1999). Addressing and challenging these stereotypes is crucial for promoting equitable participation and self-regulated learning in mathematics. Else-Quest, Hyde, and Linn (2010) found that girls tend to demonstrate higher levels of self-regulated learning skills in mathematics compared to boys. Girls were more likely to set goals, plan their mathematical tasks, monitor their progress, and persist in problem-solving. On the other hand, boys were found to rely more on external regulation and task avoidance strategies. Gender differences in self-regulated learning skills may have an impact on mathematics achievement and performance. It is important to take these differences into account when creating educational interventions and support systems, in order to ensure that all students have equal opportunities to succeed.

Research findings regarding the relationship between gender, mathematics performance, and self-regulated learning skills are not consistent and may vary across studies. While some studies suggest that females may have an advantage in self-regulated learning skills and therefore may outperform males in mathematics (Gunderson, Ramirez, Levine, & Beilock, 2012; El-Adl & Alkharusi, 2020), other studies do not necessarily support this conclusion. The relationship between self-regulated learning skills, gender, and mathematics performance is complex and multifaceted.

Studies have examined the relationship between self-regulated learning skills and mathematics achievement in secondary school students, considering gender differences. Cleary and Kitsantas (2017) found that self-regulated learning strategies predicted mathematics achievement, but did not specifically analyze gender differences. However, Zakeri and Ghonsooly (2018) investigated the role of self-regulated learning in mathematics achievement among Iranian secondary school students, with gender as a moderator. Their results showed that self-regulated learning skills significantly predicted mathematics achievement for both male and female students. Additionally, the relationship was found to be stronger for female students, suggesting that self-regulated learning may have a greater impact on the mathematics achievement of females.

Research has explored the relationship between self-regulated learning skills and mathematics achievement in secondary school students, taking into account gender differences. Findings indicate that self-regulated learning skills, including goal setting, planning, monitoring, and self-evaluation, significantly predict mathematics achievement. Moreover, gender moderates this relationship, suggesting that the impact of self-regulated learning on mathematics achievement may vary between males and females. While the specific dynamics of this relationship may differ across studies, it highlights the importance of considering gender as a factor when examining the role of self-regulated learning skills in predicting mathematics achievement in secondary school students.

The study was guided by two research questions. Firstly, to what extent does learning style, self-regulated learning skill and achievement motivation individually predict male students' achievement in Mathematics? Secondly, to what extent does self-regulated learning skill predict female students' achievement in Mathematics?

The following null hypotheses were tested at 0.05 level of significance: firstly, self-regulated learning skill does not significantly predict male students' achievement in

Mathematics. Secondly, self-regulated learning skill does not significantly predict female students' achievement in Mathematics.

RESEARCH METHODS

The study adopted a correlational survey research design. The population is made up of 17,637 (8,878 males and 8,759 females) senior secondary school students 2017/2018 in the government public secondary schools in Owerri Education Zone of Imo State, Nigeria. A total of 882 (486 males and 396 females) senior secondary students from 14 out of 124 secondary schools in Owerri Education Zone of Imo State were involved in the study. The researchers adopted a simple random sampling technique to draw the sample. Selection of male and female was done by proportion of their population.

The instruments used for data collection were Questionnaire on Self-Regulated Learning (QSRL) and Mathematics Achievement Perform. The self-regulated learning questionnaire was used to collect data on self-regulated learning (SRL), and consisted of 22 items. This Questionnaire was an adaptation of an instrument developed by Pintrich and De Groot (1990). Same items (items 7, 15 and 21) were minimally adjusted to suit the current study. The cumulative average scores of students' results were used as their academic achievement scores. The instruments were validated by experts. The reliability was established using Cronbach Alpha which was found to be 0.89. The administration of instruments was done by the researcher with the help of research assistants and this facilitated easier administration and retrieval of the instruments. Only valid (876 correctly filled; 483 males and 393 females, approximately 99.3%) instruments were used for analysis.

Table 1. Relationship Category

Correlation (*r*)	Relationship
0.00 to 0.19	Very weak correlation
0.20 to 0.39	Weak correlation
0.40 to 0.59	Moderate correlation
0.60 to 0.79	Strong correlation
0.80 to 1.00	Very strong correlation

The data collected were analyzed using correlation coefficient for research question and multiple regression analysis for null hypothesis at 0.05 alpha level with the aid of (SPSS) version 20. Decision rule for correlation coefficient was adopted from Best and

Kahn (2013) who provided the following rules for judging the strength of correlation between two variables.

The decision to reject or accept a null hypothesis was based on the probability value (*p*-value) and the 0.05 significance level. Where the *p*-value is less than 0.05 alpha level, the null hypothesis is rejected, if otherwise not.

RESULTS AND DISCUSSION

The results in Table 2 from the correlation analysis, the correlation coefficient (*r*) of 0.186. The result shows the summary of the relationship between male students' self-regulated learning skill and their mathematics achievement. The result revealed a very weak positive relationship between self-regulated learning skill of secondary school male students and their mathematics achievement. Self-regulated learning skills predicts 3.4% to the variance observed in male students' achievement in mathematics. This shows that an improvement in self-regulated learning skill would lead to a small increase in male students' mathematics achievement.

Table 2. Analysis of Correlation Coefficient for Male

Variables	*N*	*r*	r^2	Predictive value (%)
Self-regulated learning skill	483	.186	.034	3.4
Mathematics Achievement	483			

The results in Table 3 from the correlation analysis, the correlation coefficient (*r*) of 0.024. The result shows the summary of the relationship between female students' self-regulated learning skill and their mathematics achievement. The result revealed a very weak positive relationship between self-regulated learning skill of secondary school female students and their mathematics achievement. Self-regulated learning skill predicts 0.1% to the variance observed in female students' achievement in mathematics. This shows that an improvement in self-regulated learning skill would lead to a small increase in female students' mathematics achievement.

Table 3. Analysis of Correlation Coefficient for Female

Variables	*N*	*r*	r^2	Predictive value (%)
Self-regulated learning skill	393	.024	.001	0.1
Mathematics Achievement	393			

From the result of the regression analysis, the statement of null hypothesis is rejected for self-regulated learning skill (self-regulated learning skill does not significantly predict male students' achievement in mathematics); implying that self-regulated learning skill significantly predicts male students' achievement in mathematics. This is because the *p*-value (*Sig*. = 0.000) is less than the 0.05 level of significance.

Table 4. Significant Prediction of Predictor Variable to Mathematics Achievement for Male

Variables	*N*	*r*	r^2	*F*	*Sig.*
Self-regulated learning skill	483	.186	.034	17.181	.000
Mathematics Achievement	483				

From the result of the regression analysis, the statement of hypothesis 2 is accepted for self-regulated learning skill (self-regulated learning skill does not significantly predict female students' achievement in mathematics); implying that self-regulated learning skill does not significantly predict female students' achievement in mathematics. This is because the *p*-value (*Sig*. = 0.636) is greater than the 0.05 level of significance.

Table 5. Significant prediction of predictor variable to Mathematics achievement for female

Variables	*N*	*r*	r^2	*F*	*Sig.*
Self-regulated learning skill	393	.024	.001	.224	.636
Mathematics Achievement	393				

The result revealed a very weak positive relationship between self-regulated learning skills of secondary school male students and their mathematics achievement. This shows that an improvement in self-regulated learning skill would lead to an increase in male students' mathematics achievement. While the result also revealed a very weak positive relationship between self-regulated learning skills of secondary school female students and their mathematics achievement. This shows that an improvement in self-regulated learning skill would lead to a small increase in female students' Mathematics achievement. It suggests that the relationship between self-regulated learning skills and mathematics achievement may not be as strong or consistent for female students as it is for other groups or factors. This result indicates that self-regulated learning skills may not be the primary predictor of mathematics achievement specifically for female students in the studied context. It is important to note that this outcome does not diminish the value or importance of self-regulated learning skills in general. Self-regulated learning skills have been widely recognized as crucial for academic success across various subjects and student populations. However, the specific dynamics and factors influencing mathematics achievement for female students may differ from those seen in other contexts or populations.

From the result of the regression analysis, the statement of hypothesis was rejected for self-regulated learning; implying that self-regulated learning skill significantly predicts male students' achievement in Mathematics. From the result of the study, there is no significant prediction of self-regulated learning skill to female students' achievement in Mathematics. This study contrasts study conducted by Al-Hmoud and Albalawi (2018), which found that self-regulated learning was a significant predictor of mathematics achievement. The finding that self-regulated learning skills significantly predict mathematics achievement in male students but not in female students suggests the presence of gender differences in the relationship. This discrepancy could be due to variations in the types of self-regulated learning strategies employed by male and female students, as well as the influence of other factors such as motivation and interest on mathematics achievement. These findings differ somewhat from previous studies, such as (Gunderson, Ramirez, Levine, & Beilock, 2012; Zakeri & Ghonsooly, 2018; Ma & Klinger, 2019; El-Adl & Alkharusi, 2020), which reported a stronger relationship between self-regulated learning and mathematics achievement in female students compared to male students.

The finding that self-regulated learning significantly predicts male students' achievement in mathematics is consistent with previous literature highlighting the importance of self-regulated learning in academic success. This suggests that male students who possess stronger self-regulated learning skills may be better equipped to manage their learning processes and employ effective strategies to excel in mathematics. It underscores the importance of promoting self-regulated learning skills among male students to enhance their mathematics achievement. Various studies have consistently demonstrated the positive relationship between self-regulated learning and mathematics achievement in male students. Pintrich and De Groot (1990) found that self-regulated learning strategies, including goal setting, planning, and self-monitoring, significantly predicted mathematics achievement among college students. Zimmerman and Kitsantas (2005) reported similar findings, highlighting the predictive role of self-regulated learning skills in male students' mathematics performance. Karimi and Venkatesan (2017) found a positive association between self-regulated learning and academic achievement in mathematics among male students in Iranian high schools. Similarly, Erdem Keklik and Keklik (2013) found that self-regulated learning positively predicted mathematics achievement in Turkish male secondary school students. El-Adl and Alkharusi (2020) further supported these findings by demonstrating a positive correlation between self-regulated learning strategies and mathematics achievement in male students at the middle school level. These studies collectively highlight the importance of fostering self-regulated learning skills in male students to enhance their mathematics achievement.

CONCLUSION

The results of this study presented evidence of the existence of a positive relationship between self-regulated learning skill and students' achievement in Mathematics with respect to gender. Self-regulated learning skills significantly predict mathematics achievement in male students but not in female students.

Based on the findings of the study, the following recommendations were made. Firstly, secondary school students should regulate their learning to increase their mathematics achievement. Schools should provide opportunities for students to learn and practice self-regulated learning skills such as goal setting, planning, monitoring, and self-evaluation. This can be done through classroom activities, workshops, and training programs.

Secondly, to address gender differences in the relationship between self-regulated learning and mathematics achievement, future research should investigate effective self-regulated learning strategies for male and female students and explore potential barriers that may impact female students' utilization of these skills in mathematics.

Thirdly, to provide teacher professional development to enhance their knowledge and skills in promoting self-regulated learning in mathematics education.

Fourthly, schools should collaborate with parents to support the development of self-regulated learning skills in students. Parents can be involved in goal setting, monitoring, and providing feedback to their children.

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ANALYSIS OF STUDENTS' DIFFICULTIES IN SOLVING PROBLEMS RELATED TO SOLID GEOMETRY

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Abstract

The aim of this research is to identify the challenges faced by students when solving problems related to solid geometry. The research design employed in this study is descriptive qualitative research. The target population was 23 class VI MI Muhammaduddarain students in the 2022/2023 academic year, who were selected using purposive sampling. The research sample consists of three students who encountered difficulties while solving problems in solid geometry. The selection of research subjects was based on their work, which exhibited the most errors in problem-solving related to solid geometry. Data collection techniques encompassed interviews, tests, and documentation. The research findings indicate that the students encountered various difficulties when solving problems related to solid geometry, including (1) challenges in comprehending the concepts, (2) difficulties in applying principles, and (3) struggles in employing process skills.

Keywords: Geometric material, Mathematical difficulties, Students' difficulties.

Abstrak

Tujuan penelitian ini adalah untuk mengidentifikasi tantangan yang dihadapi oleh siswa saat menyelesaikan masalah terkait geometri ruang. Desain penelitian yang digunakan dalam studi ini adalah penelitian kualitatif deskriptif. Populasi target adalah 23 siswa kelas VI MI Muhammaduddarain pada tahun akademik 2022/2023, yang dipilih menggunakan purposive sampling. Sampel penelitian terdiri dari tiga siswa yang mengalami kesulitan saat menyelesaikan masalah dalam geometri ruang. Pemilihan subjek penelitian didasarkan pada pekerjaan mereka, yang menunjukkan kesalahan terbanyak dalam menyelesaikan masalah terkait geometri ruang. Teknik pengumpulan data meliputi wawancara, tes, dan dokumentasi. Temuan penelitian menunjukkan bahwa siswa menghadapi berbagai kesulitan saat menyelesaikan masalah terkait geometri ruang, termasuk (1) tantangan dalam memahami konsep, (2) kesulitan dalam menerapkan prinsip-prinsip, dan (3) kesulitan dalam menggunakan keterampilan proses.

Kata kunci: *Kesulitan matematika, Kesulitan siswa, Materi geometri.*

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INTRODUCTION

In the realm of education, mathematics plays a crucial role as it is intertwined with almost all fields of study. It is essential for individuals to have a solid understanding of mathematics as it serves as a powerful tool for problem-solving in everyday life. Mathematics is an integral part of education, from elementary school to university level. However, it is worth noting that many students still perceive mathematics as a challenging subject, leading them to avoid it (Hardiansyah et al., 2022; Kristin et al., 2021; Nursalam, 2016; Qolbi et al., 2022; Rosalinda et al., 2022). According to Zanthy (2016), studying mathematics constantly demands the development of students' thinking skills, as it is an important subject that can be applied to various real-life problems using mathematical models. Engaging with mathematics helps individuals develop logical, scientific, critical, and creative reasoning skills. Furthermore, Suherman et al. (2003) describes how mathematics teaches structured patterns and regularity. Mathematical concepts are introduced in a logical, systematic, and hierarchical manner, progressing from the simplest understanding to more complex concepts.

Abdurrahman (2012) suggests that there are five reasons for learning mathematics: as a means for clear and logical thinking, as a method for solving problems in everyday life, as a means for recognizing patterns and generalizations through experience, as a means to develop one's creativity, and as a means to increase awareness of cultural development. In the learning process carried out in schools, mathematics is one of the subjects in the spotlight. This is caused by a large number of students who experience difficulties in solving math problems, particularly those found in mathematics lessons. More specifically, students find it challenging to understand geometric material (Fauzi et al., 2019; MdYunus et al., 2019), due to difficulties in forming real and accurate constructions, requiring precision in measurement, taking a significant amount of time, and many students even face obstacles in proving their answers (Noto et al., 2019). Geometry, a branch of mathematics closely related to everyday life, studies three-dimensional geometric shapes and their elements, namely points, lines, and planes. Although it has practical applications, geometry is a branch of mathematics that poses challenges in understanding. Therefore, it is necessary to analyze the causes of the difficulties students face (Kusuma & Rahmawati, 2019). Geometry is taught as a subject in elementary schools and is closely tied to the formation of abstract concepts. To achieve this learning, direct student participation in various activities is essential, going beyond mere transmission of information through lectures or other methods (Nurhasanah et al., 2017).

In studying geometry, students need to have a mature understanding of the concepts. This enables them to apply their geometric skills, such as visualizing, identifying various shapes and areas, describing images, sketching shapes, marking specific locations, and having the ability to distinguish and compare geometric shapes (Muhassanah et al., 2014). However, students' mastery of geometric material has a relatively low percentage compared to the material taught in class VIII (Kusuma & Susanty, 2019). Dadang's research (2018) suggests that the understanding and creative thinking capacity of junior high school students in relation to flat shape material is categorized as low due to its influence on student psychology.

According to Hasibuan (2018), students face difficulties in learning mathematics, particularly in understanding how the concept determines the surface area of a cube, beam, prism, pyramid, and the volume of a pyramid. Furthermore, students struggle to differentiate between diagonal spaces and diagonal fields. These difficulties in mathematics can be characterized by the inability to remember one or more terms of a concept within the material. This indicates that students still encounter challenges in interpreting mathematical concepts during the learning process.

Moreover, students frequently make errors when solving problems. While working on questions, several common mistakes were identified, including a lack of understanding of symbols, place values, calculations, incorrect use of processes, and illegible writing (Abdurrahman, 2012). This finding is consistent with the research conducted by Ariyani (2019), who discovered that some students made mistakes in understanding word problems.

There are several causes for the mistakes made by students, including: (a) Students often rush and fail to pay attention to the units mentioned in the questions, (b) Students may lack attentiveness when reading and comprehending the questions, (c) Students face difficulty in identifying the given information in the problem, (d) Students may overlook or misunderstand the requirements stated in the problem, (e) Students frequently forget or neglect to record the given information while solving problems. Baskorowati and Wijayanti (2020) suggest that one of the reasons students make mistakes when solving arithmetic problems presented as story problems is their incomplete understanding of the problem's intention.

The inclusion of story questions in spatial material poses a significant challenge for many students, resulting in lower performance compared to criterion-based questions in geometric shapes. According to Shoimah (2020), the abstract nature of mathematical objects, including facts, concepts, operations, and principles, requires more than just memorization and formula usage in the learning process. To enhance the understanding of abstractness in mathematics, it is crucial to foster connections and multiply the diversity of concepts. In the context of geometric learning, students are not only expected to comprehend the abstract nature of geometric shapes but also to explain definitions by directly observing the objects.

When students engage with geometric materials, they often encounter difficulties, particularly when working on problems related to surface area and volume. This observation aligns with the research findings which indicate that students' scores in the realm of geometric shapes are consistently low and require improvement (Sumadiasa, 2014). According to information provided by teachers, students frequently make mistakes during the calculation process when solving questions related to geometric shapes.

Based on observations conducted in class VI at MI Muhammaduddarain, it has been identified that students face challenges with math lessons involving geometric materials. Additionally, the researcher conducted interviews with educators from the same class to understand their perception of the difficulties faced by students when solving mathematical problems related to geometric material. The interviews revealed that some students continue to struggle with solving questions on geometric material. The class teacher also expressed that geometric material is the most challenging topic for students to grasp. Several factors contribute to this situation, including a weak mastery of geometric material, a lack of knowledge about basic mathematical concepts, and student's inadequate attention during the teaching and learning process.

Based on the results of the Middle Semester Assessment (in Indonesia it is called *Penilaian Tengah Semester*, PTS), the overall mathematics scores of class VI at Muhammaduddarain MI are still below the Minimum Completeness Criteria (in Indonesia it is called *Kriteria Ketuntasan Minimal*, KKM) of 75. This indicates that none of the students in class VI at MI Muhammaduddarain have fully grasped the concept of spatial geometry. The low scores in mathematics can be attributed to several factors, including difficulties in understanding concepts, challenges in applying principles, and struggles with process skills. To improve the student's learning outcomes in mathematics, it is essential for them to possess strong foundational arithmetic skills. Mathematics materials are interconnected and multilevel, making a solid grasp of the basics crucial for understanding the concepts taught by the teacher. Additionally, students should demonstrate enthusiasm and focus during their learning activities. Given the aforementioned challenges, an analysis is necessary to address the difficulties students face in solving mathematical problems related to geometric shapes. The analysis will involve the use of tests, interviews, and documentation to gather relevant data and insights.

Based on the information provided, the researcher acknowledges the necessity of conducting a study to explore the difficulties that students encounter when solving problems related to geometric materials. The proposed research will be titled "Analysis of Students' Difficulties in Solving Problems in Building Spatial Materials". The study will focus on investigating the types of difficulties students face, including challenges in understanding concepts, applying principles, and utilizing process skills. In general, this section provides an overview of the background, problem formulation, and research objectives. In scientific studies, this introductory section typically includes the background and objectives or scope of the writing, while research articles encompass the background of the problem, problem formulation, and objectives.

RESEARCH METHODS

This research employs a qualitative descriptive research methodology. According to Moleong (2017), qualitative research aims to comprehend the phenomenon experienced by research participants holistically, such as their behaviors and perceptions, through natural methods and by utilizing descriptive language and words within a natural context. Sugiyono (2011) states that qualitative research is rooted in the philosophy of postpositivism. It is particularly suitable for studying natural objects, where the researcher serves as the key instrument, and data collection techniques involve triangulation, combining multiple approaches. The data analysis in qualitative research is inductive and emphasizes the interpretation of meaning rather than generalization.

This study will utilize the collected information to analyze the difficulties faced by students when solving mathematical problems using geometric materials. The study population consists of 26 students, including 10 boys and 16 girls. The subjects of the study are three students from class VI at MI Muhammaduddarain for the 2022/2023 Academic Year. The research sample was selected based on the students who made the most mistakes in solving problems related to geometric materials. Additionally, subjects were chosen based on the diversity and uniqueness of their answers, as well as their communication skills. To ensure data accuracy and validity, a data validation technique will be employed during the data analysis process.

The utilization of qualitative methods in this study is highly appropriate as it aligns with the research objective of describing the types of difficulties students face when solving problems related to geometric materials. The study employs two main sources of data, namely primary data sources and secondary data sources. The primary data source in this study consists of the answer sheets of class VI students at MI Muhammaduddarain. Purposive sampling is employed as the data collection technique to select the specific students whose answer sheets will be analyzed. On the other hand, the secondary data sources encompass teachers specialized in mathematics for class VI, documents, academic records, books, and photographs from activities conducted during the research period. The data collection techniques utilized in this study include interviews, tests, and documentation. These methods, along with their respective instruments, are employed to gather relevant and comprehensive data for the analysis of students' difficulties in solving problems related to geometric materials.

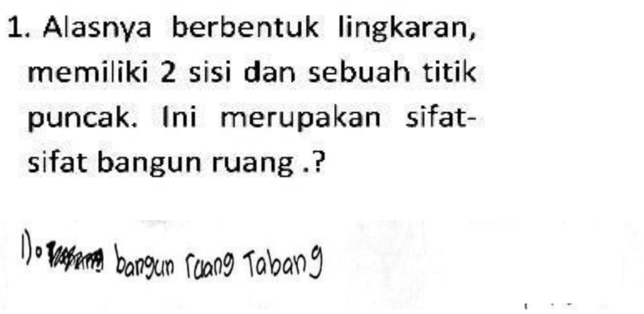
In this study, the validity of the data is ensured through the use of a triangulation technique. The triangulation technique, as described by Wau, Hesti A., et al. (2022), involves cross-checking the validity of data by utilizing additional sources or methods for comparison or verification. In this research, the validity of the data is established by comparing the results obtained from student answer sheets with the findings derived from interviews conducted with the research sample, which consists of the students themselves. Through the triangulation method, the study aims to identify the types of difficulties students encounter when solving problems related to geometric materials, specifically difficulties in understanding concepts, applying principles, and utilizing process skills. The data analysis technique employed in this research follows the Miles and Huberman model, as outlined by Ananda (2018). This model includes three stages: data reduction, data presentation, and drawing conclusions or verification. In qualitative research, the validity of findings or data can be ascertained when there is consistency between the researcher's report and the actual events observed in the study. To ensure such consistency, researchers employ the triangulation method, comparing data obtained from two similar problems at different times. By implementing these methods, the study strives to maintain the validity and reliability of the data collected and analyzed, enhancing the overall quality of the research findings.

RESULTS AND DISCUSSION

Based on the test results obtained from the 26 students, it was found that 5 students (19.22%) scored in the high category, 57.70% scored in the medium category, and 23.08% scored in the low category. The research commenced with learning observations on the spatial concept material in class VI. The focus of the research was to select research subjects only from students who fell into the moderate category based on their test scores. Subsequently, in-depth interviews were conducted with the selected research subjects. The teaching and learning process was monitored for a duration of 2 hours, equivalent to one class session. Following the observations, the students were provided with material related to geometric shapes, and they were subsequently given a test consisting of three questions to identify areas of difficulty. The test questions were essay-based, allowing for a more comprehensive understanding of the students' thought processes and problem-solving abilities.

Difficulty in understanding the concept

During the interviews conducted between the researchers and the students, it was identified that students face difficulties in understanding the concepts and properties of geometric figures, specifically in relation to conical shapes. This example highlights the challenges students encounter in comprehending the nature of conical shapes.


1. Alasnya berbentuk lingkaran, memiliki 2 sisi dan sebuah titik puncak. Ini merupakan sifat-sifat bangun ruang .?

1). bangun ruang Tabang

Figure 1. The Results of Student Worksheets for Question No.1

The interview results shed light on the specific difficulties experienced by the students.

P : "Is there a part that you can't understand from the problem?"
S1 : "There is ma'am. I'm still confused on the difference between the properties of a cone and a cylinder. The problem is that both are based on a circle."
P : "Isn't it obvious that a cone has a peak, whereas a cylinder doesn't."
S1 : "So like that, ma'am."
P : "In addition, you need to remember that a tube has no corner points, while a cone has 1 corner point, namely at the tip of the cone."
S1 : "Oh, that's right ma'am, how to tell the difference. Thank you mom. The problem is that at the time of presentation and discussion of the material I did not pay much attention, that's why I did not understand this material. Because I think it's difficult, ma'am."

Based on the interview results, it can be concluded that students exhibit a lack of attentiveness during teaching and learning activities, primarily due to perceiving geometric material as difficult to comprehend. Consequently, students' motivation and interest in learning are negatively impacted. This is evident in the interview session where students struggled to grasp the differences in characteristics. Specifically, students faced difficulties in understanding the concept of spatial properties. This finding aligns with previous research that highlights students' learning barriers concerning squares and rectangles based on their properties (Nursaidah & Pranata, 2018).

To address students' difficulties in understanding the concept of geometric properties, educators can employ teaching aids or effective learning media. This suggestion is supported by research conducted by Jagom, Uskono, and Fernandez, (2020), which demonstrated that the use of mathematical teaching aids as learning media improved students' engagement and understanding of the concepts. Despite efforts to facilitate learning, students still face challenges in understanding the material related to Flat Sided Space Construct, particularly when solving problems. This difficulty can be attributed to a lack of accuracy in comprehending the questions (Fahlevi & Zanty, 2020). Similarly, research conducted by Melisari et al. (2020) identified that grade IV SDS Pangkalan students frequently encounter difficulties in understanding questions when attempting to solve arithmetic problems involving flat shapes. These findings highlight the importance of addressing students' difficulties in understanding geometric material and developing strategies to enhance their comprehension and problem-solving skills.

In addition, students require effective learning methods to facilitate their understanding of geometric concepts. The learning methods are techniques that educators or teachers must master in order to present the subject matter to each student in the class, both individually and in groups, thus enabling students to grasp the taught material more easily.

Difficulty in applying principles

The students' proficiency in understanding geometric materials can be considered inadequate. It is evident that students face difficulties when solving given questions. While attempting to answer questions, students display imprecision in identifying the appropriate formula for solving geometric problems. Some students even forget the geometric formulas that were previously taught, leading to incorrect answers. The following are samples of students' work, in Figure 2.

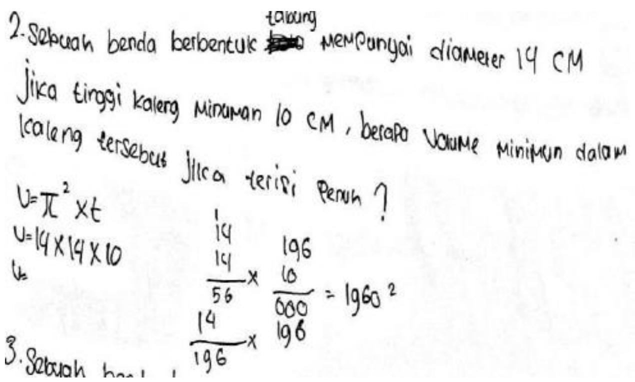


Figure 2. The Results of Student Worksheets for Question No.2

The results of the interview are as follows.

P :	*"What were your difficulties when working on the problem of constructing a cylinder chamber?"*
S2:	*"I feel confused when I have to calculate the volume of the cylinder."*
P :	*"What is it that makes you confused?"*
S2:	*"Sometimes I forget the formula for the volume of a cylinder because there are a lot of geometric shapes to learn too. Then there are many different volume formulas, so it makes me confused when I answer."*

This is evident in cases where students make mistakes or omissions in writing formulas. These students rely solely on memorization techniques, resulting in frequent forgetfulness of the formulas and a lack of comprehension of the given questions. Consequently, students experience confusion, leading to incorrect and inaccurate problem-solving. This aligns with the notion presented by Jumiati and Zanthy (2020), who state that many students face difficulties when solving problems and comprehending questions, deeming them challenging.

Hence, it is imperative for students not only to memorize formulas but also to have a thorough understanding of them and engage in extensive problem-solving practice. By practicing the resolution of questions, students will comprehend the process of utilizing the formulas, and with sufficient practice, they will easily recall the formulas on their own.

Difficulties of students in process skills

To identify the challenges encountered by students in problem-solving, the researcher administered a test consisting of story questions. These word problems demand systematic thinking and a step-by-step approach to finding solutions. Students are expected to analyze the given information carefully. Therefore, they should be capable of distinguishing between the known elements (what is "given") and the desired information (what is "asked") when attempting to answer the questions. However, in practice, students frequently provide only the final answers without showing any calculations or problem-solving processes. The student work sample, presented in Figure 3, provides insights into the difficulties faced by students in this regard.

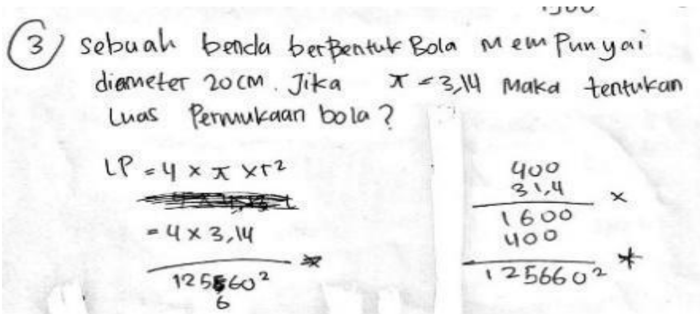


Figure 3. The Results of Student Worksheets for Question No.3

The results of the interview are as follows.

P	:	*What are your difficulties in doing question no. 3?*
S3	:	*I'm still confused about how to calculate it.*
P	:	*What's confusing you? How to calculate the surface area of a sphere?*
S3	:	*Yes, mother. I also find it difficult to calculate multiplication to answer that question.*
P	:	*From now on you have to get used to doing practice questions at home, so that you are able to solve questions correctly and correctly.*
S3	:	*Okay, ma'am. Later I will study it again at home.*

Based on the student's work (S3) on question number 3, it is evident that students are still not following systematic problem-solving steps or employing proper procedures.

This is apparent from the absence of information regarding what is "known" and what is "asked" in their responses. To minimize errors in students' understanding, it is crucial for them to practice extensively, independently working on problems. This practice will help improve their problem-solving abilities and enable them to develop the habit of accurately noting the given information and the desired information in questions. This aligns with the findings of Ario (Lestari, Aripin, & Hendriana, 2018), who identified issues among students such as a lack of precision in comprehending questions, making calculations, and remembering formulas.

It is evident that students' calculation process is prone to inaccuracies, as reflected in their incorrect final answers. This error can be attributed to students' lack of attentiveness when answering questions and their insufficient mastery of basic arithmetic operations such as multiplication and division. Due to their inadequate understanding of arithmetic concepts and operations, mistakes are bound to occur, leading to incorrect results.

To minimize such errors, it is crucial to encourage students to consistently double-check their answers and problem-solving steps. Additionally, it is important to address students' weaknesses in arithmetic operations by revisiting the concepts of addition, subtraction, multiplication, and division. Students should engage in extensive practice, working on exercises that involve continuous arithmetic operations to enhance their foundational arithmetic knowledge. By doing so, they can improve their accuracy in calculations and develop a stronger grasp of arithmetic operations.

CONCLUSION

Based on the results and discussions presented, several key difficulties have been identified in students' ability to solve mathematical problems related to geometric material. These difficulties include: (1) difficulties in understanding concepts, (2) difficulties in applying principles, and (3) difficulties in process skills. The interviews conducted with students revealed their struggles in comprehending and applying geometric concepts and principles, even when provided with visual stimuli such as pictures to enhance understanding. Therefore, it is recommended for teachers to utilize concrete or real learning media and teaching aids to facilitate better understanding.

Additionally, students have shown a lack of systematic problem-solving approaches, as evidenced by their failure to write down relevant information about what is known and what is being asked in the questions. Furthermore, students often rely on memorization techniques, resulting in a tendency to forget formulas and consequently struggle to solve questions accurately.

To address these challenges, it is crucial to emphasize the importance of practice in problem-solving. By engaging in extensive practice, students can develop a deeper understanding of the formulae used and improve their ability to recall them. Moreover, it is necessary to consider factors that contribute to students' difficulty in understanding geometric materials, such as limited attention during lessons and low motivation and interest in learning. In light of these factors, teachers are advised to employ effective and tailored learning methods, such as Problem-Based Learning (PBL), which can enhance students' engagement and comprehension of the subject matter.

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MATHEMATICS RESILIENCY IN THE NEW NORMAL: A THEORY DEVELOPMENT

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Abstract

This paper aimed to generate a theory that answers the question, "How do students cope with the challenges in learning mathematics in the normal? This study made used of the deductive axiomatic approach in theory generation following the steps prescribed by Padua (2012). Four axioms were formulated: (1) Students employ time management in studying math; (2) Students uses compensation strategies in overcoming challenges; (3) Students' resourcefulness leads them to learn mathematics; and (4) Students asked help from teachers and peers in understanding mathematical concepts. Two propositions were derived from these axioms: students' cope with the challenges in learning mathematics by (1) direct coping strategies support students' resiliency in learning mathematics and (2) Indirect coping strategies indirectly provide support for coping strategies through planning, socializing with others and increasing empathy. From these propositions, the Students' Mathematics Resiliency Based Theory is formulated: The Students' Mathematics Resiliency Theory states that resiliency in learning mathematics is affected by both direct and indirect coping strategies. Direct coping strategies include compensation strategies, while indirect strategies include social, time management, and resourcefulness.

Keywords: Coping mechanism, Deductive theory development, Resiliency.

Abstrak

Makalah ini bertujuan untuk menghasilkan suatu teori yang menjawab pertanyaan, "Bagaimana siswa mengatasi tantangan dalam pembelajaran matematika secara normal?" Studi ini menerapkan pendekatan aksiomatik deduktif dalam menghasilkan teori dan mengikuti langkah-langkah yang ditentukan oleh Padua (2012). Empat aksioma dirumuskan: (1) Siswa menggunakan manajemen waktu dalam mempelajari matematika; (2) Siswa menggunakan strategi kompensasi dalam mengatasi tantangan; (3) Keterampilan siswa membawa mereka untuk belajar matematika; dan (4) Siswa meminta bantuan dari guru dan teman sebaya dalam memahami konsep matematika. Dua proposisi diperoleh dari aksioma-aksioma ini: siswa mengatasi tantangan dalam pembelajaran matematika melalui (1) strategi penanganan langsung yang mendukung resiliensi siswa dalam mempelajari matematika, dan (2) strategi penanganan tidak langsung yang secara tidak langsung memberikan dukungan bagi strategi penanganan melalui perencanaan, bersosialisasi dengan orang lain, dan meningkatkan empati. Dari proposisi-proposisi ini, dirumuskanlah Teori Resiliensi Matematika Siswa: Teori Resiliensi Matematika Siswa menyatakan bahwa resiliensi dalam mempelajari matematika dipengaruhi oleh strategi penanganan langsung dan tidak langsung. Strategi penanganan langsung meliputi strategi kompensasi, sedangkan strategi tidak langsung meliputi aspek sosial, manajemen waktu, dan kemampuan dalam menggunakan sumber daya.

***Kata kunci**: Ketangguhan, Mekanisme penanganan, Pengembangan teori deduktif.*

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INTRODUCTION

This present time of the global pandemic of COVID 19 poses more stressful and adverse psychological problems among our students. As students are confronted with these challenges in their day-to-day living, these affect their way of thinking and the way they deal with others and manage situations. Thus, these impel students to cope and be able to manage challenges.

In the teaching and learning process that practically happens daily, resilience is the most important factors in dealing with challenges (Masten, 2014). It encompasses the ability of a system, given such condition of its being dynamic, to adapt disturbances successfully, which by principle threaten the functionality, viability, and development of the said system (Lehmann & Joseph, 2015). Resilience observed to have positive effects on reducing depression among college students (Zamirinejad et al., 2014; Wu et al., 2020) and on alleviating mental health problems among children and adolescents (Smith et al., 2018; Dray et al., 2017; Wu et al., 2020). However, most existing studies about resilience and coping styles among university students are done separately, but only a few investigated its relationship (Wu et al., 2020). Further, the majority of these few studies examined the relationship between resilience and coping among adults and patients (Chen, Das, & Ivanov, 2019; Chen, Song, & Wei, 2017) and the relationship between resilience and coping among undergraduate students (Chen, 2016; Wu et al., 2020). But, the nature of the relationship between resilience and coping styles of students has not been established. In addition, inconsistent findings are reported in the literature.

Examining the coping mechanisms in this challenging time is imperative and prompted the researchers to explore the coping mechanisms of the students and to develop theory about the phenomena. It is through this study that the positive coping mechanisms of students employed would bring into the picture as encouraged by The World Health Organization, to employ positive coping strategies in addressing various stressful and mental health concerns (Wu et al., 2020). The theory developed on this study form part of the existing literature that guides teachers and students in designing the teaching-learning activities in the new normal.

That instance, resilience is frequently defined as the capacity to recover from or overcome some kind of adversity and so enjoy favorable results in spite of an adverse occurrence or circumstance. Hence, adversity and successful outcomes are important components of resilience (Pai & Vella, 2018). That is, resilience is commonly described as the ability to bounce back or overcome some form of adversity and thus experience positive outcomes despite an adverse event or situation. Debate continues as to whether resilience is best conceptualized as a state or trait phenomenon (Stainton et. al., 2019) when resilience is considered as a personal characteristic (Ayed, Toner, and Priebe, 2019).

Resilience in arithmetic, according to Dilla, Hidayat, and Rohaeti (2018) is a crucial mathematical soft talent. Students with resilience, which is a positive character trait in mathematics instruction incorporates assurance in its achievement through working hard and remaining persistent while faced with challenges. With this type of resilience, students are capable of overcoming difficulties in learning mathematics that stem from low self-confidence, nervousness, and a lack of interest in the subject which impact on learners' intellectual capacity.

In the study conducted by the researchers Williams and Bryan (2014), and Hernandez-Martinez and Williams (2013), there are four classifications of mathematics resiliency: growing mindset, valuing of mathematics in a personal way, minding the fact that there are struggle in learning mathematics, considering ways to be able to get support in learning mathematics. In the same manner, Kooken et al. (2016) explored how such construct work with people who has already mathematical resilience. In addition, Simbulas (2018) revealed that mathematical resilience of the students is significantly correlated to mathematics achievement. It was concluded that among the three dimensions of mathematical resilience only struggle best influenced mathematics achievement.

Meanwhile, in the study conducted by Kiel and Callaman (2021) about assessing the mathematics resiliency of BSEd-Math students, it was reported that the students face the following challenges: (1) technology-related problems; (2) Input processing-related challenges; (3) limited student-teacher interactions; (4) psycho-emotional challenges; and (5) overlap between school and household tasks. Moreover, the college students’ time management, study strategies, resourcefulness, the presence of more knowledgeable others and social strategies were found to be their coping mechanisms in this time of pandemic. It was also found out that students developed time management and self-discipline, cultivate self-reliance, and prepared contingency plans to cope with their challenges in the new normal setup of education (Agum et al., 2021).

In addition, Gueta and Janer (2021) claimed that time management, motivation, seeking assistance from neighbors and teachers and interactive communication between students-teachers and students-students were the coping strategies of elementary students in distance learning challenges.

However, Castroverde and Acala (2021) opined that teacher should use various ways to cope with the challenges encountered in modular distance learning modality such as time management, innovating teaching strategies, being adapting, being flexible, providing alternative plans, being optimistic, patient, and equipping oneself with the necessary skills for the new normal ways of education.

Combining all these studies, and principles on resiliency, there has been a gap on the development of theory on how to wrap all the factors to describe the holistic view that contributes the students' mathematics resiliency in the new normal. Hence, this is the goal of the study.

This paper is aimed to answer the question" How do students cope with the challenges in learning mathematics in the new normal?" and formulate a theory describing the phenomenon.

RESEARCH METHODS

The paper utilized the process of deduction in theory development. The deductive approach starts with a few axioms—simple true statements about how the world works. The understanding of the phenomenon can be deduced from the nature of the axioms Nisbet, Miner, and Yale (2018). Specifically, the deduction process was done through the deductive axiomatic approach so to generate the theory on students' mathematics resiliency in the new normal.

The primitive assumptions are called axioms, and the consequences of these axioms are the propositions. These propositions are put to test through using appropriate methodology with specific data. When these propositions are accepted, then the generated theory must be accepted (Zalaghi & Khazaei, 2016). The steps that the paper followed are reflective of the deductive axiomatic approach in generating the theory (adapted from Padua, 2012), as illustrated in Figure 1.

The first step was choosing the phenomenon of interest. The first step for theory generation using the deductive axiomatic approach was to select the phenomenon of interest. This stage is crucial since it will serve as the focal point for the theory development, which may include a variety of underlying ideas (Grageda, Diokno, &

Abadiano, 2023). The phenomenon may originate in either the practical world of affairs, a theoretical discipline, or a personal experience or insight (Van de Ven, 2016).

Steps in Theory Development

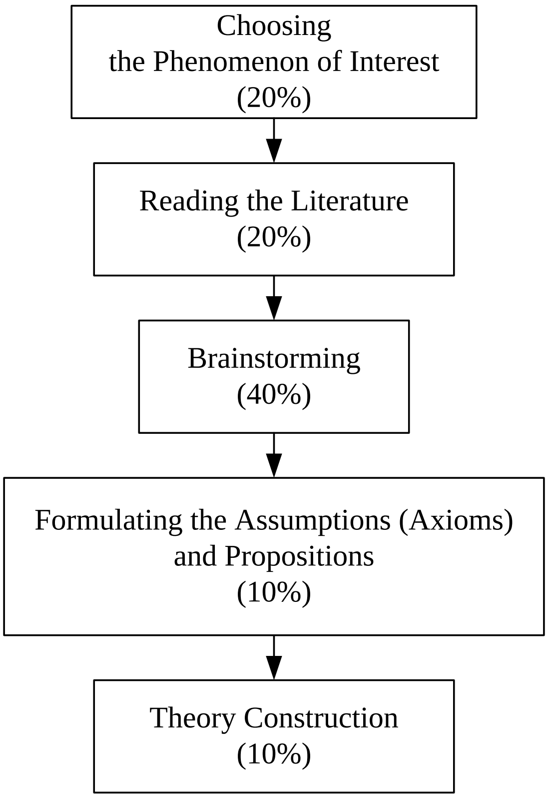

Figure 1. Deductive Axiomatic Approach in Theory Development

The second step was reading the literature. After selecting the phenomenon of interest, a researcher should consider reading the many examined resources as a crucial next step (Selden, Widdowson, & Brooker, 2016). Furthermore, reviews summarize the literature that has been published on a subject and describe the state of the art. Hence, borrowing from systematic review procedures that are meant to minimize bias in the selection of articles for review and utilizing a successful bibliographic research strategy can both enhance the quality of a narrative review (Ferrari, 2015). Among these, broadening of the knowledge base is the most vital in theory generation as this strengthens the formulation of the axioms and propositions concerning the phenomenon.

The third step was brainstorming. After reviewing the existing literature, the researcher investigated many aspects of the phenomenon through developing and analyzing the facts, and gaining multiple perspectives about it (Mickenberg, 2017). Brainstorming is essential for convergently aligning facts and related articles to demonstrate the significance of the phenomenon (Seeber et al., 2017). These helped the researcher to formulate axioms appropriate to the phenomenon, as well as to make propositions coherent with the axioms. This stage supports the coherence and cohesion of data to be used in the theory development process (Henningsen & Henningsen, 2018).

The fourth step was formulating the axioms and propositions. The outcomes of the brainstorming were gathered, assessed and synthesized to formulate axioms and propositions. The formulation of axioms and propositions is an important step in theory development. Propositions are statements that come from the axioms, whereas axioms are basic theorems and primitive assumptions that regulate them (Novikov, 2011). These axioms and propositions are the essential in theory development.

The fifth step was theory construction. The alignment of all premises to identify and conclude a theory is the last step in theory building using a deductive axiomatic approach (Stergiou & Airey, 2018). The methodology for theory construction presented by Borsboom et al. (2021) outlines a realistic process for making explanatory theories. The systemic structure of Theory Construction Methodology (TCM) makes clear that developing theories requires talent; involves both focused practice and teaching.

RESULTS AND DISCUSSION

Phenomenon

The phenomenon in this research study is the coping mechanism of students in learning mathematics in the new normal. Student's mathematics resiliency accounts for the increasing number of students who survived schooling. Further, these students hurdle adversity and find effective coping strategies in this time of pandemic. These circumstances led the researcher in formulating its research problem "How do students cope with challenges in learning mathematics in the new normal? Thus, this paper develops the "Students Mathematics Resiliency Based Theory".

Axioms

Literature review and brainstorming led the researcher to formulate statements, which are regarded to be recognized, putative, and self-evidently factual. These statements or axioms are as follows: (1) Students employ time management in studying math; (2) Students uses compensation strategies in overcoming challenges; (3) Students' resourcefulness leads them to learn mathematics; and (4) Students asked help from teachers and peers in understanding mathematical concepts.

AXIOM 1: *Students employ time management in studying math.*

Time management has been also acknowledged as being crucial in the education field. In fact, in the study conducted by Kiel and Callaman (2021) about assessing mathematics resiliency, time management found to be one of the coping mechanisms of students. In a research project conducted by Bettinger et al. (2018), data enable them to look into the amount of time spent on each algebraic problem. On the one hand, it is conceivable that pupils who are more tenacious are able to maintain greater concentration and work harder, and as a result, are able to work through the challenges more quickly. On the other hand, given the complexity of the problems, more tenacious students might have persisted longer before giving up on a problem. Instead of making a guess at random and moving on to the next question, they might have chosen to explore several strategies. As a result, they are unable to state with certainty how the study's intervention affects time utilization. Furthermore, it was discovered that there are no significant treatment effects on either the entire sample or the pertinent subsamples when looking at time spent on the first 10, 20 or 32 min. Indeed, different styles of time management work for different people. Taking all of the above into consideration, it is clear that the tools supporting students in their time management activities will have to be very flexible to meet the needs and expectations of such a diversified population (Mamman, 2013; Xu, 2013). Consequently, according to Trueman and Hartley (1996) they will have to inter alia account for different levels of time management, permit the gradual development and refinements of schedules and allow for modifications (also in main goals and priorities). Furthermore, arguably the main barriers for people to engage in time management activities are a lack of self-discipline or motivation and time-consumption (Grey, Al Saihati, & McClean, 2013). Planning, scheduling, prioritizing, monitoring, or evaluating all takes time and patience.

Learning mathematics in the new normal context requires time management among learners. Because of the circumstances, students are challenged on how to give prioritization in the overlapping activities in both school and personal lives. Hence, it can be assumed that students employ time management in studying math.

AXIOM 2: *Students use compensation strategies in overcoming challenges*.

Compensation strategies are those that are used by learners to compensate for their weaknesses in learning. These strategies are used to help learners use techniques for comprehension and production regardless of the limited knowledge learners have with learning math. Making up for an inadequate repertoire of mathematics concepts is the purpose of compensation strategies (Oxford, 1990). For example, when given a complex Mathematics task, students tend to be practical and responsible by watching YouTube tutorial videos about the topic. Others would look for some alternative ways to help them overcome the challenges. Hence, it can be assumed that learners use compensation strategies to make up for their deficiencies.

AXIOM 3: *Students' resourcefulness leads them to learn mathematics*.

Students overcome challenges in learning mathematics in the new normal by finding ways to be connected virtually during the online synchronous sessions and looking for available options in submitting their learning tasks (Kiel & Callaman, 2021). Resourcefulness is the ability to find quick and clever ways to overcome difficulties. The level of learned resourcefulness was associated with classroom and stress training. Individuals' self-leadership levels showed a positive relationship with their learned resourcefulness level (Avcı & Kaya, 2021).

The limited resources and the seemingly lack of readiness of the system in the new normal education has made it difficult for students to learn mathematics. For instance, in a study conducted by Russo et al. (2020), majority of students repeatedly stated that enabling prompts gave them more authority as learners and allowed them to take ownership of and succeed in their mathematics study. Students thought that prompts had the ability to deepen their comprehension and to help them approach mathematical activities with more confidence. They particularly valued being able to access prompts when they were stuck on a subject. In general, students did not equate using enabling prompts with being "bad" at arithmetic and acknowledged that even accomplished mathematicians occasionally needed a suggestion. Hence, the innate tendency of learners to adapt to the demands of time and making use of available resources to cope with the demands of education have made them succeed in learning. This, it is assumed that students' resourcefulness leads them to learn mathematics.

AXIOM 4: *Students asked help from teachers and peers in understanding mathematical concepts.*

Social strategies refer to learner's communication with people who also are into learning mathematics. According to Oxford (1990), these strategies include asking question, cooperating with others, and empathizing with others. Among the three, asking question is the most helpful and comes closest to understanding the meaning. It is also helps in conversation by generating response from the partner and shows interest and involvement. Cooperating with others eliminates competition and, in its place, brings group spirit. Empathy means to put oneself in someone else's situation to understand that person's point of view. Learners can social strategies to develop cultural understanding and become aware of thoughts and feeling of others.

Communication plays a big role in learning mathematics (Castroverde & Acala, 2021). Moreover, Kiel and Callaman (2021) emphasized that students learned mathematics lesson by asking help from their classmates who fully understand the concepts and friends who were knowledgeable about the lesson. Another illustration is guided discovery learning, which is still student-centered and uses the teacher as a guide. However, the amount of guidance provided by the teacher must be kept to a minimum since too much direction can resemble direct learning, which negates the advantages of learning. Through creative learning, it encourages students' capacity for innovation, investigation, problem-solving, and independent thought. Students can integrate and build their own knowledge while engaging in guided exploration learning, according to Shieh and Yu (2016). Furthermore, students are learning the processes of the scientific method for issue solving in groups, commencing with stimulation, problem formulation/identification, data collection, data processing, verification, and drawing conclusions (Yerizon, Putra, & Subhan, 2018).

Social strategies are very important for a successful learning. Learning does not need to mean competing with one another but forging a relationship that promotes support system and positive enablers in learning. Hence, it is assumed that students asked held from teachers and peers in understanding mathematics concepts.

Propositions

The formulation of the four axioms further lead to the formulation of two proposition. These propositions are as follows: (1) direct coping strategies support students' resiliency in learning mathematics and (2) Indirect coping strategies indirectly provide support for coping strategies through planning, socializing with others and increasing empathy.

PROPOSITION 1: *Direct coping strategies support students' resiliency in learning mathematics.*

According to Oxford's (1990) definition which directly involve the target concepts are called direct strategies. These strategies include compensation strategies (Axiom 2). All of these direct strategies involve mental processing of concepts.

PROPOSITION 2: *Indirect coping strategies indirectly provide support for coping strategies through planning, socializing with others and increasing empathy.*

Indirect strategies include social strategies (Axiom 4) and they provide indirect support for language learning through focusing, planning (Axiom 1), evaluating, seeking opportunities, controlling anxiety, increasing cooperation and empathy, and other means (Axiom 3) (Oxford, 1990). This proposition was supported by the study of Gueta and Janer (2021) who claimed that time management, motivation, seeking assistance from neighbors and teachers and interactive communication between students-teachers and students-students were the coping strategies of elementary students in distance learning challenges. This was also affirmed in the study of Agum et al. (2021) that students developed time management and self-discipline, cultivate self-reliance, and prepared contingency plans to cope with their challenges in the new normal setup of education.

Theory

The Students' Mathematics Resiliency Theory states that resiliency in learning mathematics is affected by both direct and indirect coping strategies. Direct coping strategies include compensation strategies, while indirect strategies include social, time management, and resourcefulness. It is presented in Figure 2.

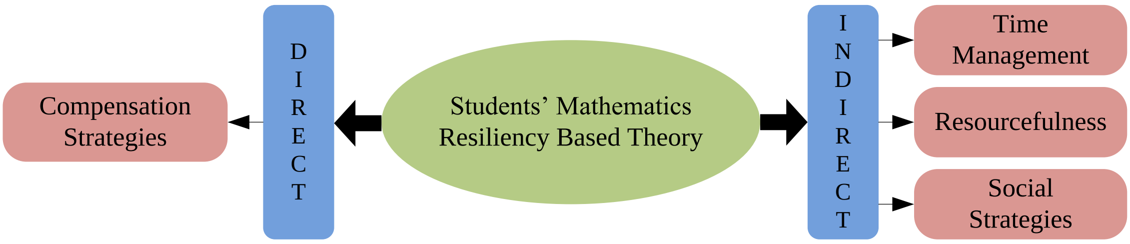

Figure 2. Students' Mathematics Resiliency Based Theory

Future direction

As part of the theory development process, a validation of the generated theory on Students' Mathematics Resiliency Based Theory must be conducted. Survey questionnaires can be administered in all propositions. In-depth interview and Focus group discussion can be carried out to students. The participants of the theory validation will be the college students in across Region XI. This will be done through stratified random sampling and purposive sampling technique. Ethical considerations in the conduct of the study will be dealt seriously.

Data gathering is done through audiotaped interviews and questionnaires. The obtained data will be analyzed through appropriate tools. Results and conclusion for each proposition will be presented and discussed as separate chapters.

CONCLUSION

Resilience in learning mathematics can be influenced by both direct and indirect coping strategies. Direct coping strategies, such as compensation strategies, involve finding ways to overcome difficulties in mathematical tasks directly. Whereas, indirect coping strategies, such as social, time management, and resourcefulness strategies, involve using external resources to overcome challenges.

Overall, even though the new normal poses difficulties for children learning mathematics, they are adapting and discovering fresh approaches to succeed in their studies.

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