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Effects of Learning-About-Learning on Senior Secondary School Students' Achievement in Mathematics by Birth Order in the Southern Ijaw Local Government Area of Bayelsa State, Nigeria

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Abstract**—*This study assessed the effects of learning-about-learning on senior secondary school students' achievement in mathematics by birth order. The study adopted a pre-test post-test, and control group quasi-experimental design. The population of the study comprised all the SSII students in the Southern Ijaw Local Government Area of Bayelsa State, out of which a sample of 75 students was selected from two purposively sampled schools based on three criteria. Two intact classes from the two schools were randomly assigned to experimental and control groups to be taught using the learning-about-learning approach and the lecture strategy respectively. The study lasted for five weeks. Two research questions and two null hypotheses were raised to guide the study. There were two instructional guides, a Personalized Learning Data Form (PLDF) was used to collect data on students' learning for the experimental group, and a Mathematics Achievement Test (MAT) was the instrument used for data collection. MAT had a reliability index of 0.83 using Kuder-Richardson Formula 21 (K-R 21). The research questions were answered through mean and standard deviation, while Analysis of Covariance (ANCOVA) was used to test the null hypotheses at a 0.05 level of significance. The findings of the study showed that treatment had a statistically significant effect on students' achievement in mathematics. The findings further showed a non-significant effect of treatment on students' achievement in mathematics by birth order. It was recommended amongst others that; teachers should adopt the learning-about-learning approach to enhance students' achievement in mathematics.*

Keywords**—** *Achievement, Birth Order, Learning-About-Learning, Lecture Instructional Strategy.*

I. Introduction

Mathematics is part and parcel of human activities. It is a field of study that can be considered the heartbeat of society's existence. Sinay and Nahronick (2016), states that mathematics is a universal field, and a fundamental part of man's everyday life across all domains. Apart from the essential roles it plays in man's daily activities and tasks, mathematics is also important because it plays indispensable roles in the world and societal development; exposes knowledgeable individuals to a wide plethora of opportunities; is necessary for the advancement of knowledge of the world, is functional in all fields, and all forms of research; is the basis for the workings, growth, and development of science and technology; is important for the handling of all economic, commercial, and financial tasks; useful for the building up of learners' cognitive structures, etc. (Audsley, 2019; Macutay, 2020; Yadav, 2017, Onasanya, 2020). All the structures that characterize our modern world might fail without mathematical knowledge.

Considering the numerous benefits of mathematics, good performance in the field is a matter of utmost necessity. Also, mathematics is a core school subject for nations like Nigeria, and as such a credit pass in the subject is a requirement to enrol for further tertiary studies no matter the field. Unfortunately, the vast majority of reports show a trend of poor achievement in the subject. Varaidzai Makondo and Makondo (2020), state that mathematics is still considered by most learners to be the most difficult subject to learn. In line with this, Owan, Etudor-Eyo, & Esuong (2019) state that with the high rate of poor achievement in mathematics, parents and other stakeholders in education have become increasingly worried, leading to them questioning just how effective the educational process is, as little progress has been made in enhancing students' achievement in the subject. The studies by Tobih (2016), and Idowu (2016), amongst others, all explored the students' mathematics achievement in the Secondary School Certificate Examination (SSCE) across varying years and populations, and all reported an underwhelming persistent of poor achievement in the subject.

Various reasons are attributed to be the root cause of students' poor achievement in mathematics, including issues arising from the students' poor background, and their perceptions, issues arising from the nature of mathematics, and those from classroom instruction (Brezavscek, Jerebic, Rus, & Znidarsic, 2020; Butakor & Dziwornu, 2018). The issues from the nature of mathematics contents, and classroom instruction are prominent. Most of these issues can be easily traced to the continued use of poor teaching approaches that are not suitable for handling the mathematics content.

The issue of poor instructional strategies has received much attention and the utilization of appropriate and effective teaching strategies can address several of the observed issues with learning mathematics. Traditionally, mathematics

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teaching and learning are carried out through the lecture method, and herein lays the primary problem, as the lecture method is largely considered not to be an effective way to teach subjects like mathematics and sciences to ensure meaningful learning and knowledge retention (Saira & Hafeez, 2021). Some reasons associated with the inadequacy of the lecture strategy are; its dependence on passive rather than active learning, its inability to engage the students and hold their interest, the emphasis placed on passing examinations rather than long-term knowledge retention, following a pattern of rote learning and memorization (Abedi, Keshmirshekan, & Namaziandost, 2019; Farashahi & Tajeddin, 2018).

Considering the limitations of the lecture strategy, it becomes necessary to introduce new and better strategies, approaches, and innovations, which can either supplement and enhance the lecture strategy, or entirely replace it. One such approach is "learning-about-learning". As an approach to teaching and learning, learning-about-learning (sometimes referred to as learning to learn), basically involves the students' building up of understanding of their learning process, where this knowledge will be used for optimizing their learning and ensuring better and meaningful learning outcomes. This strategy falls under the broad heading of metacognition, whose framework is thinking about thinking. Metacognition involves the creation of awareness and understanding of one's thinking, and utilizing such to solve problems and influence experiences, in the form of self-regulation (Siagan, Saragih, & Sinaga 2019).

Thus, the framework of learning-about-learning revolves around guiding the students to create awareness or understanding of how they learn (like which type of learner they are, or which teaching or studying technique will prove the most effective for their learning) so that this knowledge can be used to optimize classroom instruction and even personal study time (Engeness, 2020). Under this context, the students are charged with a significantly bigger role in determining how they learn. Denning and Flores (2016) described the core of the learning-about-learning approach, as a navigational skill, that can be used by students to recognize moods, situations, and strategies that enhance or inhibit meaningful learning, to maintain those enhancing variables, and apply contrasting moods to the inhibitors, to create a more effective learning experience.

In precise terms for learning-about-learning to be accomplished in the classroom, several components have to be considered in the process, which includes making the learning an object of attention, conversation, and reflection. First, hold learners' attention by guiding them to develop useful understandings about their learning. Interaction and communication are other ways to promote learning-about-learning. This can be achieved through discussions, and conclusions reached from their peers. Reflection is one key variable in learning-about-learning that enables the student to think and reflect on previous learning to understand the present information.

Stringher (2016) mentions several components that are essential to learning about learning. All these components are described as having a role to play in developing an understanding of learning and the best way to learn. The components were grouped into social and personal domains. Units under social domain components include; an accounting for and understanding of the learning environment (including its limitations, and implicit rules), interpersonal relations, collaborative features, resources for learning, etc. Units under the personal domain components include; innate assets (e.g., intelligence, aptitude, innate desire to learn), cognitive variables (e.g., knowledge levels, problem-solving and practical thinking skills), knowledge of self, affective-motivational variables, etc.

Some other components that are essential for learning-about-learning and should be noted and accounted for in a learning-about-learning classroom, as cited by Haukas (2018) include; preparing and planning for learning (where the students reflect and focus on the intended goals for their learning), selecting and using strategies (where the students can select and use appropriate learning strategies, based on the reflection and development of understanding on how best they can learn concepts), monitoring strategy (where the students need to keep track of the use of their selected strategy in terms of effectiveness, feasibility in the context etc.), orchestrating various strategies, evaluating learning etc. The learning-about-learning approach can be said to be guided by several questions that a student needs to ask his/herself during self-reflection, typically in terms of the goal to be accomplished, strategies being used, how well they are being used, ways it can be enhanced or better alternatives, etc. When teaching, the teacher has to encourage and guide the students, so they study and notice essential aspects of their learning, as they engage in instructional tasks and activities. The developed understandings are then further applied to influence the educational experience. This process can amongst others involve the teacher giving opportunities for the learners to describe their perceptions and knowledge they have developed about their learning, which the teacher can then use in reviewing the learning process and adapting it to fit the needs of learners.

There are potential benefits in utilizing learning-about-learning in the educational process. Scharff, Draeger, Verpoorten, Devlin, Dvorakova, Lodge, & Smith (2017) state that supplementing the educational process with approaches like learning-about-learning is beneficial, as research implies that merely focusing on the teaching of factual knowledge, is not effective in facilitating life-long learning, or retention of knowledge. The use of the learning-about-learning approach can also enable the learner to have higher self-efficacy in learning, to become more flexible and adaptable to varying learning contents and situations, and even make the learners more self-organized regarding their learning (Espada, Navia, Rocu, & Gomez-Lopez, 2019). Stringher (2016) states that the functions associated with learning-about-learning includes, the improvement and empowerment of the learner, increased autonomy and adaptability of learning, and better regulation of the learning process, etc. Pandolpho (2018) supports the adoption of approaches like learning-about-learning, stating that the students' development of proper knowledge and understanding of their learning experiences, can make them more reflective and strategic, and this can in turn lead to better learning outcomes in subjects like mathematics.

There are several other variables affecting students' learning and educational experiences such as birth order. Birth order simply refers to the chronological order or pattern of birth of children in a family (Frederick-Jonah, Moses, & Benneth, 2020). While its effects on educational experience and outcomes might not be barefaced at first, Barclay (2018) points to it being a factor that can affect an individual's experience in various domains including education, intelligence, personality, career choice, etc. making it a focus of scholarly interest. The focus of this study is built on all of the above discussion and concerned with the possible effects of learning-about-learning in regards to the achievement of students, and the effects of birth order, as a moderating variable.

The learning-about-learning approach is not popular by any means, and as such there is a major absence of literature exploring its utilization in practical scenarios. However, there exist several studies exploring the use of metacognition, the general idea, on which learning-about-learning is based. Such a study by Abari and Tyovenda (2021) explored the effects of metacognition on the achievement of post primary school mathematics students in Benue State. The study adopted a quasi-experimental design and reported that learners taught mathematics using the metacognitive-based method had a significantly improved achievement/performance rate, than those taught through the conventional teaching method.

Again, the study by Gaylo and Dales (2017) considered the effects of metacognitive strategies on students' academic achievement and engagement in mathematics and was conducted in Philippines, during the school year 2015-2016. The study was quasi-experimental and the findings reported show that the students taught mathematics using the metacognitive strategy, had a significantly better achievement rate, than those taught using the conventional lecture/teaching strategies. Also, Jain et al., (2017) in their study examined the impacts of metacognition on tertiary education students' academic achievement, employing a correlational research design. The finding of the study revealed that students with a higher level of metacognitive awareness exhibited higher levels of academic achievement than their counterparts. The study by Akpur (2017) assessed how well a student's metacognition levels and need for cognition predict their academic achievement. The study focused on undergraduate students during the 2016/2017 academic year and adopted a correlational research design. Correlational analysis of the study showed a significant positive relationship between students' levels of metacognition and their academic achievement.

Akpur (2017) explored how students' level of metacognitive awareness and self-directed learning affected their academic achievement in a university. The study utilized the survey method, and the findings show that neither of the two variables (metacognitive awareness and self-directed learning readiness) had any significant impact or relationship with the student's academic achievement. Likewise, Goll, Omidi, & Momeni (2016) explored the effect of metacognitive skills training on university students' academic achievement amongst others. The study made use of a semi-experimental approach and reported that there exists no significant difference in the academic achievement of students in the intervention and control groups.

A lack of previous studies is prevalent with learning-about-learning and the birth order variable. However, birth order has been explored with other intervention studies on students' achievement. The study by Frederick-Jonah, Moses, & Benneth (2020) explored the moderating effects of birth order using YouTube videos instructional strategy on students' mathematics achievement. The findings of the study showed that birth order had no significant effect on students' achievement in mathematics. AlSaleh, Abdulla, Ayoub, & Hafsyan (2021) explored the effects of birth order and family size on the academic achievement of gifted students, along with other variables, and found that first-born students had significantly better achievement than the later-born children, as evidenced by their higher-grade point averages (GPAs). Also, the birth order effect was observed to be non-significant in students' achievement in mathematics using scaffolding as an intervention (Frederick-Jonah, Akporekhew, & King, 2020)

The adoption of the learning-about-learning approach to teaching is supported by the theoretical model of cognitive theory. The theory covers the mental structures and processes including reasoning, thinking, and reflection (Alahmad, 2020; Pritchard, 2017), which is a major focus of learning about learning. Furthermore, the learning-about-learning approach falls under a metacognitive approach to teaching and learning, which is directly under the heading of cognitive theories.

II. Statement of the Problem

The broad range of mathematics functions has made it quite an indispensable field. However, the achievement of students in the subject has remained below expectations. This issue is most prominently associated with the continued adoption of poor instructional strategies, as the conventional lecture strategy is regarded as not effective for ensuring meaningful learning. Thus, there is a need to introduce innovative and better approaches to the teaching of mathematics, one of which is learning and learning. Despite the potential of applying this metacognitive approach, little work has been done to explore its usage in practical classroom situations. Therefore, this study examines the effectiveness of learning-about-learning in teaching mathematics and further determines the moderating effect of birth order on the dependent variable.

III. Research Questions/Hypotheses

Two research questions were raised to guide the study. They are:

1. What is the difference in the mean achievement of students in mathematics when taught using learning-about-learning, and those with the lecture instructional strategy?
2. What difference exists between first-second and later-born students' mean achievement in mathematics when taught

using the learning-about-learning and those with the lecture instructional strategy?

The following two null hypotheses were tested at a 0.05 level of significance to guide the study

H_{01}: There is no statistically significant difference in the mean achievement of students in mathematics when taught using learning-about-learning, and those with the lecture instructional strategy.

H_{02}: There is no statistically significant difference between first-second and later-born students' mean achievement in mathematics when taught using the learning-about-learning and those with the lecture instructional strategy.

IV. METHODOLOGY

The pre-test, post-test control group quasi-experimental design was adopted to carry out this study. Two public secondary schools were purposively selected for the study. The selection of schools was based on four criteria; 1) The schools must be public secondary schools; 2) The mathematics teachers involved in the study must be professionally qualified; and must have teaching experience for a minimum of four years; 3) The teachers and authorities of the school must be willing to be involved in the study. One intact class from each school was randomly assigned to the control and experimental group. A total of 75 students were involved in the study. Two instructional guides were used in this study; Instructional Guide on Learning-about-Learning (IGLL), and Instructional Guide on Lecture Instructional Strategy (IGLIS), for the experimental and control group respectively. Data on students' achievement was collected through the Mathematics Achievement Test (MAT). MAT was used to test the students' cognitive achievement and had a reliability of 0.83 using Kuder-Richardson Formula 21 (KR-21). The Personalized Learning Data Form (PLDF) was utilized for only the experimental group to collect data on students' learning. All the instruments were validated through expert review.

The first week was used for the training of participating teachers in the schools on the use of IGLL and IGLIS. During the second week, MAT was given to the students as a pre-test for both experimental and control groups. Weeks three and four were used for the actual treatment for both the experimental group; the Learning-about-Learning Approach (LLA) and the control group; Lecture Instructional Strategy (LIS). MAT was re-administered as a post-test to the students during the fifth week. The research questions were answered using mean and standard deviation. The hypotheses were analyzed using Analysis of Covariance (ANCOVA), with the pre-test scores used as covariates.

V. RESULTS

Research Question 1: What is the difference in the mean achievement of students in mathematics when taught using learning-about-learning, and those with the lecture instructional strategy?

The data in table 1 shows that the post-test mean score of students taught with the learning-about-learning approach (M = 57.44, SD = 7.81), is greater than the scores of students taught through lecture strategy (M = 41.0, SD = 4.91). The data further shows that the mean gain scores of students taught using the learning-about-learning approach (30.67), are greater than the mean gain of those taught with the lecture strategy (12.56). This implies that using the learning-about-learning approach leads to better achievement in mathematics than the lecture strategy. The ANCOVA test was carried out to check for significance after the observed differences.

TABLE 1: Summary of Mean and Standard Deviation of Pre-test and Post-test Scores on the Effect of Instructional Strategies on Students' Achievement in Mathematics

Treatment	N	Pre-test Scores Mean	Pre-test Scores STD	Post-test Scores Mean	Post-test Scores STD	Mean Gain
Learning-About-Learning	39	26.77	6.82	57.44	7.81	30.67
Lecture Instructional Strategy	36	28.44	7.39	41.0	4.91	12.56
Total	75	27.57	7.10	49.55	10.54	21.98

Research Question 2: What difference exists between first-second and later-born students' mean achievement in mathematics when taught using the learning-about-learning and those with the lecture instructional strategy?

TABLE 2: Summary of the Mean and Standard Deviation of Pre-test and Post-test Scores on the Effect of Instructional Strategies on First-Second and Later-born Students' Achievement in Mathematics

Treatment	Birth Order	N	Pre-test Scores Mean	Pre-test Scores STD	Post-test Scores Mean	Post-test Scores STD	Mean Gain
Learning about-Learning	First-Second	13	25.23	7.00	53.23	7.00	28.0
	Later born	26	27.54	6.72	59.54	7.45	32.0
	Total	39	26.77	6.82	57.44	7.81	30.67
Lecture Strategy	First-second	`16	26.50	7.98	40.0	5.84	13.50
	Later-born	20	30.0	6.68	41.80	3.99	11.80
	Total	36	28.44	7.39	41.0	4.91	12.56
Total	First-second	29	25.93	7.45	45.93	9.17	20.0
	Later-born	46	28.61	6.74	51.83	10.80	23.22
	Total	75	27.57	7.10	49.55	10.54	21.98

The data in table 2 shows that for students taught with the learning-about-learning approach, the post-test mean scores of later-born students (M = 59.54, SD = 7.45), is greater than that of first-second born students (M = 53.23, SD = 7.00). For the students taught with the lecture strategy, the post-test mean score of later-born students (M = 41.80, SD = 3.99) is greater than that of first-born students (M = 40.0, SD = 5.84). The total post-test mean score of later-born students (M = 51.83, SD = 10.80) was also greater than that of first-born students (M = 45.93, SD = 9.17). The table further shows that the total mean gain score of later-born students (23.22) is greater than that of first-second-born students (20.0). Following the observed differences, ANCOVA was used to ascertain if the difference was statistically significant.

Test of Null Hypotheses

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Null Hypothesis 1: There is no statistically significant difference in the mean achievement of students in mathematics when taught using learning-about-learning, and those with the lecture instructional strategy.

The data in table 3 shows that treatment had a significant effect on students' achievement in mathematics ($F_{1,72}$ = 116.377, $p < 0.05$; partial eta squared = 0.618), which gives an effect size of 61.8 percent. Therefore, the null hypothesis, which states that "there is no statistically significant difference in the mean achievement of students in mathematics when taught using learning-about-learning, and those taught with the lecture strategy" was rejected.

Null Hypothesis 2: There is no statistically significant difference between first-second and later-born students' mean achievement in mathematics when taught using the learning-about-learning and those with the lecture instructional strategy.

TABLE 3: One-way Analysis of Covariance (ANCOVA) of Post-test Scores of Students' Achievement in Mathematics when Taught with Learning-About-Learning and those with the Lecture Instructional Strategy

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Decision
Corrected Model	5082.945[a]	2	2541.473	58.320	.000	.618	
Intercept	9971.521	1	9971.521	228.818	.000	.761	
Pre-test	25.948	1	25.948	.595	.443	.008	
Instructional Strategies	5071.513	1	5071.513	116.377	.000	.618	*sig
Error	3137.641	72	43.578				
Total	192336.000	75					
Corrected Total	8220.587	74					

*R Squared = .618 (Adjusted R Squared = .608) *=Significant at p < 0.05 alpha level*

TABLE 4: 2 x 2 Factorial Analysis of Covariance (ANCOVA) of Post-test Scores of First-Second Born and Later-Born Students' Achievement in Mathematics when Taught with Learning-about-Learning and those with the Lecture Instructional Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Decision
Corrected Model	5435.179[a]	4	1358.795	34.148	.000	.661	
Intercept	10047.146	1	10047.146	252.495	.000	.783	
Pre-test	4.562	1	4.562	.115	.736	.002	
Instructional Strategies	4172.899	1	4172.899	104.869	.000	.600	
Birth Order	262.737	1	262.737	6.603	.012	.086	
2-way Interaction: Instructional Strategies * Birth Order	90.710	1	90.710	2.280	.136	.032	NS
Error	2785.407	70	39.792				
Total	192336.000	75					
Corrected Total	8220.587	74					

*a. R Squared = .661 (Adjusted R Squared = .642) *=Significant at p < 0.05 alpha level*

The data in table 4 shows that the interaction effect was not significant on first-second and later-born students' achievement in mathematics ($F_{1,70}$ = 2.280, $p > 0.05$; partial eta squared = 0.032), which gives an effect size of 3.2 per cent. Thus, the null hypothesis which states that "there is no statistically significant difference between first and second and later born students' mean achievement in mathematics when taught using the learning-about-learning approach and the lecture instructional strategy" was upheld.

VI. DISCUSSION OF FINDINGS

The findings of the study revealed that there is a statistically significant difference between students taught mathematics through the learning-about-learning approach and those taught with the lecture instructional strategy in favor of learning-about-learning. This is in line with the findings by Abari and Tyovenda (2021), and Gaylo and Dales (2017) who explored the effects of metacognition on mathematics achievement and reported that metacognition is significantly more effective in enhancing students' achievement than the conventional teaching approach. The finding also agrees with those of Akpur (2017) and Jain et al., (2017) who explored the effects of metacognition on the general achievement of tertiary education students and reported it to have a significant positive effect. The superior performance of students in the experimental group might come from the fact that the teacher was able to understand a lot of information about the students' learning from the students' personalized learning data and such students' needs are individually considered during the teaching and learning process. Some of the information gathered includes: the teacher should follow their pace of understanding, break down the topic into simple parts, explain formulae very well, and avoid calling them names that bring down their self-worth and abusive speech. Students still need a lot of questions and answer sessions, solved examples, classwork, test, home works/assignments, group works in mathematics, a conducive classroom environment where their classmates do not distract them during lessons, and simplified mathematics textbooks that they can read and understand in personal study time. Also, students desired to watch videos that have mathematics content in class and at home to improve personal study and make it interesting. Students need to stop pressing phones and charting during class lessons, during personal study time, etc. Incorporating this vital information in the teaching and learning process may have accounted for the better achievement of students in the experimental group. However, the finding disagrees with that of Goll, Omidi, & Momeni (2016) who explored how tertiary education students'

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level of metacognitive awareness, and metacognitive skills training affected their academic achievement and reported no significant impact on students' academic achievement.

Also, the findings of this study showed that there is no significant difference in the mean achievement of students based on birth order. This finding agrees with the findings of Frederick-Jonah, Moses, & Benneth (2020) that explored the birth order effect using YouTube instructional strategy, and reported it to be non-significant. The finding disagrees with that of AlSaleh, Abdulla, Ayoub, & Hafsyan (2021) who explored the effects of birth order on the academic achievement of students and reported that first-born students have significantly better achievement than later-born children. The disagreement could be due to the difference in which the birth order variable was arranged and the nature of the study.

VII. CONCLUSION

Utilizing a learning-about-learning approach to teach mathematics concepts is more effective in enhancing students' achievement, than using the conventional lecture strategy. Exposing students to mathematics instruction through a learning-about-learning approach is not affected by birth order, making it a suitable strategy for all students, despite their family subtleness in the form of birth order.

VIII. RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made;

1. Mathematics teachers should adopt innovative strategies like the learning-about-learning approach to mathematics instruction at the secondary school level.
2. Federal and State Governments should organize regular training, workshops, and seminars for teachers on how to implement learning-about-learning interventions in the classroom.
3. Teachers should always seek information about students' learning styles in mathematics to take care of individual learning problems of students.
4. Students should as much as possible avoid those things that distract them during personal study time such as pressing phones and charting.
5. Authors of mathematics textbooks should simplify and break down the concepts to enable students to study mathematics with understanding by themselves.

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