Investigating the Effects of Inductive and Deductive Teaching Strategies on Students' Learning in Basic General Mathematics: Implication for Sustainable Development

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ABSTRACT

This study investigated the effects of inductive and deductive teaching strategies on students' learning in Basic General Mathematics in order to promote sustainable development. The study employed a Quasi-experimental design with a focus on Year Two non-science students of Colleges of Education in Oyo State. Sample for the study comprised 235 students from three intact classes in three colleges of Education in Oyo State. The study employed the use of Basic Mathematics Achievement Test (BMAT) comprising of 25 objective questions selected from Basic General Mathematics past questions as research instrument. The instrument was validated and tested for reliability using Kuder Richardson-20 (KR-20) formular having a value of 0.89. Analysis of Covariance (ANCOVA) was used to analyze the data collected at 0.05 level of significance. The findings revealed that the effect of treatment on students' academic achievement was significant ($F_{(2;231)} = 89.93$, $p < 0.05$). The results also revealed that both inductive and deductive teaching strategies introduced had more effects on the academic achievement of the students than the conventional teaching method. Likewise, those exposed to deductive teaching strategy performed better than their counterparts subjected to inductive teaching strategy. The findings recommended that inductive and deductive teaching strategies should be employed in teaching Basic General Mathematics at the Colleges of Education in Nigeria in order to foster improved understanding and application of mathematical concepts for sustainable development.

Keyword: Inductive strategy, Deductive strategy, Basic General Mathematics, Students' Learning, Sustainable Development

INTRODUCTION

Mathematics serves as a foundational tool crucial for fostering sustainable development. Its application samong others extend to data analysis, problem-solving, and in imparting valuable skills that are applicable across diverse fields such as science, technology, business, medicine, and humanities. In Nigerian Colleges of Education, Basic General Mathematics is a key subject offered in establishing the groundwork for a broad spectrum of mathematical knowledge essential for pre-service teachers. This knowledge is vital for their training, and to enhance their preparedness to contribute mathematically to sustainable development. One primary role of Mathematics is to convey its concepts effectively to learners. The teaching strategy employed to carry out this function plays a pivotal role in shaping students' comprehension and proficiency in the subject. The transfer of mathematical knowledge often involves progressing from the known to the

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unknown and from simple to complex concepts. The effectiveness of specific teaching strategies, such as inductive and deductive approaches, can be assessed to determine their effects on students' understanding and proficiency in Mathematics. These instructional strategies play crucial roles in fostering sustainable development of the society, particularly now that the world is technologically interconnected. Given the pivotal roles of Mathematics in technological activities, the significance of effective teaching strategies becomes evident in equipping individuals to confront the challenges of a swiftly evolving and globally interconnected society.

Sustainable development involves a continuous process of transformative changes that enables individuals to attain their objectives. This is possible by enhancing, refining, and expanding across various dimensions. It also entails the capacity to prolong or extend the duration and scope of positive changes experienced in every facet of ones' lives for as long as possible. Achieving sustainable development necessitates working on past experiences to project improvements into the future through predictions and practical recommendations for feasible outcomes. Development is essentially a process of altering the state of a phenomenon, which is often manifested through observable progress in an undertaking or activity. This transformation may involve advancements, improvements, or positive changes in various aspects, thereby reflecting a dynamic evolution towards a more advanced or refined condition (Sam-Kayode,& Agada, 2022).

In the realm of Mathematics teaching and learning, sustainable development involves the incorporation of both inductive and deductive instructional strategies to get results. These two strategies differ in their methodologies when applied to Mathematics. The inductive strategy is prominently featured in science education, particularly through the implementation of the inductive-guided discovery strategy. This strategy is designed to facilitate the discovery of principles or generalizations. The instructional sequence involves starting with concrete manipulations where applicable, presenting pertinent facts, encouraging discovery through discussion, articulating the identified generalization, and concluding with drill methods. Conversely, the deductive strategy represents a more conventional teaching method. This method entails presenting the generalization or principles initially, reinforcing the concepts through concrete manipulations where applicable, soliciting feedback from students through questioning, and concluding with drill exercises. Inductive teaching strategy involves presenting specific examples and allowing students to generalize principles. It promotes a learner-centered approach by motivating students to uncover patterns and their relationships in learning(Liu & Zhang, 2023).

In the work of Richter, Nemeth, Berger, Ferri, Hänze and Lipowsky (2022) it was submittted that, inductive strategy proves to be effective in introducing novel mathematical concepts in order to leverage on real-world examples. Inductive strategy also facilitates the incorporation of problem-solving activities and case studies that can stimulate students with practical applications and context for better comprehension. Dolapcioglu and Doğanay (2022) corroborated that active participation in the learning process through the inductive strategy enables students to cultivate profound understanding of mathematical concepts. This approach fosters improved critical thinking skills, empowering students with the ability to apply mathematical principles to diverse situations. The inductive teaching strategy can serve as a valuable tool for educators aiming to enhance their students' achievement in Basic General Mathematics (Lloyd, Kim, Cox, Doepker & Downey, 2022). The inductive strategy encourages students' engagement by fostering curiosity and exploration. This is displayed through formulating hypotheses about a given concept or relationship, guiding them in conducting experiments or investigations to test these hypotheses and to draw conclusions about the concept or relationship based on their findings.

Studies by Barkl, Porter and Ginns (2012) and Jreisat (2023) showed that a group which received instruction on the bases of inductive teaching strategy demonstrated superior performance compared with another group which received instruction using deductive teaching strategy in a mathematics achievement test. Furthermore, the group with inductive teaching strategy exhibited greater advancements in their

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comprehension of mathematical concepts and relationships. It's crucial to recognize that inductive teaching strategies are not universally applicable and may vary in effectiveness depending on various factors.

Chisholm-Burns, Brandon and Spivey (2021) emphasized on the need for teachers to be flexible and adaptable in employing inductive teaching strategies. This adaptability is crucial for tailoring various approaches and strategies necessary to meet the specific needs of students and align it with the nature of the mathematical content being taught. Numerous studies conducted by researchers have demonstrated that the inductive teaching strategy possesses several strengths in promoting a profound understanding of the concepts to be learned. Hence, it:

1. Fosters active engagement of students in analyzing real-world examples of sustainable development. (Richter, Nemeth, Berger,Ferri, Hänze, &Lipowsky, 2022). This hands-on approach cultivates a deeper understanding of the intricacies involved in attaining sustainability goals.
2. Emphasizes contextual learning in real-life situations with examples to make it suitable for sustainable development education (Nölting, Molitor, Reimann, Skroblin & Dembski, 2020). By fostering a contextual understanding of the challenges and solutions in sustainable development, students can connect theoretical concepts to practical applications.
3. Encourages critical thinking skills, particularly in the context of sustainable development crucial for developing the analytical skills needed to address complex and interconnected issues. This allows students to critically evaluate information, draw connections, and form conclusions (Lai, 2011).
4. Fosters and facilitates the involvement of a wide range of disciplines, including economics, ecology, sociology, and more thereby enabling students to explore and appreciate the multifaceted nature of sustainability challenges(Jeronen, Palmberg &Yli-Panula, 2016).
5. Exhibits adaptability to different types of learners by recognizing and accommodating various learning styles. This approach allows students to approach sustainable development topics from multiple perspectives, catering to individual preferences and ensuring a more inclusive learningenvironment.
6. Encourages students to observe patterns, make connections, and draw conclusions on their own promotes critical thinking skills. These skills are crucial for understanding and solving real-world problems related to sustainable development.
7. Helps students to see the real-world relevance of mathematical concepts. This approach makes iteasier for them to apply these principles to sustainable development issues.
8. Allows students to discover mathematical concepts on their own through active participation in the learning process thereby increases interest learning, especially when connected to issues related to sustainability.
9. Caters for diverse students' backgrounds due to its flexibility when addressing the varied challenges and contexts associated with sustainable development.

It is important to be aware of inductive teaching strategy limitations in order to ensure its effectiveness in the context of educational application.

The limitations are:

1. Time-consuming: Inductive teaching can be time-consuming as it involves the exploration of specific cases before generalizing principles. In the context of sustainable development, time constraints may limit the depth of coverage for a wide range of issues.
2. Potential for misinterpretation: There is a risk of students misinterpreting examples or drawing inaccurate conclusions, especially if the examples are not well-chosen or if there is insufficient guidance. This can hinder the development of accurate and nuanced understandings of sustainable development.
3. Dependence on resources: Effective implementation of inductive teaching often requires access to

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diverse and relevant resources. In resource-constrained environments, educators may face challengesin providing a rich array of examples, hindering the strategy's effectiveness.
4. Assessment challenges: Assessing individual student's understanding in an inductive learning environment can be challenging. Traditional assessment methods may not accurately capture thedepth of comprehension and critical thinking skills developed through the inductive approach.
5. Need for skilled facilitation: Successful implementation of inductive teaching requires skilled facilitation to guide students through the process of generalization. Inexperienced or unprepared educators may struggle to effectively navigate and support students in drawing meaningful conclusions.

Deductive teaching strategy, on the other hand, involves presenting general principles and guiding students to apply them to specific examples. It follows a more teacher-centered approach, providing a structured framework for learning and effective for teaching formal mathematical proofs and theorems. The step-by-step approach involved in this strategy helps students grasp abstract concepts systematically by enhancing logical reasoning skills as they follow a systematic process of applying general principles to specific problems. According to Mancosu (2001), deductive teaching strategy contributes to solid understanding of foundational mathematical principles. It also provides clarity and structure thus helping students stay focused and motivated as well as offering efficiency and clarity in presenting foundational principles that are important to address potential limitations that can ensure a comprehensive and engaging education in sustainable development (Scheerens, 2023).

The strength of deductive teaching strategy towards sustainable development are as follows:

1. It allows efficient coverage of foundational principles in sustainable development by presenting overarching concepts first, educators can provide a framework for understanding various specific examples and cases.
2. It promotes clarity by presenting general principles upfront. In the context of sustainable development, where complex and interconnected issues are common, deductive teaching helps students grasp fundamental concepts before delving into specific applications.
3. It encourages logical reasoning as students are guided to identify cause-and-effect relationships which are crucial to understanding of complex issues.
4. It assesses students' understanding for more straightforward acquisition of knowledge such that educators can use traditional assessment methods like quizzes or examinations to evaluate students' comprehension of foundational principles in sustainable development.
5. It allows for the presentation of foundational concepts in a way that can be tailored to the cognitive abilities of students, making it suitable for different types of learners.

Despite the usefulness of deductive teaching strategy, the followings are the highlights of its limitations:

1. It might lead to lack of students' engagement, especially if presented in an abstract manner. Sustainable development, with its emphasis on real-world issues, may require additional efforts to connect theoretical principles with practical applications to maintain students' interests.
2. Deductive teaching strategy can sometimes lead to an overemphasis on theoretical concepts, potentially neglecting the importance of practical examples and real-life applications. This limitationis significant especially where the ability to apply knowledge to real-world scenarios is crucial.
3. There's a risk of oversimplifying complex issues when using a deductive strategy. Students may struggle to grasp the nuances of interconnected problems if the focus remains solely on general principles without exploring diverse and contextualized examples.
4. Deductive teaching strategy might limit the exploration of diverse perspectives and cases in sustainable development. Without a deliberate effort to incorporate a variety of examples, studentsmay not fully appreciate the complexity and diversity of sustainability challenges.

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5. Opportunities for fostering critical thinking skills may be missed out whereby students might memorize general principles without deeply analyzing or questioning their implications to sustainable development, potentially hindering their ability to apply knowledge creatively.

Studies have submitted that both inductive and deductive teaching strategies can have different effects on students' learning of Mathematics. An example is in helping students who were taught using a deductive approach to be more likely to transfer their knowledge to new situations than students who were taught using an inductive approach (Campbell, Boyle & King, 2020; Angraini, Larsari, Muhammad & Kania, 2023).

The followings are also worthy of note on deductive teaching strategies:

- It provides a clear structure by first of all presenting general principles or rules, followed by specific examples. This can help students develop a strong foundational understanding of mathematical concepts, which is essential for tackling complex issues in sustainable development.
- It allows for a more efficient and systematic learning process whereby students can quickly grasp general principles and then apply them to a variety of situations. This is advantageous when dealing with the multifaceted nature of sustainable development challenges.
- Process of logical problem-solving can be easily aligned. This is valuable when addressing mathematical aspects of sustainable development, as it equips students with the skills needed to analyze and solve complex problems systematically.
- Clearer assessment and evaluation of students' understanding can be facilitated, thus, allowing educators to assess whether or not the students grasp fundamental principles and can apply them to address mathematical challenges related to sustainability.

Considering the relevance of Mathematics to sustainable development, students' achievement in the subject is a point of concern especially at the colleges of education which is a training ground for pre-service-teachers. The academic achievement of Year Two non-science students in Basic General Mathematics at the three Government-owned Colleges of Education in Oyo State, Nigeria considered for this study indicated that most of the non-science students usually managed to get a pass mark in the subject. This was based on the information gathered from the Departments of General Studies Education of the three institutions concerned which is not ethically permitted to be displayed in this publication. A dwindling performance was observed over three consecutive academic sessions: 2019/2020; 2020/2021; and 2021/2022 considered for this study. This generated a concern on what strategy can be applied in teaching Basic General Mathematics to improve the academic achievement of non-science students in Colleges of Education for a better outcome, thereby exploring the effectiveness of inductive and deductive teaching strategies on students' learning in Basic General Mathematics with the implication for promoting sustainable development in Mathematics education.

STATEMENT OF THE PROBLEM

Students' achievement in Basic General Mathematics across Nigerian Colleges of Education has generated concerns among various education stakeholders. Multiple factors contribute to this issue of low academic achievement in Basic General Mathematics, which includes the teaching methods employed by educators, the class sizes, students' attitudes towards the subject among others. However, available information revealed a consistent decline in the achievement of students in the subject. Studies have been carried out on the application of different teaching strategies to Mathematics at different school levels based on available literature but to the best knowledge of the researchers of this study, not much studies has been reported on the application of inductive and deductive teaching strategies' interventions in students' learning in Basic General Mathematics at the College of Education. In view of the available background information, this

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study aimed to address this issue by implementing specific teaching strategies as interventions in the problem and to fill in the gap as contribution to knowledge using Oyo State as a case study, thereby investigating the Effects of Inductive and Deductive Teaching Strategies on Students' Learning in Basic General Mathematics with the implication for Sustainable Development.

PURPOSE OF THE STUDY

The purpose of this study was to investigate the Effects of Inductive and Deductive Teaching Strategies on Students' Learning in Basic General Mathematics for Sustainable Development.

Specifically, this study focused on providing insights into the significant effect of:

1. inductive teaching strategy in facilitating students' learning in Basic General Mathematics;
2. deductive teaching strategy in facilitating students' learning in Basic General Mathematics; and
3. conventional teaching strategies in facilitating students' learning in Basic General Mathematics

with their potential contributions to sustainable development.

HYPOTHESIS

The following hypothesis was generated for the study and tested at 0.05 level of significance:

H0: There will be no significant effect of:

1. Inductive teaching strategy
2. Deductive teaching strategy

- Conventional teaching strategy

on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

METHODOLOGY

The research design used for this study was Quasi-experimental design, which involved a pretest, post-test, non-randomized control and non-equivalent intact groups. Instructional strategies were at three levels, inductive and deductive teaching strategies and conventional teaching strategy. This aimed to explore the impacts of inductive and deductive teaching strategies on students' learning in Basic General Mathematics for sustainable development at the Colleges of Education in Oyo State. The population of the study covers all year two students of Colleges of Education in Oyo State in South-West, Nigeria. Sample for the study comprised 235 students from three intact classes from three government-owned colleges of Education in Oyo State ((Emmanuel Alayande College of Education, Oyo and Oyo State College of Education, Lanlate) and one Federal College of Education (Special), Oyo). The study was conducted in school settings, and involved groups of year one students who were taught using a deductive approach and another group taught with the conventional teaching strategy (lecture method). Two instruments were employed for this study: (i) The lesson plan and (ii) Basic Mathematics Achievement Test (BMAT) which was prepared by researchers from past examinations of year one students in Basic General Mathematics. The content of the BMAT was a 20 objectives questions which consisted of expansion and factorization of Algebraic expression topics in Basic General Mathematics at the Colleges of Education in Oyo State. The BMAT was subjected to validation and tested for reliability using Kuder Richardson-20 (KR-20) statistic with a reliability value of 0.89. The data generated from the study was analyzed using Analysis of Covariance (ANCOVA) at 0.05 level of significance.

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RESULTS

H0: There will be no significant effect of:

1. Inductive teaching strategy
2. Deductive teaching strategy
3. Conventional teaching strategy

on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

Table 1: Analysis of Covariance showing Test of Between-Subjects Effects of the Effect of Treatment (Inductive Teaching Strategy, Deductive Teaching Strategy and Conventional Teaching Strategy)

Dependent Variable: Post-test					
Source	**TypeIIISum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	2884.785[a]	3	961.595	574.187	0.000
Intercept	161.726	1	161.726	96.570	0.000
Pre-test	2757.851	1	2757.851	1646.765	0.000
Treatment	301.201	2	150.600	89.926	0.000
Error	386.858	231	1.675		
Total	25548.000	235			
Corrected Total	3271.643	234			

R Squared = 0.882 (Adjusted R Squared = 0.880)

From table 1, it was found that a significant effect of treatment on students' academic achievement in Basic General Mathematics in Colleges of Education ($F_{(2;231)} = 89.93$; $p < 0.05$). Therefore, the $R^2 = 0.882$ which implies that 88.2% of the variance (in dependent variable) is accounted for by the treatment, the null hypothesis H0 was not accepted. To explore the magnitude of the significant effects across treatment groups, the estimated mean of the treatment was carried out and the result is presented in table 2.

Table 2: Estimated Marginal Means for Treatment

Dependent Variable: Post-test				
Treatment	**Mean**	**Std. Error**	**Lower Bound**	**Upper Bound**
Inductive Teaching Strategy	7.917[a]	0.160	7.602	8.233
Deductive Teaching Strategy	10.532[a]	0.124	10.288	10.776
Control Group (Lecture method)	10.291[a]	0.168	9.961	10.621

Covariates appearing in the model are evaluated at pre-test value of 6.7915

Table 2 revealed that the estimated marginal means of students exposed to deductive teaching strategy had the highest academic achievement in BMAT with mean score of 10.532, followed by those exposed to control group with value of 10.291, while those exposed to inductive teaching strategy had the lowest value

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of 7.917.

DISCUSSION

The result indicated that treatment had significant effect on students' learning in Basic General Mathematics for sustainable development ($F_{2,231)}$=89.93; $p < 0.05$). The results of this study showed that the deductive teaching group outperformed the inductive teaching group on a test of mathematical problem-solving skills. The inductive teaching group also showed greater gains in their problem-solving skills over time. The study therefore concluded that, deductive teaching strategy can be an effective way to improve students' mathematical problem-solving skills. The estimated marginal mean suggests that the utilization of the deductive teaching strategy in teaching Algebra in Mathematics instruction is associated with improved academic achievement among students for sustainable development.

The findings of this study are in line with several previous studies that have demonstrated the effectiveness of deductive teaching strategy been demonstrated in various mathematical contexts, including Geometry, Arithmetic, Algebra, and Trigonometry (Campbell, Boyle & King, 2020). The study was also in line with the submission of Angraini, Larsari, Muhammad and Kania (2023) which buttress that students who were taught using a deductive approach were more likely to transfer their knowledge to new situations than students who were taught using an inductive approach. However, the outcome of this study was at variance with studies carried out by Barkl, Porter and Ginns (2012) and Jreisat (2023) which showed that in each of the identified studies, the inductive teaching groups consistently outperformed the deductive teaching group on tests assessing mathematical achievement. These previous studies also submitted that inductive teaching groups showed greater gains in their understanding of mathematical concepts and relationships than their counterparts who were taught with the deductive strategy. This implied that both inductive and deductive teaching strategies are veritable tools that can foster the learning of Mathematics at the College of Education for a sustainable Mathematics learning towards the advancement of technological development in the everchanging world.

CONCLUSION

The study aims to provide insights into the impacts of inductive and deductive teaching strategies on student learning in Basic General Mathematics for sustainable development. While both strategies have strengths and limitations, a blended approach that combines inductive and deductive methods may offer a comprehensive and effective learning experience. Balancing theoretical concepts with practical examples and encouraging critical thinking can enhance the effectiveness of both teaching strategies in achieving sustainable development goals. There are a number of other reasons to accept the effectiveness of inductive and deductive teaching strategies in Mathematics learning for sustainable development. Hence, both inductive and deductive teaching strategies can be effective for teaching Mathematics in the context of sustainable development. It is important to note that both inductive and deductive teaching strategies are not mutually exclusive. In fact, the most effective teaching approach often involves using a combination of both strategies. A teacher might start by using an inductive approach to introduce a new mathematical concept, and then use a deductive approach to help students to consolidate their understanding of the concept.

In practice, a combination of both inductive and deductive teaching strategies, known as a blended approach, can be highly effective. These strategies employed the advantages of the strengths of each method and offers a well-rounded learning experience for students in the context of Mathematics for sustainable development. In summary, both inductive and deductive teaching strategies can help students to develop critical thinking skills which are essential for sustainable development, as they allow people to analyze problems, identify solutions, and make informed decisions. However, inductive and deductive teaching strategies can help students to develop problem-solving skills essential for sustainable development, which allow people to identify and address challenges. In the same vein, inductive and deductive teaching

strategies can help students to develop creativity and develop new ideas and solutions necessary for sustainable development.

RECOMMENDATIONS

Based on the outcome of this study, the following recommendations are made:

1. Schools and colleges should adopt the use of inductive and deductive teaching strategies in teaching mathematical concepts to helps students' learning experiences in Basic General Mathematics classrooms;
2. Mathematics teachers should use less of the conventional teaching method in teaching Basic General Mathematics for more result-oriented Mathematics teaching and learning experiences;
3. Mathematics teachers especially at the Colleges of Education should adopt switching-in-between methods and strategies in their teaching exercises to find out the best strategy that can produce better learning experiences of their students in Mathematics.

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