Physics Teacher's Pedagogical Competency and Years of Experience as Predictors of Students' Numerical Proficiency in Solving Physics Problems

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Abstract
The research examined the relationship between teachers' pedagogical competencies, years of experience and students' abilities in numerical problem-solving within the context of physics. The study was guided by a specific objective, two research questions, and two hypotheses. A correlational survey research design was employed. Conducted in the Onitsha Education Zone of Anambra State, the study involved a population of 61 physics teachers (4 males and 57 females) and 6,348 SS2 students across 32 public secondary schools during the 2022/2023 academic year. A sample of 220 participants, consisting of 20 teachers and 200 physics students, was selected using a multi-stage sampling technique. Data collection utilized two instruments: the Physics Teachers' Pedagogical Competency Rating Scale (PTPCRS) and the Physics Students' Numerical Proficiency Test (PSNPT), both of which were validated by three experts. The reliabilities of the scoring was assessed using the Kendall coefficient of concordance, yielding reliability indices of 0.79 for the PTPCRS and 0.81 for the PSNPT. The researcher, along with five research assistants, administered the instruments. The data collected were analyzed using simple linear regression for the research question and one-way analysis of variance (ANOVA) for the hypothesis. The results indicated that teachers' characteristics, specifically pedagogical competency (R^2 = 54.6%), significantly predict students' numerical proficiency in solving physics problems. Also, it was found that teacher's years of experience moderate the predictability of teacher's pedagogical competence on students' numerical proficiency in solving physics problems. Based on these findings, it was recommended that teacher training institutions prioritize the development of essential pedagogical skills for all prospective teachers prior to graduation.

Keywords*:* Physics teacher, Pedagogical competency, years of experience, predictors, numerical proficiency, physics problems

Introduction

Teachers' pedagogical competencies are the key education driver that proffers practical policies, practice and regulations to guide teachers in the conduct to improve instructions. Pedagogical competency is the key to teachers instructional successes. It is the pivot of teachers classroom successes. Izaak (2016) defined pedagogical competency as the ability of teachers with regard to the management of learners. The concept under discussion pertains to the capacity to oversee the learning process, which encompasses the stages of planning, execution, and assessment of learners' educational outcomes. Pedagogical competence is characterized by essential knowledge and skills that underpin effective teaching, including a profound understanding of the subject matter, the ability to connect theoretical frameworks and research to practical teaching and learning, and the application of this knowledge and skill set within a coherent context (Sahana, 2015).

However, despite the significant roles, benefits, and widespread recognition of physics in various domains of human activity and national progress, student performance, particularly in the numerical components of physics, remains unsatisfactory. This is highlighted in the reports from the Chief Examiners of the West African Examination Council (WAEC, 2020 & 2021), which identified several factors contributing to students' difficulties in solving physics problems. Key issues include

insufficient mathematical skills, ineffective instructional methods, or a combination of both (Amasuomo & Ntibi, 2017; Muriithi, 2018). Consequently, it appears that enhancing students' performance, particularly in numerical skills, is likely to occur when they are instructed by effective teachers who possess not only pedagogical expertise, but also experienced in the profession. In light of this, numerous studies have been conducted focusing on students' numerical proficiency in physics, proposing strategies to enhance their problem-solving abilities, including the necessity for experienced and qualified teachers. It is important to highlight that the accumulation of being experience significantly aids physics teachers in deepening their understanding of concepts and effectively evaluating students' learning outcomes, including their numerical proficiency.

Numerical proficiency in physics encompasses the ability to tackle mathematically oriented problems, which is vital for elucidating theoretical concepts within the field. This skill set includes both mathematical and computational competencies that enable students to grasp the interconnections among various physics principles, thereby enhancing their problem-solving approaches. As noted by Skills Panorama (2020), numerical proficiency entails the capacity to access, apply, interpret, and convey mathematical information and concepts, which is essential for navigating the mathematical challenges faced in different facets of adult life. Zewdie (2014) emphasized that the ability to resolve complex issues is a fundamental skill for individuals in today's fast-evolving technological landscape. Given the quantitative essence of physics, it encourages students to distill problems through calculations that may be either memorized or sourced externally (Beiser, Mahajan & Choudhury, 2011). Students who excel in physics are those capable of transforming intricate physics equations into more manageable forms, thus effectively solving numerical challenges (Beiser, Mahajan & Choudhury, 2011). The authors further argue that a robust comprehension of core physics concepts, combined with the ability to apply this understanding to complex formulas, significantly enhances students' problem-solving capabilities in the domain of physics.

Problem-solving is widely acknowledged as a vital factor influencing academic achievement in scientific disciplines, particularly in Physics. This challenge arises from students' tendency to memorize solutions presented by their teachers rather than developing a genuine understanding of problem-solving techniques, which is characteristic of traditional pedagogical approaches. Research has shown that a significant number of Physics educators believe that students entering the subject often lack adequate preparation for performing calculations (Frederick & Joan, 2010). Furthermore, studies suggest that while students may excel in solving standard quantitative physics problems, they frequently do not possess a robust understanding of the essential conceptual or qualitative aspects of the field (Tenzin, 2019). This situation underscores the reality that students often acquire computational skills through memorization, without a comprehensive understanding of the underlying principles that inform their solutions. Additionally, it is widely recognized in physics education that students often substitute values in equations without fully grasping when to assign a parameter a positive, negative, or zero value. Essentially, the knowledge acquired by physics teachers over a good number of years is organized from a pedagogical perspective and serves as a basis for facilitating student comprehension of the subject matter.

Experience means knowledge or practical wisdom gained from what one has observed, encountered, or undergone. Experience refers to conscious events in general, more specifically to perceptions or to the practical knowledge and familiarity that is produced by these conscious processes (*Smith, 2018)*. The teacher is the builder whose performance depends on adequate experience and mastery of the subject matter (Amasuomo & Ntibi, 2017; Ntibi & Orim 2017). This adequate experience could be attained or achieved by acquiring additional knowledge that will stimulate his communication in teaching for efficiency. It could also be noted that the physics teachers' years of experience is important in selecting appropriate learning experiences and effective instructional approaches for improving achievement in physics as well as numerical proficiency in

problem solving. Hence, experienced physics teachers may have a richer background of experience to draw from and can contribute insight and ideas to the course of teaching and learning of physics concepts.

From literature, it has been observed that some research studies attempted to interpret the relationship between teachers' years of experience and students' numerical proficiency in problem solving in physics. On this note, Apata (2013) revealed that numerical proficiency of students taught by experienced teachers where better than those taught by less experienced teachers. Also, Kiptum (2016) and Muriithi (2018) revealed that experience contribute significantly towards variations in students achievement and that teaching experience contribute to high learning outcome. However, these findings have not been substantiated by many study especially in the area of teachers' experience and students' numerical proficiency in physics problem solving. This situation has created the need for more studieand it then becomes necessary to find out whether teachers' pedagogical competencies can predict students' numerical proficiency in solving numerical problems in physics using experience as a moderator variable to redress the situation and strengthen the already existing literature.

Research Questions

In accordance with the objectives of the study, the following research questions were posed to guide the study:

1. To what extent does teachers pedagogical competency predict students' proficiency in solving numerical physics problems?
2. What is the predictive power of teacher's pedagogical competency on students' numerical proficiency in solving physics problems as moderated by teachers years of experience?

Hypotheses

The following null hypotheses were formulated to guide the study and will be tested at 5% probability level.

Ho1: Physics teachers pedagogical competency is not a significant predictor of students' numerical proficiency in solving physics problems

HO_2: Physics teacher's pedagogical competency does not significantly predict students' numerical proficiency in solving physics problems as moderated by teacher's years of experience.

Method

The research framework employed in this investigation is a correlational research design. As articulated by Nworgu (2015), a correlational study aims to identify the nature of the relationship between two or more variables. This design is particularly suitable for the current study, as it seeks to assess the predictive capacity of pedagogical competency in relation to students' numerical proficiency in solving physics problems. The geographical focus of the study is the Onitsha education zone within Anambra State, which encompasses three local government areas: Onitsha North, Onitsha South, and Ogbaru. Within this zone, there are a total of thirty-two public secondary schools, distributed as follows: sixteen schools in Onitsha North, six in Onitsha South, and ten in Ogbaru. The choice of this area is anchored on the fact that the area is a business area and that most teachers are business men and women who mostly combine their teaching job with their various businesses and often do not prioritize their level of competencies on the job.

Two instruments titled Teachers' Pedagogical Competency Rating Scale (PTPCRS) and Physics Students' Numerical Proficiency Test (PSNPT) were used for data collection. PTPCRS, and PSNPT were developed and structured by the researchers to suit the present study based on empirical sources of information. PTPCRS has three clusters containing the items on physics teachers' pedagogical competencies to be measured and was structured on a four point rating scale of, 1 –

Poor, 2 – Fair, 3 – Good, 4 – Excellent, while PSNPT has twenty (20) calculation based questions. This was done to find out their numerical competency in problem solving in physics. Three experts, including one from the Measurement and Evaluation unit and two from the Physics Education unit, all associated with the Faculty of Education at the University of Nigeria, Nsukka (UNN), were assigned the responsibility of validating the instruments. The reliability of the instruments, specifically the PTPCRS and PSNPT, was evaluated through scorer's reliability using the Kendall coefficient of concordance. This method was chosen because it involved three raters who assessed the responses given by both teachers and students. The reliability coefficients calculated were 0.79 for the PTPCRS and 0.71 for the PSNPT. The instruments were administered and collected immediately. The data gathered were subsequently analyzed using simple linear regression for the research question and analysis of variance for the hypothesis.

Results

The results of the study are presented in the tables below

Research Question 1

What is the extent to which teacher's pedagogical competence can predict students' ability to solve numerical problems in physics?

Table 1

Regression coefficient of the predictive power of teacher's pedagogical competency on students' numerical proficiency in solving physics problems

Model Summary

Model	R	R Square	Adjusted Square	RStd. Error of the Estimate
1	.739[a]	.546	.521	14.83073

a. Predictors: (Constant), PTPCR

Table 1 presents a regression coefficient of 0.739, indicating that teacher's pedagogical competence serves as a significant predictor of students' numerical proficiency in addressing physics problems. Furthermore, the coefficient of determination (R squared) of 0.546 suggests that teacher pedagogical competence accounts for 54.6% of the variance in students' numerical proficiency in solving physics-related challenges.

Hypothesis 1

Physics teacher's pedagogical competency is not a significant predictor of students' numerical proficiency in solving physics problems.

Table 2

Analysis of variance (ANOVA) on predictive power of teacher's pedagogical competency on students' numerical proficiency in solving physics problems.

ANOVA[a]

Model		Sum Squares	ofdf	Mean Square	F	Sig.
1	Regression	4764.643	1	4764.643	21.662	.000[b]
	Residual	3959.107	18	219.950		
	Total	8723.750	19			

a. Dependent Variable: NP

b. Predictors: (Constant), PTPCR

Table 2 displays the findings, revealing F(1, 18)=21.662, p=0.000, a value that falls below the significance threshold of 0.05. This outcome implies the rejection of the null hypothesis in support of the alternative hypothesis. As a result, the pedagogical competence of physics educators is identified as a significant predictor of students' ability to solve numerical problems related to physics.

Research Question 2

What is the predictive power of teacher's pedagogical competency on students' numerical proficiency in solving physics problems as moderated by teacher's years of experience

Table 3

Regression coefficient of the predictive power of teacher's pedagogical competency *on students' numerical proficiency in solving physics problems as moderated by teacher 'teaching experience*

S/N	Experience	N	R	R^2	F ratio	p-value	Decision
1	Experienced Teachers	12	0.85	0.73	29.025	0.000	S
2	Inexperienced Teachers	8	0.23	0.053	2.544	0.620	NS

Table 3 shows regression coefficient, R= 0.85. Meaning that experienced teacher's pedagogical competency is a high predictor of students' numerical proficiency in solving physics problems. Similarly, the regression coefficient is 0.23 for the inexperienced teachers. Hence, inexperienced teacher's pedagogical competence predict students' numerical proficiency at a low level. In all, teacher's years of experience moderate the predictive power of teacher's pedagogical competency on students' numerical proficiency in solving physics problems by 0.62. Also, the coefficient of determination (R^2) for the two groups, shows that the teacher's years of experience contributes 67.7% in moderating the predictive power of teacher's pedagogical competency on students' numerical proficiency in solving physics problems. This means that pedagogical competence of experienced teachers contributed more to students' numeral proficiency than the one of the inexperienced teachers.

Hypothesis 2

Physics teacher's pedagogical competency does not significantly predict students' numerical proficiency in solving physics problems as moderated by teacher's years of experience.

Table 3 equally shows F (18) =29.025, p=0.000 < 0.05 for the experienced teachers. This means that pedagogical competency of experienced teachers significantly predict students' numerical proficiency in solving physics problems. Similarly, F(18)=2.544, p=0.620 > 0.05 for inexperienced teachers. This suggests that pedagogical competency of inexperienced teachers does not significantly predict students' numerical proficiency in solving physics problems. Thus, it could be summarized that physics teacher's years of experience significantly moderate the prediction of pedagogical competency on students' numerical proficiency in solving physics problems.

Discussion

The research results suggest that teacher's pedagogical skills significantly influence students' ability to solve numerical problems in physics. This suggests that the pedagogical skills of educators play a crucial role in enhancing students' abilities in this area. Such results may be explained by the notion that teachers who exhibit effective instructional strategies are able to facilitate a more meaningful teaching and learning experience. Such teacher employs instructional materials and suitable teaching methods in teaching a particular topic(s). Also, it is worthy of note to mention that a pedagogical sound teacher understands the individual differences of the learners and their learning styles and tailor teaching towards that direction; linking previous knowledge of the learners with their new knowledge. Such teacher inspires her/his students by employing appropriate instructional skills like set induction and stimulus variations to drive home her/his lessons. The teacher uses step by step

approaches in solving mathematical/numerical related problems, making it easy for the students to comprehend and master. The results of this study align with the conclusions drawn by Marzano and Toth (2013), which indicated that a teacher's pedagogical knowledge has a significant impact on student achievement. The results stand in contrast to the conclusions drawn by Asuru and Ikpa (2020), who found no substantial relationship between teachers' pedagogical competencies in the use of instructional resources, teaching methodologies, and teaching skills, and the academic performance of students. These discrepancies in findings may be explained by the varying samples employed in the respective studies, as teachers from different regions may exhibit differing levels of pedagogical competencies.

Also, findings revealed that teacher's years of experience contributes 67.7% in moderating the predictive power of teacher's pedagogical competency on students' numerical proficiency in solving physics problems. Thus, pedagogical competence of experienced teachers contributes more to students' numeral proficiency than the one of the inexperienced teachers. This finding is true because teachers who have been in the teaching profession for years are most likely to have acquired reasonable amount of experience in instructional delivery and understanding both students and instructional/pedagogical peculiarity, and uniqueness. Thus, this experience could translate into good mathematical/numerical proficiency on the part of the students.

Conclusion

The findings and subsequent discussion lead the researchers to assert that teacher's pedagogical competence serves as a crucial determinant of students' ability to effectively solve physics problems involving numerical concepts. Also teacher's years of experience moderate the predictability of teacher's pedagogical competence on students' numerical proficiency in solving physics problems.

Recommendation

In light of the study's conclusions, it is advisable for educators to deepen their understanding of instructional pedagogies to enhance their ability to impart numerical proficiency to their students. Also, efforts should be made in making sure that experienced teachers are retained by providing them with appropriate remuneration that will make the job interesting to them, while new/inexperienced ones are mentored by the experienced ones.

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