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Effects of Cognitively Guided Instruction on Senior Secondary School Students' Attitude towards Physics

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Abstract. In an effort to achieve educational goals and improve students' enthusiasm for Physics, it is important to take into account the prior experiences that students bring with them to the classroom. Teachers' exploration of these prior experiences is crucial when implementing the constructivist approach to classroom instruction, as it helps in achieving the desired objectives. Consequently, this research aimed to investigate how the application of cognitively guided instruction influences the attitudes of senior secondary school students towards Physics. The study employed a pretest-posttest control group quasi-experimental design and utilized multilevel linear models for data analysis, considering the hierarchical structure of the data with participants nested at both classroom and school levels. Students' Attitude to Physics Questionnaire was used to collect data during the study. The study's findings revealed a significant positive impact of cognitively guided instructional strategy (CGIS) on students' attitudes towards Physics, and a significant difference in the post-attitude mean scores of students in the CGIS and the conventional teacher-centred instructional groups. Thus, cognitively guided instruction holds substantial promise as an effective pedagogical strategy for teaching Physics. In conclusion, this research underscores the importance of contextualizing instruction, as it actively engages students in the learning process and significantly enhances their attitudes towards the subject of Physics. The instructional structure which CGIS provides enables the validation of students' knowledge-creation ability.

Keywords: Attitudes; Senior Secondary School Physics; instructional contextualisation; cognitively guided instruction; prior knowledge

1. Introduction

Physics, often regarded as the fundamental science, plays a pivotal role in shaping our understanding of the natural world. It provides the foundation for many technological advancements and scientific breakthroughs. Physics has been highlighted as vital for the technological and scientific advancement of society.

However, the study of Physics has frequently been met with apprehension and disinterest among students, particularly those in senior secondary school (Dognia & Dah, 2023; Kapanadze et al., 2023). A myriad of factors contributes to this phenomenon, ranging from the perceived complexity of the subject matter to the teaching methods employed in classrooms (Steidtmann et al., 2022). The attitude of students towards Physics can significantly impact their academic performance, career choices, and overall engagement in scientific inquiry. Consequently, it is imperative to explore innovative instructional approaches that can potentially enhance students' attitudes towards Physics. Cognitively Guided Instruction (CGI) emerges as a promising pedagogical framework that seeks to foster deeper understanding, critical thinking, and a positive disposition towards the subject.

Differences in cognitive backgrounds stemming from students' prior experiences, especially their exposure to informal science contexts, can have a detrimental impact on their attitudes toward subjects such as Physics in science and technology education (Kervinen et al., 2020). According to Hazari et al. (2022), there are growing concerns in the field of science education that the structured nature of secondary school (K-12) education can suppress and, in some cases, diminish students' enthusiasm and agency within the domains of science and technology. In response, stakeholders are increasingly turning towards informal learning experiences to inspire students to take an interest in science and technology-related subjects (Shaby, Assaraf & Tal 2017; Walan & Gericke, 2021). This shift is driven by the recognition that the formal classroom environment may limit students' opportunities to actively participate in science-related activities (Hazari et al., 2022).

There is substantial evidence indicating that when students actively engage in the process of constructing and reconstructing knowledge, it positively impacts their enthusiasm for learning (Xhomara, 2018; Alhawiti, 2022) and fosters the development of intricate individual perspectives on various concepts (Cantor et al., 2018; Darling-Hammond et al., 2019). Consequently, it becomes evident that teachers' exploration of students' prior knowledge is imperative for achieving the objectives of the constructivist approach to classroom instruction (Hattan & Alexander, 2020). Mavuru and Ramnarain (2019) posit that there is a gap in research on how teachers can negotiate and create learner autonomy and freedom of expression through the utilisation of everyday experiences in the science classroom by designing appropriate instructional activities and materials for meaningful understanding of science concepts. When effectively leveraged, prior knowledge serves as a robust foundation for students' learning, as underscored by Festinger's cognitive theory (Miller et al., 2015) and Ausubel's cognitive theory (Brod, 2021). Accordingly, Brod (2021) emphasized that prior experiences significantly influence students' attitudes toward scientific concepts and encouraged educators to acknowledge this influence and adapt their teaching strategies accordingly.

This paper delves into an empirical investigation aimed at unravelling the effects of Cognitively Guided Instruction on senior secondary school students’ attitude towards Physics. By scrutinizing the impact of CGI in the classroom, this study aims to shed light on whether this instructional approach can not only improve students' grasp of Physics concepts but also ignite a newfound enthusiasm for the subject. Furthermore, it explores the potential mechanisms through which CGI influences students' attitudes, such as increased self-efficacy, problem-solving skills, and a deeper appreciation for the relevance of Physics in everyday life. In an era where scientific literacy is of paramount importance, understanding how to cultivate a positive attitude towards Physics is crucial. The findings of this study may provide valuable insights for educators, curriculum designers, and policymakers seeking to enhance the quality of Physics education and promote a culture of scientific curiosity among senior secondary school students.

2. Students' attitude towards Physics

The concept of attitude toward Physics encompasses various elements, including having a positive view of Physics as a subject or field, showing support for Physics educators, displaying a favourable outlook on school-based Physics, and appreciating the experiences of learning Physics. However, this study defines attitude as comprising three key components: cognitive disposition (which includes information, opinions, and thoughts), affective disposition (encompassing feelings, preferences, and aversions), and behavioural disposition (referring to the inclination to take action) (Svenningsson et al., 2022). As a result, students' attitudes toward Physics are shaped by their beliefs about the subject, with these beliefs having the potential to influence their behaviour, whether cognitive or emotional, as highlighted by Sheldrake et al. (2019). Svenningsson et al. (2021) further elaborates on this by explaining that the cognitive disposition component addresses the role of cognitive processes in shaping a person's attitude toward Physics. The affective disposition component encompasses the positive or negative emotions that students associate with Physics, ranging from enjoyment to aversion. Additionally, interest, which is a subset of the affective dimension, is understood both analytically as an emotional schema and in reality as including cognitive aspects as well (Svenningsson et al., 2021).

Attitude represents an emotional dimension that is open to modification through effective instruction and can undergo transformation through persuasion using various strategies, as noted by Tytler and Osborne (2017). As emphasized by Reeve et al. (2015), interest is a dynamic aspect that can be shaped and cultivated over time through the acquisition of new experiences, allowing for a shift from situational interest to enduring individual interest. Research on students' attitudes toward learning underscores the pivotal role of attitude in both their current and future professional engagement, significantly influencing their career decisions (Mujtaba et al., 2018). Villa and Candeias (2019) have affirmed a strong connection between students' attitudes and their motivation to learn. The attitudes that students hold towards science have a substantial impact on their interest in the subject and their academic achievements in the field (Shahzad et al., 2022). Nevertheless, the prevailing narrative often portrays Physics as a challenging and abstract subject (Chetri, 2022), leading to a lack of interest among students.

The problem of students' unfavourable attitude (assessed as limited interest) towards Physics in Nigeria has remained a subject of ongoing discussion (Erinosho, 2013). Table 1 presented below illustrates the discrepancy in the enrolment of students in the three principal science subjects for the West African Senior School Certificate Examination (WASSCE) from 2010 to 2019.

Table 1: Students' Enrolment in WASSCE Science Subjects from 2010 to 2019

Year	Enrolment Rate		
	Biology	**Chemistry**	**Physics**
2010	1,300,418	465,643	463,755
2011	1,505,199	565,692	563,161
2012	1,646,150	627,302	624,658
2013	1,648,363	639,296	637,023
2014	1,365,384	636,268	635,729
2015	1,390,234	680,357	684,124
2016	1,200,367	706,873	705,125
2017	580,449	377,970	377,851
2018	1,087,063	728,551	728,354
2019	1,033,304	726,132	725,853

Source: *Statistics Section, West African Examinations Council (WAEC) National Office, Onipanu, Lagos, Nigeria*

Examining the data presented in Table i above reveals that Biology consistently garners a significantly larger number of applicants compared to the more mathematically-oriented subjects of Chemistry and Physics. Furthermore, there exists a noticeable disparity in student enrolment between Chemistry and Physics, which gives rise to concerns. It's worth noting that neither Chemistry nor Physics can be deemed expendable for core science and technology-related disciplines, as virtually every science and technology-related program that necessitates Chemistry also mandates Physics. Thus, the question arises: Why is there such a difference in student enrolment between Chemistry and Physics?

The reports authored by Chief Examiners for the West African Examinations Council (WAEC) spanning the years 2010 to 2018 have pinpointed specific shortcomings in students' performance in Physics examinations administered by WAEC. These deficiencies include a weak grasp of fundamental concepts and language barriers (WAEC, 2013; 2014) as well as an inability to connect acquired knowledge with real-life scenarios (WAEC, 2014). The reports have recommended that educators place a greater emphasis on illustrating how Physics principles can be applied in everyday situations and encourage students to provide explanations that enable them to apply these fundamental principles to real-life contexts (WAEC, 2015). Additionally, the reports suggest discouraging rote learning and strengthening classroom instruction by incorporating appropriate demonstrations (WAEC, 2018).

Supporting the recommendations of the WAEC Chief Examiners, research findings attribute students' unfavourable attitude toward Physics to the neglect of their prior informal Physics knowledge by teachers (Brod, 2021). Studies conducted by Osondu (2018) and Adolphus et al. (2021) have unveiled that the prevailing approach employed by many Physics educators in Nigerian public senior secondary schools is the traditional method of instruction, primarily relying on teacher-centred techniques such as lectures and dictation of notes. Osondu (2018) contends that the persistent use of the lecture method by Physics teachers contributes to students' negative perception of the subject. It has been demonstrated that students' active engagement during instruction leads to improved learning outcomes (Isa & Opara, 2018; Adolphus et al., 2021). Therefore, it is imperative to adopt instructional strategies that facilitate students' active involvement in classroom learning and bridge the gap between their experiences outside the classroom and their encounters with Physics within the classroom (Chetri, 2022).

Numerous studies have explored the impact of various strategies on students' attitudes toward Physics. These investigations encompass a range of approaches, including the utilization of Pictorial, Written, and Verbal Advance Organizers (Akinbobola, 2015); the assessment of the Effects of Outdoor Activities (Jegede & Awodun, 2015); a comparative study on the Relative Effectiveness of Cooperative Learning Strategies such as Computer-Supported Jigsaw II, STAD, and TAI (Gambari & Yusuf, 2017); the implementation of Combined Physical and Inquiry Virtual Laboratories (Onuh & Okigbo, 2019); the application of the Metacognitive Scaffolding Teaching Strategy (Agu & Iyanu, 2020); the use of the Jigsaw Instructional Strategy (Damoeroem, 2021); the exploration of Brain-Based Learning Strategy (Kyado et al., 2021); and the investigation into Gagne's Learning Hierarchy (Agboghoroma et al., 2022), among others. Despite the introduction of these interventions, the persistent challenge of low student enrolment in Physics, particularly in certification examinations, continues to be a concern. Consequently, there is a need to examine the effects of the cognitively guided instructional strategy, which has previously demonstrated successful outcomes in enhancing students' learning in mathematics.

3. Cognitively Guided Instructional Strategy

The cognitively guided instructional strategy represents an approach to teaching that centres on the learner and leverages students' prior classroom experiences as a starting point for achieving educational goals (Moore & Cuevas, 2022). This instructional method is contextually adaptive, allowing educators to firmly establish students' contextual understanding of Physics by utilizing their everyday experiences as the basis for all instructional activities. Moore and Cuevas (2022) underscored that the Cognitively Guided Instructional Strategy (CGIS) is a constructivist approach to teaching both science and mathematics, employing extensive discourse and problem-solving to cultivate a conceptual grasp of fundamental scientific and mathematical concepts.

CGIS is firmly rooted in the belief that children are inherently curious and possess the capacity to harness their curiosity to seek answers to complex narrative exercises, even outside the formal educational environment provided by schools (Conowal, 2018). Moscardini (2014) pointed out that one of the advantages of CGIS is its capacity to harness and expand upon students' existing scientific knowledge, fostering a deep conceptual understanding rather than mere surfacelevel scientific facts. CGIS empowers students to seek solutions to challenges through a variety of approaches, encouraging active engagement with both their peers and teachers through rich discourse (Sencibaugh et al., 2016).

The primary aim of any educational program is to equip students to confront novel situations that involve various levels of connections and comparisons with their existing knowledge. Therefore, the teaching challenge, as articulated by Akinbobola (2015), revolves around creating experiences that encompass students and support their perception, learning methods, explanation, interaction, and application of the scientific principles necessary to comprehend these experiences. Within the context of CGIS, advance organizers serve as a bridge between the intended knowledge and the students' pre-existing content knowledge. Advance organizers, as defined by Akinbobola (2015), are materials provided at the beginning of a learning activity designed to help students synchronize and validate new knowledge. These advance organizers are appropriately pertinent and encompassing materials introduced at the outset of instruction, presenting a higher level of abstraction, inclusiveness, and generality compared to the instructional materials, thereby incorporating essential overarching concepts. Research has demonstrated that advance organizers facilitate students in structuring the learning material into a recognizable pattern. This process involves integrating new knowledge into the existing cognitive framework known as "schemas," which holds specific knowledge of various concepts (Akinbobola, 2015). The connection between the experiences within these schemas plays a pivotal role in establishing robust associations with the newly introduced concepts.

This approach has been widely applied in educational literature to improve students' performance in mathematics. Given the close relationship between Physics and mathematics, the study anticipates that employing this strategy will lead to improved learning outcomes, particularly addressing the issue of students' negative attitudes towards Physics, often linked to apprehensions about the mathematical aspects of the subject.

Table 2: Difference between CGIS and the Conventional Teacher-Centred Instruction

Cognitively Guided Instruction	Conventional Teacher-Centred Instruction
i. CGIS pays much attention and utilizes students' prior experiences of science albeit informal ii. Students' play active role in the instructional exercise.	i. Teacher-centred instruction pays much attention to the coverage of the Scheme of Work provided by the Ministry of Education ii. Teacher supplies students with an already prepared lesson note

4. Research Questions

The study addressed the following research questions:

- How does the implementation of the instructional strategies impact the attitudes of senior secondary school students toward Physics?

- Is there a notable difference in the attitudes of students between the CGIS group and the control group?

5. Relevance of the study

This study holds significant relevance as it offers stakeholders in science education an instructional approach that has consistently yielded positive results in students' mathematics learning over the years. Within the existing literature, one of the factors frequently cited for students' negative attitudes toward Physics is the subject's abstract and mathematical nature. Therefore, this study anticipates that the instructional approach, which has demonstrated success in teaching mathematics, will have a positive impact on students' attitudes toward Physics. Furthermore, this study's emphasis on incorporating and integrating students' experiences outside the classroom as a foundational element for Physics instruction underscores the importance of students' everyday experiences in shaping their learning outcomes.

6. Methodology

The methodology employed in this study is outlined below.

Research design

The research employed a pretest-posttest control group quasi-experimental design, which was well-suited for achieving the study's objectives, allowing for manipulation and data collection. Pretest-posttest research is a type of quasi-experimental design which has the advantage of directionality of the study, which simply implies the testing of the dependent variable (attitude) before and after the intervention of the independent variable (treatment) (Stratton, 2019). The qualitative method of participant observation was adopted in the selection of teachers for the study. Participants were randomly allocated to either the experimental group or the control group. The Experimental Group (E) received instruction using the Contextually-Responsive Cognitively Guided Instructional Strategy, whereas the Control Group received instruction through the Conventional Instructional Strategy.

Study population and Demography

The study drew its participants from Senior Secondary Schools located in the urban region of Ibadan known as the Ibadan metropolis, which comprises five Local Government Areas (LGAs) in Nigeria. To ensure fairness and eliminate bias, a simple random technique was employed to select three LGAs from within the Ibadan metropolis. Subsequently, one school was purposefully chosen from each of these three selected LGAs. The selection of schools was guided by various criteria, including proximity to the research site, the presence of a functional Physics laboratory, and the qualification of Physics teachers.

The study focused on Senior Secondary II students as its participants. This selection was made to include students who had a minimum of one year of experience in learning Physics and who were not under the added pressure and distractions associated with the West African Senior School Certificate Examination (WASSCE) at the time of the study. The age of the participants ranged from 14 to 20 years, with an average age of 15.00 ± 1.05 years. Among the participants, the oldest was 20 years old, while the youngest was 14 years old. The study's population consisted of 55.8% males and 44.2% females.

Criteria for selection of schools
A survey was conducted to identify government-owned secondary schools that had Physics teachers meeting the required qualifications. Moreover, the survey assessed the extent to which these schools covered the senior secondary school Physics curriculum and their willingness to take part in the study. The aim was to ensure that the study participants had a comparable level of exposure to Physics content, thereby minimizing the potential for any group of students to have an unfair advantage. Additionally, factors like the availability of instructional resources, a well-equipped Physics laboratory, and a favourable learning environment were taken into account during this selection process.

Selection and Training of Research Assistants/Teachers for the Study
Three highly qualified Physics teachers, each possessing more than four years of teaching experience, were carefully chosen for this study. These teachers were selected from a pool of six instructors who actively participated in the training and assessment program organized as part of the study. All the teachers underwent comprehensive training in both CGIS and the conventional teaching strategy. Following the training, the top-performing three teachers were selected out of the original six. This meticulous selection process aimed to minimize any potential impact of variations in teacher quality on the study's outcomes.

The process of selecting teachers involved a thorough assessment, which encompassed participant observation and the evaluation of the teaching skills demonstrated by the teachers following their training. An Evaluation Form for Assessing Teachers' Performance (EFATP) was developed and used to assess the teachers' proficiency in applying the instructional guidelines provided for the study. EFATP outlined the specific skills that teachers were expected to exhibit during the teaching and learning process. These skills included the Presentation of Concepts, Introduction, Lesson Progression, Communication, Student Participation, Classroom Activities, Use of Instructional Materials for Activities, and Subject Mastery.

Instruments for Data Collection
For data collection, the study employed the use of research instruments divided into two distinct groups: Stimulus and Response. These instruments include:

1. ***Stimulus:***
i. Instructional Guide for Cognitively Guided Instructional Strategy (ICGIS)
ii. Instructional Guide for Conventional Strategy (IGCS)

2. ***Response:***
i. Students' Attitude towards Physics Questionnaire (SAPQ)

The instructional guides were created to provide a systematic framework for implementing the lesson plans. Copies of these instructional guides were submitted to four experts in Science Education for content evaluation, face validity assessment, and logicality appraisal of the instructional steps and stages. The grades obtained from the four raters were subjected to analysis using Fleiss' Kappa inter-rater reliability scale. The resulting reliability indices were 0.75 for IGCGIS and 0.73 for IGCS, indicating a consensus among the four raters and affirming the instrument's reliability for use.

The Students' Attitude towards Physics Questionnaire (SAPQ) comprises a set of questions adapted from the Test of Science-Related Attitudes (TOSRA), a multiple-choice instrument devised by Fraser (1978). SAPQ consists of 20 items intended to explore the three key components of attitude considered in this study, which include cognitive, affective, and behavioural components. The cognitive component assesses students' disposition concerning Information, Opinions, and Thoughts; the affective disposition examines students' Feelings, Likes, and Dislikes; while the Behavioural Disposition scrutinizes students' actions in response to Physics instruction. The instrument was constructed using a 4-point Likert scale, offering the following response options: Strongly Disagree (SD), Disagree (D), Agree (A), and Strongly Agree (SA). The Test of Science-Related Attitudes (TOSRA), developed by Fraser (1978), focuses on Perceived Utility of Science, Attitudes toward Science as a School Subject, Pursuing Science, and Science as Leisure. This focus is aligned with the objectives of the study, prompting the adaptation of TOSRA while considering the content wording, which was reviewed to suit the study's specific goals. Given that the TOSRA has been in use for a considerable time and concerns exist regarding its reliability in accurately measuring the construct, the instrument underwent rigorous reliability and validity testing.

The validation and reliability assessment of the Students' Attitude Towards Physics Questionnaire (SAPQ) involved distributing copies of the questionnaire to specialists in both Science Education and Educational Psychology. Their evaluation focused on assessing the face and content validity, emphasizing aspects like clarity, adequacy, comprehensiveness, and the language used in the questionnaire. After the experts' review and necessary adjustments, the SAPQ, initially containing 50 items, was subjected to a reliability test, resulting in a reduced set of 20 questions. The reliability of the instrument was assessed using Cronbach's alpha analytical tool, yielding a reliability coefficient of 0.70.

Duration of the study

The study extended over a duration of 13 weeks. This timeframe aligns with the academic calendar in Nigeria, where an academic year is divided into three terms, each spanning 12 weeks. This choice is consistent with the findings of Lally et al. (2010), who suggested that it takes anywhere from 18 to 254 days to effect a change in an individual's attitude, and up to 66 days for this change to become internalized. Additionally, Brinor et al. (2015) supported the idea that meaningful attitude change occurs gradually, unfolding over a period of weeks and months, driven by thoughtful and persuasive consideration of significant perspectives (LaCour & Green, 2014). The schedule of activities is presented as follows:
Week 1- Selection of schools
Week 2- Training of Teachers and Pre-test Administration

It is important to state that prior to the training of the teachers, none of them had any prior experience of CGIS. They are used to the conventional strategy.

Week 3 – 12- Implementation of the intervention

None of the students had any previous encounter with CGIS, they were only familiar with the conventional strategy.

Week 13 - Post-test Administration

Aggregate = 13 weeks

Fidelity of implementation of the intervention

To measure the accuracy of the degree of implementation of the intervention, teachers' performance data was collected through observation sheets. Three research assistants, who are doctoral students, were employed to observe and rate teachers' level of implementation of the steps in the instructional guide. The experts ticked [√] the number of items that were accurately implemented on the observation sheets. The numbers of ticked [√] items were divided by the total number of items on the observation sheet and multiplied by 100%.

$$\text{Fidelity score} = \frac{\text{number of ticked [}\surd\text{] items}}{\text{Number of items on the observation Sheet}} \text{ x } 100\%$$

The observers' ratings were collated and the mean scores were computed for each of the interventionists. Based on the information collected by the observers, a mean fidelity score of 96.7% was obtained. This shows that the intervention was implemented with about 96.7% accuracy.

7. Data Analysis

The analysis of the data was conducted using multilevel linear models. This choice was made because the data exhibited a hierarchical and nested structure. Nesting arises when the levels of independent variables are confined to a single level of influence. For instance, in the case of repeated-measures designs, participants are nested within themselves (Tabachnick & Fidell, 2014; Mertler & Reinhart, 2017). However, when participants are influenced by variables such as the teacher, classroom, and/or school, the data becomes nested at different levels. In this particular study, participants were subject to influences at the personal, teacher/classroom, and school levels, resulting in data nesting at three distinct levels, constituting a hierarchical structure. The mean score of all the students in each classroom was computed and used as the dependent variable.

This study encompassed a 3-level hierarchical structure (participants, classes, and schools). The socio-demographic characteristics of the schools could potentially impact the study (Field, 2018). Therefore, the adoption of multilevel linear models was necessary to address issues related to the error term associated with the random assignment of intact classes and the challenge of uneven sample sizes among different classes. One notable advantage of this model is its ability to mitigate the assumption of homogeneity of regression slopes, the assumption of independence, and the challenges posed by missing data (Field, 2018).

8. Findings of the Study

Following the multilevel linear models analysis of the data, the outcome of the study is presented below.

Effect of Cognitively Guided Instruction on students' attitude towards Physics
A multilevel model was constructed to investigate the impact of Cognitively Guided Instruction on students' attitudes toward Physics. In the initial stage, a linear mixed model analysis was conducted to assess students' attitudes toward Physics, with CGIS being the sole predictor included in the model, as illustrated in Table 1 below.

Table 1: Tests of Fixed Effects

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	109	1678.436	.000
Intervention	1	100	11.620	.000

The results indicated that the intervention had a significant predictive effect on students' attitudes toward Physics, as evidenced by the statistical significance ($F(1, 109.00) = 11.62$, $p < 0.001$). However, this outcome was derived without taking into account the influence of students' initial attitudes toward Physics, which were assessed as Pre-attitudes based on their pretest scores. Consequently, a modified model was constructed to incorporate these baseline attitudes, and the results are presented in Table 2 below.

Table 2: Tests of Fixed Effects

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	109	151.891	.000
Intervention	1	109	16.542	.000
Pre-attitude	1	109	4.453	.037

The results reveal that both the intervention, indicated by $F(1, 109) = 16.542$, $p < 0.000$, and the baseline attitudes of students toward Physics, assessed as Pre-attitudes and represented by $F(1, 109) = 4.453$, $p < 0.037$, significantly influence students' attitudes. The data exhibited a hierarchical structure with three levels (participants, class, and school levels). Consequently, the study took into account this hierarchical data structure when constructing the model. However, the analysis outcome indicates that the model was unable to effectively predict students' attitudes toward Physics, as presented in Table 3 below.

Table 3: Tests of Fixed Effects

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	105	62.220	.000
Intervention	1	105	5.618	.020
Pre-Attitude	1	105	5.118	.072

The outcome indicates that the intervention, as indicated by $F(1, 105) = 5.618$, $p = 0.020$, led to an improvement in students' attitudes toward Physics. However, the baseline scores of the students (Pre-Attitude), represented by $F(1, 105) = 5.118$, $p < 0.072$, did not have a significant effect in enhancing students' attitudes toward Physics. Concerning the relationship between the intervention and students' attitudes toward Physics, significant variances in intercepts were observed among participants, as indicated by Var (u0j) = 3.06, $\chi^2(1) = 11.1$, $p < 0.01$. Furthermore, the slopes exhibited variations across participants, with Var (u1j) = 2.35, $\chi^2(1) = 9.33$, $p < 0.01$, and the slopes and intercepts demonstrated a positive and significant covariance, with Cov (u0j,u1j) = 0.82, $\chi^2(1) = 9.15$, $p < 0.01$. The study's findings showed that the intervention significantly predicted students' attitudes, reflected by $F (1, 105) = 5.618$ and $p = 0.020$

Difference in the attitude of students to Physics

Upon conducting a more in-depth examination of the data presented in Table 4 below, it becomes evident that students who received instruction using CGIS achieved the highest mean scores on post-tests assessing their attitudes toward Physics across all three schools (School-1, School-2, and School-3).

Table 4: Descriptive statistics showing the Estimated Mean of students' attitude towards Physics

School	Intervention		No. of Students	Mean
School-1	Cognitively Guided Instructional Strategy (CGIS)	Post-Attitude	18	59.56
	Conventional Strategy(CS)	Post-Attitude	20	56.65
School-2	Cognitively Guided Instructional Strategy (CGIS)	Post-Attitude	17	59.88
	Conventional Strategy(CS)	Post-Attitude	18	56.22
School-3	Cognitively Guided Instructional Strategy (CGIS)	Post-Attitude	18	59.56
	Conventional Strategy(CS)	Post-Attitude	18	56.22
Total	Cognitively Guided Instructional Strategy (CGIS)	Post-Attitude	53	59.66
	Conventional Strategy(CS)	Post-Attitude	56	56.37

As shown in Table 4 above, students in CGIS showed improved post-test mean scores on attitude towards Physics.

9. Discussion

The findings unveiled a significant impact of the intervention on students' attitudes toward Physics. However, when accounting for the hierarchical nature of the data, with participants nested within school and class levels, the model failed to improve students' attitudes toward Physics. Further examination of the data revealed that students who experienced CGIS achieved the highest adjusted post-attitude mean scores (59.56, 59.88, and 59.66, with an average mean score of 59.66) compared to the Conventional Strategy (control group) (56.65, 56.22, and 56.22, with an average mean score of 56.37), which had the lowest adjusted post-attitude mean scores in the study. This improvement in students' attitudes can be attributed to the active role of the students in the CGIS during the instructional activities, which enabled them to co-create the learning experiences.

The cognitive guidance provided to students and the consideration of their prior informal experiences contributed to the enhancement of their attitudes toward learning activities. This is in line with the cognitive theories of Festinger (Miller et al., 2015) and Ausubel (Brod, 2021). Moore and Cuevas (2022) found that when students' prior knowledge is taken into account during instruction, new strategies are generated and internalized, and students take ownership of the techniques they employ to tackle challenges. CGIS is also an instructional strategy that enables the structuring of students' learning experiences. The results of this study aligns with the position of Leenknecht et al. (2017) which emphasized that when structures are provided for students learning, it enhances their effectiveness and enables them to extend their capabilities thereby enhancing their attitude to learn more. In the implementation of CGIS, teachers provide structures for the students' active participation in the learning exercise. Structure, as Stroet et al. (2013) explained, consists of four main parts, which are: first, the provision of measures of clarity by the teacher, in terms of giving clear, understandable, explicit, and detailed instruction as well as articulate framing of the instruction exercise; the second part addresses, teachers' guidance of students' classroom activities; the third part highlights teachers' support and reinforcement, which enhances students' interest and control over their studies; and the fourth aspect of structure is teachers' provision of constructive feedback which enables the students gain control over there learning.

Additionally, the findings of this study reinforce the position of Suryawati and Osman (2018) which emphasized that cognitively guided instruction can inspire students to develop a more positive attitude toward science instruction by facilitating the connection between classroom learning and their everyday experiences.

10. Implications for curriculum reform

The study highlights the potential of Cognitively Guided Instruction Strategy (CGIS) as an effective approach to enhancing students' attitudes toward Physics. This has implications for educators and curriculum developers who can consider implementing CGIS in science education to promote more positive attitudes among students. Teachers can benefit from the findings by adopting CGIS in their instruction, which encourages active student participation and consideration of students' prior knowledge and experiences.

The curriculum is an embodiment of values and skills which the society intends to promote for functional living of members, as well as the sustenance, of the society. Hence, the curriculum is the nexus between the town and gown (the society and education). In other words, values, skills and experiences that are important to any society are drafted into the curriculum and subsequently utilised as a tool for educating (initiating) the young members of the society who would utilise these learned values and skills in the development of the society. Therefore, important considerations must be given to the informal experiences of science that resides within the society. For instance, some of the Physics topics, especially those relating to the interaction of Matter, Space and Time; Mechanics; and Waves, Motion without Material Transfer, are concepts which the students interact with in their daily experiences. These children, especially those in rural and/or poor environments innovatively produce motor able devices/gadgets which serve as a form of car for sporting and leisure activities as well as an aid in carrying loads. They improvise and utilise musical instruments which is evidently captured by the popular Ikorodu Boys in Nigeria. These informal experiences can be captured by instructional designers and implementers. This pedagogical shift may lead to improved attitudes and engagement in the subject.

CGIS is also an instructional strategy that enables the structuring of students' learning experiences. In the implementation of CGIS, teachers must provide structures for the students' active participation in the learning exercise. Instructional structure consist of four main parts, which are: provision of measures of clarity by the teacher, in terms of giving concise, comprehensible, explicit, and specified instruction as well as very articulate framing of the lesson; the second part addresses, teachers' guidance of students' classroom activities; the third part highlights teachers' support and reinforcement, which enhances students' interest and control over their studies; and the fourth aspect of structure is teachers' provision of constructive feedback which enables the students gain control over there learning.

Curriculum designers may consider integrating CGIS or similar learner-centred strategies into the Physics curriculum to promote a more positive learning environment and foster better attitudes among students. Teacher training programs should include elements of CGIS and other constructivist teaching strategies to equip educators with the skills to effectively implement these approaches and positively impact students' attitudes. Education policymakers can consider the adoption of CGIS or similar methods in science education policies to address the issue of low enrolment and negative attitudes toward Physics in secondary schools.

The study opens up opportunities for further research into the effectiveness of CGIS in different educational contexts, subjects, and age groups. Future research can explore the long-term impact of CGIS on students' attitudes and their academic achievements. The study underscores the importance of student-entered learning approaches that consider students' prior knowledge and experiences. This shift towards more personalized learning experiences can enhance overall education quality. The study's focus on the connection between teaching methods and attitudes toward a subject like Physics provides valuable interdisciplinary insights into the fields of education, psychology, and science. The findings may inform efforts to address the gender gap in STEM fields by promoting more positive attitudes toward Physics among female students through learner-centred approaches. The study's implications extend beyond the specific context of the research, offering insights that can benefit science education globally, particularly in addressing challenges related to student attitudes and engagement in science subjects.

In summary, the paper's findings and implications suggest that Cognitively Guided Instruction can be a promising approach to improve students' attitudes toward Physics in senior secondary schools, with potential benefits for educators, students, curriculum developers, and policymakers in the field of education.

11. Conclusion

This study has shed light on the transformative potential of Cognitively Guided Instruction (CGIS) in shaping the attitudes of senior secondary school students toward the challenging subject of Physics especially when we consider the enrolment ratio of student into Physics with that of other vital science subjects as highlighted in Table i. The investigation revealed several key insights and implications that hold significance for both educators and policymakers in the field of science education. Our findings unequivocally demonstrate that the implementation of CGIS significantly enhanced students' attitudes toward Physics. The study also revealed a significant difference in the attitude of students taught with CGIS when compared with the attitude of students in the conventional teacher centred instructional strategy. This is possible because through the adoption of CGIS, students were actively engaged in the learning process, drawing upon their prior knowledge and real-life experiences to construct meaningful understanding of Physics concepts. This learner-centred approach not only fostered a more positive and enjoyable learning environment but also bridged the gap between students' out-of-classroom experiences and formal classroom instruction.

Studies have established the significance relationship among students’ prior informal experiences, skills, belief in the relevance of the subject, and their attitude towards the subject, and which also formed the basis of Festinger's and Ausubel’s cognitive theories. This study, therefore, underscores the critical importance of considering students' prior knowledge and experiences as a foundational element in science education. When educators recognize and harness the cognitive and affective dimensions of students' attitudes, it can lead to more effective teaching strategies and a greater appreciation for the subject matter. The implications of our research extend beyond the classroom. Educational policymakers should take note of the potential of CGIS to address the persistent issue of low enrolment and negative attitudes toward Physics. By incorporating learner-centred strategies like CGIS into science education policies, we can foster a generation of students who not only excel in Physics but also develop a genuine passion for the subject. Furthermore, our study highlights the broader significance of student-centred learning approaches in enhancing the overall quality of education. By prioritizing students' active involvement, we can create more personalized and engaging learning experiences that empower students to take ownership of their learning journey.

As we look ahead, this research opens the door to further investigations into the effectiveness, and practical implementation of CGIS in diverse educational contexts and age groups. It also encourages us to explore the long-term impact of learner-centred strategies on students' attitudes and academic achievements. In a world where science and technology play an increasingly pivotal role, nurturing positive attitudes toward Physics and other STEM subjects is paramount and should include practical applications of the tenets of constructivists' instructional model. The insights gained from this study, therefore, serve as a testament to the potential of innovative pedagogical approaches like CGIS to transform not only the way we teach but also the way students perceive and embrace the complexities of the physical sciences. With a commitment to student-centred education, we can inspire future generations to embark on a journey of scientific discovery and innovation, driving progress and prosperity for society as a whole.

12. Limitation of the Study

While this study has provided valuable insights into the effects of Cognitively Guided Instruction (CGIS) on senior secondary school students' attitudes toward Physics, it is important to acknowledge its limitations. These limitations offer opportunities for further research and provide context for the interpretation of the study's findings:

i. **Generalizability**: The study was conducted in a specific geographic area with a limited number of schools and participants. Consequently, the findings may not be fully generalizable to different regions, educational systems, or cultural contexts. Future research should seek to replicate the study in diverse settings to enhance the external validity of the results.
ii. **Sample Size**: The sample size in this study may be considered relatively small, which could affect the statistical power of the findings. A larger and more diverse sample could provide a more robust foundation for drawing conclusions and detecting smaller effect sizes.
iii. **Duration of Intervention**: The study was conducted over a 13-week period, which, while suitable for an academic term, may not capture the long-term effects of CGIS. Longer-term studies could investigate whether the positive changes in attitude are sustained over time.
iv. **Teacher Variability**: The study included three qualified Physics teachers, but variations in their teaching styles and effectiveness may have influenced the results. Future research could explore the impact of teacher variability and instructional fidelity on the outcomes of CGIS.
v. **Self-Reported Data**: The measurement of students' attitudes relied on self-report questionnaires, which may be subject to response bias or social desirability bias. Combining self-reported data with other assessment methods, such as interviews or classroom observations, could provide a more comprehensive understanding of students' attitudes.
vi. **Control Group**: While efforts were made to establish a control group, it is challenging to ensure complete equivalence between the experimental and control groups in real educational settings. Factors beyond the instructional method, such as teacher-student relationships and classroom dynamics, could have influenced the results.
vii. **Long-Term Impact**: The study primarily focused on short-term changes in students' attitudes. A longitudinal approach that tracks participants' attitudes over an extended period could provide valuable insights into the enduring effects of CGIS.
viii. **Resource Availability**: The study considered factors such as the availability of functional Physics laboratories and qualified teachers in the

selection of schools. Resource constraints in other settings may limit the feasibility of implementing CGIS or similar instructional approaches.

ix. **External Factors**: External factors such as societal perceptions of Physics and cultural influences on education were not extensively explored in this study. These factors could play a significant role in shaping students' attitudes and merit further investigation.

x. **Instrumentation**: While the Students' Attitude Towards Physics Questionnaire (SAPQ) demonstrated reliability and validity, it is essential to acknowledge the limitations of any measurement instrument. Researchers may consider refining or supplementing existing instruments for a more comprehensive assessment of attitudes.

In summary, it is crucial to recognize its limitations in terms of generalizability, sample size, duration, teacher variability, measurement, and external factors. Future research should build upon these findings and address these limitations to provide a more comprehensive understanding of the potential of CGIS in diverse educational contexts.

13. Recommendations

Based on the findings and limitations of the study, the following research and practical based recommendations are offered to inform future research and guide educational practices:

Research Based Recommendations

a. **Replication and Generalization**: Conduct similar studies in various geographic regions, educational systems, and cultural contexts to assess the generalizability of the positive effects of Cognitively Guided Instruction (CGIS) on students' attitudes towards Physics. This will help establish the external validity of the approach.

b. **Collaborative Research**: Foster collaborative research between educators, researchers, and policymakers to continue exploring innovative instructional strategies and their impact on students' attitudes towards Physics.

c. **Longitudinal Studies**: Implement long-term, longitudinal studies to track the sustainability of the positive changes in students' attitudes over extended periods. This will provide insights into the enduring impact of CGIS on students' attitudes.

d. **Teacher Variability**: Investigate the influence of teacher variability on the effectiveness of CGIS. Research should explore how different teaching styles and instructional practices impact students' attitudes towards Physics.

e. **Diverse Assessment Methods**: Combine self-report questionnaires with alternative assessment methods, such as interviews, classroom observations, and performance assessments, to gain a comprehensive understanding of students' attitudes and learning experiences.

f. **Incorporate External Factors**: Explore the role of external factors, including societal perceptions of Physics and cultural influences on education, in shaping students' attitudes. Understanding these factors can inform the development of targeted interventions.

Practical Based Recommendation

g. **Pedagogical Guidelines**: Develop pedagogical guidelines and best practices for implementing CGIS in Physics classrooms. These guidelines should provide practical strategies for teachers to integrate students' prior knowledge and experiences into their instruction effectively.
h. **Resource Allocation**: Educational authorities should allocate resources to ensure the availability of functional Physics laboratories, qualified teachers, and instructional materials in schools. Adequate resources are essential for implementing CGIS effectively.
i. **Interdisciplinary Approaches**: Encourage interdisciplinary approaches that connect Physics to other STEM subjects, emphasizing the real-world applications of Physics concepts. This can enhance students' motivation and interest in the subject.
j. **Teacher Training**: Develop and implement professional development programs for Physics teachers that focus on CGIS and other learner-centred instructional strategies. These programs should emphasize the importance of contextualizing instruction and actively involving students in the learning process.
k. **Policy Advocacy**: Educational policymakers should consider integrating learner-centred approaches like CGIS into science education policies and curriculum development. These approaches can help address issues of low enrolment and negative attitudes towards Physics.
l. **Community Engagement**: Involve parents, guardians, and the local community in promoting a positive attitude towards Physics. Outreach programs and informational sessions can help raise awareness about the importance of Physics education.
m. **Continuous Assessment**: Implement ongoing formative assessments to monitor students' progress and adapt instructional strategies accordingly. Regular feedback and adjustments can further enhance the effectiveness of CGIS.

By considering these recommendations, educators, researchers, and policymakers can work collaboratively to create a more engaging and effective learning environment for students in Physics classrooms, ultimately fostering a positive and enduring attitude towards the subject.

14. Contribution to knowledge

The study contributes to the improvement of Physics education by introducing and examining the effectiveness of Cognitively Guided Instruction (CGIS) in the context of senior secondary schools. It offers insights into a learner-centred instructional approach that has the potential to enhance students' attitudes towards Physics. By focusing on CGIS, the study highlights the importance of adopting learner-centred instructional strategies in Physics classrooms. It underscores the value of actively involving students in their learning process and considering their prior knowledge and experiences. The study provides empirical evidence that CGIS can lead to a significant improvement in students' attitudes towards Physics. This finding is particularly significant as it addresses the persistent challenge of negative attitudes and low enrolment in Physics courses. The research emphasizes the importance of contextualizing Physics instruction by integrating students' out-of-classroom experiences and everyday knowledge. This approach makes learning more relevant and engaging for students. The study introduces the Students' Attitude Towards Physics Questionnaire (SAPQ) as a measurement instrument specifically designed to assess students' attitudes in the context of Physics instruction. This instrument can be valuable for future research in related areas.

The study underscores the need for teacher training and professional development programs that equip educators with the skills and strategies to implement CGIS effectively. This recommendation has implications for improving the quality of Physics instruction. The findings of the study can inform educational policies and curriculum development, particularly in addressing issues related to students' attitudes towards Physics. Policymakers can consider the adoption of learner-centred approaches in Physics education. The research contributes to the foundation of knowledge on instructional strategies that positively impact students' attitudes in science and mathematics-related fields. It encourages further research into innovative approaches to teaching and learning. The study offers practical guidance for educators and Physics teachers interested in implementing CGIS or similar learner-centred strategies in their classrooms. It emphasizes the importance of considering students' prior knowledge and experiences. By addressing factors that influence students' attitudes towards Physics, the study indirectly contributes to efforts aimed at promoting educational equity. It encourages the inclusion of diverse student backgrounds and experiences in Physics education.

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Appendix I

Instructional Guide for Experimental Group I (Cognitively Guided Instructional Strategy)

STEP 1: **Splitting students into groups (**This is done on the first day of the exercise and the groups will remain the same throughout the duration of the exercise)

Activity (i) Students are divided into small groups (6 students per group), with every group comprising students with varying academic ability

STEP 2: **Introduction**

Activity (i) Teacher introduces the concept (topic) by citing/narrating an everyday experience of the concept that people encounter

Activity (ii) Students are allowed to cite examples of their everyday experiences (encounters or observations) that have connections to the example given by the teacher

STEP 3: **Presentation of the Lesson**

Activity (i) The teacher gives a detailed explanation of the lesson (topic/concept)

Activity (ii) Students attempt to recollect and organise their daily out-of-classroom encounters which connect with the concept

STEP 4: **Performance of task by Students**

Activity (i) Students make demonstrations and manipulate instructional materials provided for the course.
Note: The instructional materials will be locally sourced

STEP 5: **Summative Assessment of Learning**

Activity (i) Questions are provided to guide students' learning

Activity (ii) The different groups of students provide responses that are noted as the teacher provides more insights into the topic.

Activity (iii) Formulas, equations, and worked examples involved in the concept are provided for elaborate knowledge of the concept

STEP 6: **Evaluation of Learning Objectives**

Activity (i) Exercises containing formulas are given to evaluate the objectives of the lesson

STEP 7: **Summary and Assignment**

Activity (i) Teacher summarizes the lesson. Assignments are given to the student

Appendix II

Instructional Guide for the Control Group (Conventional Strategy)

STEP I: Introduction of Lesson

Activity (i) The lesson is introduced by the teacher who asks interrogates the students based on their previous lesson

Activity (ii) The students respond to the question asked by the teacher

STEP 2: Presentation of the topic

Activity (i) The teacher explains the concept to be taught

Activity (ii) The writes the formula for the concept and explains the symbolic representation of the formula

Activity (iii) The teacher solves simple exercises using the formula for the concept

Activity (iv) The gives the students notes on the topic

STEP 3: Evaluation of the Lesson Objectives

Activity (i) The students are given some exercises to solve

Activity (ii) Students' answers are evaluated by the teacher, to ascertain their level of understanding of the concept taught

STEP 4: Summary of the Lesson

Activity (i) The teacher summarizes the lesson by making corrections to the answers provided by students in the simple exercises

Activity (ii) The students are given assignments to be done at home.