

## RESEARCH ARTICLE

# Pre-service teachers' preparedness to teach selected physics topics within integrated science at the basic schools in Ghana

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### Abstract

This study, employing a descriptive survey design, examined the competencies of pre-service teachers and their preparedness to teach selected physics topics within integrated science at the basic school level. The sample comprised 560 second-year pre-service teachers from a population of 880, all studying General Physics at Colleges of Education affiliated with the University of Cape Coast, Ghana. Data were collected using a closed-ended questionnaire and analysed with descriptive statistics (frequency tables). An independent sample t-test was conducted to identify disparities in preparedness between male and female pre-service teachers. The findings revealed that pre-service teachers were generally well-prepared to teach physics topics such as energy, measurement, motion, basic electronics, and electricity, as indicated by their high scores in related dimensions. However, male pre-service teachers showed higher preparedness across most dimensions. It is recommended that colleges provide more opportunities for female pre-service teachers to engage with experienced educators as mentors and role models. Such mentorship programs could offer crucial guidance, support, and encouragement, aiding pre-service teachers in navigating their teaching careers.

### Keywords

preparedness, competence, pre-service teachers, physics education, gender disparities, mentorship

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### State of the literature

- The research on pre-service teachers' preparedness to teach physics subjects in Ghana's basic school integrated science curriculum is noticeably lacking.
- The majority of current research concentrates on teaching general science or secondary education, with little focus on basic school students' preparedness for physics.
- Furthermore, there is still a lack of research on gender differences in physics teacher preparation, especially in fields like electronics and electricity in Ghana.

### Contribution of this paper to the literature

- This study examined pre-service teachers' competencies and preparedness to teach specific physics topics within integrated science at the basic school level.
- It investigated gender disparities in preparedness and provides data to guide curriculum design, policy, and targeted interventions such as training and mentoring.
- The study aimed to promote gender parity in STEM education, support teacher education reforms, and ultimately improve the quality of physics instruction in Ghana's basic schools.

### Introduction

Ghana has embarked on a reform initiative to align the training of professional teachers with international trends, necessitating a more varied curriculum in teacher education. This reform is driven by the poor performance of basic school students nationally and locally, with many deficiencies attributed to the teachers (Anane, 2014). To address this, teachers must possess the requisite knowledge, skills, and mindset to effectively impact their pupils and deliver high-quality education suitable for the modern era. The reforms aim to equip pre-service teachers with advanced teaching skills, enabling students to become independent lifelong learners better prepared to navigate political, social, and economic uncertainties than traditional knowledge-based curricula (Sungkim & Ishak, 2022).

Teachers must possess expertise in their respective fields to instruct effectively. It is crucial to recognize that teachers' professional competence comprises both cognitive and emotive components (Depaepe & König, 2018). Cognitive components include teachers' knowledge, abilities, and skills related to content delivery, while emotional components encompass traits like motivation, optimism, and self-assurance. Despite often being overlooked in the literature, the latter is a crucial determinant of teachers' professional competence (Depaepe & König, 2018). Additionally, pre-service teachers benefit from psychomotor components as they learn to manage tasks requiring both mental and physical skills (Birgili & Demir, 2022).

Teachers' core duties include teaching, instructing, directing, training, evaluating, and assessing students. To execute these duties effectively, teachers must possess pedagogical competence,

professional competence, social skills, and personal qualities (Sanders & Rivers, 2011). The preparedness of potential teachers to teach is essential to ensure accurate learning and the attainment of predetermined learning goals (Arief, 2015). An individual's readiness level defines their preparedness to respond or behave in a specific manner in a given situation (Muyasaroh & Hamidi, 2013; Scholz, 2014; Utami, 2015). This underscores the importance of teachers possessing the necessary competencies that pre-service teachers must acquire (Hutabarat et al., 2021). Before implementing a teaching practice program, pre-service teachers must adequately prepare themselves for various mental, physical, social, and emotional circumstances to effectively execute learning tasks in any given environment (Newstrom & Davis, 1986).

There are numerous types of teacher competencies, each with varying quality and efficacy. Sanjaya (2005), Smolikevych (2019), and Birgili and Demir (2022) evaluated the performance of teachers in the areas of planning, learning management, and assessment of student learning outcomes. They suggested that professional teachers should possess four key abilities: pedagogical competence, personal competence, professional competence, and social competence. These competencies are closely linked to the teacher's performance in the learning process. The need for education for sustainable development (ESD) is higher than ever in the midst of a worldwide crisis (Ammonet et al., 2022). Sustainable Development "empowers learners with knowledge, skills, values, and attitudes to make informed decisions and take responsible actions for environmental integrity, economic viability, and a just society, empowering people of all genders, for present and future generations, while respecting cultural diversity" (Chala et al., 2020; Villar et al., 2022). Gender roles and expectations are among the societal and cultural factors that may impact these inequalities. Educational and vocational institutions can assess if the curriculum is having the intended effect on students' teaching and learning through the academic performance of their pupils. Additionally, it provides a measure of how well educators and learners have achieved their desired learning outcomes (Arshad et al., 2015; Caballero et al., 2007). Academic performance, according to Narad and Abdullah (2016), is an assessment of the knowledge that pupils have learnt in school over a specific amount of time. Alva & Manuel (2017) defines it as the degree of knowledge gained in a given area, and marks earned during an evaluation are typically used to gauge it.

Significant public discussions on educational issues have dominated the public space within the twenty-first century's second decade. These issues include improving teacher preparation (i.e., improving teacher effectiveness and changing teacher training curricula) and improving classroom instruction and student performance. A re-examination of education is often the next step after these dialogues (Anane, 2014). These reflections aid in identifying strategies to support pre-service teachers in acquiring the essential competencies, which encompass the integration of knowledge, skills, and attitudes that are suitable for a specific context and are crucial for achieving success in contemporary labour markets and society at large (European Commission, 2012;

UNESCO, 2015; World Bank, 2013). Nonetheless, pre-service teachers' preparedness to teach physics topics has rarely been the subject of previous studies in physics education (Cheng, 2013; Sakib & Obra Jr., 2019; Sungkim & Ishak, 2022). As a result of the paucity of studies in this field, a practical knowledge gap in physics education research needs to be filled, especially in Ghana.

Specifically, the study examined pre-service teachers' competencies and their effect on their preparedness to teach selected physics topics within integrated science at the basic school. The research question addressed was as follows: How are components of competence related to pre-service teachers and their gender preparedness to teach selected physics topics within integrated science at the basic school? The study may impact pre-service teachers' understanding of the competencies needed before entering the teaching field.

### Theoretical Framework

This study addresses two prominent theories of learning: **behaviourism** and **constructivism**, in the context of pre-service teachers' preparedness to teach selected physics topics within integrated science at basic schools in Ghana.

**Behaviourism** focuses on how individuals acquire knowledge through interactions with their environment. This theory posits that all behaviours are learned through conditioning, which involves rewards and penalties. According to Yusra (2022), this process transforms individuals from ignorance to knowledge, from incorrect attitudes to correct ones (Shi, 2022), and from incompetence to skilfulness through intentional learning. Skinner's perspective on learning involves shaping behavioural responses by rewarding target behaviours and improving subsequent approximations (Dündar, 2018). Reinforcement is key in progressively modifying and shaping behaviour to promote goal behaviours. The application of behaviouristic theory in educational activities is influenced by various factors, including learning objectives, subject matter, student characteristics, media, and available learning facilities (Shepard et al., 2018). In this framework, teaching is the process of imparting knowledge, while learning is the process of acquiring it, with the expectation that students will widely understand the material being taught (Shepard et al., 2018). Implication of practicing behaviourism enable the teacher to give prompt feedback to promote or suppress behaviours.

**Constructivism** argues that students learn best through interaction with their environment and that the context of education is crucial (Shi, 2022). Social engagement, for instance, helps individuals acquire skills and knowledge useful to society and provides a means to handle situations requiring personal adjustment. Unlike behaviourist classrooms, constructivist classrooms emphasize teacher-student interaction. Teachers act as scaffolds, aiding students in learning and growing until they can perform tasks independently (Zhao et al., 2022). Constructivism views learning as situated, meaning it should be connected to students' personal experiences to solve real-world problems (Omodan, 2022). In contextual learning, students are

more motivated when they can explore and evaluate issues in a real setting. Constructivism sees education as a dynamic and purposeful process involving interaction with the external world and the individual's construction of knowledge based on personal experience.

These theories provide educators with a better understanding of how learning occurs, enabling them to engage students in teaching and learning processes that foster problem-solving skills. Effective physics education requires students to actively seek understanding, rather than passively receiving knowledge from teachers. Consequently, there is a clear correlation between teachers' beliefs and their instructional methods. Sancassani (2021) suggests that understanding teachers' knowledge of their teaching topics can be a reference point for comprehending their instructional practices.

### Methods

This study investigated the components of competence related to pre-service teachers and their gender preparedness to teach selected physics topics within integrated science at the basic school level. A descriptive survey design was employed, which is effective for accurately describing variables and gathering data about content knowledge from a sampled population (Creswell & Creswell, 2018).

The study population included all level 200 pre-service teachers (880) pursuing Primary Education and Early Grade Programmes in Colleges of Education affiliated with the University of Cape Coast (UCC). These colleges are grouped into four zones, and for convenience, the oldest college and the one with the highest student numbers offering general physics were selected. The sample size was determined to be 560, calculated using the sample size table by Krejcie and Morgan (1970).

Data were collected using a closed-ended questionnaire, an objective means of gathering data and concepts from respondents. The questionnaire captured pre-service teachers' preparedness to teach selected physics topics within integrated science at the basic school level. The first section of the questionnaire focused on respondents' age, gender, and the programmes they were pursuing. The second section, which assessed the pre-service teachers' competency, included items from the Nicholson McBride Resilience Questionnaire (NMRQ), the Centro de Estudios Investigaciones Docentes (CEID), and the Centre for Teaching Studies and Research. A four-point Likert scale was used, with options ranging from "Very well prepared" to "Not sure." The internal consistency was assessed to ensure reliability.

To ensure the validity of the questionnaire, supervisors from the Department of Teacher Education at Kwame Nkrumah University of Science and Technology reviewed the items for face and content validity. When research is legitimate, it indicates that your measurement and methods are sound and able to produce findings that support the study's goal. Additionally, the

**Table 1.** Average Abitur grade in relation to the year.

Topics	Very well prepared	Adequately prepared	Not well prepared	Not sure	Mean	SD	Male pre-service teachers	Female pre-services teachers	P-value
Measurement	307 (54)	140 (25)	84 (15)	29 (5.2)	3.97	0.92	4.0273	3.9444	0.309
Motion	227 (40.5)	226 (49.3)	28 (5.0)	29 (5.2)	4.09	0.89	4.1972	4.0508	0.056
Energy	222 (39.6)	280 (50.0)	29 (5.2)	29 (5.2)	3.98	0.85	4.0324	3.9597	0.326
Basic electronics	227 (40.5)	248 (44.3)	28 (5.0)	57 (10.2)	4.00	0.91	4.1574	3.9414	0.005
Electricity	225 (40.2)	194 (34.6)	56 (10)	85 (15.2)	3.98	1.06	4.2029	3.8763	0.000

questionnaire was pre-tested in a college of education affiliated with UCC, where primary education students offered General Physics, and did not participate in the main study. The pre-test aimed to clarify instructions, prevent ambiguity between questions and response options, determine the time required to complete the questionnaire, and refine the instrument based on the results. The reliability of the pre-test data was analysed using the Cronbach alpha coefficient, with the reliability coefficient of pre-service teachers' competence being 0.91. In addition to encouraging transparency, inter-rater agreement, and methodological improvement, it improves credibility, trustworthiness, and replicability. Responses from the actual study were analysed using descriptive statistics, including frequency tables and independent sample t-tests.

### Results

The analysis of the data gathered from the questionnaire addressed pre-service teachers' competencies and their effect on their preparedness to teach selected physics topics within integrated science at the basic school. The results are presented in **Table 1**.

The results in **Table 1** are summarized:

#### Measurement

A majority of pre-service teachers felt "Very well prepared" (54%) or "Adequately prepared" (25%) to teach measurement. The mean score is 3.97 with a standard deviation of 0.92, indicating a generally high level of preparedness with some variability. Male pre-service teachers had a slightly higher mean score (4.0273) compared to female pre-service teachers (3.9444). The p-value of 0.309 suggests no significant difference in preparedness between male and female pre-service teachers for this topic.

### *Motion*

A significant portion felt “Very well prepared” (40.5%) or “Adequately prepared” (49.3%) to teach motion. The mean score is 4.09 with a standard deviation of 0.89, indicating high preparedness with less variability. Male pre-service teachers had a higher mean score (4.1972) compared to female pre-service teachers (4.0508). The p-value of 0.056 indicates a marginally significant difference in preparedness between genders, with males feeling slightly more prepared.

### *Energy*

Most pre-service teachers felt “Very well prepared” (39.6%) or “Adequately prepared” (50%) to teach energy. The mean score is 3.98 with a standard deviation of 0.85, showing high preparedness with low variability. Male pre-service teachers had a slightly higher mean score (4.0324) compared to female pre-service teachers (3.9597). The p-value of 0.326 suggests no significant difference in preparedness between genders for this topic.

### *Basic Electronics*

A large number felt “Very well prepared” (40.5%) or “Adequately prepared” (44.3%) to teach basic electronics. The mean score is 4.00 with a standard deviation of 0.91, indicating high preparedness with some variability. Male pre-service teachers had a higher mean score (4.1574) compared to female pre-service teachers (3.9414). The p-value of 0.005 indicates a significant difference in preparedness between genders, with males feeling more prepared.

### *Electricity*

Many felt “Very well prepared” (40.2%) or “Adequately prepared” (34.6%) to teach electricity. The mean score is 3.98 with a standard deviation of 1.06, showing high preparedness but with more variability. Male pre-service teachers had a higher mean score (4.2029) than female pre-service teachers (3.8763). The p-value of 0.000 indicates a significant difference in preparedness between genders, with males feeling more prepared.

Overall, pre-service teachers generally feel well-prepared to teach the selected physics topics, with males often reporting slightly higher preparedness than females. Significant gender differences were noted in the issues of basic electronics and electricity.

### **Discussion, Conclusion and Recommendation**

Pre-service teachers' preparedness is critical to the sustenance and development of the education system. It is essential to assess their readiness to teach selected physics topics – motion, measurements, energy, electronics, and electricity. The study found that pre-service teachers were generally prepared to teach these topics. However, male pre-service teachers were more prepared to teach basic electronics and electricity than their female counterparts. This suggests that, in real school situations, the teaching of these topics might be dominated by male teachers.

The gender disparity in preparedness, particularly in basic electronics and electricity, could have long-term implications. The dominance of male teachers in these subjects may perpetuate the gender gap in careers related to electronics and electricity. Fewer female teachers in these fields mean fewer role models for young girls, potentially discouraging them from pursuing careers in these areas.

The preparedness of pre-service teachers to teach physics topics is a significant boost to the education sector. According to Newstrom & Davis (1986), prepared teachers can better support their students to excel academically. Sanders and Rivers (2011) also highlight that students taught by prepared teachers achieve higher than those taught by unprepared teachers. Scholz (2014) confirms that low teacher preparedness can contribute to poor student performance and declining educational standards.

**Table 1** indicates that female pre-service teachers are gradually showing interest in teaching physics topics, although males are still more prepared in basic electronics and electricity. Chala et al. (2020) suggest that supporting female pre-service teachers could enhance their preparedness in other areas of physics, helping to close the gender gap in physics education in Ghana. This support could include targeted training, mentorship programs, and incentives.

Pre-service teachers' preparedness is not the only factor influencing academic achievement and educational development. Cheng (2013) asserts that the availability and adequacy of teaching and learning resources also play a crucial role. Textbooks and other learning materials significantly impact students' academic performance, as documented by UNESCO (2015). Therefore, while supporting pre-service teachers' preparedness, it is also essential to ensure the availability of resources and good working conditions to attract and retain teachers in physics education. The findings indicate pre-service teachers' preparedness to teach physics dialogue supports constructivist epistemology or inquiry-based teaching and learning. Thus, the support pre-service teachers receive from their tutors enables them to construct learning new ideas based on their prior knowledge and experiences.

Notwithstanding this general preparedness to teach, male dominance in almost all dimensions of the construct is apparent. This observation likely explains why male teachers predominantly teach science-related subjects like physics in Ghanaian basic schools. Whilst it is imperative to continue to encourage females to study physics courses, it is equally important to develop policy measures to address females' preparedness at the tertiary level. However, the fact that both males and females have demonstrated satisfactorily high levels of preparedness to teach physics topics suggests that if females are adequately encouraged and motivated to train as science (physics) teachers, the gender gap in teaching the subject can be closed shortly.



In conclusion, pre-service teachers were prepared to teach physics topics such as measurement, motion, energy, basic electronics, and electricity. There was no statistically significant difference between the preparedness of males and females to teach measurement, motion, and energy. However, male pre-service teachers were more prepared to teach basic electronics and electricity than female pre-service teachers. It is recommended that special training programs, such as workshops addressing the unique challenges of female pre-service teachers, be organized. Additionally, opportunities should be provided for female pre-service teachers to connect with mentors and role models. The chief aim must be to address the attitude of females towards substituting economic interest for academic interest at the tertiary level. This requires continuous education and sensitisation of the gender stereotypes and policy measures to sustain both males and females in colleges of education for overall national development. Finally, colleges should facilitate peer collaboration and support groups where female pre-service teachers can share experiences, exchange ideas, and offer support.

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