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Gender differences in Performance in Integrated Science among Pre-Service Science Teachers: A Case of a University in Ghana

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Abstract: While pre-service science teachers are an important group of stakeholders in a nation's pursuit of scientific literacy, scientific development and technological advancement in this modern era, this study sought to determine any gender differences in performance in Integrated Science among third year pre-service senior high school science teachers at the University of Education, Winneba, Ghana using the descriptive research design. The study used the sample of 168 students in five courses taken by the students at that level. The study employed the SPSS version 22.0 software to conduct an independent samples t-test so as to determine differences in performance between male and female students. Evidence from this study proves no gender gap in integrated science achievement among pre-service secondary school science teachers of the Department of Integrated Science Education of the University of Education, Winneba. The study recommends the need to conscientize females on the need to put up more positive attitudes towards the study of science and related courses, especially the physical sciences.

Keywords: Gender difference; STEM; Integrated Science; Pre-Service Teachers; Performance

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Introduction

Science education plays a vital role in the lives of individuals and in the development of a nation scientifically and technologically (Ifamuyiwa & Alebiosu, 2008). According to Gödek (2004), scientific literacy is the gateway to the survival of a nation and this can only be achieved through providing sound science education. The author further reiterates that science education provides good standards for people in a country and expands the range of opportunities available to individuals, thereby equipping them with tools to make better and informed choices. Shadreck and Mambanda (2012) opined that a country's development rests on science and its application in the world of work and industry. Therefore, for any country aiming to achieve scientific and technological prowess, its workers and citizenry need a strong and competent understanding of science and mathematics (Anamuah-Mensah, 2004).

In Ghana, Integrated Science is considered a grassroots subject that introduces young learners into the field of science (Taylor, 2018). Consequently, the study of Integrated Science helps learners to understand the natural world and also enables them to obtain the knowledge and scientific

attitudes needed to solve challenges in life in a systematic and logical manner. Hence, the subject is studied as a core subject by all learners from upper primary (primary 4) to the senior high school level.

Pre-service teachers in science may be considered to be among major stakeholders in advancing the drive for a nation to achieve scientific literacy and technological advancement. They are required to be well trained in the field of science, expected to have general and specific efficacy demanded by the teaching profession (Guerriero, 2014) and to obtain the requisite knowledge and skills in science education in order to teach and guide young learners in their study of science. It is common knowledge in the field of the teaching profession that a teacher's knowledge of the subject matter (science) affects students' achievement in the subject. Also, these pre-service teachers being trained to teach Integrated Science irrespective of gender, are expected to have the requisite subject matter knowledge and capable teaching skills needed to impart the right scientific knowledge to learners. However, the issue of students' performance in science has been a major concern worldwide with disparity in gender which attracts more attention in recent times (Asante, 2010). Laanan (2007) as cited by Juma, et al. (2018) determined in their study whether there were significant gender differences in academic performance among undergraduate students in a large public university in Turkey. Findings from their study indicated that a smaller number of female students managed to enter the university and when they did so, they entered with lower scores. However, once they were admitted to the university, they excelled in their studies and outperformed their male counterparts.

In Ghana, even though the country seems to be making positive progress towards bridging gender disparities in education, the disparities still exist in various educational levels (Yusif et al., 2013). A study by Bardley (2000) in Ghana about barriers to girls' education revealed that despite females outnumbering males in Ghana, fewer girls than boys are enrolled in school; and those enrolled generally performed at a lower standard. Public university education in Ghana has been found to be highly inequitable, with women only making up 34.9% of enrolment (Yusif et al. 2013).

Recent data from STATISTA (2022) indicates that as at 2019, the number of male students was found to be higher in all program disciplines in public universities in Ghana. Further, the percentage of girls in school declines as learners climb the academic ladder to the university level and particularly in mathematics and science related programs. For many of these girls, even while they attend school, they are still expected to perform their everyday family duties such as laundry, cooking and selling goods in the market. This tends to have a derailing effect on their pursuit towards academic achievement, with many dropping off along the line. According to Andam et al. (2005), even though Science, Technology and Mathematics Education (STME) clinics were initiated in Ghana to address gender disparities and misconceptions about girls' participation and performance in science, mathematics, engineering and technology, long-standing biases and gender stereotypes keep steering girls and women away from science related fields which affects their achievement in the subject. This study sought to determine if any the gender differences in performance in Integrated Science existed among third year university science students who are being trained to become professional teachers of science at the senior high school level in Ghana.

Undoubtedly, a number of studies (Guerriero, 2014; Mullis, et al., 2016; Francis, 2000) have been conducted on issues related to gender participation, perceptions and attitudes towards the teaching and learning of science. However, the focus of most of these studies has been on learners at the various pre-tertiary levels and also on the core science subjects which are Biology, Chemistry and Physics. Gender difference in the performance of pre-service teachers at the university level, and especially in Integrated Science, has not been given as much attention as it deserves. It appears that there has been no research work on gender differences in performance in Integrated Science among pre-service science teachers that are being trained in the Ghanaian University under investigation. This study therefore sought to determine if there exist any gender differences in performance in Integrated Science among level 300 students of the Department of Integrated Science Education of the University of Education, Winneba, Ghana. The study was guided by the following research question: What is the gender difference in performance in Integrated Science among level 300 students of the Department of Integrated Science Education of the University of Education, Winneba?

Literature Review

Gender, Science Education and Academic Performance

Women have generally been underrepresented in the field of science and this trend seems to have been created by the widely held wrong notion that the study of science is the preserve of men. Some studies (Francis, 2000; Trusz, 2020) have revealed the fact that given the option to choose subjects to study in schools, boys would normally opt for subjects considered masculine such as mathematics and physics whilst girls would opt for subjects considered feminine (language-based subjects). Many females regard the physical sciences as masculine and find the biological sciences more feminine (Smyth & Nosek, 2015; Francis et al., 2017; Turnbull et al., 2017). Findings from a study on participation in secondary mathematics and science education by Mullis, al. (2016) found out that male participants in mathematics and science mostly gravitated towards physics whereas females favored biology. A study by Brotman and Moore (2008) reported that several large quantitative studies found that girls' overall attitudes toward science are either less positive than boys' or decline more significantly with age.

According to Boateng and Gaulee (2019), until quite recently, there were very few girls studying science/technical courses in Ghana. The few that found themselves in these courses tended to struggle with most of scientific concepts which were tilted towards the physical and mathematical aspects. A study carried out by Jordan et al. (2003) revealed that there is a tendency of females to use more language-based learning strategies to solve problems than males. In their recent gender difference comparative study of three different countries (China, Japan and USA), Akabayashi et al. (2020) revealed that girls scored higher than boys on language tests in all three countries.

The issue of gender performance inequality in Science, Technology and Mathematics Education (STME) has been a dicey global concern, with research in these disciplines pointing to the fact that differences still exist (Funk & Parker, 2018; AAS, 2020; Stewart-Williams & Halsey, 2021). A recent study by Sevilla and Cuevas-Ruiz, (2022) indicated that even though there has been progress in women's college preparation and graduation rates in STEM over the last seven decades, the fact still remains that women continue to be under-represented in STEM fields. Studies conducted across the world among students studying in different levels revealed a significant gender difference in academic performance. While some studies have reported that female students outperform their male counterparts (Orabi, 2007; Dayioglu & Turut, 2007; Khwaileh & Zaza, 2010), others have argued that gender difference exists at the level of cognitive functioning in the academic environment (Akabayashi et al., 2020; Ghazvini & Khajehpour, 2011) and that girls are likely to be more adaptive in learning in a different environment. However, Wangu (2014) in a study conducted among students of secondary schools in Kenya observed boys passing more than girls.

In Africa and particularly in Ghana, women have generally been assigned certain traditional roles such as homemaking and children upbringing, which has become the norm in almost every home. Andam et al. (2005) confirmed that in the past, the economic activities of women had mostly been jobs that did not take them away from the home or the children for long periods of time. These economic activities included farming, trading and traditional food processing. Hence, these societal expectations are projected in schools into what has been described as "the hidden curriculum." On paper, all subjects are open to all students but in practice, there is often gender bias toward certain subjects. They opine that the result of this societal norm has been a categorization of careers into "men's jobs" and "women's jobs." This could possibly be the reason for a certain psychological gap that seems to have been created between males and females in terms of their participation, perceptions and attitudes in STEM disciplines at almost all levels of education in Ghana.

Methodology

This section presents the methodology that guided the study.

Research Design

This study employed the descriptive research design. This design seems appropriate if there is the need to determine the way things are in a natural setting. It involves collecting data to test hypothesis or answer research questions concerning current status of a phenomenon. Simply put, in descriptive research, the researcher merely selects the relevant variables for an analysis of their relationships. This study used already existing data, that is, the examination results of third year (level 300) students of the Integrated Science Department of

the University of Education, Winneba for its purpose.

Population and Sampling

The target population was the examination results of all 598 students of the Integrated Science Department at the University of Education, Winneba, Ghana. However, only that of 168 Level 300 students of the population was purposively used for the study. This was due to the fact that Level 300 students had completed three years of academic study in line with their preparation towards becoming Integrated Science teachers of Ghana's Senior High Schools. At this level, they were just about progressing to the field for a whole semester internship program (3-4 months) as pre-service science teachers. It could be safely assumed that this group of students had acquired enough pedagogical content knowledge to equip them in their teaching prospects and were in a better position to exhibit knowledge of their subject matter and prowess of their academic achievements. They were in preparation towards becoming Integrated Science teachers of Ghana's Senior High Schools. Thus using their examination results was deemed appropriate.

Research Instrument

The study surveyed the students' physical examination results of five major courses studied at the Department of Integrated Science Education of the Faculty of Science Education of the University of Education, Winneba for gender differences in performance. The courses which are in line with the curriculum of the level 300 program were approved for study by the National Accreditation Board of Ghana. The five major courses comprised Magnetism, Radioactivity and Infectious Diseases (ISC 351), Transport and Circulatory Systems (ISC 352), Forces in the Ecosystem and Machines (ISC 361), Variations, Inheritance and Evolution (ISC 362) and The Reproduction System (ISC 363). The pre-service science teachers' examination results of these courses were obtained from broadsheets of the University at the office of the Examination Officer of the Department, and had all been authenticated by both the Lecturers for the courses as well as the Examination Officer. All the results had been approved by the Departmental Board, the Faculty Board and the Academic Board of the University.

Statistical Treatment of Data

The independent samples t-test was used to analyze the scores of pre-service science teachers' performance in the courses using the Statistical Package for the Social Sciences (SPSS) software version 22.0. The t-test was the best to be used because it is a parametric statistical test used to check whether a difference between the means of two samples is significant. The t-test provides an exact test for the equality of means of two normal populations with unknown but equal variances. Theoretically, the t-test can be used even if the sample sizes are very small, as long as the variables are normally distributed within each group and the variation of scores in the two groups is not reliably different.

Ethical Considerations

The researchers attended to important ethical issues and also conducted the research in a professional manner by ensuring anonymity, confidentiality and privacy. There was no recourse to any individual student's results or the particular year group for this study.

Table: 1 Comparing mean scores, standard deviation and t-values for Integrated Science courses

Course	Gender	Mean	Std. Deviation	Std.Error Mean	t-values	Sig.(2-tailed)
ISC 351	males	60.6765	7.79557	1.33693		
	females	60.3529	11.84977	2.03222	0.132	0.896
ISC 352	males	70.6176	8.80088	1.50934		
	females	70.3529	8.94387	1.53386	0.108	0.914
ISC 361	males	74.1176	5.59093	0.95884		
	females	73.8235	5.9108	1.01369	0.221	0.827
ISC 362	males	72.4412	4.94326	0.84776		
	females	73.5882	5.62525	0.96472	-0.855	0.399
ISC 363	males	74.8235	4.67405	0.80159		
	females	70.8824	13.15816	2.25661	1.555	0.129

Results and Discussion

The study was guided by the following research question: What is the gender difference in performance in Integrated Science among level 300 students of the Department of Integrated Science Education of the University of Education, Winneba?

To help answer the research question for the study, an independent samples t-test was conducted on the examination results of the students to determine any differences between the male and female pre-service science teachers for five courses studied at the Department. To determine these differences, the SPSS software was used to run the independent samples t-test; and the differences in the mean scores, standard deviation, standard mean, the t-values as well as the significant level ($p< 0.05$) were obtained as appears in Table 1.

The results from Table 1 shows the mean scores, standard deviation, standard error means, t-values and significant two tailed values (p values) obtained by both male and female pre-service science teachers for each of the five courses respectively.

In-depth analysis of the results in Table 1 reveals that male students had higher mean scores in four of the courses (ISC351, ISC 352, ISC 361 and ISC 363), while the females had higher mean scores in one course (ISC 362). However, in both situations where either the males had higher means than the females or vice versa, the differences were minimal and the differences were not statistically significant, with *p* values ranging between 0.129 and 0.914. The results in this work therefore indicate that there was no statistically significant gender difference in performance in Integrated Science among the Level 300 students. The differences between the male and female students' scores were so minimal that they did not result in any significant statistical difference between the two groups of students. Therefore, there is no gap in science achievement between male and female pre-service science students, an assertion which seems to agree with the work of some researchers (Akabayashi, et al, 2020; Ghazvini & Khajehpour, 2011; Friedman, 1989), who indicated that gender difference is gradually being weakened within education systems.

The authors further observed that the only course (ISC 362 - Variations, Inheritance and Evolution) in which the females had a slightly higher mean score than the males was a course that had majority of its concepts geared towards the biological sciences. ISC 362 was more of a reading course and had significantly no mathematical concepts embedded in it. The course had concepts such as Nucleus of cells, Chromosomes, Genes and genotypes, Phenotypes, Sex determination and sex-linked characters, Blood groups and Rhesus factor, Inheritance of blood groups and Rh-factor, Inheritance of sickle cell anaemia, Fossil records and geographical distribution of organisms. The study of these concepts mostly required the students to use more language-based explanations to solve problems.

On the other hand, with the other four courses (ISC 351, ISC 352, ISC 361 and ISC 363) in which the males had higher mean scores than the females, majority of the concepts were physical science concepts, which demanded a good foundation and understanding in mathematics and physics in order to achieve success in their study. The concepts involved in these four courses included but not limited to aspects of physical sciences such as Electromagnetism, Nuclear Physics, Radioactivity, Forces, Work, Energy and Machines. Hence, males tended to be more comfortable with those concepts and so their results indicated higher means than that of the females. The above observations are in agreement with the study by Jordan, Hanich and Kaplan (2003) in which they indicated that there is a tendency of females to use more language-based strategies to solve problems. The findings of the present study also aligns with that of Mullis et al. (2016) who also revealed that male participants in mathematics and science mostly gravitated towards physics, whereas females favoured biology. Akabayashi et al. (2020) also found that girls scored higher than boys on language tests in three different countries; China, Japan and USA.

Conclusions and Recommendations

Conclusion

Evidence from this study proves that there is no gender gap in integrated science achievement among pre-service secondary school science teachers of the Department of Integrated Science Education of the University of Education, Winneba. Pre-service science teachers are tomorrow's educational leaders who will be guiding the next generation through their study of science. Hence, it is gratifying to note that there is no difference in performance between male and female students in their own study of science. This is quite assuring considering the fact that both male and female pre-service science teachers need to be equally capable

of effectively teaching integrated science at the Senior High School.

Recommendation

The study recommends the need to conscientize females on the need to put up more positive attitudes towards the study of science and related courses, especially the physical sciences.

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