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PERCEPTIONS OF SCIENCE LEARNING SELF-EFFICACY IN GHANA: INSIGHTS AND IMPLICATIONS FOR EDUCATION

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Abstract:
Self-efficacy is an important attribute capable of shaping a person's behavior. Perceived academic efficacy plays an influential role in students' school success, motivation, persistence, engagement, and academic achievements for science disciplines. Although various factors have been found to affect Ghanaian high school students' science learning, their perceived self-efficacy has not been gauged. This study explored senior high school students' science learning self-efficacy through a cross-sectional survey of 1,507 students. Data collected were analyzed with means, standard deviation and multivariate analysis of variance (MANOVA). The results revealed that students had positive perception about their science learning self-efficacy except for their practical skills. Also, no gender differences in science learning self-efficacy between males and females were seen. It is, therefore, recommended that teachers take active steps by planning and structuring science lessons to include more practical to enhance students' efficacy in practical skills to boost their overall perception of their science learning abilities.

Keywords: science learning self-efficacy, high school students, gender differences, practical skills, academic achievement

1. Introduction

Self-efficacy refers to individuals' beliefs about their ability to organize, learn, understand, and execute tasks successfully in specific situations to achieve desired goals

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(Bandura, 1986, 1997). In educational contexts, self-efficacy is particularly significant as it shapes students' judgments of their competence to complete academic tasks and influences their behaviour, motivation, and perseverance. Students with high self-efficacy tend to approach challenges with resilience, invest more effort, and persist when faced with difficulties. Conversely, individuals with low self-efficacy are more likely to avoid tasks they perceive as beyond their abilities, which can become a self-limiting impediment to success. This makes self-efficacy a crucial psychological construct for understanding academic engagement and achievement.

The importance of self-efficacy is even more pronounced in science education, a critical driver of 21st-century global progress and innovation (National Science Board, 2010). However, a concerning trend has emerged: a decline in student enrolment in science-related programs at the university level, which often originates during high school (Maltese & Tai, 2011; OECD, 2017; National Science Board, 2018). Students who lack confidence in performing science-related tasks tend to disengage from science pathways, reducing the pool of future scientists, engineers, and innovators.

Self-efficacy has been recognized as a key factor influencing students' learning, motivation, and academic achievement (Bandura, 1977; Rodríguez *et al.*, 2009). It determines how students select tasks, how much effort they invest, how they respond emotionally to challenges, and how they persevere. Komarraju and Nadler (2013) emphasize that self-efficacy is a strong predictor of students' academic performance, including grade point average. Empirical evidence suggests that self-efficacy predicts intellectual performance more effectively than skills alone because it directly influences cognitive processes, effort, and persistence (Multon, Brown, & Lent, 2001; Tenaw, 2013; Kiran & Usher, 2015). For example, students with high self-efficacy are more likely to regulate their learning processes effectively, persist in the face of difficulties, and tackle challenging goals (Zimmerman, 2000; McConnell *et al.*, 2010).

Gender disparities in self-efficacy, particularly in science disciplines, have also been widely documented. Research suggests that starting from adolescence, girls tend to underestimate their abilities in mathematics and science despite comparable performance to boys (Sadker & Sadker, 1995; American Association of University Women, 1999). These self-perceptions may contribute to the underrepresentation of women in science-related fields, often referred to as the "leaky pipeline" phenomenon (Alper, 1993). For example, studies in physics and chemistry classrooms have consistently reported higher self-efficacy scores among male students, particularly in practical or laboratory skills (Smist, 2003; Sawtelle, Brewe, & Kramer, 2012; Tenaw, 2013). Lindstrom and Sharma (2011) further highlight that gender differences in self-efficacy are influenced by prior instructional experiences, with male students often displaying overconfidence in their abilities. However, Burgel *et al.* (2010) observed a nuanced pattern, where women outperformed men in career self-efficacy but reported lower academic self-efficacy, indicating the multifaceted nature of self-efficacy across different domains.

In addition to gender, self-efficacy beliefs vary across grade levels and become increasingly aligned with specific academic tasks as students' progress through school.

Shell, Colvin, and Bruning (1995) found that self-efficacy for reading and writing skills becomes more specialized in higher grades. Similarly, Zimmerman and Martinez-Pons (1990) reported that self-regulated learning abilities improve significantly across grade levels, with older students demonstrating higher levels of self-efficacy compared to their younger counterparts. Leach *et al.* (2003) further suggest that self-efficacy moderates the relationship between achievement goals and academic outcomes, with distinct patterns emerging across different grade levels.

In Ghana, a growing concern is the low participation of students in science programs compared to other disciplines (Ministry of Education, 2019, 2023; Tetteh *et al.*, 2019). Moreover, the academic performance of students enrolled in science courses remains suboptimal (Buabeng, Owusu, & Ntow, 2014; Abreh, Owusu, & Amedahe, 2018; WAEC, 2018, 2021). While several studies have explored factors influencing students' academic performance in science (Abreh *et al.*, 2018; Brobbey, Baah, & Ampon-Wireko, 2020), the role of science learning self-efficacy in this context remains unexplored. Given that self-efficacy is strongly associated with motivation, persistence, and achievement (Honicke & Broadbent, 2016; Rittmayer & Beier, 2008; Usher & Pajares, 2008), understanding students' self-efficacy beliefs is essential for developing targeted interventions to improve their engagement and performance in science disciplines.

This study, therefore, sought to address this research gap by examining the science learning self-efficacy of senior high school students in Ghana. Specifically, the study was guided by the following research questions:

- What are students' perceptions of their science learning self-efficacy?
- What differences exist in science learning self-efficacy between male and female senior high school students?
- What differences exist in science learning self-efficacy between students at different grade levels in senior high schools

2. Methods and Materials

2.1 Research Design

This study employed a cross-sectional survey design to assess students' beliefs regarding their science learning self-efficacy at a specific point in time (Cohen, Manion, & Morrison, 2007; Fraenkel, Wallen, & Hyun, 2012). This design was appropriate for obtaining data from a large sample of students across multiple schools to identify patterns and differences in self-efficacy perceptions.

2.2 Sample and Sampling Procedures

The study was conducted in six randomly sampled senior high schools within the Cape Coast Metropolis, selected from a total of ten schools in the area. The sample included two single-sex schools (one boys' school and one girls' school) and four co-educational schools to ensure a balanced representation of school types.

Within each selected school, stratified random sampling was used to choose four classes from grades 10 and 11, ensuring a proportional representation of students at different grade levels. Once a class was selected, all students in that class, irrespective of class size, were included as participants in the study. This sampling strategy minimized bias and ensured comprehensive data collection.

In total, the study included 1,507 participants, consisting of 797 males and 710 females. Of the total participants, 828 were grade 10 students, and 679 were grade 11 students, with ages ranging from 15 to 18 years.

2.3 Instrument

A structured questionnaire was used to collect data and was designed to address the study's research questions. The questionnaire was divided into two sections:

- Section A: Captured the demographic characteristics of the respondents, including age, sex, and grade level.
- Section B: Assessed students' science learning self-efficacy using items adapted from the Science Learning Self-Efficacy Questionnaire (SLSEQ) developed by Lin and Tsai (2013). The SLSEQ includes five sub-dimensions: Conceptual Understanding (CU); Everyday Application (EA); Practical Work (PW); Higher-Order Cognitive Skills (HCS); Science Communication (SC).

All items were closed-ended and measured on a 5-point Likert scale coded as: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree.

2.4 Reliability of the Instrument

Although the instrument was adapted from a validated source, a reliability analysis was conducted to confirm its appropriateness for the Ghanaian context. Cronbach's alpha was used to determine the internal consistency of each sub-dimension, given the non-dichotomous nature of the responses. The reliability coefficients for the sub-scales were as follows:

Conceptual Understanding (CU): $\alpha = 0.57$, Everyday Application (EA): $\alpha = 0.70$, Practical Work (PW): $\alpha = 0.77$, Higher-Order Cognitive Skills (HCS): $\alpha = 0.80$, Science Communication (SC): $\alpha = 0.74$.

Since all the reliability values exceeded the threshold of 0.50 (Nunnally & Bernstein, 1994), the instrument was deemed reliable for use in this study, and no items were removed.

2.5 Data Collection Procedure

The first author administered the questionnaires in person with the assistance of teachers in each school. This direct administration approach ensured a high response rate and minimized non-response bias. Prior to data collection, students were briefed about the purpose of the study, assured of their anonymity, and encouraged to provide honest responses.

2.6 Data Analysis

The data were analysed using both descriptive and inferential statistical techniques to address the research questions. Responses on the 5-point Likert scale were assigned numerical values ranging from 5 (Strongly Agree) to 1 (Strongly Disagree). Mean scores were interpreted using a threshold of 0.5 based on standard decimal point interpretation. For example, a mean score of 3.5 was categorized as "Agree," while a mean score of 3.4 remained "Neutral."

For Research Question 1, Descriptive statistics, including means and standard deviations, were used to determine students' perceptions of their science learning self-efficacy across the five sub-dimensions (CU, EA, PW, HCS, and SC).

A One-Way Multivariate Analysis of Variance (MANOVA) was conducted to compare the mean scores of the five self-efficacy sub-dimensions between male and female students regarding Research Question 2. In this analysis, the five sub-dimensions (CU, EA, PW, HCS, and SC) served as the dependent variables, and gender (male vs. female) was the independent variable.

Again, a One-Way Multivariate Analysis of Variance (MANOVA) was also used to examine differences in self-efficacy perceptions between grade 10 and grade 11 students with respect to Research Question 3. In this case, the five sub-dimensions of science learning self-efficacy were again treated as dependent variables, while grade level (grade 10 vs. grade 11) served as the independent variable. This robust analysis enabled a comprehensive examination of the data to identify patterns, gender differences, and grade-level differences in science learning self-efficacy perceptions among senior high school students in Ghana.

3. Results

The results of the study have been organized according to the research questions. The first research question sought to identify students' perceptions of their science learning self-efficacy. The results in Table 1 show that Senior High School students had mostly positive perceptions about their science learning self-efficacy. This was evident in the mean scores for the various sub-constructs: science communication (M = 4.0, SD = 1.0); conceptual understanding (M = 3.9, SD = 1.0); everyday application (M = 3.8, SD = 0.8); higher-order cognitive skills (M = 3.5, SD = 1.1). However, in Practical Work (M = 3.4, SD = 0.9), students seemed unsure about their science learning self-efficacy.

Table 1: SHS Students' Mean Scores on the Sub-constructs of SLSE

Sub-scales	M	SD
Practical Work	3.4	0.9
Higher Order Cognitive Skills	3.5	1.1
Everyday Application	3.8	0.8
Conceptual Understanding	3.9	1.0
Science Communication	4.0	1.0

The second research question sought to identify if differences existed between male and female students in their perception of science learning efficacy. The results on the perception of males and females on science learning self-efficacy are presented in Table 2.

Table 2: SHS Male and Female Students' Mean Scores on Sub-construct of SLSE

Subscales	Male		Female	
	M	SD	M	SD
Practical Work	3.4	0.9	3.4	0.9
Higher Order Cognitive Skills	3.5	0.7	3.5	0.7
Everyday Application	3.8	0.8	3.8	0.7
Conceptual Understanding	3.9	0.7	3.8	0.7
Science Communication	4.0	0.8	4.0	0.8

From Table 2, the perceptions of male and female students across all subscales were similar. While both male and female students were at par in most of the constructs, they differed slightly in their conceptual understanding perception, as seen in Table 2.

To ensure that similarities being seen in means and standard deviation were not due to chance, a one-way Multivariate Analysis of Variance (MANOVA) was conducted. The five sub-constructs on science learning self-efficacy, namely Conceptual Understanding (CU), Everyday Application (EA), Practical Work (PW), Higher Order Cognitive Skills (HCS), and Science Communication (SC), were used as the dependent variables. The independent variable was sex, which comprised males and females. Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity, with no violations of assumptions noted. The results are presented in Table 3.

Table 3: Multivariate Results on Sex Differences Against
Sub-constructs of Self-Efficacy in Science Learning

Sub-scales	Male	Female	F	p	eta squared
	M	M			
Conceptual Understanding	3.9	3.8	0.43	0.51	0.00
Everyday Application	3.8	3.8	3.00	0.08	0.00
Practical Work	3.4	3.4	0.02	0.89	0.00
Higher Order Cognitive Skills	3.5	3.5	0.00	0.97	0.00
Science Communication	4.0	4.0	0.73	0.39	0.00

n = 1,507.

The results in Table 3 show that there is no statistically significant difference between males and females on the combined dependent variables: F (5, 1,501) = 1.60, p = .157; Wilk's Lambda = .995. This means that males and females from the schools sampled do not differ in terms of their science learning self-efficacy.

The third research question dealt with the perception of students at different grade levels on their science learning self-efficacy. Students in grades 10 and 11 were used in this research. Table 4 shows the means and standard deviations for the students at the two grade levels. With the exception of the Everyday Application construct, grade 10 students had a slightly higher perception of their science learning self-efficacy on all the constructs of science learning self-efficacy than their grade 11 counterparts.

Table 4: Grades 10 and 11 Students' Mean Scores on Sub-constructs of SLSE

Sub-scales	Grade 10		Grade 11	
	M	SD	M	SD
Practical Work	3.5	0.9	3.4	0.9
Higher Order Cognitive Skills	3.6	0.7	3.5	0.7
Everyday Application	3.8	0.8	3.8	0.7
Conceptual Understanding	3.9	0.7	3.8	0.7
Science Communication	4.1	0.8	3.9	0.8

The results show that there were marginal differences in the mean scores of all the sub-constructs of science learning self-efficacy. Practical work seemed to be the construct with the least perceived self-efficacy for both grades, with science communication having the highest self-efficacy beliefs. A one-way multivariate analysis of variance was conducted. The results are presented in Table 5.

Table 5: Multivariate Results on Grade 10 and Grade 11
Students Against Sub-constructs of Science Learning Self-Efficacy

Subscales	Grade 10	Grade 11	F	p	eta-squared
	M	M			
Conceptual Understanding	3.9	3.8	1.11	0.29	0.00
Everyday Application	3.8	3.8	1.80	0.18	0.00
Practical Work	3.5	3.4	3.55	0.06	0.00
Higher Order Cognitive Skills	3.6	3.5	4.34	0.04*	0.00
Science Communication	4.1	3.9	23.12	0.00*	0.01

From Table 5, there was a statistically significant difference between students in grade 10 and students in grade 11 on the combined dependent variables: F (5, 1,501) = 5.293, $p <$ .001; Wilk's Lambda = .983. As a result, further analysis was done to find where the differences lie. As noted by Tabachnick and Fidell (2007), an alpha correction must be made to account for the five ANOVAs being run by applying a Bonferroni correction when the difference is observed in a multivariate analysis. Since there were five of dependent variables, the Bonferroni correction was obtained by dividing the original alpha of 0.05 by the number of dependent variables. Thus, in the case of the post-hoc analysis we accept statistical significance at p < .01 since there were five univariate ANOVA test statistics.

When the results for the dependent variables were considered separately, the only difference to reach statistical significance, using a Bonferroni adjusted alpha level of .01, was Science Communication: F (1, 1,505) = 23.12, $p < .001$, partial eta squared = .015. An inspection of the mean scores indicated that grade 10 students reported slightly higher levels of Science Communication (M = 4.1, SD=0.8) than grade 11 students (M = 3.9, SD=0.8). Higher Order Cognitive Ability showed significance on the combined mean but could not meet the Bonferroni adjusted alpha level of .01, which means that grade 10 and grade 11 students in this study are relatively at the same level about their cognitive abilities in the higher order.

4. Discussion

The results show that senior high school students had a relatively good perception of their science learning self-efficacy. The mean scores were above the midpoint for higher-order cognitive skills, everyday application, conceptual understanding, and science communication constructs, indicating that senior high school students perceived themselves as efficacious in science learning, except for practical work, where students displayed uncertainty. This result is in line with Lin and Tsai (2013), who had similar results of perception regarding students' science learning efficacy. A little departure from Lin and Tsai (2013) is that while their lowest construct was higher-order cognitive skills, this current study had practical work as the lowest construct in terms of perception.

The quest to explore students' science learning self-efficacy cannot be underestimated since evidence points to the fact that students who are gifted excel based on their perceptions of their cognitive ability (Pajares, 1996). Zimmerman and Kitsantas (2005) also argue that students with high self-efficacy towards learning tend to be more responsible towards their learning. They further accentuated that it is a student's self-efficacy to complete a task, which is the most important variable in learning. There is also a positive relationship between high academic self-efficacy beliefs and school-to-work transition (Pinquart, Juang, & Silbereisen, 2003). The importance of self-efficacy beliefs was brought to bear by DeBacker and Nelson (2000) when they revealed that perceived ability was the greatest predictor of semester grades for females in high school biology. Thus, it is anticipated that since students in this study demonstrated a positive perception of their self-efficacy in learning science, it will fuel their passion for acquiring higher academic degrees and become self-confident in their future occupations and transition well from school to work. Students' positive perception is essentially important for science adoption in education and its effectiveness and implementation. Hence, it is expected that students' positive perceptions in this study will serve as motivation for their achievement outcomes.

In this study, Ghanaian high school students' science learning self-efficacy was found not to differ between males and females. This indicates that in learning science, both male and female students in Ghanaian high schools have similar perceptions of their abilities. This is a positive development which can be harnessed to promote the learning of science among females in the country since the participation of females in science-related areas has dwindled over the years. Again, the fact that there is no difference between males and females in terms of their science learning efficacy beliefs, it can be extrapolated that the nature and difficulty of science is not a factor that is influencing the low participation of females in science in Ghana.

This outcome contradicts Tas and Busher (2010), who studied the perception of identity in science education among secondary school students in England and found out that gender biases hampered the efficacy of female students. Despite the improvements made over recent decades, girls are still less likely than boys to take chemistry and higher-level mathematics and science courses in schools of higher learning (American Association of University Women, 1999). Sadker and Sadker (1995) also noted that girls from 7th grade tend to underestimate their abilities in mathematics and science even though their performances remain the same as boys. The trend continues through high school and results in a loss of self-confidence rather than any difference in abilities, which may be what produces the first leak in the female science pipeline (Alper, 1993, p. 410).

Furthermore, Lindstrom and Sharma (2011) found that gender had a significant effect on the physics self-efficacy of any subgroup, suggesting a male overconfidence in learning physics. High school male students were found to have higher self-efficacy in physics, chemistry, and the laboratory, while female students were found to score higher in self-efficacy than males in biology (Smist, 2003). DeBacker and Nelson (2000) asserted that regardless of achievement level, girls scored lower in self-efficacy. There seems to be enough evidence suggesting that males are dominant in science learning self-efficacy. Such negative perceptions and stereotypical beliefs about science have the tendency to prevent females from pursuing science-related programmes at a higher level. If females perceive their abilities to be low in science, a whole technological sector of highly esteemed, high-paying careers may become off-limits to them. Fortunately, females in this study did not exhibit such negative stereotypes and perceptions about science.

The research brought to the fore that students in grade 10 tend to have a more positive perception of their science learning self-efficacy than their counterparts in grade 11. Research has shown that adolescents' science learning self-efficacy tends to decline during late elementary and middle school (Barth *et al.*, 2011; Rice *et al.*, 2013; Rittmayer & Beier, 2008). This decline may be one of the reasons for the relatively low proportion of students choosing to major in science studies and pursue science-related careers (Maltese & Tai, 2011; OECD, 2017). Self-efficacy is not static and can change over time, resulting from periodic reassessments of how adequate one's performance is (Bandura, 1986). According to Bandura (1977), efficacy beliefs vary between individuals and will actually fluctuate within an individual for different tasks. For example, in a college population, Chemistry laboratory self-efficacy increased over the course of a school year whereas Biology self-efficacy decreased over the same duration (Smist, as cited in Tenaw, 2013). Taken together, these results suggest that the construct of self-efficacy helps explain the finding that the behaviour of individuals is not always accurately predicted by their capability to accomplish a specific task. How a person believes they will perform is often more important. Perhaps, like other types of beliefs, self-efficacy beliefs are formed through personal experiences and persuasions received from others (Bandura, 1986).

The results of this study point out the unique differences in science learning self-efficacy between grade 10 and grade 11 students with regard to conceptual understanding of science.

5. Conclusion

The study, generally revealed that there is a lack of Practical Work in Ghanaian high schools, for which reason students seemed not to be so positive about their perception of their science learning self-efficacy. Males and female high school students in this study are at the same level on the subject of their science learning self-efficacy. There is a reason to believe from the findings of this study that males and females in senior high schools in Cape Coast perform equally in science learning. Judging from the findings of the study, senior high school students in Grade 10 communicate better in science than those in Grade 11. In terms of Higher Order Cognitive Skills, Grade 10 students, again, perceived their cognitive abilities to be of higher levels than students in Grade 11.

The study brings to the fore that high school science students in the Cape Coast Metropolis are positive and confident in their science learning self-efficacy. Since students showed a relatively low perception of their practical work efficacy, it is, therefore, recommended that teachers take active steps by planning and structuring science lessons to include more practical work as a means to enhance students' efficacy in practical skills.

5.1 Implications for Science Education

Science education, as a cornerstone of modern education systems, plays a vital role in equipping students with the skills and knowledge necessary for addressing real-world challenges. Therefore, translating research into practical applications is essential for ensuring that teaching methods remain aligned with the evolving needs of students and society. The findings of this study hold significant relevance for educators, curriculum developers, and policymakers in science education.

Teachers should prioritize incorporating hands-on activities and experiments in the teaching of science. This can bridge the gap in practical work exposure, enhance students' practical skills, and improve their overall self-efficacy in science learning. Since males and females demonstrated similar levels of science learning self-efficacy, science teachers should continue using teaching strategies that foster equity and inclusivity, ensuring equal opportunities for both genders to engage and excel in science.

Considering the decline in perceived cognitive abilities and communication skills among Grade 11 students compared to Grade 10, teachers should implement targeted interventions. These could include collaborative projects, critical thinking exercises, and communication-focused activities to strengthen these skills in senior grades. Again, workshops and training sessions can equip teachers with innovative strategies to integrate practical work into their lessons. This includes using affordable, locally available materials for experiments in resource-constrained schools. Lastly, stakeholders in education, including policymakers, should ensure adequate resources are available for practical science education. This includes well-equipped laboratories and materials that align with the curriculum's demands.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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