**Pre-Service Mathematics Teachers’ Demographics and Their Algebraic Thinking Levels in Colleges of Education, Ghana**

# ABSTRACT

The study was to investigate the relationship between prospective basic education mathematics teachers’ demographic factors and their algebraic thinking levels. The study employed positivist philosophical paradigm with quantitative method research approach. Descriptive Survey design was used to reach out to participants through simple random sampling technique. Prospective mathematics teachers in colleges of education in Ghana were the sample frame for the study. Data were collected from 250 participants with the aid of super item test on SOLO taxonomy. Descriptive and inferential statistics including frequencies, percentages, means, standard deviations, correlation and regression alongside two-way analysis of variance were used to analyse the quantitative data. The study revealed that neither age nor gender significantly related to participants' algebraic thinking levels. The study recommended that female students perform just as well as their male counterparts and should be encouraged to compete confidently in mathematics subject. Again, the study strongly suggested that age has no major influence on pre-service mathematics teachers' algebraic thinking, underlining the importance of focusing on other contributing factors to promote their mathematical development.

***Keywords****: Mathematics Teachers; Quantitative Method; Algebraic; Demographic factors,* *frequencies, percentages*

**INTRODUCTION**

Mathematics holds a special and significant place within the school curriculum, as proficiency in this subject enhances an individual's opportunities for social progress (Adjei & Oppong, 2024). Mathematics is therefore seen in relation to its rationale as a subject of study as well as its utilitarian role and benefits regarding national development and an individual’s life processes. In terms of its utilitarian role, the Ghanaian curriculum recognizes that Mathematics is the backbone of social, economic, political, and physical development and its learning is vital for future development (Hodson, 2020). The curriculum is therefore designed to meet expected standards of mathematics in many parts of the world.

According to Ackerman (2003) cited in (Agbofa et al., 2023), the concept of curriculum has evolved to be seen as integral to our everyday existence. Curriculum development is described as a methodical and continuously evolving process that is contextually sensitive, considering both the timing and the specific location. This process encompasses various stages, including the planning, creation, execution, and assessment of the curriculum (Jadhav & Patankar, 2013). There have been numerous attempts in recent years to introduce novel concepts, techniques, and procedures into educational organizations and structures. These are intended to address the demands of students, instructors, and lecturers as well as those of business and public policy. Much like numerous other developing nations, Ghana underwent substantial educational and curriculum reforms during the early 1990s (Kuyini, Yeboah, Das, Alhassan, & Mangope, 2016). In 2017, the Ghanaian government assigned the National Council for Curriculum and Assessment (NaCCA) the responsibility of revising the pre-tertiary curriculum to align it with international best practices. Subsequently, in February 2019, the President of Ghana, during his State of the Nation Address, disclosed the imminent introduction of a Standard-based Curriculum. This new curriculum was officially implemented by the Ghanaian government in September 2019.

The introduction of the new curriculum aimed to address several issues associated with the previous objective-based curriculum. These challenges encompassed issues like excessive content, limitations inherent to the objective-based curriculum, and shortcomings in the assessment system's ability to provide sufficient data for meaningful improvements in teaching and learning practices (Aboagye & Yawson, 2020).

As per the Ministry of Education in 2018, there was a recognized necessity for a substantial shift from the objective-oriented curriculum towards a standards-based approach. This shift was deemed necessary due to various problems linked to the existing curriculum, notably the overemphasis on preparing students solely for examinations, often at the expense of acquiring crucial skills essential for human capital development. The implementation of the new curriculum was therefore driven by the goal of enhancing the development of fundamental skills such as reading, writing, arithmetic, and creativity, particularly at the primary school level. Additionally, the adoption of the standards-based curriculum aimed to enhance the teaching and learning of mathematics.

The primary purpose of including mathematics in a standards-based curriculum is to guarantee that every student attains a strong grasp and proficiency in fundamental mathematical principles and abilities, which can be practically employed in real-life scenarios. Furthermore, the objective is to establish a well-structured and cohesive structure for the cultivation of mathematical literacy, problem-solving capabilities, and logical reasoning skills. This methodology underscores the significance of comprehending concepts, mastering procedures, and effectively using mathematical knowledge. A standard-based mathematics curriculum is designed to ensure that students have necessary knowledge and skills to succeed in higher-level mathematics courses as well as in college, career, and life. The curriculum is organized around clear and measurable learning objectives or standards that outline the knowledge and skills students acquire at each grade level or course level. The standards provide a roadmap for curriculum development, instructional planning, and assessment, ensuring that all students have equitable to learn and succeed. The updated curriculum also strives to improve the teaching and learning of French and other subjects. It places an emphasis on learner-centered teaching approaches and leveraging ICT (Information and Communication Technology) as an instructional tool. Furthermore, it prioritizes an educational approach that highlights equity, equality, and inclusivity (Ghana Web, 2019, as cited in Agbofa et al., 2023). On this note, the curriculum has a lot of emphasis on 21st century skills (ICT, Critical thinking, and etc), Social and Emotional Learning (SEL) and Gender Equality and Social Inclusion (GESI)

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Mathematics education is an active, dynamic, and an ongoing process in which students develop their reasoning, think rationally, systematically, critically, and thoroughly, and adopt an objective and open approach while dealing with mathematics problems (Sumarmo, 2004). Teachers, students, and materials are the three main components of teaching and learning. Students must be armed with information and advanced talents, and teachers must be competent and professional. Materials refer to the various resources such as textbooks, videos, handout, technology etc., that teachers use to facilitate learning. Appropriate and high-quality materials are essential for effective teaching and learning as they help to explain and reinforce concepts and support students at different learning levels.

An effective teaching and learning process of mathematics requires the active involvement of these three key components stated above. These components need to work together in a harmonious manner to ensure that students acquire the necessary knowledge and skills to succeed in life and beyond.

It is impossible to underestimate the importance of mathematics in a country's scientific and technical advancement (Enu, Agyman, & Nkum, 2015). This is because mathematical abilities are required to comprehend other fields such as engineering, physics, social science, and even the arts (Patena & Dinglasan, 2013; Phonapichat, Wongwanich, and Sujiva, 2014; Schofield, 1982). Mathematics, according to Abe and Gbenro (2015), has a multifaceted function in science and technology, with applications spanning all fields of science, technology, and commercial operations. As a result, it is critical that students be assisted in developing the ability to apply mathematical skills and inquiry strategies to solve issues in mathematics in a variety of settings.

Algebraic thinking is a critical tool in learning mathematics, particularly in comprehending algebraic concepts and fostering the process of generalizing mathematical ideas based on examples. Individuals who engage in algebraic thinking while learning mathematics often employ symbolic representations to solve quantitative problems that involve relationships between variables (as noted by Andriani, 2015). Consequently, it is imperative for prospective mathematics teachers to explore the emergence of algebraic thinking, gain insight into students' thought processes and their characteristics, and grasp the nuances of algebraic reasoning and its development.

In Ghana, one of the main objectives of mathematics education is to promote higher-order thinking abilities. This focuses on how mathematics is taught and tested in Ghanaian classrooms. As a result, evaluating algebraic thinking must go beyond a paper and pencil test that relies solely on recollection and traditional methods and student grades (Owusu-Ansah, Apawu & Akayuure, 2018). There must be a different way all together of assessing students in Ghanaian classroom in the way they solve mathematics related problems. Curriculum developers need to set some standards in assessing students learning process other than paper and pencil test which we have been doing in our classrooms, Ghana. In solving a mathematical problem, a student must be able to select and determine the elements that can be used in helping to solve the problem. The problem-solving process is related to the cognitive domain of the students. "Hence, the proficiency in problem-solving is intricately connected to the academic performance of students in mathematics. It's worth noting that each mathematical problem presents unique attributes, resulting in varied responses from individual students. According to Biggs and Collis in their 1982 work, the cognitive response to problem-solving progresses through different stages, evolving from simple to abstract.

The SOLO taxonomy is a cognitive psychology model utilized to categorize students' proficiency in addressing problems and their performance in assessments. Unlike traditional assessment methods that primarily focus on the correctness of answers, the SOLO taxonomy places a greater emphasis on understanding the internal cognitive processes involved in problem-solving.This approach is more interested in examining how students tackle problems, rather than solely evaluating whether their responses are right or wrong.

Researchers have used SOLO taxonomy to analyze students’ thinking levels comprehensively by the use of Super-item test model to compile test items (Adjei & Oppong, 2024; Owusu-Ansah et al., 2018). A Super-item is a format of item that provides more user friendly and effective way to determine the learners’ ability level and detects their strengths and weakness if they are not progressing past a certain level. These Super-item tests are arranged according to the five (5) levels with respect to SOLO taxonomy, starting from simple questions to complex questions. The Super-item test model is used as an alternative assessment tool for students’ cognitive development.

Therefore, in this study, the researchers used the Super-item test based on the Structure of the Observed Learning Outcome (SOLO) taxonomy, to investigate the relationship between preservice mathematics teachers and algebraic thinking, specifically in relation to their demographic factors (Age and Sex) .

According to Chimuka (2017), any group of learners, regardless of age or gender, could benefit from using any model such as Van Hiele's model etc. The concept, according to Chimuka (2017), is not a developmental one in which students must reach a specific age to move up the stages; rather, it is based on the activities they take part in and their prior experiences. To achieve this, the learning environment or instructional practices must offer opportunities for learners to move from the visualization stage through the rigor stage.

Hanan, Marie-Anne, and Lori (2015) stated that age and gender could predict postsecondary students' academic achievement only if traditional face-to-face classroom discussions were used instead of online learning. Conversely, Eze, Ezenwafor, and Obi (2015) found no linear relationship between age, gender, and academic performance, with their combined influence being insignificant. However, they observed significant differences in academic performance among university students in the Vocational and Technical Education (VTE) Department due to age and gender, attributing this to the involvement of Mathematics, Science, and ICT in VTE courses. Similarly, Ebenuwa-Okoh (2010) concluded that gender, age, and financial status were not significant factors in undergraduate academic performance.

John, Jackson, and Simiyu (2015) argued that a student’s chronological age significantly impacts academic performance, with younger students tending to score higher than their older counterparts in teacher-made tests. Abubakar and Adegboyega (2012) found a positive correlation between age and academic achievement, as well as gender and academic achievement in Mathematics among students in Colleges of Education. However, while both factors were deemed insignificant overall, age was identified as a stronger contributor to academic success. Aransi (2017) emphasized that academic performance in secondary schools is largely determined by class streams, such as Science, Arts, or Commerce, particularly in English Language, while gender and class size had no significant impact.

Regarding productivity, Kotur and Anbazhagan (2014) suggested that changes in age and gender influence factory workers' performance. They noted that worker productivity improves with age up to a certain point, after which it declines. They also identified a significant gender difference in productivity, favoring female workers. In entrepreneurship, Rani and Hundie (2016) found no statistically significant performance differences between male and female entrepreneurs. Additionally, Wiebke et al. (2016) studied gender and age differences in self-esteem across 48 Western industrialized nations, concluding that men generally have higher self-esteem than women, and both genders experience age-related increases in self-esteem from late adolescence to middle adulthood. However, cultural differences affect the magnitude of these age and gender interactions. Given these findings, further research is needed to examine the relationship between age, gender, and algebraic thinking levels of prospective mathematics teacher’ at colleges of education, Ghana.

The historical dominance of men in the field of mathematics is reflected in various aspects, such as the significant disparity in the number of publications authored by men compared to women (Mihaljevic-Brandt, Santamaria, Tullney, 2016). Again, the authors stated that, men have traditionally received more recognition for their mathematical achievements and discoveries. This signifies that, gender imbalance in mathematics is not only a matter of representation but is also influenced by societal laws and cultural norms that historically excluded women from opportunities in mathematics publishing and education.

Although the gender achievement gap in secondary mathematics has reduced over time (Mullis, Martin, Foy, & Hooper, 2016; Mullis, Martin, Foy & Arora, 2012), there remain significant differences in the attitudes and dispositions towards mathematics between boys and girls, especially during middle school and high school years.

Research suggests that middle and high school girls often have a more negative attitude towards mathematics compared to their male peers. They commonly express a lack of interest in the subject, believe that mathematics is less relevant to their future (Samuelsson & Samuelsson, 2016; Meyer & Kohler, 1990), perceive math environments as unwelcoming and exclusionary (Lubienski & Ganley, 2017; Herzig, 2004), and frequently experience feelings of self-doubt and anxiety about their mathematics skills (Else-Quest, Hyde, & Linn, 2010; Hill, Mammarella, Devine, Caviola, Passolunghi, & Szucs, 2016; Lacampagne, Campbell, Herzig, Damarin, & Vogt, 2007; Devine, Fawcett, Szucs, & Dowker, 2012).

Research have identified various factors contributing to the gender disparity in mathematical attitudes and achievements, including teacher biases and behaviours that marginalize female students in mathematics classrooms, as well as classroom activities that do not incorporate female perspectives or discourse, as discussed by Gee (Adjei, 2023).

It is argued that the underrepresentation of women in STEM fields may not be primarily due to systemic marginalization, but rather related to personal choices influenced by factors like career preferences and work-life balance considerations. Research conducted by Eccles and Wang in 2016 suggests that women tend to gravitate towards professions involving people, such as teaching or caregiving, while men are more inclined towards careers working with objects, like engineering or plumbing. Additionally, the research indicates that women prioritize the enjoyment of their work and the ability to balance work and family life over financial incentives in their career choices.

Based on these findings, one could conclude that women may be exercising their freedom to choose careers that align with their interests and lifestyle preferences, without feeling compelled by societal pressures to pursue high-paying STEM jobs to support their families. Viviline, Enose, and Dorothy (2013) identified several factors influencing girls’ academic achievement in both day and boarding secondary schools. These include school levies, indiscipline, family issues, a child's entry behavior, lack of interest among girls in completing their work, parental attitudes favoring boys over girls, and inadequate school materials such as books. Similarly, Ahmad and Yusuf (2013) highlighted poverty, household responsibilities, prioritization of boys' education, early marriage, lack of security, disinterest in school, parental loss, long travel distances, expected disobedience from female students, and religious beliefs as key psycho-social factors contributing to the higher dropout rates among girls compared to boys. Additionally, some girls start school later in life, which leads to over-age enrollment. Jabor et al. (2011) noted that when students are older than their peers, their academic performance tends to decline, and they face a higher likelihood of dropping out, particularly when reaching puberty while still in school, as this increases their vulnerability to sexual abuse.

This idea that "females are to go to the kitchen, not to read mathematics" is an outdated stereotype based on cultural biases rather than scientific or intellectual merit. Again, family disinterest in mathematics and lack of proper guidance in early stage of learning mathematics. This perspective challenges the notion that the lack of female representation in STEM is solely a result of discrimination or exclusion and suggests that women's choices play a significant role in shaping these disparities. Parents and the government's efforts to educate students at school levels ensure that both male and female students gain the expected knowledge and skills to benefit them and society. In Ghana, there is no gender or age discrimination in school enrollment. This is to provide all students with equal educational opportunities, regardless of age or gender. However, despite the fact that both parents and government want students (male and female) to excel in school, significant relationship still exist among age, gender and their algebraic thinking levels. In this light, the study was to investigate the effect of pre-service teachers’ demographic characteristics (sex and age) have on their algebraic thinking level and which is fundamental in STEM Education.

**Research Hypothesis**

The researchers used the following hypothesis to address the question:

$H\_{0}$: There is no significant effect of pre-service mathematics teachers’ demographic characteristics on their algebraic thinking levels.

# Methods

This study used a quantitative research method approach with descriptive survey design. A sample size of 250 was selected from four main colleges of education in the Eastern region, including College 1, 2, 3, and 4. Simple random sampling was used to select the colleges, while simple random sampling was used to select individuals to respond to two super-item test questions based on SOLO taxonomy test format. The cognitive test (Super-Item test) was used to collect data from prospective mathematics teachers. Descriptive statistics including frequencies, percentages, means, standard deviations, correlation and regression analysis alongside two-way analysis of variance were used to analyse the quantitative data.

The researchers consulted the mathematics curriculum and relevant mathematics books used by pre-service teachers in Ghana. This was done to gain a thorough understanding of what the pre-service teachers are expected to learn, which guided the construction of the research instruments (test items). Again, the researchers employed the same set of test items for all participants, allocated the same amount of time to each participant, and administered the test items to all students before they began answering them. Additionally, the test items underwent a pilot test prior to being given to the students involved in the study.

The researchers obtained permission from the relevant authorities, including the principals of selected Colleges of Education and the Heads of the Mathematics Department. Furthermore, the participants in the study were treated with utmost respect and their identities were kept confidential. They were given a comprehensive orientation that clearly explained the purpose of the study and their rights, including the option to withdraw from participation without needing to provide any justification.

# RESULTS

## **Demographic Characteristics**

Demographic characteristics refer to the quantifiable attributes of a population or specific group of people. These characteristics provide information about the composition, distribution, and traits of individuals within a given population. In this study, such characteristics as gender and age were explored.

### **1.0 Age**

Details on the age characteristics of participants is shown in Figure 1

### ***Figure 1: Age of Respondents***

*Source: Survey data (2023)*

The age characteristics of respondents showed that the majority of the prospective basic education mathematics teachers fall within the age range of 21-23 (57.2%). A significant proportion of the teachers were also within the age range of 24-26 (22.8%). There are fewer teachers in the older age groups, with the age range of 30-32 having the lowest percentage (2.0%). The age range of 17-20 has a moderate percentage (7.2%) whereas 6% were not able to indicate their age and for that matter treated as a missing system. This suggest that prospective basic education mathematics teachers used in the study were predominantly comprised of individuals in their early twenties.

### **1.1 Gender Characteristics**

The gender characteristics describe the sex divisions of participants. Details on the gender of participants is shown in Figure 2

### *Figure 2: Gender of Respondents*

*Source: Survey data (2023)*

The gender characteristics of respondents revealed that majority of the prospective basic education mathematics teachers are male (60.0%). Female teachers make up a slightly smaller proportion (40.0%) compared to male teachers. This is an indication that there is a higher representation of male teachers compared to female teachers.

Through quantitative data collection and analysis, two-way ANOVA was used to analyse the difference between algebraic thinking levels of the prospective mathematics teachers regarding age and gender. The result on the difference between the algebraic thinking levels of the participants is shown in Table 1 to 4.

The effect of pre-service teachers’ demographic characteristics (sex and age) on their algebraic thinking level was assessed using two-way ANOVA. The analysis includes descriptive statistics, Levene's test of equality of error variances, and tests of between-subjects effects. The ANOVA results explaining the between-subjects factors is shown in Table 1.

## **Table 1: Between-Subjects Factors**

|  |  |  |
| --- | --- | --- |
| **Demographic Features** | **Value Label** | **N** |
| Age | Young (teachers less than 24 years) | 147 |
| Old (teachers who are 24 years or more) | 88 |
| Gender | Male | 141 |
| Female | 94 |

*Source: Survey data (2023)*

Table 1 presents the between-subjects factors, which are the two independent variables: AGE (age group with two levels - Young students and Old students) and GENDER (gender with two levels - Male and Female). The table also shows the number of participants (N) in each group.

**Descriptive Statistics**

The Table 2 displays the descriptive statistics for the dependent variable, which is "Algebraic Thinking Level." The data is presented separately for each combination of age and gender. It includes the mean (average) score, standard deviation (Std. Deviation), and the number of participants (N) in each group.

## Table 2: Descriptive Statistics

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Age** | **Gender** | **Mean** | **Std. Deviation** | **N** |
| Young prospective teachers | Male | 17.49 | 1.99 | 96 |
| Female | 17.84 | 2.17 | 51 |
| Old prospective teachers | Male | 17.49 | 2.05 | 45 |
| Female | 17.98 | 2.19 | 43 |
| Total  | Male | 17.49 | 2.01 | 141 |
| Female | 17.90 | 2.17 | 94 |
|  | **Total** | 17.66 | 2.08 | 235 |

*Source: Survey data (2023)*

The mean algebraic thinking level for young male prospective teachers is 17.49 out of 100. Signifying that on average, young male pre-service teachers scored approximately 17.49% of the total possible score on the algebraic thinking assessment. The mean algebraic thinking level for their female counterparts is 17.84 out of 100 indicating that on average, young female pre-service teachers scored approximately 17.84%. Similarly, the mean algebraic thinking level for old male prospective teachers is 17.49 out of 100. This indicates that old male pre-service teachers scored approximately 17.49% of the total possible score on the algebraic thinking assessment. The mean algebraic thinking level for old female prospective teachers is 17.98 suggesting that on average, old female pre-service teachers scored approximately 17.98% of the total possible score on the algebraic thinking assessment.

Therefore, with a total possible score of 100%, the mean values indicate that, on average, pre-service teachers' performance on the algebraic thinking assessment is relatively low across participants demographic characteristics (age and gender). The average scores for both young and old prospective teachers, as well as for both males and females, are around 17% of the total possible score. This suggests that there a room for improvement in their algebraic thinking abilities, as they are performing at a relatively low level compared to the maximum achievable score

**Levene's Test of Equality of Error Variances**

Levene's test of equality of error variances was used to check if the assumption of homogeneity of variances is met for the dependent variable across different groups. The test compares the variability (variance) of the dependent variable between groups; the result of which is shown in Table 3 below.

## Table 3: Levene's Test of Equality of Error Variances

|  |  |  |  |
| --- | --- | --- | --- |
| **F** | **df1** | **df2** | **Sig.** |
| .706 | 3 | 231 | .550 |
| a. Design: Intercept +age +gender |

*Source: Survey data (2023)*

In Table 3 the degrees of freedom for Levene's Test are df1 (3) and df2 (231). The test statistic (F-ratio) compares the variability between the groups (df1) to the variability within the groups (df2) to determine if there is a significant difference in the variances of the dependent variable across the groups. In this case, the F-ratio value is 0.706, and the associated p-value (Sig.) is 0.550, indicating that there is no significant difference in the variances of the dependent variable between the groups. This means that the assumption of equal variances is met, which is important for conducting valid statistical analyses.

**Tests of Between-Subjects Effects**

Table 4 presents the results of the tests of between-subjects effects, which analyze the main effects of the independent variables (age and gender) on the dependent variable (Algebraic Thinking Level).

## Table 4: Tests of Between-Subjects Effects

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source | Sum of Squares | Df | Mean Square | F | Sig. | Partial Eta Squared |
| Corrected Model | 9.886a | 2 | 4.943 | 1.148 | .319 | .010 |
| Intercept | 67198.917 | 1 | 67198.917 | 15602.713 | .000 | .985 |
| Age | .178 | 1 | .178 | .041 | .839 | .000 |
| Gender | 9.158 | 1 | 9.158 | 2.126 | .146 | .009 |
| Error | 999.195 | 232 | 4.307 |  |  |  |
| Total | 74261.000 | 235 |  |  |  |  |
| Corrected Total | 1009.081 | 234 |  |  |  |  |
| a. R Squared = .010 (Adjusted R Squared = .001) |

*Source: Survey data (2023)*

The analysis conducted for the research question examines the relationship between pre-service teachers' demographic characteristics (age and gender) and their algebraic thinking level. The "Corrected Model" section provides overall model fit statistics for the analysis. It indicates how well the independent variables (age and gender) collectively explain the variation in the dependent variable (algebraic thinking level) when accounting for the effects of other variables. The "Intercept" represents the baseline group, likely male young prospective teachers with an average algebraic thinking level of 17.4896.

The effect of age (Young prospective teachers vs. Old prospective teachers) on algebraic thinking level. The "Mean Square" value of 0.178 suggests that the difference in algebraic thinking level between young and old prospective teachers is not statistically significant (p > .05). Similarly, in assessing the effect of gender (Male vs. Female) on algebraic thinking level, the "Mean Square" value of 9.158 indicates that the difference in algebraic thinking level between male and female students is not statistically significant (p > .05).

## The "Error" section of the analysis reveals the unexplained variation within each group due to factors not accounted for by the independent variables. The "Total" section represents the overall variability in the dependent variable, giving us a basis to understand how much of this variability is accounted for by the independent variables. The "R Squared" value of 0.010 signifies that only a very small portion (1%) of the variation in algebraic thinking level can be attributed to age and gender combined. This indicates that factors beyond what we've examined in this analysis likely have a more significant impact on pre-service teachers' algebraic thinking abilities.

##

## In simpler terms, this implies that neither age nor gender seems to have a significant influence on the algebraic thinking level of the participants. The differences in algebraic thinking levels among younger and older prospective teachers and between male and female prospective teachers are minimal and not statistically meaningful. Together, age and gender as independent variables explain only a very small fraction of the variation seen in the dependent variable.

## **DISCUSSION**

The level of algebraic thinking varies from individual to individual and can depend on factors such as mathematical background, education, and experience. Some individuals may develop strong algebraic thinking skills and grasp complex algebraic concepts quickly, while others may require more time and practice to develop proficiency. It is not directly correlated with gender or any other specific demographic characteristic. Algebraic thinking can be cultivated and improved through instruction, practice, and problem-solving activities. In this study, gender and algebraic thinking level among prospective mathematics teachers was assessed using the SOLO taxonomy.

An evaluation was conducted to compare the levels of algebraic thinking between males and females across different degrees of complexity, using the SOLO taxonomy. This involved assessing the algebraic thinking abilities of participants at the stages of pre-structural, uni-structural, multi-structural, relational, and extended abstract thinking. The results indicated that there is no significant statistical distinction between male and female prospective mathematics teachers in terms of their algebraic thinking abilities across various levels of complexity in algebraic thinking.

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Same is applied to participants’ age as both age and gender proved to have insignificant effect on algebraic thinking levels of pre-service mathematics teachers. This implied that, regardless of whether individuals are male or female and irrespective of their age, the pre-service mathematics teachers in the study exhibit similar patterns of development across the different levels of algebraic thinking. In other words, gender and age do not appear to be determining factors in how these individuals progress from having limited or basic understandings of algebraic concepts (pre-structural and uni-structural levels) to more complex and abstract understandings (multi-structural, relational, and extended abstract levels). The findings indicate that other factors, says educational background, teaching methods, exposure to mathematical concepts, or individual learning styles may play a more significant role in influencing the progression of algebraic thinking levels among pre-service mathematics teachers. While gender and age may not be statistically significant predictors in this study.

The results were in line with previous studies that used a similar approach. For example, a study by Ajai and Imoko in 2015 found that female students performed better than their male counterparts in both post-tests and retention, but this difference was not statistically significant. This finding was consistent with a study conducted in the United States by Hydea and Mertzb in 2009, which suggested that girls had achieved parity with boys in mathematics, with no significant difference between them. However, other studies have reported the opposite, indicating that while the achievement gap between boys and girls in mathematics has narrowed (Mullis, Martin, Foy, & Hooper, 2016; Mullis, Martin, Foy & Arora, 2012), boys and girls have different attitudes towards mathematics.

According to the literature, research has shown that middle school and high school females tend to have a more negative attitude towards mathematics compared to their male peers. They often express a dislike for the subject and believe that mathematics is less relevant to their future (Samuelsson & Samuelsson, 2016; Meyer & Kohler, 1990). However, the findings of this study contradict these trends, as no significant differences were found between genders and age groups regarding the prospective mathematics teachers' understanding of algebraic thinking. In a related study, Anjum in 2015 compared the mathematical thinking ability of primary school students and discovered a significant difference in mathematics achievement between girls and boys at the upper primary school level.

Neither age nor gender significantly impacted participants' algebraic thinking levels. The differences observed between young and old prospective teachers and between male and female prospective teachers were not statistically significant.

## **CONCLUSIONS**

The study discovered that neither age nor gender significantly affected participants' algebraic thinking levels. The differences observed between young and old prospective teachers and between male and female prospective teachers were not statistically significant. The researchers concluded that the idea that the field of mathematics is dominated by men might not necessarily be true.

## **RECOMMENDATIONS**

With demographic characteristics (*age and gender)* having no significant effect on participants algebraic thinking levels, the narrative in literature that seems to place female students as mathematics phobias, could be re-examined. This is because female students are equally doing well just as their male counterparts and must be encouraged to do as their male counterparts in the mathematics subject.

AcknowledgEments

The work is part of my Master’s thesis under the supervision of my co-author. Special appreciation to the department of mathematics Education of the University of Education, Winneba for the opportunity offered me to come out with this study. I also want to thank the various colleges that allowed me to use their preservice teachers for the study. Finally, to participants and all others who contributed in any form to make the work a success. God bless you all.

Authors’ Contributions

Both authors, Adjei Emmanuel Antwi and Asumadu Richard Oppong, contributed equally in all aspects of the study and therefore can be regarded as co-corresponding authors. We conceived and designed the research together, collected and analyzed the data, and interpreted the findings. All authors drafted and revised the manuscript and approved the final version. This is a joint work which we acknowledge authorship of and assume all responsibility for.

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# REFERENCE

Abe, T. O., & Gbenro, S. O. (2015). A comparison of students’ attitudinal variables towards mathematics between private and public senior secondary schools. World, 1(2).

Aboagye, E., & Yawson, J. A. (2020). Teachers’ perception of the new educational curriculum in Ghana. African Educational Research Journal, 8, 6–12. <https://eric.ed.gov/?id=EJ1242678>

Abubakar, R. B., & Adegboyega, B. I. (2012). Age and gender as determinants of academic achievements in college mathematics. Asian Journal of Natural & Applied Sciences, 1(2), 121–127.

Adjei, E. A. (2023). Assessing prospective basic education teachers’ algebraic thinking levels using SOLO taxonomy (Master’s thesis). University of Education, Winneba, Ghana.

Agbofa, F. J. K., Mensah, D. K. D., Opoku-Amankwaah, K., Kyeremeh, S., & Adu-Boahen, A. O. (2023). Teachers’ concerns on the implementation of the standards-based curriculum in Ghana: A case of New Juaben North Municipal. Creative Education, 14, 1076–1093. <https://doi.org/10.4236/ce.2023.145069>

Ahmad, K., & Yusuf, N. B. M. (2013). Parents’ perspective on female students’ dropouts in Nigeria. Asian Journal of Education and e-Learning, 1(4), 250–261.

Ajai, J. T., & Imoko, B. I. (2015). Gender differences in mathematics achievement and retention scores: A case of problem-based learning method. International Journal of Research in Education and Science, 1(1), 45–50.

Akufo-Addo, N. A. D. (2017). Statement by the president of the Republic, Nana Addo Dankwa Akufo-Addo, at the commencement of the Free Senior High School Policy. <https://www.adomonline.com/ghana-news/full-text-presidents-speech-launch-free-shs/>

Aransi, W. O. (2017). Effect of class classification, class size and gender on academic performance among Fatima High School students in Irewole Local Government Area of Osun State, Nigeria. European Journal of Education Studies, 3(11), 756–771.

Armah, R. B., Cofie, P. O., & Okpoti, C. A. (2017). The geometric thinking levels of pre-service teachers in Ghana. Higher Education Research, 2(3), 98–106. https://doi.org/10.11648/j.her.20170203.14

Biggs, J. B., & Collis, K. F. (1982). Evaluating the quality of learning: The SOLO taxonomy (Structure of the Observed Learning Outcome). Academic Press.

Brown, S., & Bergman, J. (2013). Preservice teachers’ understanding of variable. Investigations in Mathematics Learning, 6(1), 1–17.

Buabeng, I., Ntow, F. D., & Otami, C. D. (2020). Teacher education in Ghana: Policies and practices. Journal of Curriculum and Teaching, 9(1), 86–95.

Buabeng, I., Owusu, K. A., & Ntow, F. D. (2014). TIMSS 2011 science assessment results: A review of Ghana's performance. Journal of Curriculum and Teaching, 3(2), 1–12.

Chimuka, A. (2017). The effect of integration of Geogebra software in the teaching of circle geometry on grade 11 students’ achievement (Master’s thesis). University of South Africa, South Africa.

Devine, A., Fawcett, K., Szűcs, D., & Dowker, A. (2012). Gender differences in mathematics anxiety and the relation to mathematics performance while controlling for test anxiety. Behavioral and Brain Functions, 8, 1–9.

Ebenuwa-Okoh, E. E. (2010). Influence of age, financial status, and gender on academic performance among undergraduates. Journal of Psychology, 1(2), 99–103.

Enu, J. A. O. K., Agyman, O. K., & Nkum, D. (2015). Factors influencing students’ mathematics performance in some selected colleges of education in Ghana. International Journal of Education Learning and Development, 3(3), 68–74.

Eze, T. I., Ezenwafor, J. I., & Obi, M. N. (2015). Effects of age and gender on academic achievement of vocational and technical education (VTE) students of a Nigerian university. Journal of Emerging Trends in Educational Research and Policy Studies, 6(1), 96–101.

Ghana Web. (2018, July 16). Over 190,000 SHS graduates miss varsity due to failure in mathematics. <https://www.ghanaweb.com/GhanaHomePage/NewsArchive/Over-190-000-SHS-graduates-to-miss-varsity-due-to-failure-in-Mathematics-669054>

Hanan, J. A., Marie-Anne, M., & Lori, K. (2015). The effects of age and gender on student achievement in face-to-face and online college algebra classes. Research in Higher Education Journal, 27, 1–22.

Hodson, D. (2020). Going beyond STS education: Building a curriculum for sociopolitical activism. Canadian Journal of Science, Mathematics and Technology Education, 20(4), 592–622.

Hook, P. (2015). First steps with SOLO taxonomy: Applying the model in your classroom. Essential Resources Educational Publishers Limited.

Jabor, M. K., Machtmes, K., Buntat, Y., Kungu, K., & Nordin, M. S. (2011). The influence of age and gender on the students’ achievement in mathematics. International Conference on Social Science and Humanity, 5, 304–308.

John, M. M., Jackson, T., & Simiyu, C. (2015). Effect of students’ age on academic motivation and academic performance among high school students in Kenya. Asian Journal of Education and e-Learning, 3(5), 337–342.

Kotur, B. R., & Anbazhagan, S. (2014). Influence of age and gender on the performance. Journal of Business and Management, 16(5), 97–103.

Kuyini, A. B., Yeboah, K. A., Das, A. K., Alhassa, A. M., & Mangope, B. (2016). Ghanaian teachers: Competencies perceived as important for inclusive education. International Journal of Inclusive Education, 20, 1009–1023. <https://doi.org/10.1080/13603116.2016.1145261>

Lim, H. L., Wun, T. Y., & Idris, N. (2010). Super-item test: An alternative assessment tool to assess students’ algebraic solving ability.

Mereku, K. D. (2010). School mathematics: The misplaced emphasis. The People’s Daily Graphic.

Mullis, I. V., Martin, M. O., Foy, P., & Arora, A. (2012). TIMSS 2011 international results in mathematics. International Association for the Evaluation of Educational Achievement.

Mullis, I. V., Martin, M. O., Foy, P., & Hooper, M. (2016). TIMSS advanced 2015 international results in advanced mathematics and physics. Boston College TIMSS & PIRLS International Study Center.

Oketch, M., Rolleston, C., & Rossiter, J. (2021). Diagnosing the learning crisis: What can value-added analysis contribute? International Journal of Educational Development, 87, 102507.

Owusu‐Ansah, N. A., Apawu, J., & Akayuure, P. (2018). A study on the algebraic working processes of senior high school students in Ghana. European Journal of Science and Mathematics Education, 6(2), 62‐68.

Rani, D. L., & Hundie, R. M. (2016). Gender and entrepreneurship performance differences in Ethiopia. Excel International Journal of Multidisciplinary Management Studies, 6(3), 24–36.

Salifu, A. S. (2021). Pre-service teachers’ conceptual and procedural knowledge of rational numbers in EP College of Education, Bimbilla, Ghana. Education Journal, 10(4), 126–137.

Samuelsson, M., & Samuelsson, J. (2016). Gender differences in boys' and girls' perception of teaching and learning mathematics. Open Review of Educational Research, 3(1), 18–34.

Sumarmo, U. (2004, July). Kemandirian belajar: Apa, mengapa, dan bagaimana dikembangkan pada peserta didik. Proceedings of the Seminar Tingkat Nasional, FPMIPA UNY Yogyakarta.

Triana, H., Abustang, P. B., Utomo, E., Rakhman, G. G. F., & Fahrurrozi, F. (2023). Assessment evaluation using SOLO taxonomy for measuring levels of critical thinking skills: PYP International Baccalaureate case study. Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram, 11(2), 581–595.

Van Hiele, P. M. (1986). Developing geometric thinking through abilities that begin with play. Teaching Children Mathematics, 6, 310–316.

Viviline, C. N., Enose, M. W. S., & Dorothy, C. S. (2013). Determinants of girl students’ academic achievement in mixed day and boarding secondary schools in Kericho District: An analytical study. International Research Journals, 4(7), 543–554.

Wahyuniar, L. S., Shofia, N., & Rochana, S. (2018). Proses berpikir aljabar siswa MTs kelas VIII menurut taksonomi SOLO ditinjau dari perbedaan gender. Jurnal Aksioma, 7(2), 275-282.

Wiebke, B., Ruben, C. A., Jaap, J. A. D., Peter, J. R., Jochen, E. G., Jeff, P., & Samuel, D. G. (2016). Age and gender differences in self-esteem—A cross-cultural window. Journal of Personality and Social Psychology, 111(3), 396–410.