Gender Disparities Impact on Pre-Service Teachers' Attitudes in Mathematics and Statistics Education

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ABSTRACT

The research investigates the impact of gender disparities on prospective teachers' attitudes towards statistics in mathematics education. The problem is a lack of understanding of how gender influences attitudes towards statistics. This research aims to explore differences in attitudes towards statistics based on gender and identify factors that influence these attitudes. The urgency lies in the importance of better understanding how gender can influence attitudes toward statistics among prospective teachers. This research method uses the Attitudes towards Statistics Survey (SATS-36) survey which was completed by 355 prospective teachers from 7 TTCs who were randomly selected. Data was collected through an online survey and analyzed using an independent T-test to compare the attitudes of prospective teachers based on gender. The results show that prospective teachers have a positive attitude towards statistics and gender has a significant influence on attitudes towards statistics. A significant difference was found in attitudes towards statistics between male and female teacher candidates, with men tending to have more positive attitudes. The conclusion is that gender plays an important role in shaping prospective teachers' attitudes towards statistics. The implication is that special attention is needed to pay attention to gender factors in developing mathematics education curricula to increase interest and understanding of statistics among prospective teachers.

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A. INTRODUCTION

The way students learn in the classroom has an impact on how much influence the teacher has in imparting knowledge and how much students learn (Suhaini, 2020). Students' attitudes towards lessons are one of the several factors that influence learning outcomes and achievement in mathematics lessons, especially statistics material (Nja et al., 2022). Sahin & Yilmaz (2020) conducted on the influence of students' attitudes towards subjects found that there was a correlation between students' attitudes and their academic achievements. Knowledge about students' attitudes towards subjects is very important because this information can help students, and teachers, and can be used to develop curricula to improve the teaching and learning process (Ahmed & Melad, 2022). A positive attitude provides students with a better understanding of the nature of learning, it also makes students more open to lessons which could increase their expectations in learning, and reduces students' anxiety levels in the learning process (Silvola et al., 2021).

Statistics is needed in almost all sciences, professional fields, and educational fields. By knowing statistics, students can use statistics in many fields, including information technology,

engineering, science, and mathematics, using statistical knowledge as a structural method (Madaki, 2021). Many countries, one of which is Indonesia, have included statistics from the elementary school curriculum to the university level. However, in fact, many students, especially in countries such as Sub-Saharan Africa (SSA), find statistics a difficult subject (Bethell, 2016). The reasons put forward by researchers include non-cognitive factors such as attitudes, perceptions, interests, hopes, and motivation (Dhlamini et al., 2019). Cognitive factors such as mathematical background also greatly influence students' ability to understand basic statistical concepts because many statistical concepts are abstract in nature, which often leads to the development of misconceptions in understanding and reasoning about statistics (Lin et al., 2016). The lack of a positive attitude toward statistics has resulted in reduced and even lost student interest in statistics subjects in most African countries including Rwanda (Oluoch et al., 2020). A study conducted on student performance in statistics in Rwanda showed poor performance in the subject (Dushimimana & Uworwabayeho, 2020). These studies recommend that statistics should be taught in an active atmosphere where students investigate, collect, and analyze data to provide answers to statistical questions. Sáez-López et al. (2020) emphasized that increasing students' enthusiasm for learning can be achieved through various elements, including the care of teachers who teach students.

Alalwan et al. (2020) on effective statistics learning that students' negative attitudes towards the subject, teaching methods, and numerical complexity are some of the factors that cause statistics to be a difficult subject for students. Some students have difficulty understanding statistical concepts due to a lack of adequate statistical reasoning (Legesse et al., 2020; Ahn et al., 2020). One aspect of students' proficiency in statistical reasoning is that they must also apply their knowledge to practical issues in real-world experiences (Berndt et al., 2021). In knowledge and reasoning abilities as a statistics educator, you must be able to demonstrate problem solving (Hämäläinen et al., 2019).

Male & Lumbantoruan (2021) emphasize statistical knowledge as a valuable skill for future prospects. Several studies Uttl et al. (2017; Male & Lumbantoruan (2021); Uttl et al. (2017); Patricia Aguilera-Hermida (2020) students' attitudes towards statistics are related to the development of statistical thinking skills. Lack of motivation and interest in statistics subjects has an impact on academic achievement and decreased understanding of the context (Estrada & Batanero, 2019; X. Huang et al., 2020). Improving students' attitudes toward statistics through educational interventions can help them gain confidence in their ability to use statistics to solve problems outside the classroom (Groth & Meletiou-Mavrotheris, 2018). Students' attitudes toward statistics may have a major impact on the development of statistical thinking skills that are useful for applying statistical knowledge. The SATS-36 method can be used in student-centered teaching and is one of the most effective ways to overcome the problem of low achievement in statistics classes (Filiz et al., 2020a; Wakhata et al., 2023). The integration of the SATS-36 method plays a major role in improving students' knowledge and attitudes (Cladera, 2021).

Gender differences in students' attitudes towards statistics, with women generally showing lower interest and more negative attitudes towards statistics than men (Gao et al., 2020; Kucuk & Sisman, 2020). Yu & Deng (2022) found that female students in a statistics course reported significantly lower levels of motivation and self-efficacy in statistics learning than male

students. Similarly, a study by Keng (2020) found that female students in a psychology statistics course reported more negative attitudes towards statistics than male students. There are several factors that can contribute to female students' negative attitudes towards statistics. One of the most commonly cited factors is stereotype threat (Barber, 2020). Stereotype threat occurs when individuals are aware of negative stereotypes associated with their group and feel pressure to conform to those stereotypes. In the case of female students in statistics, they may be aware of the stereotype that women are not as good at math or quantitative subjects as men, which can create anxiety and decrease their motivation to learn statistics.

Huh (2020) female students are more likely to see statistics as relevant to the fields of business and social sciences, while male students are more likely to see statistics as relevant to the fields of natural sciences and engineering. The perception of statistics as less relevant to their interests and future careers can also cause decreased motivation to learn and negative attitudes toward statistics. Despite extensive studies of attitudes toward statistics, the domain of attitudes remains poorly understood, and some of the areas may have evolved over time as a result of improvements in the way courses are delivered.

In addition, students' attitudes towards statistics were conducted at the university level, and only a few focused on prospective elementary school teachers. Guillen-Gamez et al. (2020) that prospective elementary school teachers have a moderate attitude towards statistics, when comparing the attitudes of prospective elementary school teachers about statistics Chang et al. (2020) found out that both groups have moderate or positive attitudes. In-service teachers better understand the importance of statistics in everyday life, while prospective teachers tend to think about using statistics in their lessons and find them more interesting and easier to learn. Tatto et al. (2020) Conceptual knowledge and attitudes towards statistics for prospective secondary school mathematics teachers are aware that statistics requires discipline and is not something that can be learned quickly by everyone. In exploring the attitudes of prospective elementary school teachers toward statistics. They attributed this positive attitude to various reasons including class size, the level of statistical concepts covered, the use of hands-on experiments when teaching and learning, and the discipline exercised by students with the SATS-36 method (Cladera, 2021).

To ensure all students' knowledge, attitudes, abilities and values need to review the curriculum to ensure it is aligned with National goals. The transition from a Knowledge-Based Curriculum to a Competency-Based Curriculum, as well as the reactivation of the mission assigned to pre-service teacher training institutions to produce quality teachers, is a major change in the education system. Pre-service primary school teachers are trained at Teacher Training Colleges (TTC) with the ultimate goal of transforming the country from an agriculture-based economy to a knowledge-based economy. With the new curriculum, new content is introduced. Interestingly, the concepts of statistics and probability which were previously taught at the advanced level are now being introduced to basic education within the framework of the Competency Curriculum. Since teacher training colleges are mandated to train reserve teachers for the primary school level, it is important to check the extent to which the prospective teachers understand the new subjects introduced at the primary school level. The mathematics syllabus at all levels of basic education is made up of units, and from elementary school, there are four statistical units at each level of learning (Lu, 2023). This means that this

is not the first time these students have studied statistics. However, many prospective teachers are still found to have low statistical scores on the final exam which is held at the end of their professional training (S. Y. Huang et al., 2020).

The gender gap in attitudes toward statistics among prospective mathematics teachers is a pressing issue in mathematics education. This research provides an in-depth understanding of differences in attitudes towards statistics based on gender, which can provide valuable insights for the development of more inclusive curricula and learning strategies. The urgency of this research lies in the importance of understanding the factors that influence attitudes toward statistics among prospective teachers because a positive attitude toward the subject can improve the quality of mathematics teaching and learning. By highlighting gender gaps in attitudes toward statistics, educators can design more effective training programs to increase prospective mathematics teachers' interest and motivation to learn, especially in the field of statistics. With a better understanding of the factors that influence attitudes toward statistics, educational institutions can develop more targeted strategies to address the uncertainty and anxiety that female teacher candidates may feel. So this research aims to explore differences in attitudes towards statistics among prospective teachers based on gender and to identify factors that influence these attitudes. The main research questions include how attitudes toward statistics differ between male and female teacher candidates, as well as what factors can influence attitudes toward statistics among teacher candidates.

B. METHODS

Statistics Education in Rwanda. In 2015 the Knowledge-Based Curriculum (KBC) education system was replaced with the Competency-Based Curriculum (CBC) to align it with national goals and ensure that students' knowledge, abilities, attitudes, and values are in line with 21st-century requirements (Udin Supriadi, Tedi Supriyadi, Aam Abdussalam, 2020). With these reforms, new content was added to the mathematics curriculum for elementary and secondary levels. The concepts of statistics and probability, which were previously taught at advanced levels, are now taught starting in primary education (Batanero & Álvarez-Arroyo, 2023). At CBC Baru, teaching and learning statistics emphasizes the integration of ICT and the use of real data. However, research conducted on student performance in statistics found that pre-service teachers performed poorly in the subject (Valtonen et al., 2021). However, there is one statistical unit at each level of education starting from elementary school in the new KBK. It was also found that sixth-grade mathematics teachers demonstrated lower levels of statistical content knowledge (Yi et al., 2020)(Backfisch et al., 2020). Since students' attitudes have been identified as one of the factors influencing their performance, this paper examines pre-service teachers' attitudes toward statistics.

Participants and Data Collection. The study took place during the 2022-2023 school year, and 355 preservice teachers from 7 randomly selected TTCs participated in the study. Participants were from the first-year equivalent to four seniors in the current 6-3-3-4 system (Elementary School, Middle School, High School, and University Bachelor's degrees). The TTC is part of the advanced level which specializes in primary/primary school teacher training and there are currently 16 TTCs located throughout the country. This research uses the Attitudes Towards Statistics Survey (SATS-36) developed by (Filiz et al., 2020a). In the SATS-36 items

are grouped into six factors that assess student attitudes including components of affect, cognitive ability, value, difficulty, interest, and effort. This scale uses a 7-point Likert scale, with 1 being strongly disagree and 7 being strongly agree. Before preparing the instrument, small changes were made where the word module was changed to unit and in some items, the terms tense and difficult were changed to help pre-service teachers understand the questions because English is not their mother tongue. In addition, item 27 "I will attend every statistics class session" was deleted because attendance is mandatory for all prospective teachers. The survey was designed in Google form with links prepared by research and completed by students in the presence of their tutors first to ensure each participant had submitted data. The data was interpreted using Mahmud's (2010) interpretation of student attitudes toward statistics courses, with positive scores ranging from 4.50 to 7.00, neutral scores ranging from 3.50 to 4.49, and negative scores ranging from 0.00 to 3.49. An independent samples T-test was used to test whether there were statistically significant differences in attitudes of teacher candidates between genders.

Statistical Analysis. This study adopted the SATS-36 Filiz et al. (2020b), to investigate the attitudes of pre-service primary school mathematics teachers toward statistics. Cronbach's alpha and confirmatory factor analysis were used to test reliability and validity. Preliminary confirmatory factor analysis (CFA), Cronbach's alpha and confirmatory factor analysis were used to test reliability and validity. Because the model fit for confirmatory factor analysis failed to produce a good fit for Shau's SATS-36, an exploratory factor analysis was conducted to find a new model. Exploratory factor analysis (EFA), the Vermax rotation method Wakhata et al. (2023) was used for better interpretation of factors. This study conducted CFA for SATS-36, then the research turned to EFA. New confirmatory factor analysis (CFA), Cronbach's alpha and confirmatory factor analysis were reused to test the new reliability and validity. Because the model is suitable for confirmatory factor analysis in producing a good fit for SATS-36 Shau.

According to Kline (2009), three measures of model fit are used to evaluate the model. Relative Fit Index: Bantler-Bonett Non-normed Fit Index (NNFI). Absolute Fit Indices: Root Mean Square Error Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), Goodness of Fit Index (GFI) and Comparative Fit Index (CFI). Chi-Square was not used because the sample size was large and it is very rare to obtain a chi-square that is not significant for a large sample (Uğurlu et al., 2020). Literature Dash & Paul (2021) shows that the NNFI value is greater than 0.95, RMSEA is less than 0.06, SRMR is less than 0.08, GFI is greater than 0.90, and CFI is greater than 0.95 indicates acceptable model fit. Principal components and principal axis factoring are used. Pre-service teachers' attitudes were analyzed using SPSS version 21 and CFA was analyzed using SPSS AMOS 21.

C. RESULT AND DISCUSSION

This study investigated the attitudes of pre-service primary school mathematics teachers towards statistics using the SATS-36 Schau. CFA and all model fit measures used to evaluate model fit for the SATS-36 indicated that the data produced a good model. However, EFA needs to be carried out to produce a new model that is better and eliminates doubts. Table 1 shows the Goodness of Fit Index for the SATS-36 Schau and the new 25-item model with four factors.

Table 1. Fit Indices for SATS-36 Schau and new models

Fit Index Measures	SATS-36 (Six factors)	New model (Four Factors)
Bantler-Bonett NFFI	0.79	0.92
RMSEA	0.085	0.058
SRMR	0. 127	0.073
GFI	0.72	0.91
CFI	0.81	0.95

The results of this table show that none of the fit indices for SATS-36 yield an acceptable fit while for the new model only one fit index (Bantler-Bonett NFFI) produced a value which is slightly small to the cutoff value. We can also observe that the fit indices for the new model with four factor show a significant improvement compared to the six-factor model. The new model includes four attitudes' components named competence, values, difficulty, and interest. The items for the two other components affect and effort components were either removed or moved to other components. Table 2 the factor structure and factor loadings for the new model, the reliability and convergent validity. The overall Cronbach's Alpha for the new model is 0.906.

Table 2. Factor structure, factor loadings and Cronbach's Alpha

Factor	Item	Factor Loading	Cronbach's Alpha
Competence	I like statistics (affect).	.821	.914
	I use statistics in my everyday life (values).	.767	
	Statistics should be a required part of my professional Training (values).	.756	
	Statistics conclusions are rarely presented in everyday Life.	.758	
	I can learn statistics (values).	.724	
	I will understand statistics equations.	.707	
	Most people have to learn a new way of thinking to do statistics (difficulty)	.702	
	I plan to complete all of my statistics assignments (Effort)	.682	
	I plan to study hard for every statistics test (Effort)	.598	
Values	Statistics is worthy	.852	.907
	Statistics is useful to my typical professional	.811	
	Statistical thinking is applicable in my life outside my job	.791	
	I will have applications for statistics in my profession	.753	
	Statistics is relevant in my life	.746	
Difficulty	I will make a lot of math errors in statistics (Cognitive).	.822	.816
	I will find it difficult to understand statistical concepts (Cognitive).	.806	
	Statistics involves massive computations.	.728	
	Statistics is not a complicated subject	.706	
	Statistics formulas are easy to understand	.691	
Interest	I am interested in being able to communicate Statistical information to others.	.812	.878
	I am interested in using statistics	.807	

Factor	Item	Factor Loading	Cronbach's Alpha
	I am interested in understanding statistical information	.779	
	I am interested in learning statistics	.723	
	Statistical skills will make me more employable (Value)	.712	
	I will enjoy taking statistics courses (affect)	.692	

The term in the brackets indicates the components where the item belongs in Schau's model. The items that were excluded include:

1. I feel not intimidated when I have to do statistics problems (item 4).
2. I will get frustrated going over statistics tests in class (item 15).
3. I will be under stress during statistics class (item 18).
4. I will enjoy taking statistics courses (item 19).
5. I am scared by statistics (item 28).
6. I will have trouble understanding statistics because of how I think (item 5).
7. I will have no idea of what's going on in this statistics course (item 11).
8. Statistics is a subject quickly learned by most people (item 22).
9. Learning statistics requires a great deal of discipline (item 24).
10. Statistics is highly technical (item 34).
11. I plan to attend every statistics class session (item 27).

From the new model with four components, students' attitudes toward statistics were examined and the results are presented in Table 3.

Table 3. Pre-service teachers' attitudes according to the factors of the new model

Components	Gender	N	Mean	Std. Deviation	Std. Error	t	df	Independent T- test	Effect Size
Overall	Female	118	5.82	.7817	.07197				
	Male	182	5.45	1.221	.09051				
Competence	Overall	304	5.92	1.113	.06383				
	Female	118	6.17	.699	.06438	3.438	289.611	.001	.012
	Male	182	5.77	1.297	.09616				
Values	Overall	304	5.49	1.634	.09371				
	Female	118	5.82	1.324	.12195	2.971	292.722	.003	.010
	Male	182	5.29	1.789	.13261				
Difficulty	Overall	304	5.90	1.153	.06612				
	Female	118	6.13	.807	.07437	2.978	297.230	.003	.010
	Male	182	5.76	1.315	.09751				
Interest	Overall	304	4.85	1.299	.07450				
	Female	118	4.98	1.220	.11240	1.426	267.176	.115	.005
	Male	182	4.77	1.348	.09994				

From Table 3, we can see that pre-service teachers have positive attitudes in all components of the new model with difficulty having the least positive while in other components, pre-service teachers' attitudes is relatively the same. The positive attitudes for

these prospective teachers can be attributed to the fact that they have been learning statistics before. The independent sample t-test was used to evaluate if there is difference in attitudes among gender. The results indicate that there is a statistically significant difference in pre-service teachers' attitudes between females and male for competence, values and interest components. For the difficulty component, there is no statistically significance difference in attitudes between genders. However, female have slightly higher positive attitudes compared to men in all components.

It was found in research that prospective teachers generally have positive attitudes toward statistics, with men tending to have more positive attitudes than women. In the educational context, it is important to understand how gender can influence attitudes toward statistics among prospective teachers. This research provides valuable insight into how factors such as gender can influence perceptions and attitudes towards certain subjects, such as statistics. This can help in the development of teacher education programs that are more inclusive and supportive for all prospective teachers, regardless of gender. In addition, this research also highlights the importance of curriculum revisions that integrate real-world applications of statistics and interactive teaching methods. By demonstrating the relevance and appeal of statistics education through a more interactive and applicable approach, teacher education programs can create a culture of appreciation and enthusiasm for statistics among prospective teachers. This research examines the attitudes of prospective elementary school teachers toward statistics using the attitude survey instrument towards statistics (SATS-36) adapted from Schlau. Since the model was designed for undergraduate students, this study first investigated the validity and reliability of the model using EFA in the Rwandan context for prospective primary school mathematics teachers. A modified model was obtained with 25 items grouped into four factors. CFA validated the modified four-factor model and the model fit index thresholds indicated that the model could be considered acceptable. The four-factor model was obtained by many researchers Sebastien, (2020); Bardach and Klassen, (2020); Rodríguez-Hernández et al., (2020) who adapted the SATS to their respective areas, although some items may come from different components and components such as understanding attitudes, different knowledge and grasping power. The attitudes of prospective teachers were analyzed using a modified four-factor model. The results indicated that preservice teachers expressed positive attitudes toward statistics for all four factors of the new model. The results of this study are in line with other studies that found positive attitudes toward tolerance (García-Castro et al., 2020; Sokal et al., 2020). Gender effects were also tested and the results showed differences between boys and girls and girls on the four components. In contrast to other research Hommik & Luik, (2017) which shows that female students tend to have slightly smaller attitudes compared to boys, this research finds that female students have slightly positive attitudes towards all matter, four components of the modified model.

The implication of this research is a better understanding of how gender disparities may influence attitudes toward statistics among prospective teachers. By recognizing these differences in attitudes, more inclusive and supportive learning approaches can be developed to ensure that all prospective teachers feel comfortable and motivated in studying statistics. In addition, this research also provides insight into the factors that influence attitudes toward statistics, which can serve as a basis for designing more effective training programs for

prospective teachers. However, this research also has limitations. One is the focus on teacher candidates from 7 specific TTCs, which may limit the generalizability of the findings to the teacher-candidate population as a whole. Additionally, the use of questionnaires as a data collection tool may not be able to capture the nuances and deeper context of attitudes toward statistics. Furthermore, this research does not explore cultural or social factors that may also influence attitudes toward statistics among prospective teachers. Therefore, further research involving more representative samples and using a qualitative approach could provide a more comprehensive understanding of the factors that influence attitudes toward statistics among prospective teachers.

D. CONCLUSION AND SUGGESTIONS

The study of gender disparities in prospective teachers' attitudes toward statistics in mathematics education shows that there are significant differences between male and female prospective teachers. Men showed slightly more positive attitudes toward statistics than women across various components. This highlights the importance of considering gender as an important factor in shaping attitudes toward statistics among prospective teachers. These findings emphasize the need for targeted interventions and strategies to address differences in attitudes toward statistics in gender-based teacher education programs. Based on the research results, several suggestions can be given to improve the attitudes of prospective teachers towards statistics in mathematics education. First, teacher education programs must adopt a gender-sensitive approach to address the gap in attitudes toward statistics. Providing additional support and resources tailored to the specific needs of male and female teacher candidates can help increase their engagement and interest in statistics. Additionally, professional development opportunities focused on increasing positive attitudes toward statistics should be offered to prospective teachers. These programs can take the form of workshops, seminars, and training sessions aimed at building confidence and competency in statistical concepts. Additionally, mentorship programs that pair pre-service teachers with experienced educators can provide valuable guidance and support in developing positive attitudes toward statistics. Additionally, curriculum revisions that integrate real-world applications of statistics and interactive teaching methods could increase the relevance and appeal of statistics education for prospective teachers. By making statistics more accessible and engaging, teacher education programs can foster a culture of appreciation and enthusiasm for statistics among prospective teachers.

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