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Research articles

Prospective primary mathematics teachers' attitude towards statistics

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Abstrak Penelitian ini bertujuan menilai sikap calon guru matematika sekolah dasar terhadap statistika dan bagaimana sikap tersebut dipengaruhi oleh jenis kelamin. Penelitian ini mengadopsi Survei Sikap terhadap Statistik (SATS-36) dan melibatkan 455 calon guru dari 9 Lembaga Pendidik Tenaga Kependidikan. Analisis faktor eksploratori (EFA) dilakukan karena model yang cocok untuk analisis faktor konfirmatori (CFA) gagal menghasilkan indeks yang baik untuk reliabilitas dan validitas. Model yang telah divalidasi hanya memuat 27 item dalam empat faktor untuk menilai sikap yang meliputi kompetensi, nilai, kesulitan, dan minat. Sikap calon guru terhadap statistik dan dampak gender kemudian dievaluasi menggunakan model empat faktor yang dimodifikasi. Hasil penelitian menunjukkan bahwa calon guru mempunyai sikap positif terhadap statistik. Secara spesifik, calon guru perempuan lebih mempunyai sikap positif terhadap statistik daripada calon guru laki-laki.

Kata kunci *Sikap, Statistik, Calon guru, Jenis kelamin*

Abstract This study aimed to assess attitudes of prospective primary mathematics teachers (PPTs) toward statistics and how these attitudes are influenced by gender. It adopted Attitudes Towards Statistics Survey (SATS-36) and involved 455 PPTs from 9 Teachers Training Institutions (TTI). Exploratory factor analysis (EFA) was performed because the model fit for confirmatory factor analysis (CFA) failed to yield good indices of reliability and validity. The validated model only contains 27 items in four factors that assess attitudes including competence, values, difficulties, and interests. The prospective teachers' attitudes toward statistics and the impact of gender were then evaluated using a modified four-factor model. The finding shows that PPTs have a positive attitude toward statistics. In specific, the female participants tend to have a more positive attitude toward statistics than the male.

Keywords *Attitudes, Statistics, Prospective teachers, Gender*

Introduction

The learning outcomes obtained by students cannot be separated from the way a teacher designs and how the teacher implements the material (Ribosa & Duran, 2022). Students' attitudes towards learning are one of the factors that cause high interest in learning in mathematics, especially in statistics lessons (Ting et al., 2023). Sahin and Yilmaz (2020) argue that the focus

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was on the influence of student attitudes towards school subjects and found a correlation between student attitudes and student learning outcomes. In increasing student interest, attitudes towards subjects are very important because it can help teachers improve the teaching and learning process (Guo et al., 2020). 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).

Almost all science requires statistics. By understanding statistics lessons, students can understand other sciences such as information technology, engineering, science, mathematics, and use statistics to predict problem solutions (Madaki, 2021). In education, statistics lessons have been included from the elementary school curriculum level to the higher education level. However, there are still many students whose learning outcomes and interest in learning are low in statistics lessons (Legaki et al., 2020). The reasons put forward by researchers include non-cognitive factors such as attitudes, perceptions, interests, hopes, and motivation (Kreft et al., 2021). In mathematics lessons such as statistics, cognitive factors influence students' ability to understand basic statistical concepts. The basic concepts of statistics are too abstract and often give rise to misconceptions in understanding (Meier et al., 2022). The lack of a positive attitude towards statistics has resulted in reduced and even lost student interest in statistics in most African countries including Rwanda (Oluoch et al., 2020). A study conducted on student performance in statistics showed poor performance in the subject (Dushimimana & Uworwabayeho, 2020). Sáez-López et al. (2020) emphasize that increasing students' enthusiasm for learning can be achieved through various elements, including the care of teachers who teach students.

In order to improve students' attitudes and knowledge in statistics lessons, it is necessary to review the curriculum so that it is in line with the goals of education in Indonesia. The transition from a Knowledge-based Curriculum to a Competency-based Curriculum, as well as the reactivation of the mission assigned to prospective teacher training institutions to produce quality teachers, is a major change in the education system in Indonesia. Prospective primary school teachers are trained at Teachers Training Institutions (TTI) with the ultimate goal of preparing them to be qualified teachers. With the curriculum, new content is introduced including statistics. 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 curriculum. In fact, prior research indicated that many prospective teachers have low statistical scores on exams held by higher education (Huang et al., 2020). This research aimed to examine the attitudes of prospective teachers towards statistics based on gender.

Prior studies

Alalwan et al. (2020) posit that students' negative attitudes towards statistics, teaching methods, and numerical complexity are some of the factors that cause the subject to be difficult for students. Some students have difficulty understanding statistical concepts because prospective teachers' reasoning is inadequate regarding statistics (Legesse et al., 2020; Ahn et al., 2020). One aspect of proficiency in statistical reasoning is that students must also apply their knowledge to practical problems in the field and the real world (Berndt et al., 2021).

Male and Lumbantoruan (2021) argue that statistical knowledge as a valuable skill for future prospects. Several studies (Uttl et al., 2017; Patricia Aguilera-Hermida, 2020) indicated students'

attitudes towards statistics related to the development of statistical thinking skills. Lack of motivation and interest in statistics has an impact on academic achievement and decreased understanding of the context (Estrada & Batanero, 2019; 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.

Gender differences in students' attitudes towards statistics have been inquired, with women generally showing lower interest and more negative attitudes towards statistics than men (Gao et al., 2020; Kucuk & Sisman, 2020). Yu and 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. Furthermore, Huh (2020) indicated that female students see statistics more relevant to the fields of business and social sciences, while male students see statistics more relevant to the fields of natural sciences and engineering. Perceptions of statistics that are less relevant to interests and careers can lead to decreased motivation to learn and negative attitudes towards statistics.

Many studies have examined attitudes towards statistics as mentioned above. They were conducted at the university level but only a few focused on prospective elementary school teachers. Guillen-Gamez et al. (2020) show that prospective elementary school teachers have a moderate attitude towards statistics. Similarly, when comparing the attitudes of prospective elementary school teachers about statistics, Chang et al. (2020) found that both groups have moderate or positive attitudes. The current study is expected to further shed light into PPTs' attitudes toward statistics based on gender.

Methods

This research survey took place from 2022 to 2023 academic year involving 455 PPTs from 9 Teachers Training Institutions (TTI) in Jakarta, Indonesia which specialize in primary school teacher training. Attitudes towards Statistics Survey (SATS-36), a Likert scale developed by Schau et al. (1995) and further used by Filiz et al. (2020), was adapted for data collection. The SATS-36 is grouped into six factors in assessing student attitudes: affect, cognitive, values, difficulties, interests, and efforts. The scale ranges from 7 (strongly agree) to 1 (strongly disagree). The instrument was slightly changed where the word module was changed to units in several items, the terms tense and difficult were changed to help prospective teachers understand the questions because their mother tongue was Indonesian and not English. The survey was designed in a Google form with a link prepared and filled in by participants in the presence of an expert beforehand to ensure each participant had submitted their assessment. Data was interpreted using Frederick et al. (2020) interpretation of prospective teachers' attitudes towards

statistics with a positive score between 4.50 to 7.00, a neutral score between 3.50 to 4.49, and a negative score between 0.00. to 3.49. Independent samples T test was applied to examine whether there is a statistically significant difference in the gender attitudes of prospective teachers.

To determine the PPTs' attitudes towards statistics, Cronbach's alpha and confirmatory factor analysis were used to test reliability and validity following the procedures below.

- Preliminary confirmatory factor analysis (CFA)
  Cronbach's alpha and confirmatory factors aim to test the reliability and validity of the instrument. The model fit in confirmatory factor analysis yielded a good fit for Schau's SATS-36 and exploratory factors were conducted to find a new model.
- Exploratory factor analysis (EFA)
  The Verma 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)
  According to Mai et al. (2021), there are three measures of model fit used to evaluate the model. The Relative Fit Index is the Bandler-Bonett Non-norm Fit Index (NNFI). Absolute Fit Indexes are 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 of the large sample size and it is very rare to obtain a chi-square that is not significant for a large sample (Uğurlu et al., 2020). Dash and Paul (2021) maintain that if 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, then the model fit is acceptable. SPSS version 21 and SPSS AMOS 21 were used to analyze the PPTs' attitudes and CFA data.

Findings

Data analysis indicated that the data produced a good model. EFA was carried out to produce a new model. Table 1 shows the Goodness of Fit Index for the SATS-36 Schau and the new 27-item model with four factors.

Table 1. Fit indices for Schau's SATS-36 and new models

Fit Index Measures	SATS-36 (Six factors)	New model (Four Factors)
Bandler-Bonett NFFI	0.79	0.89
RMSEA	0.085	0.058
SRMR	0.136	0.083
GFI	0.72	0.89
CFI	0.79	0.95

The results from table 1 show that none of the fit indices for SATS-36 is acceptable, while for the new model only one fit index (Bandler-Bonett NFFI) produces a value slightly smaller than the limit value. The fit indices of the new model with four factors show significant improvement compared to the six-factor model. This new model includes four attitudinal components, namely competence, value, difficulty, and interest. Items for the other two

components of influence and effort were omitted. The following tables (Table 2, Table 3, Table 4, Table 5) illustrates factor structure for the new model, reliability, and convergent validity. The overall Cronbach's alpha for the new model was 0.915.

Table 2. Competence items, factor loadings, and Cronbach's Alpha

Factor	Item	Factor loading	Cronbach's Alpha
Competence	I like statistics (affect)	0.821	0.915
	I use statistics in everyday life (values).	0.767	
	Statistics should be a mandatory part of my professionalism In Training (grade).	0.755	
		0.757	
	Statistical conclusions are rarely presented in everyday life.	0.728	
	I can study statistics well and correctly (values).	0.737	
	I will understand statistical equations properly and correctly.	0.722	

Table 3. Values items, factor loadings and Cronbach's Alpha

Factor	Item	Factor loading	Cronbach's Alpha
Values	I plan to complete all the statistics assignments	0.589	0.943
	I plan to study hard for every statistical test (Effort)	0.598	
	Statistics is worth studying well	0.878	
	Statistics are useful for my professional	0.877	
	Statistical concepts can be applied in my daily life	0.876	
	I will have applications of statistics in my profession	0.753	
	Relevant statistics in my life	0.746	

Table 4. Difficulty items, factor loading and Cronbach's Alpha

Factor	Item	Factor loading	Cronbach's Alpha
Difficulty	I make a lot of math mistakes in statistics	0.792	0.826
	(Cognitive).	0.826	
	I will have difficulty understanding statistical concepts	0.728	
	(Cognitive).	0.806	
	Statistics involves massive calculations.	0.791	
	Statistics is not a complicated subject	0.723	

Table 5. Interest items, factor loading and Cronbach's Alpha

Factor	Item	Factor loading	Cronbach's Alpha
Interest	I'm interested in being able to communicate	0.912	0.912
	Statistical information to others around me.	0.813	
	I am interested in using statistics to solve problems	0.778	
	I am interested in understanding statistics	0.723	
	information	0.712	
	I am interested in studying statistics	0.767	

The term in the brackets indicates the components where the item belongs in the Schau's model. The excluded items were as follows.

- I feel not intimidated when I have to do statistics problems (item 3)
- I will get frustrated going over statistics tests in class (item 15)
- I will be under stress during statistics class (item 18)
- I will enjoy taking statistics courses (item 19)
- I am scared by statistics (item 28)
- I will have trouble understanding statistics because of how I think (item 7)
- I will have no idea of what's going on in this statistics course (item 12)
- Statistics is a subject quickly learned by most people (item 23)
- Learning statistics requires a great deal of discipline (item 24).
- Statistics is highly technical (item 34)
- I plan to attend every statistics class session (item 27)

From the new model with four components, PPTs' attitudes towards statistics were examined and the results are presented in Table 6.

Table 6. Prospective 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	128	5.93	0.8717	0.07197				
	Male	128	5.67	1.221	0.09051				
	Overall	327	5.92	1.113	0.06383				
Competence	Female	128	6.28	0.689	0.07938	3.438	289.611	0.001	0.013
	Male	128	5.77	1.297	0.09616				
	Overall	327	5.49	1.634	0.09371				
Values	Female	128	5.82	1.324	0.12195	2.971	292.722	0.003	0.010
	Male	128	5.29	1.789	0.13261				
	Overall	327	5.90	1.153	0.06612				
Difficulty	Female	128	6.13	0.807	0.08637	2.978	297.230	0.003	0.010
	Male	128	5.76	1.315	0.06751				
	Overall	327	4.86	1.299	0.07450				
Interest	Female	128	4.98	1.220	0.11240	1.536	356.176	0.216	0.235
	Male	128	4.88	1.348	0.09994				

Based on Table 6, PPTs have a positive attitude towards all components of the new model with the lowest level of difficulty, while for other components of the attitudes are relatively the same. The PPTs' positive attitudes might not be separated from the fact that they have studied statistics before. An independent samples t-test was used to evaluate whether there were differences in attitudes between genders. The result shows that there are statistically significant differences in the attitudes between women and men in the components of competence, values and interests. For the level of difficulty component, there is no statistically significant difference

in attitudes between genders. However, women have a higher positive attitude than male teacher candidates in all components.

Discussion and conclusion

This research found that the PPTs' positive attitudes towards statistics using adapted Schau's SATS-36. It first investigated the validity and reliability of the model involving PPTs in Jakarta, Indonesia. A modified model was obtained with 27 items grouped into four factors. A CFA validated the modified four-factor model and the model fit index thresholds indicated that the model was considered acceptable as a measurement tool. The four factor model was obtained and developed by many researchers such as Sebastien (2020); Bardach and Klassen (2020); Rodríguez-Hernández et al., (2020) who adapted SATS to their respective fields, although some items may come from different components such as understanding, attitudes, differences in knowledge and comprehension skills.

The first finding in this study showed that none of the fit indices in the SATS-36 produced an acceptable fit and for the new model only one fit index produced a value and it was slightly smaller than the specified cutoff value. This new model includes four components: competence, value, difficulty, and interest. Items for the other two components of influence and effort were removed and the overall Cronbach's Alpha for this new model was 0.943. Prospective teachers have a positive attitude towards all components of the new model with the lowest level of difficulty. They have a positive attitude and in other components, the attitudes of prospective teachers are relatively the same. The positive attitude of the teacher's point of view can be attributed to the fact that the teacher had studied statistics long before. In this evaluation, it was also found that there were statistically significant differences in the components of competence, values, and interests in the attitudes of female and male teacher candidates. For the level of difficulty component, there is no statistically significant difference in attitudes between genders. However, women had slightly higher positive attitudes than men in all components. These findings are in line with previous research (Saloviita & Pakarinen, 2021; Kucuk & Sisman, 2020). The attitudes of prospective teachers were analysed using a modified four-factor model namely competence, values, difficulties, and interests and it was found that prospective teachers expressed positive attitudes towards statistics for the four factors of this new model. The results of this study are in line with other research which found positive attitudes (García-Castro et al., 2020; Sokal et al., 2020). The impact of gender was also tested and the results showed differences in understanding between boys and girls on the four components. This finding is different from other research (Espinoza & Taut, 2020; Martynenko et al., 2023) which shows that male students tend to have slightly better attitudes than female students. This study reports that female students have a slightly positive attitude towards statistics with the four components of the modified model.

In general, this study implies that prospective teachers' attitudes toward math subjects, statistics, specifically, need to be shared attention amongst educational planners and administrators. Prior studies (Uttl et al., 2017; Patricia Aguilera-Hermida, 2020) have indicated that attitudes affect students' achievement in learning. Future research could investigate factors that improve preservice teachers' attitudes by including qualitative data to learn more about the root causes of their attitudes toward the subject.

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