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The Effects of Gender, Study Major, and Year of Study on Prospective Teachers' Mathematical, Didactic, and Technological Knowledge

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Abstract

Teachers' mathematical, didactic, and technological knowledge has been a central issue for the last few decades. Therefore, this study investigates and compares prospective teachers' mathematical, didactic, and technological knowledge referring to gender, year of study, and academic major. This study used an online survey through online questionnaires. The population was prospective elementary and mathematics teachers from a public university in Riau province, Indonesia. The questionnaires were distributed via WhatsApp, and LMS integrated in courses in the University. There were 195 prospective teachers participated in this study. A non-parametric statistical analysis was used to compare teachers' knowledge based on gender, year of study, and academic major. The findings reveal that there were no significant differences of teachers' mathematical, didactic, and technological knowledge based on gender, year of study, and academic major. Therefore, mathematics learning at university has no impact on prospective teachers' self-evaluation of their knowledge.

Keywords: *academic major; gender; teachers' knowledge; year of study*

1. INTRODUCTION

Technological developments and advances require teachers to have qualified mathematical, didactic and technological skills in teaching mathematics. Unqualified knowledge of mathematics by teachers will have an impact on their didactic knowledge, specifically knowledge related to the ability to teach mathematics contents to students, including elementary school students (Putra, 2019a, 2019b; Putra et al., 2020). Therefore, teachers must recognize that the factors influencing practices of teaching are complex and that it is necessary to have sufficient didactic mathematical knowledge (Neto et al, 2020).

This shift in thinking has the potential to have repercussions for teacher education in an era of continual technological innovation. Therefore, the accurate measurement of teachers' knowledge, including mathematical, didactic, and technological knowledge, is imperative to teacher education. This sort of information is crucial because it helps with decision making and the skills required to select appropriate technology to assist content learning (Stoilescu, 2015). Similarly, this understanding can assist instructors in

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avoiding the use of improper technology to teach information that is restricted or hampered using that technology. Similarly, technological knowledge helps instructors better comprehend the affordances and restrictions of technology in the classroom. Teachers' technical expertise enables them to develop classes and activities that employ technology to aid in content learning. Technology is used to offer didactic activities that encourage learning, such as simulations, and to assist teachers in facilitating these activities (Young et al., 2012).

Concerning teachers' knowledge, Shulman (1987) argued that content and pedagogy are indistinguishable parts of the same body of knowledge. Content knowledge, especially mathematics, is a very important basis for a teacher to master. Therefore, this knowledge must also be well understood by prospective elementary school teachers. Many previous studies have shown that teacher candidates' mastery of mathematics content is still very limited, so they have difficulty in teaching it to students later when they become teachers (Depaepe et al., 2015; Putra, 2018, 2019b; Putra et al., 2020).

In addition to content knowledge, didactic knowledge is also very important to be mastered by prospective teachers. Didactic knowledge is related to the knowledge of prospective teachers or teachers in conveying mathematical content to students (Winsløw & Durand-Guerrier, 2007). Teachers who master the content well can easily determine the techniques or strategies in teaching the content to students. Meanwhile, limited knowledge of mathematical content will cause teacher difficulties in finding the right way to convey the material (Putra, 2018). Meanwhile, integrating technology in learning mathematics is a challenge for teachers in teaching in schools. This is because in choosing technology, of course, there are many things that need to be considered, including the usefulness of the technology in supporting student learning and understanding of the material presented.

There are many issues needed to be address on investigating of prospective teachers' knowledge, and one of them is gender. Gender issues in mathematics education have gained academic attention in several nations over the last three decades, with the result that male success in mathematics is much higher than female accomplishment (Haroun et al., 2016). However, based on a large scale study (TIMSS results from 2011) on the investigation of gender differences in mathematics, and sciences conducted by Reilly et al. (2019) found that although there were no general worldwide gender disparities, females outperformed boys in mathematics and science proficiency across non-OECD countries. Boys are regarded to have more positive views about math and science than girls, who expressed lower self-efficacy beliefs (Reilly et al., 2019). Similarly, in other nations, the traditional gender inequalities in mathematics success are reversed, with females outperforming their male colleagues (Haroun et al., 2016).

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Because of the other characteristics, teachers' gender is often a strong predictor of student achievement (Haroun et al., 2016). The attitudes of male and female teachers regarding numbers and operations vary dramatically. Male teachers thought this issue was more essential than female teachers did. Second, gender disparities in student views regarding the difficulty of the selected topics have been widely noted. Finally, gender disparities in teacher perceptions mirror gender differences in student beliefs regarding the significance and difficulty of mathematical topics (Li, 2004). Female teachers, on the other hand, were found to be better communicators in the classroom and to have better teaching practices than their male counterparts (Rinehart & Young, 1996). In this study, the researchers focused on the comparison based on gender of the issues on mathematical, didactics, and technological knowledge.

Besides gender, year of study can be a factor affects prospective teachers' knowledge. A previous study conducted by Rahmadhani et al. (2021) have found that there is no a signifanctly difference between first and third year prospective elementary teachers' attitude toward the use of technology-based mathematics assessment. This means that the time used by prospective teachers to learn mathematics at the university does not change their attitude on how technology used in mathematics assessment.

The last issue is about an academic major of prospective teachers that can affect their mathematical, didactic, and technological knowledge. A previous study conducted by Depaepe et al. (2015) have shown that lower secondary teachers (trained as subject-specific classroom teachers) have a better mathematical knowledge regarding rational numbers than prospective elementary teachers (trained as general classroom teachers). However, there are no significantly differences towards their didactic knowledge of rational numbers.

In the present study, we are interested to investigate prospective teachers' perspective towards mathematical, didactic, and technological knowledge. We also compare that knowledge based on gender, year of study, and academic major. Through this study, we could provide an insight regarding an approach of improving teachers' knowledge in teacher education.

2. METHODOLOGY

Research Design

The present study was conducted through an online survey (Cohan et al., 2007). The researchers developed instruments to measure prospective teachers' self-evaluation towards their mathematical, didactic, and technological knowledge. There were fifteen items to measure prospective teachers' mathematical, didactic, and technological knowledge, in which each variable consists five items. Each item has five choice using Likert scale (1-5) from poor to outstanding.

The items of mathematical and didactic knowledge were established based on the standard body,

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curriculum, and educational assessment of the ministry of education, culture, research, and technology number 008/H/KR/2022 regarding learning outcomes in the independent curriculum. Mathematics contents in each basic education lesson are packaged through the study of numbers, algebra, measurement, geometry, data analysis and probability. Meanwhile, the items of technological knowledge was developed based on the previous study conducted by Fogarty et al. (2001) which is related to prospective teachers' knowledge of computers, computer general program, such as Ms. Office, computer applications in learning mathematics such as GeoGebra, learning management systems in learning mathematics, and designing mathematics learning activities using computer applications such as GeoGebra. We present the five items for measuring prospective teachers' technological knowledge on figure 1.

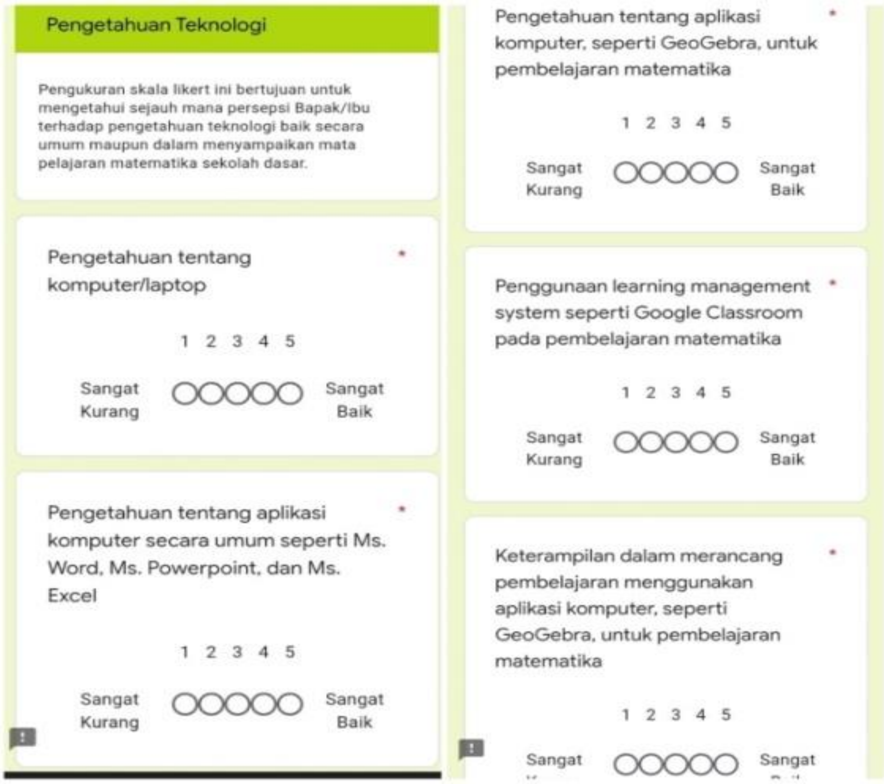

Figure 1. Questionnaires on technological knowledge

Sample and Data Collection

The participants of this study consisted of 195 prospective elementary teachers from elementary education study program and mathematics education study program from a public university in Riau province, Indonesia. Table 1 presents the background of participants. Most of the participants are female from elementary education study program and first year students.

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Table 1. The Background of Participant

Teachers background	**Demography Character**	**Number of Participant**	**Percentage**
Gender	Male	22	11.28%
	Female	173	88.72%
Study Major	Elementary Education	130	66.67%
	Mathematics Education	65	33.33%
Year of study	First Year	115	58.97%
	Third Year	80	41.03%

Data collection in the form of questionnaire was distributed using Google Forms during the even semester of 2021-2022 academic year. The participants were reached via Google Classroom from their participation in a course organizing by first author.

Analyzing of Data

The questionnaire data was statistically analyzed using the SPSS statistical software package, which included descriptive and inferential statistics. The analysis consisted of mean, standard deviation, range, minimum, and maximum. Table 1 presents the category for mathematical, didactic, and technological knowledge using the overall mean.

Table 2. Category For Mathematical, Didactic, and Technological Knowledge

Range	**Category**
Mean ≥ 4.2	Outstanding
3.4 ≥ Mean > 4.2	Very satisfactory
2.6 ≥ Mean > 3.4	Satisfactory
1.8 ≥ Mean > 2.6	Unsatisfactory
Mean < 1.8	Poor

The Mann-Whitney U test was utilized in the data statistical analysis. The Mann-Whitney U test is a non-parametric statistical tool. It is used to see if there are variations in the dependent variable between two independent groups. The Mann-Whitney U test is used when the values in a sample do not entirely match the normal or t-distribution. (Milenović, 2011). Furthermore, it gives a more adaptable test tool. Nonparametric tests differ from parametric tests in that the model structure is determined by the data rather than being provided beforehand. The word nonparametric does not indicate that such models are wholly devoid of parameters, but rather that the quantity and type of the parameters is adjustable and not predetermined. As a result, nonparametric tests are sometimes known as distribution free tests. The Mann-Whitney U test can be used to address the researchers' inquiries

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about the differences between his groups (Nachar, 2008). The following assumptions are made for the Mann-Whitney U test: (a) the two studied groups must be picked at random from the target population; and (b) each measurement or observation must belong to a separate participant. (c) The scale of data measurement is ordinal or continuous (Nachar, 2008).

3. RESULTS

Results of Descriptive Statistics

The descriptive statistical analysis is a statistical approach that provides an overview of the data acquired from the sample without requiring additional analysis to derive conclusions (Quraisy & Madya, 2021). In terms of the general mean, standard deviation, range, minimum, and maximum, the descriptive analysis generated frequencies pertaining to the respondents' gender, years of study, and major to their performance on the questionnaire. The questionnaire was completed by 195 people (n = 195).

The respondents' overall mean score on the questionnaire is M = 9.40 as shown in Table 3 below, which accounts for prospective teachers' mathematical, didactic, and technological knowledge who participated in this research. The descriptive statistics present gaps in the assessment knowledge base on the study sample for each individual standard (Table 3).

Table 3. Total questionnaire respondents and overall means

	N	Range	Minimum	Maximum	Mean	SD
Mathematics	195	3.20	1.60	4.80	3.587	0.632
Didactics	195	3.00	1.80	4.80	3.478	0.600
Technology	195	3.20	1.80	5.00	3.422	0.650

Overall, two knowledge (mathematics and technology) get a mean score of 3.20 (satisfactory category), and didactic knowledge has a little lower mean score of 3.00 (satisfactory category), but it is still in the same category. According to the study's findings, prospective teachers had adequate knowledge of those three variables.

Teachers' Knowledge from Gender Perspectives

The mean test scores, standard deviations, and Mann-Whitney U test results of prospective teachers' mathematical, didactic, and technological knowledge are shown in Table 4. Female prospective teachers' knowledge had a higher mean score (M = 3.51) than male prospective teachers' knowledge (3.33). The most notable difference is in technological knowledge (D = 0.27), but both groups had lower mean scores in technological knowledge than the others. When compared to other knowledge, prospective teachers' didactic knowledge has the biggest standard variation. Furthermore, male prospective teachers had a higher standard deviation than female teachers. However, there is no substantial difference in awareness of those factors between male and female teachers.

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Table 4. Mean test scores, standard deviations, and Mann-Whitney U test results of teachers' knowledge domains (n = 195, male = 22, female= 173)

	Gender				
	Male		**Female**		**Mann-Whitney U**
	Mean	**SD**	**Mean**	**SD**	**Asymp. Sig (2-tailed)**
Mathematics	3.45	0.78	3.60	0.61	0.475
Didactics	3.36	0.67	3.49	0.59	0.496
Technology	3.18	0.66	3.45	0.64	0.062

Teachers' Knowledge from Year of Study

Table 5 displays the mean test scores, standard deviations, and Mann-Whitney U test results for prospective teachers' mathematical, didactic, and technological knowledge by year of study. The mean scores for prospective teachers in their first year of study (M = 3.52) are higher than those in their third year of study (M = 3.46). When compared, each group has the lowest level of technological expertise (3.42). There is no evidence that the more learning experiences prospective teachers have, the better their knowledge perspectives. However, there is no discernible variation in prospective teachers' expertise based on their academic year.

Table 5. Mean test scores, standard deviations, and Mann-Whitney U test results of teachers' knowledge domains (n = 195, first year = 115, third year= 80)

	Year of Study				
	First Year		**Third Year**		**Mann-Whitney U**
	Mean	**SD**	**Mean**	**SD**	**Asymp. Sig (2-tailed)**
Mathematics	3.62	0.67	3.54	0.57	0.432
Didactics	3.50	0.63	3.44	0.55	0.436
Technology	3.44	0.64	3.40	0.67	0.795

Teachers' Knowledge from Study Major

Table 6 shows the mean test scores, standard deviations, and Mann-Whitney U test results for teachers' mathematical, didactic, and technological competence by study major. The mean score of prospective teachers' knowledge from elementary education (M = 3.43) is somewhat higher than that of mathematics education (M = 3.44). The disparity in didactic knowledge is substantial, yet prospective teachers from mathematics education have stronger didactic knowledge than elementary teachers. Prospective teachers in elementary education had larger standard deviation disparities than those in mathematics education. Furthermore, there is no statistically significant variation in prospective teachers' knowledge based on their study major.

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Table 6. Mean test scores, standard deviations, and Mann-Whitney U test results of teachers' knowledge domains (n = 195, elementary education = 130, mathematics education= 65)

	Study Major				Mann-Whitney U
	Elem Edu		Math Edu		
	Mean	SD	Mean	SD	Asymp. Sig (2-tailed)
Mathematics	3.53	0.64	3.40	0.60	0.166
Didactics	3.42	0.59	3.59	0.59	0.059
Technology	3.47	0.67	3.32	0.59	0.093

4. DISCUSSION

The purpose of this study is to analyze and compare potential teachers' mathematical, didactic, and technical expertise by gender, year of study, and major of study.

In terms of prospective teachers' mathematical, didactic, and technical skills, this study finds that female prospective teachers outperform male prospective teachers in all three domains. However, there is no substantial difference in expertise between male and female prospective teachers. This study supported the fact that female instructors estimate their knowledge to be greater than male teachers, which was supported by TIMSS data from 2011 (Reilly et al., 2019; Rinehart & Young, 1996).

The year of study of prospective instructors has little bearing on their mathematical, didactic, and technical expertise. However, prospective instructors with fewer years of study believe their expertise is superior to those with more years of study. This suggests that prospective teachers' attitudes regarding mathematical, didactic, and technical knowledge are unaffected by their learning experiences in teacher education. This study supports a recent study done by Rahmadhani et al., (2021), which found no change in views regarding technology-based mathematics assessment between first and third-year prospective primary teachers.

There is no substantial difference in prospective teachers' mathematical, didactic, and technical competence based on their study major. Prospective teachers in elementary education thought they had greater mathematical and technology skills than those in mathematics education. This study, however, contradicts a study done by Depaepe et al., (2015), who discovered that prospective teachers from mathematics education have considerably different mathematical understanding than those from primary education.

5. CONCLUSION

Examining Prospective instructors' mathematical, didactic, and technical expertise are complex, making this study more difficult than earlier investigations. The researcher studied prospective instructors' knowledge using the self-evaluation approach in this study and obtained evidences.

Prospective teachers' mathematical, didactic, and technical skills are unaffected by gender, year of study, or

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study major. As a result, it is possible to conclude that such variables are not among those that can influence prospective instructors' expertise. This study, on the other hand, evaluates prospective teachers' mathematical, didactic, and technical expertise utilizing a self-evaluation technique, and it has to be further developed and applied. As a result, the researchers consider it a shortcoming of this study and urge that it be repeated.

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