The effect of demographic variables on mathematics teachers’
TPACK: Indonesian context

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Abstract. In Indonesia, teachers are required to integrate digital technology in the secondary school mathematics classroom. Therefore, it is necessary to examine mathematics teachers’ technological, pedagogical and content knowledge (TPACK) according to their demographic background. The purpose of this study was to examine Indonesian mathematics teachers TPACK and investigate if TPACK levels are significantly different in terms of gender, teaching experience, the level of schools and teacher level of education. We conducted a quantitative study with a cross-sectional survey design. Data were collected from 210 mathematics teachers and analyzed by ANOVA. This study suggests that there were significant differences in teachers’ level of TPACK according to their gender and the level of education. However, it was found that there was no significant difference in teacher level of TPACK according to their teaching experience and the level of schools. To a large extent, this study suggested that teacher demographic background determine their TPACK.

1. Introduction

Mishra and Koehler [1] proposed technological pedagogical and content knowledge that emphasizes the importance of interaction of three knowledge, namely, technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK) when teachers integrate technology in the classroom. Furthermore, [2] argues that TPACK is the knowledge and skills required to effectively integrate digital technology in lessons.

TPACK was developed based on Shulman’s [3] pedagogical content knowledge (PCK) framework. Therefore, TPACK is referred to “technological knowledge contextually situated within pedagogical knowledge and content knowledge” [2]. The framework suggests that teaching with technology will be effective when teachers are able to integrate technology content knowledge and pedagogical knowledge. Figure 1 is the TPACK framework that shows three basic components of TPACK and the results of their interaction.
According to Schmidt, Baran [2], “TPACK is knowledge of using various technologies to teach and represent the content”. The interaction technological knowledge, pedagogical knowledge and content knowledge will enable teachers to rethink lessons and transform their instruction into better representation by integrating technology [4]. Therefore, teachers who have sufficient TPAK view digital technology as the tool as one which constructs students’ knowledge.

The TPACK framework has been used in many studies, both quantitative [5-7] and qualitative studies [8, 9]. Regarding mathematics education, the TPACK framework has been employed to examine the mathematics teachers’ knowledge in the use of technology in the classroom [7, 10-12]. In term of mathematics teachers’ TPACK, a qualitative study conducted by Kartal and Çinar [13], showing that teachers perceived technology as a visualization tool. However, when they noticed the important digital tools such as dynamic mathematic software, they realized that the tool makes learning easier and can help teachers to avoid rote learning. This realization indicates that the teachers have developed their TPACK.

According to [14], teachers’ TPACK are influenced by many factors. Previous studies have revealed that teachers’ TPACK are influenced by Gender, age, and school levels [4, 11, 15]. In term of Gender, for instance, Erdogan and Sahin [11] found that male teachers’ TPACK higher than female teachers. In term of teaching experience, previous studies suggested varying results. For example, Jang and Tsai [4] found that less experienced teachers’ TPACK components were higher than less experienced teaches. Furthermore, regarding age, Luik, Taimalu [15] suggested that senior teachers had relatively low TPACK. In addition, research on TPACK suggested that there were significant differences in TPACK in terms of the level of school.

The purpose of this is to investigate if secondary school mathematics teachers’ TPACK levels in terms of Gender, the level of schools, teaching experience and the level of education. Regarding the purpose of the study, we proposed this research question: What are the effects of Gender, the level of the school, teaching experience and the level of education on mathematics teachers’ TPACK?
2. Methods
To achieve the aim of this study, we used a quantitative method with a cross-sectional survey [16]. We used an online survey for data collection. The survey was hosted on a Google form. Participants of this study were secondary mathematics teachers in Indonesia. We randomly distributed questioner to several virtual groups of mathematics teachers in the country. There were 210 participants who responded to the questioner. Participants’ demographic information is provided in Table 1.

Table 1. Participants’ demographic background information.

| Demographic Background         | Frequency |
|-------------------------------|-----------|
| Gender                        |           |
| Male                          | 97        |
| Female                        | 113       |
| School-level                  |           |
| Senior High School            | 75        |
| Junior High School            | 135       |
| Teacher’s level of education  |           |
| Undergraduate Degree          | 161       |
| Post-graduate Degree          | 49        |
| Teaching experience (Year)    |           |
| 0-5                           | 74        |
| 6-10                          | 54        |
| 11-15                         | 43        |
| 16-20                         | 26        |
| Above 20                      | 13        |

We adapted the research instrument from previous studies related to TPACK [2, 17, 18]. We examined a face and construct validity of the instrument through discussion with experts and teachers. For face validity, seven teachers were involved in discussing the instrument. For content validity, we discussed the instrument with two experts in educational technology. After we conducted face and content validity, we used Google form and administered the questioner through an online survey. We sent the link of the questioner to several virtual groups such as WhatsApp, Telegram and Facebook groups of mathematics teachers. Finally, 210 teachers completed the questioner. Regarding data analysis, we conducted an inferential statistical analysis. We employed ANOVA tests to examine the significant difference of TPACK level according to teacher demographic background, namely Gender, school level, education level and teaching experience.

3. Results
We present results of this study according to teacher demographic background assessed in this study, namely, Gender, school level, level of education and teaching experience.

3.1. Gender
Results of descriptive analysis and ANOVA analysis on difference of teachers’ TPACK are presented in Table 2 and Table 3, respectively. Overall, the results show that there is no significant difference in teachers’ TPACK across the construct. Only two components of the TPACK that do not significantly differ, namely content knowledge and pedagogical knowledge. Therefore, we conclude that Gender plays a significant role in teachers’ TPACK in which male teachers’ TPACK is higher than female teachers’ TPACK.
### Table 2. Mean of Teachers' TPACK according to Gender.

| TPACK Construct | Gender      | TK          | CK          | PK          | PCK         | TPK          | TCK          | TPACK       |
|-----------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Male            | 4.1581      | 4.3737      | 4.2866      | 4.1804      | 4.2268      | 4.2433      | 4.1856      |             |
| Female          | 3.9838      | 4.3075      | 4.1593      | 4.1062      | 4.0389      | 3.9611      | 3.9086      |             |

### Table 3. Results of ANOVA on teachers' TPACK according to their Gender.

| TPACK Constructs | Sum of Squares | df | Mean Square | F | Sig  |
|------------------|----------------|----|-------------|---|------|
| TK               | 1.586          | 1  | 1.586       | 6.529 | .011 |
| CK               | .229           | 1  | .229        | 1.170 | .281 |
| PK               | .846           | 1  | .846        | 4.205 | .042 |
| PCK              | .288           | 1  | .288        | 1.320 | .252 |
| TPK              | 1.842          | 1  | 1.842       | 7.070 | .008 |
| TCK              | 4.158          | 1  | 4.158       | 16.254 | .000 |
| TPACK            | 4.005          | 1  | 4.005       | 12.153 | .001 |

### 3.2. School Level

In term of school level, in this study, we examine the level of teachers’ TPACK based on their school level, namely the senior high school level and the junior high school level. Table 4 shows the mean score of teachers’ TPACK scores according to school levels, while table 5 reveals the results of ANOVA tests on teachers’ TPACK according to the level of schools where they teach. Overall, the results show that there are no significant differences in teachers’ TPACK according to the school level. Therefore, we conclude that school levels do play a significant role in teachers’ level of TPACK.

### Table 4. Mean of Teachers' TPACK according to school levels.

| School Level          | TPACK Constructs | TK       | CK       | PK       | PCK      | TPK      | TCK      | TPACK     |
|-----------------------|------------------|----------|----------|----------|----------|----------|----------|-----------|
| Senior High School    |                  | 3.9956   | 4.2933   | 4.1653   | 4.0967   | 4.0773   | 4.0080   | 3.9956    |
| Junior High School    |                  | 4.1025   | 4.3630   | 4.2474   | 4.1648   | 4.1526   | 4.1378   | 4.0593    |

### Table 5. Results of ANOVA on teachers' TPACK according to school level.

| TPACK Constructs | Sum of Squares | df | Mean Square | F   | Sig  |
|------------------|----------------|----|-------------|-----|------|
| TK               | .551           | 1  | .551        | 2.224 | .137 |
| CK               | .234           | 1  | .234        | 1.196 | .275 |
| PK               | .325           | 1  | .325        | 1.595 | .208 |
| PCK              | .224           | 1  | .224        | 1.026 | .312 |
| TPK              | .273           | 1  | .273        | 1.019 | .314 |
| TCK              | .812           | 1  | .812        | 2.987 | .085 |
| TPACK            | .196           | 1  | .196        | .562  | .454 |
3.3. Education Level
Regarding teachers' education level, we examined teachers' TPACK according to their level of education, namely an undergraduate degree and a post-graduate degree. Table 6 and Table 7 show that there are significant differences in teachers' TPACK across all constructs. It shows that teachers with a post-graduate degree have a higher level of TPACK than those with an undergraduate degree.

| TPACK Construct | Teachers' education level | TK  | CK  | PK  | PCK | TPK | TCK | TPACK |
|-----------------|--------------------------|-----|-----|-----|-----|-----|-----|-------|
|                 | Undergraduate Degree     | 4.0062 | 4.2950 | 4.1677 | 4.0947 | 4.0758 | 4.0199 | 3.9731 |
|                 | Post Graduate Degree     | 4.2551 | 4.4796 | 4.3837 | 4.2908 | 4.2898 | 4.3265 | 4.2449 |

Table 7. Results of ANOVA on teachers' TPACK according to teachers' education level.

| TPAK Constructs | Sum of Squares | df | Mean Square | F    | Sig  |
|-----------------|----------------|----|-------------|------|------|
| TK              | 2.327          | 1  | 2.327       | 9.724| .002 |
| CK              | 1.280          | 1  | 1.280       | 6.723| .010 |
| PK              | 1.752          | 1  | 1.752       | 8.903| .003 |
| PCK             | 1.445          | 1  | 1.445       | 6.804| .010 |
| TPK             | 1.721          | 1  | 1.721       | 6.589| .011 |
| TCK             | 3.533          | 1  | 3.533       | 13.650| .000 |
| TPACK           | 2.776          | 1  | 2.776       | 8.273| .004 |

3.4. Teaching Experience
Teachers’ TPACK was also examined according to teachers’ years of teaching experience. We classified teachers’ teaching experience into five categories, namely, 0-5 years, 6-10 years, 11-15 years, 16-20 years, and above 20 years. Table 8 and Table 9 show that there were no statistically significant differences in teachers’ TPACK according to their teaching experience.

| TPAK Constructs | Teachers' experience (Year) | TK  | CK  | PK  | PCK | TPK | TCK | TPACK |
|-----------------|-----------------------------|-----|-----|-----|-----|-----|-----|-------|
|                 | 0-5                         | 4.1149 | 4.3514 | 4.2135 | 4.1622 | 4.1622 | 4.1108 | 4.0495 |
|                 | 6-10                        | 4.1173 | 4.3611 | 4.2519 | 4.0972 | 4.1185 | 4.1407 | 4.0463 |
|                 | 11-15                       | 3.9535 | 4.2384 | 4.1256 | 4.0698 | 4.0093 | 3.9256 | 3.9884 |
|                 | 16-20                       | 4.0577 | 4.2788 | 4.1923 | 4.0962 | 4.1154 | 4.1231 | 3.9679 |
|                 | Above 20                    | 3.9359 | 4.6154 | 4.4615 | 4.5192 | 4.3538 | 4.2615 | 4.2179 |
Table 9. Results of ANOVA on teachers’ TPACK according to teaching experience.

| TPACK Constructs | Sum of Squares | df | Mean Square | F   | Sig |
|------------------|----------------|----|-------------|-----|-----|
| TK               | 1.084          | 4  | .271        | 1.089 | .363 |
| CK               | 1.560          | 4  | .390        | 2.034 | .091 |
| PK               | 1.219          | 4  | .305        | 1.506 | .202 |
| PCK              | 2.267          | 4  | .567        | 2.681 | .033 |
| TPK              | 1.363          | 4  | .341        | 1.278 | .280 |
| TCK              | 1.744          | 4  | .436        | 1.607 | .174 |
| TPACK            | .668           | 4  | .167        | .476  | .753 |

4. Discussion
This study aimed to examine mathematics teachers’ TPACK according to their demographic background, namely, Gender, school level, educational level and teaching experience. We conducted a survey and collected data form 210 secondary school mathematics teachers. The findings showed that teachers’ TPACK are statistically significant difference according to gender and teachers’ level of education while school level and teaching experience do not play an important role in teachers’ TPACK. The findings suggest several important points need to discuss.

First, this study supports findings of previous studies that reveal teachers’ TPACK are influenced by gender [11, 15, 19]. Furthermore, the finding of this study is in line with other studies [11, 20], revealing that teacher perceived TPACK significantly higher than female teachers. This finding indicates that researcher and practitioners need to take Gender into account when they propose a training program to develop teacher knowledge in the integration of technology in the classroom. Female teachers require more training programs than male teachers.

Second, in term of school level, this study suggests that there was not a significant difference in TPACK of senior secondary school teachers and junior secondary school teacher. This finding is in line with [21] who revealed that there was no significant difference in teachers’ TPACK according to the level of schools. However, this finding is different from [11] that showed that there were significant differences in TPACK of primary and secondary mathematics teachers. This might happen due to our study investigate in-service teachers’ TPACK while the other study explored pre-service teachers’ TPACK.

Third, this study confirms that teachers’ level of education plays an important role in their TPACK. Teacher with a higher level of education has significantly higher TPACK than teachers with a lower level of education. This is in agreement with the common view that the education level plays an important role in teachers quality [22]. Furthermore, in the context of Indonesia, the finding of this study supports [7], indicating teachers with a post-graduate degree have a higher level of TPACK than teachers with an undergraduate degree.

Fourth, this study suggests that there was no significant difference in teachers’ TPACK according to their teaching experience. This study challenges previous studies that suggest teaching experience play an important role in teachers’ TPACK [23, 24]. In addition, improving teacher knowledge of ICT integration such as TPACK is necessary in order to enhance the integration of technology in mathematics classroom [25].
5. Conclusion
In this study, we examined secondary mathematics teachers’ TPACK according to their demographic background, namely, Gender, school level, education level and teaching experience. To some extent, demographic variables play a significant role in teachers’ TPACK. This study suggests that mathematics teachers’ TPACK is significantly differentiated according to Gender and the level of education where male teachers’ TPACK is significantly higher than female teacher and TPACK of teachers with a post-graduate is significantly higher than teachers with an undergraduate degree. On the other hand, teaching experience and the level of schools do not play an important role in mathematics teachers’ TPACK. This study indicates that researcher and practitioner need to take demographic variables into account when they design and develop a training program to enhance teachers’ TPACK in order to obtain a better achievement of the program.

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