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Gender Influence on Pre-service Biology Teachers' TPACK Profile

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Abstract: TPACK research has been conducted on several subject teachers in schools in Jambi. However, research on prospective teachers, especially Biology, has not been widely conducted. What is new about this study is seeing the differences in TPACK results of female and male prospective teachers, which has not previously been done on prospective Biology teachers in Jambi. This research aims to examine the gap between two groups of male and female teacher candidates in assessing their TPACK knowledge. This study was conducted by distributing questionnaires to prospective teacher students using Google Form. There were 63 students consisting of 13 males and 50 females. The research method used was quantitative descriptive. The results showed that there were quite significant differences in TK and TCK indicators related to technology use. This is due to differences in training and time of technology use. Although male and female prospective teachers rated their domain knowledge very high, especially regarding CK, they rated their technological knowledge lower, including their ability to link this knowledge into TCK, TPK, and TPACK. This study has also produced recommendations for future research to improve TPACK of prospective biology teacher students

Keywords: Biology; Gender; Knowledge; Pre-service teacher; TPACK

Introduction

The development of the TPACK framework by Koehler et al. (2006) has met with considerable interest by the educational technology research community, not only in the United States, but also in Australia, the U.K, Singapore and Taiwan (Abbit, 2011; Baran et al., 2011; Bull et al., 2010; Harris et al., 2009). In 2013, 463 papers could be referenced from the TPACK organization website (see http://tpack.org/). Researchers have had a particular interest in developing a tool to measure TPACK knowledge and a number of instruments developed for this purpose. However, little attention has been given to the possible influence of gender on assessment of TPACK knowledge. This gap focuses on gender and ICT generally to play a significant role. This study aims to address this gap in the literature by focusing on the influence of gender in survey findings from two cohorts of pre-service teachers.

The TPACK framework builds on Shulman, (1986) premise that Content Knowledge (what to teach) and Pedagogical Knowledge (how to teach) are interconnected, and together they form Pedagogical Content Knowledge (PCK). Koehler et al. (2006) argue that by increasing the number of technologies being appropriated in the classroom, teachers require explicit Technology Knowledge (TK). Their resulting framework is then built on the notion of the connection between Pedagogical Knowledge (PK), Content Knowledge (CK) and Technological Knowledge (TK) and the resulting intersecting has three pairs of knowledge, Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), and Technological Pedagogical Knowledge (TPK). Where all three knowledges (PK, CK,

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and TK) intersect is referred to as Technological Pedagogical Content Knowledge (TPACK). Paragraph: use this for the first paragraph in a section, or to continue after an extract.

A lot of research activities around the TPACK framework have focused on developing and administering a valid and reliable tool to measure teachers' TPACK (Abbit, 2011; Jordan & Dinh, 2012; Voogt et al., 2013). Such a tool, it would be useful for teacher professional development as well as the future design and evaluation of teacher education programs (Baran et al., 2011; R. Jamieson-Proctor et al., 2010). In fact, there is no common agreement around such an instrument and "throughout efforts to further define and measure the multiple domains of the TPACK framework. Several persistent challenges have remained" (Abbit, 2011). One of these challenges relates to issues in defining the constructs to be measured Graham et al. (2010), drawing on Cox et al. (2009) doctoral research, argues that there have been 89 different definitions of the central construct as well as other constructs including technology knowledge. This challenge is the issue around defining the boundaries of the domains (Angeli & Valanides, 2009; Archambault & Crippen, 2009). A further challenge relates to the lack of clarity in the operation of the framework; whether TPACK is an integrative form of knowledge, constructed by the integration of other domains of teacher knowledge, or it is transformative and a unique knowledge constructed from other forms of teacher knowledge (Angeli & Valanides, 2009; Archambault & Barnett, 2010).

Abbit (2011) review of TPACK instruments, conducted within the context of pre- service teacher education, argues that there have been two parallel approaches to this study. One approach uses performance-based measures, such as artefacts produced by preservice teachers as evidence of TPACK. He cites the study of Graham et al. (2010) as an example of this approach. In the study, 133 early childhood and elementary teachers were asked to state how and why they would integrate ICT into three content-based design tasks (Literacy, Mathematics, Science or Social Studies). By using the themes emerged from these planning and decision-making explanations, the researchers then mapped them against the coding categories of TK, TPK and TPACK.

The second approach which Abbitt argues involves the use of self-reporting measures, which preservice teachers use to self-assess their knowledge of particular TPACK domains. In discussion session, he highlights the development and use of The Survey of Preservice Teachers' Knowledge of Teaching and Technology Schmidt et al. (2009), and describes it as "among the more mature tools", "straightforward and useful" and "a valuable instrument in terms of reliability and efficiency". Initially designed as a self-assessment tool for PK-6 pre-service teachers majoring in elementary and early childhood education, the instrument used 4 subscales within Content Knowledge (Social Studies, Sciences, Literacy and Mathematics) to reflect their needs to teach in several disciplines. The survey instrument included demographic information and open- ended questions, around the effectiveness of the teacher education program, as well as some 47 items to measure the knowledge domains in the framework; TK (7 items), CK (12 items), PK (7 items), PCK (4 items), TCK (4 items), TPK (5 items), TPCK (8 items). Eeach of these items participants was asked to indicate their level of agreement using a five-point Likert scale, Strongly Agree, Neither Agree or Disagree, Disagree and Strongly Disagree. Each item in the survey was scored and then each construct was scored by averaging item scores.

This instrument has been used by a number of other researchers, particularly international researchers who have adapted the instrument to suit their particular context. A recent search of titles of papers available on the TPACK organization website (using the term 'TPACK' or 'TPCK' or 'pedagogy' or 'pedagogical', as well as 'content', 'technology', or 'technological' and 'knowledge') located 12 papers which used this instrument. Two of these papers were produced by the survey designers, as part of their efforts to use the tool in other contexts. In one of these studies, the designers used this instrument to evaluate the TPACK of 87 pre-service teachers enrolled in an introductory technology course (Schmidt et al., 2009). Besides, Shin et al. (2009) investigated the influence of a summer course on 17 teacher's TPACK. The instrument has been adapted for use in both smaller scale surveys, such as the 17 participants in Shin et al. (2009), to larger- scale surveys involving 1185 participants, as in (Koh et al., 2010). It has been used both as a single test and a pre-test and post-test design.

Often the process of adapting the instrument for particular use involved removing the initial focus on 4 content areas, and replaced them with items reflecting the particular context. For example, Koh et al. (2010) wanted their adapted instrument to reflect the primary and secondary teaching context in Singapore, included the item, 'I know how to select effective teaching to guide student thinking in my curriculum subject'. To reflect the teaching subjects of secondary teachers in Singapore Koh et al. (2010) replaced the four items with the items, 'Curriculum Study 1' and 'Curriculum Study 2'. Often, adaptions to the instrument involved redefining the constructs. Reduced the number of

constructs from 7 to 5; Technology Knowledge, Content Knowledge, and Knowledge of Pedagogy, Knowledge of Teaching with Technology, and Knowledge from Critical Reflection, and some 29 items. Reduced the number of constructs further to 4; Technology Knowledge, Pedagogy Knowledge, Content Knowledge and TPACK. Adaptions also involved the number of levels in the agreement scale. Koh et al. (2010) and Koh et al. (2011) increased the number of levels to 7, in the belief that this aided reliability.

Investigating the role that gender may have on the assessment of TPACK knowledge is important, gi research around gender and educational computing per se has shown that there are significant gender differences in relation to attitudes to ICT, ICT skills and ICT use (Kay, 1992, 2006). The literature around the latter two areas relating to skills and use is particularly relevant given their synergies with technology knowledge as defined as knowledge of technologies and how to apply this knowledge productively (Harris et al., 2009). Through the operational premise of the TPACK framework, teachers interconnect their knowledge. How teachers assess their technology knowledge has a flow on the influence of the interconnected domains of TPK, TCK and ultimately TPACK.

In relation to computer use, Kay (2006) reviewed 42 studies and concluded that 51% showed higher use by males. In relation to computer ability, he concluded that males reported higher ability in 8 studies, females in 1 study, and no difference reported in 7 studies. Markauskaite (2006) also argues that males and females had significant differences in ICT capabilities, with males scored higher than females. Likewise, the earlier study by Jamieson-Proctor et al. (2006) indicated that female teachers were less confident to use ICT for teaching and learning, being more likely to indicate Very Little or Some confidence (on a four point scale) relating to listed ICT applications compared to male teachers. It is to be noted that more recently, the literature suggests that these gender gaps may be lessening. Koh et al. (2011), for instance, argue that, as more and more computers become prevalent in schools, this may have the effect of equalizing difference in use between males and females.

The question of gender impacted on measuring TPACK knowledge has largely not been asked. In this part, this could be because researchers have been concerned with questions in defining the constructs to be measured and the validity and reliability of the instrument itself. The few studies which have considered this question have concluded mixed results. Koh et al. (2010) in their study of 1185 pre-service teachers in Singapore concluded gender differences in Technology Knowledge, Content Knowledge and Knowledge of Teaching with Technology. He also suggested that this gap may reduce as computers become more common place in schools. In contrast, Koh et al. (2011) in their study of 214 pre-service teachers, reported no significant differences by gender. Therefore, the purpose of this study is to offer further research on this question.

TPACK research has been conducted on several subject teachers in schools in Jambi City. However, there has not been much research on prospective teachers, especially in Biology. The novelty of this study is observing the differences in TPACK results of female and male prospective teachers, which had not previously been done on prospective biology teachers in Jambi.

The previous research in Jambi was conducted on Mathematics subject teachers. Based on the research conducted, TPACK of Mathematics teachers in high schools in Jambi City showed that teachers had an understanding of TPACK performance in the good category. Teachers have low abilities in TK because most senior teachers are elderly and have difficulty understanding technology but have high flying hours (Munajib et al., 2021). The next relevant research is the TPACK Ability of Mathematics teachers in the research of Gusnidar et al. (2018) which was conducted at SMP Batanghari showed different results. The results of observations made in the field showed that the learning model used by teachers still uses conventional learning models, without utilizing technology integration.

Based on several research results, it shows that TPACK in certain areas in Jambi is still not optimal, thus it is necessary to conduct TPACK research on prospective biology teacher students. The hope is that prospective biology teachers are able to integrate technology in the learning process according to the learning materials and appropriate learning strategies according to student characteristics. This research is useful for following up on learning that needs to be given to prospective biology teachers by knowing their TPACK.

This study compared male and female pre-service teachers' self- assessments of their TPACK knowledge. These pre-service teachers of Biology Education Department of Universitas Jambi were in their fourth year and have taken seven prerequisite courses for Professional Experience Program. The study is guided by several research questions; How do male and female self- assessments compare? What are the differences and similarities in how they self-assess their domain knowledge? How do they self-assess multiple items in a given domain? What are the similarities and differences in how they self-assess these multiple items?

Method

The current study follows a quantitative approach with a survey research design. A survey design is a procedure in quantitative culture providing the opportunity for researchers to administer questionnaires to sample or entire population in order to elaborate their attitudes, perception, and behavior (Creswell, 2017). Some steps were carried out to analyze the data; content validity, measurement model, and structural model as well as t-test. Informed consent was achieved from all respondents who have been involved in the study and the researchers ensured their anonymity to provide the findings for this study.

The review of literatures support researchers with the definition and analysis of theories and concepts for the elaboration of a theoretical framework (Prasojo et al., 2020). This also helps researchers choose methods and instruments (Leguina, 2015). This research survey instrument was adapted from previous studies. There are fifty items produced at this stage. To suit the research context and setting, face and content validity were carried out. In this process, no items are dropped. After that, the instrument was tested on 63 prospective teachers with the aim of evaluating its reliability. Through the Cronbach's alpha test of 0.915, the instrument is reliable for primary data collection.

The instrument used in this research consists of 7 aspects, namely pedagogical knowledge (PK), technological knowledge (TK), content knowledge (CK), pedagogical and content knowledge (PCK), technological and content knowledge (TCK), technological and pedagogical knowledge (TPK), pedagogical and content knowledge (PCK) and technology pedagogy and content knowledge (TPACK) (Koehler & Mishra, 2006). This research focuses on the influence of gender differences on the 7 aspects of TPACK so that this research consisted of 13 male students and 50 female students. The comparison ratio is less appropriate because the number of female students in the biology education study program is more female than male.

Questionnaires were distributed to research respondents using Google Form. The data analysis technique used is quantitative descriptive using a Likert scale. Data analysis was carried out using Microsoft Excel to determine the differences in TPACK between male and female biology teacher candidates. The data obtained will be described in percentage form to determine differences in TPACK knowledge based on gender.

Result and Discussion

This study reported on how pre-service teachers self-assessed their TPACK by using an instrument. This survey instrument was administered to one cohort. Looking at the findings, this study seeks to better understand the possible role that gender has on teacher self-assessment of TPACK knowledge. In this section, we discuss the results of this study in relation to previous research which has also measured teacher's TPACK. As stated earlier, however, multiple instruments have been developed to measure the TPACK of particular respondents in particular contexts when uses particular technologies. However, researchers such as Angeli et al. (2009) and Graham et al. (2010) also suggest that multiple instruments abound as researchers face considerable challenges in designing them, as defining the domains to be measured and the boundaries between them is difficult.

Pre-service Teacher Domain Knowledge

Findings have suggested that, in both years of this study, male and female pre-service teachers rated their knowledge highly in all domains. A closer analysis of how the pre-service teachers rated their knowledge in each of the domains revealed higher mean ratings in Technological Pedagogical Knowledge. Other studies reported higher ratings in other domains. In two of these, PK was reported highest Lee et al. (2014), while in another Koh et al. (2010), Knowledge from Critical Reflection (KCR) was rated the highest, with TPK rated highest in the study by Schmidt et al. (2009). Of particular interest on how they assessed their Technology Knowledge, given that research around gender and educational computing generally has suggested that males rate their ICT skills more highly than females. Pre-service teachers in this present study also assessed their knowledge around technology, including TK, TCK, TPK and TPACK higher than Pedagogy Knowledge and Content Knowledge. This finding was not evident in other studies to any great degree. Thus, research around the self-assessment of domain knowledge has revealed different conclusions.

Male and Female Domain Knowledge

The main objective of this study was to compare how male and female pre-service teachers rated their domain knowledge. It suggests that there were considerable differences in the self-assessment patterns of males and females, with males consistently rating their domain knowledge higher than females. There were similarities in the way that male and female pre-service teachers self- assessed multiple items in domains. Both males and females similarly assessed

items in CK and TK, with both rating less knowledge in relation to solving technical problems. In relation to PK, both males and females rated their knowledge lower in two items, 'I am familiar with common student understandings and misconceptions' and 'I know how to organize and maintain classroom management'. In relation to TPK, both genders rated their knowledge lower around providing leadership.

The studies selected for inclusion in the discussion, only two explicitly examined findings in relation to gender and these reported conflicting findings. In one of these studies, Koh et al. (2010), surveyed 1185 primary and secondary pre-service teachers (809 females and 376 males) in Singapore, using an instrument with 5 constructs, a 7 point scale and some 29 items. The researchers used T-tests to consider the influence of gender as well as age, and teaching level. The results showed gender differences in relation to TK, CK, and Knowledge of Teaching with Technology (KTT), with male pre-service teachers rating their knowledge higher. While these differences were small in relation to CK and KTT, they were largest for TK. The researchers, when commenting on these findings, suggested that females needed more TK support, however added that this was probably only needed in the short- term, as the increased use of computers in schools would likely increase female ICT experiences in the future. In the other study, Koh et al. (2011) measured 214 preservice teachers (149 female and 65 male), also in Singapore. They used the TPACK for Meaningful Learning Survey, an instrument underpinned by constructivist learning also used by Chai et al. (2011), which had 7 constructs, a 7 point scale and some 33 items. The researchers considered the possible relationship between gender and the domains through independent sample T-tests, concluding however that there were no significant gender differences.

This present study also considered whether or not the patterns in self-assessment by gender were consistent in both years. Findings suggest that female patterns were more constant, with male patterns in the second year indicating some decline in knowledge of some domains (PCK, TCK, TPK and TPACK). This finding cannot be verified, as the studies by Koh et al. (2010) and Koh et al. (2011) were not conducted over the same period. The results of the questionnaire on the differences in TPACK for male and female prospective teachers are shown in Table 1.

Based on the results obtained, it is known that there is a difference of 5 percent regarding the use of technology in learning between male and female prospective teacher students. This is shown in the TK and TCK indicators. In other indicators, the difference in TPACK profile capabilities based on the PK, CK, TPK, PCK and TPACK indicators is not much different, only around 1-3 percent. The quite large differences in indicators of the use of technology in biology learning shown in the TK and TCK indicators occur due to differences in training experience and application of technology between men and women (Gómez-Trigueros et al., 2021).

Tabel 1. The Result Differences TPACK between Male and Female Pre-Service Teachers

Aspect of Knowledge	Male (%)	Female (%)
TK	81.68	76.11
PK	75.72	72.34
CK	74.23	72.60
TPK	78.68	78.40
TCK	73.85	68.40
PCK	74.87	77.93
TPACK	76.15	74.30

Information: TK = technological knowledge; PK = pedagogical knowledge; CK = content knowledge; TPK = technological and pedagogical knowledge; TCK = technological and content knowledge; PCK = pedagogical and content knowledge; TPACK = technology pedagogy and content knowledge.

The success of integrating ICT can be influenced by the teacher's gender, there can be differences in the training experienced between male and female teachers and the way they teach to integrate technology in learning. This is supported by research by Astuti et al. (2019), there is no difference in the TPACK mastery of male teachers and female teachers, where the test value was >0.05. Varank (2007) also found that gender was a significant variable for predicting computer attitudes but not perceived skills.

The gender gap is narrowing in terms of computer access and self-efficacy. Additionally, female and male students reported comparable amounts of computer use for their studies. User behavior appears to be gender specific as men spend more time in front of computers for personal purposes. There is also some evidence that male students outperform female students in computer tasks (Imhof et al., 2007). The gender gap in technology skills depends on how often male and female students utilize and spend time using technology.

Implications For Pre-Service Teacher Education

This study suggests that the pre-service teachers studied generally rate their TPACK knowledge highly, particularly in relation to their CK. This finding, however, is not consistent with other research which concluded higher rates of knowledge in a range of domains. Given that the TPACK framework is underpinned by the notion of interconnecting knowledge, pre- service teacher education providers could pay closer attention to undertaking similar studies

of their teacher education students and monitoring findings over time to inform their programs of study.

This study also suggests that there are considerable differences in how male and female pre-service teachers self-assess their domain knowledge, with males consistently self- assessing their knowledge higher than females. Pre-service teacher programs could consider giving more attention to increasing knowledge levels of females. Further research could consider the possible role that female confidence levels have on these findings. Both genders revealed some similarities in how they rated individual items within knowledge domains. Their similar rating of the item around 'having the knowledge to solve technical problems' suggests this is a possible area that could be attended to in education programs.

Future Directions

The findings from this study suggest that there are major differences in how male and female pre-service teachers assess their knowledge of the TPACK framework. Previous studies have not really focused on the influence of gender, and the few studies which have, have reported inconsistent findings. Further studies are therefore warranted, so that we can gain a much clearer understanding of its possible role. These studies could focus on pre- service and in- service teachers, and consider possible similarities and differences in how both rate their knowledge. Further studies might also examine age and gender.

Further gender-orientated study is also needed 'to test' the argument expressed by Koh et al. (2010) that gender inequities in ICT knowledge are not likely to be so important in the future, as the rates of ICT adoption increase. As well, further studies could examine the possible connections between measurement of TPACK knowledge and subsequent practice. Is there a relationship, and if so, what is it? Male pre- service teachers are more likely to rate their TPACK knowledge highly than females, will this higher rating be carried over to their practice? Related to this question around connections of knowledge to practice, is the question of to what extent could this knowledge be used as a predictor of practice. This study examined pre-service teachers, those in their first year of teaching. It would be interesting to examine their TPACK knowledge over time and to consider the influence of various factors on their ratings. For instance, this study could consider the role of a teacher mentor in schools, the school leadership team, and professional development in influencing teacher assessment of knowledge.

Conclusion

This research aims to examine the gap between two groups of male and female teacher candidates in assessing their TPACK knowledge. The results showed that there were quite significant differences in TK and TCK indicators related to technology use. This is due to differences in training and time of technology use. Although male and female prospective teachers rated their domain knowledge very high, especially regarding CK, they rated their technological knowledge lower, including their ability to link this knowledge into TCK, TPK, and TPACK. This study has also produced recommendations for future research to improve TPACK of prospective biology teacher students.

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Author Contributions

Conceptualization; M. A., methodology.; M. A., M. E. S., validation; A. S., Data analysis; G. A. M., investigation.; M. A., G. A. M., resources; M. A., data curation: A. S., writing—original draft preparation.; M. A., G. A. M., writing—review and editing: M. E. S., A. S., visualization: A. S. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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