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Between Gen X and Y: How Do Generational Differences Affect Science Teachers' TPACK Abilities?

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Abstract: Between 2020 and 2023, two groups of people have relatively the same experience in using technology, namely Generation X and Generation Y. Teachers from these two generations are expected to have the ability to integrate technology into their learning activities. The framework that can be used to identify these abilities is TPACK. This quantitative survey aims to see the differences in the TPACK abilities of biology teachers based on generations X and Y. The research sample consisted of 68 science teachers from Aceh Province. The data is distributed using Google Forms and analyzed by descriptive and inferential statistics. The results show that there is a significant difference between the TPACK abilities of teachers from generation X and generation Y. Another exciting result is that teachers from generation Y have slightly better TPACK abilities than teachers from generation X. The results of this study suggest that teachers, educational lecturers, and educational students should always try to integrate the latest technology into learning activities.

Keywords: Generation X; Generation Y; Science teacher; TPACK ability

Introduction

The rapid development of technology has an impact on human social life (Adhiarso et al., 2019). Interestingly, every leap of technological development will affect patterns of human interaction when the technology appears, either positively or negatively (Burgess, 2020; Hansen, 2018; Hoehe & Thibaut, 2020). For example, the advent of the internet and interconnected computers in the 1990s led to many changes in the way workers interact in America (CliffsNotes, 2023; Reynolds & Bibby, 2017). Likewise, the emergence of 4G cellular network technology in 2009, which made video streaming and video conferencing easier (Fitriani, 2019; Oktari, 2021; Telkomsel, 2021), caused interactions to be carried out in real-time at a low cost and without being influenced by the distance factor.

According to Dimock (2019) from the Pew Research Center, a generational cohort will provide a way to understand how different formative experiences (such as world events and technological, economic, and social changes) interact with life cycles and the aging process to shape people's views of the world. Thus, generational groups can be used as a benchmark for how the impact of the development of technology on human interaction. Furthermore, they grouped generations based on the range of years of birth, namely the Silent generation (born 1928-45), Boomers (born 1946-64), X (born 1965-80), Millennials (born 1981-96), and Z (born 1997-2012).

Generation X and Generation Y come from a close birth range; generation X was born in the range of 1965 to 1980, and generation Y was born in the range of 1981 to 1996 (Dimock, 2019; Jackson, 2018). However, the results of the research from Hutchins (2021) showed that there is a difference in scores in the use of technology between generations X and Y. Furthermore, research results from Gafni & Geri (2013) show that the longer generation Y has a smartphone, the more dependent they are on using the smartphone even though there are

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PCs around them. The results of these two studies indicate that there are differences in the way technology is used in the two generations.

The integration of technology in learning activities is not only seen from one factor, for example, the availability or ownership of technology (Yulisman et al., 2019). Teachers who have provided or brought technology into their classrooms cannot be said to be teachers who have been able to integrate technology into learning activities (Niederhauser & Lindstrom, 2018). The success of integrating technology must be viewed from the suitability of technology with learning content, and the way teachers teach (pedagogy) (Graham et al., 2009). Therefore, a model is needed to assess this ability; in this case, the suitable model is TPACK (Technological, Pedagogical, and Content Knowledge).

TPACK provides a framework that can capture information on how a teacher can effectively integrate appropriate technology with subject matter and pedagogy (Kartal & Afacan, 2017; Niederhauser & Lindstrom, 2018). TPACK is composed of seven interconnected and intersecting components, of which there are three general components and four technology-related components (Figure 1). The general components of TPACK consist of PK, CK, and PCK. Furthermore, components related to technology are TK, TPK, TCK, and TPCK. The existence of these components makes it easier for researchers to identify the technological integration capabilities of a teacher (Valtonen et al., 2017).

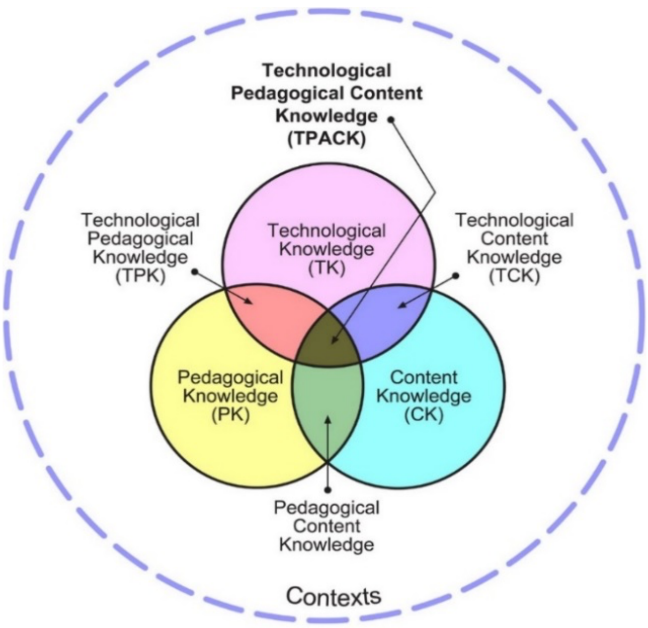

Figure 1. Model of the TPACK framework and its constituent components (Source: Koehler et al., 2013)

Currently, research on the relationship between TPACK and generation factors is still not available specifically. Several studies on TPACK are associated with demographic factors such as age (Koh et al., 2014; Koh & Sing, 2011; Nurina, 2019), gender (Kartal & Afacan, 2017; Koh et al., 2014; Koh & Sing, 2011; Nurina, 2019), teaching experience (Koh et al., 2014; Nurina, 2019; Yanti et al., 2019), and education level (Kartal & Afacan, 2017). Research on TPACK is also often associated with certain subjects or courses taught by educators, for example, how educators' TPACK abilities are related to biology (Astuti et al., 2019; Juanda et al., 2021; Lestari, 2015), physics (Sholihah & Yuliati, 2016; Supriyadi et al., 2018; Szeto & Cheng, 2017), PCK chemistry (Astuti et al., 2017; Feronika, 2018), science (Yanti et al., 2019), and geography (Nofrion et al., 2018). Furthermore, there are studies on TPACK that focus on developing instruments to measure teachers' TPACK (Scherer et al., 2017; Valtonen et al., 2015, 2017) and improving the teachers' TPACK abilities (Tanak, 2020).

These studies have not tested the factor of origin of teachers' generation, either implicitly or explicitly, on the TPACK abilities of science teachers, especially biology teachers. Although, each generation has specific characteristics and is related to the existence of technology at that time. We hope that the results of this study will provide information on how to communicate or interact with teachers from various generations, for example, when providing teacher competency improvement training, so that we can achieve the purpose of implementing these activities with optimal results. Therefore, this study aims to examine the relationship between generational differences and the TPACK ability of science teachers. Furthermore, to obtain comprehensive results, this research proposes the following research questions. Is there a significant difference between the science teachers' TPACK based on differences in generation X and generation Y? What is the difference in the percentage of science teachers' TPACK abilities based on differences in generation X and generation Y?

Method

This research is quantitative research using the survey method. The survey was conducted online using Google Forms. The research sample consisted of 68 science teachers, specifically the teachers who teach Biology, from schools in Aceh, both at the junior and senior high school levels (Table 1).

Table 1. Biology teacher demographic data

Demographic background	Components	f	%
Gender	Male	15	22%
	Female	53	78%
Age	41 – 56 (Gen X)	37	54%
	25 – 40 (Gen Y)	31	46%
Teaching experience	Less than 5 years	22	32%
	5 - 10 years	18	26%
	More than 10 years	28	41%
Teaching place	Junior high school	11	16%
	Islamic junior high school	1	1%
	Senior high school	49	72%
	Islamic senior high school	3	4%
	Vocational school	4	6%

Data on the teachers' TPACK ability was obtained by using 43 questions in the form of multiple choice. Questions are made based on instrument for the science teachers' TPACK ability (Yulisman et al., 2019, 2020). The instrument was developed based on the 21st-century TPACK instrument (Valtonen et al., 2015, 2017) and the TPACK instrument for meaningful learning (Chai et al., 2011; Deng et al., 2017). Considering that the samples were biology teachers, the 5 items from the TPACK instrument for science teachers were replaced to suit the material and learning for biology.

Table 2. TPACK components, TPACK component definitions, and the number of items for each TPACK components

TPACK Components	Definitions	Number of items
TK	Technological knowledge in this instrument refers to the definition of technology according to Magana and Marzano (2014). This knowledge refers to knowledge of various digital technologies such as the internet, digital video, interactive whiteboards, and software programs (Schmidt et al., 2009)	5
CK	Knowledge of subject matter that must be learned or taught to students (Schmidt et al., 2009)	4
PK	Knowledge of methods, teaching processes, and includes knowledge in classroom management, assessment, lesson plan development, and student learning (Schmidt et al., 2009)	12
PCK	Pedagogical knowledge that appropriates to teaching specific content. Specifically, PCK in this instrument refers to how the teacher adjusts teaching and specific content that refers to 21st-century learning and meaningful learning (Yulisman, 2019)	7
TCK	Knowledge of the interrelationships between technology and content that influence and limit each other (Yulisman, 2019)	4
TPK	Knowledge of how teaching and learning can change when technology is used in a certain way. This process includes identifying the pedagogical advantages and disadvantages of integrating various technologies (Koehler et al., 2013; Yulisman, 2019)	6
TPCK	Knowledge of how to carry out teaching that is truly meaningful and skilled with the help of technology (Yulisman, 2019)	5
Total item		43

In previous studies, this instrument has been validated by expert lecturers and tested on 55 samples. The results of the analysis have shown that this instrument is valid and reliable (Cronbach alpha = 0.847) (Yulisman et al., 2019, 2020). Furthermore, considering that 5 items had been changed, we re-validated using expert lecturers from the department of biology education, Universitas Syiah Kuala.

Instrument distribution is done online using Google Forms. We have prepared a link to fill out the instrument and share it via the alumni WhatsApp group. After waiting a month, the link to fill in the instrument is closed. Inferential and descriptive statistics were performed for data analysis. Inferential statistics were carried out by analyzing the TPACK abilities of science teachers based on generational differences using the independent sample t-test and the Mann-Whitney U Test assisted by SPSS version 26. Then descriptive statistics were performed by grouping data on the TPACK abilities of biology teachers based on differences in generations.

The research variables consisted of the TPACK ability of the science teachers and their year of birth data. Furthermore, to obtain in-depth information about teachers' TPACK abilities, we also compared TPACK abilities based on the TPACK components.

Result and Discussion

The research results are presented in two stages. The first stage is the result of inferential statistical analysis, which displays the results of the independent sample t-test and Mann-Whitney U Test. The second stage is the results of descriptive statistical analysis. This second stage shows a chart of differences in the ability of science teachers' TPACK components from generation X and generation Y.

The inferential statistical analysis aims to obtain the significance of differences in the TPACK ability of teachers from generation X and generation Y. We tested the data using an independent sample t-test. Before the independent sample t-test was used, the data had been tested for normality and homogeneity. Information on normality, homogeneity, and independent sample t-test results are shown in Table 2.

The results of statistical tests (Table 2) show that there is a significant difference in the TPACK ability of biology teachers from generation X and generation Y (0.003 < 0.05). In the context of this research, generational differences can be related to demographic factors such as age differences, the length of time the teacher has been teaching, the professionalism of the teachers, the types of technology they use, and the types of technology courses they get when they are studying at university. The results of research from Nurina (2019) showed no significant differences in the TPACK ability of science teachers based on gender, type of school, certification, educational background, age group, and length of teaching. However, the results of this study indicated significant differences in the TPACK ability of science teachers based on the number of types of training the teacher had attended. Furthermore, the research results by Koh & Sing (Koh & Sing, 2011) and Koh et al. (2014) showed that age differences did not significantly impact teachers' TPACK abilities. Based on the results of these comparisons, only the number of types of training impacts the TPACK ability of science teachers.

Table 2. The results of inferential statistical tests on the TPACK ability of biology teachers based on generations X and Y

Components	Generations	
	Gen X	Gen Y
Number of samples	37	31
Mean	21.05	24.10
Test of normality	0.200	0.200
Test of homogeneity of variance		0.953
Independent Samples Test (Sig. 2-tailed)		0.003
Significance		Significant difference

The results from Table 2 have shown the significance of differences in teachers' TPACK abilities. However, these results do not specifically indicate which TPACK component causes this significant difference. Therefore, we performed a mean comparison test for each TPACK component.

Testing the mean difference begins with the normality and homogeneity tests on each TPACK component data. The normality test was based on the Shapiro-Wilk Test, and the homogeneity test was based on Levene's Test. The results of the two assumption tests are shown in Table 3.

Table 3. The results of the normality and homogeneity test for each TPACK component

TPACK Components	Gen	N	Mean	Test of normality (Sig.)	Test of homogeneity of variance (Sig.)
TK	X	37	2.95	0.008	0.682
	Y	31	3.32	0.002	
CK	X	37	2.42	0.002	0.683
	Y	31	2.55	0.003	
PK	X	37	5.73	0.044	0.839
	Y	31	6.29	0.425	
PCK	X	37	4.11	0.019	0.087
	Y	31	4.97	0.005	
TCK	X	37	1.57	0.001	0.439
	Y	31	1.90	0.000	
TPK	X	37	2.49	0.004	0.088
	Y	31	2.90	0.035	
TPCK	X	37	1.78	0.000	0.487
	Y	31	1.81	0.011	

Table 3 shows that almost all the data is not normally distributed. Only data from Gen Y on the PK component were normally distributed ($p > 0.05$). Furthermore, all the variances of the data groups show p values > 0.05, so it can be concluded that all data groups are homogeneous. Based on the results of these two tests, the analysis process that must be carried out next is the non-parametric statistical test.

The non-parametric test used was the Mann-Whitney U Test. The Mann-Whitney U test was used to compare differences between two independent groups when the dependent variable data is either ordinal or continuous but not normally distributed. The results of the Mann-Whitney U Test are shown in Table 4.

Table 4. The results of Mann Whitney test for each TPACK component

TPACK Components	Gen	N	Mean Rank	Asymp. Sig. (2-tailed)	Significance
TK	X	37	31.01	0.098	No significant difference
	Y	31	38.66		
CK	X	37	33.51	0.636	No significant difference
	Y	31	35.68		
PK	X	37	31.38	0.146	No significant difference
	Y	31	38.23		
PCK	X	37	28.46	0.005	Significant differences
	Y	31	41.71		
TCK	X	37	31.19	0.109	No significant difference
	Y	31	38.45		
TPK	X	37	31.85	0.216	No significant difference
	Y	31	37.66		
TPCK	X	37	31.81	0.201	No significant difference
	Y	31	37.71		

Table 4 shows that there are significant differences in the PCK components. These results indicate that technology-related components do not cause science teachers' TPACK ability differences. Furthermore, these results also show that differences in PCK ability can be caused by teaching experience. Research results from Yanti et al. (2019) showed that a teacher's PCK ability is related to their teaching experience.

The results of inferential statistical analysis have shown significant differences between teachers' TPACK abilities based on differences in generations X and Y. Specifically; these differences lie in the PCK component. However, the results of these inferential statistics have yet to compare the abilities of each TPACK component from science teachers. Therefore, a descriptive statistical analysis was carried out by displaying a bar chart. The results of the descriptive analysis are shown in Figure 2.

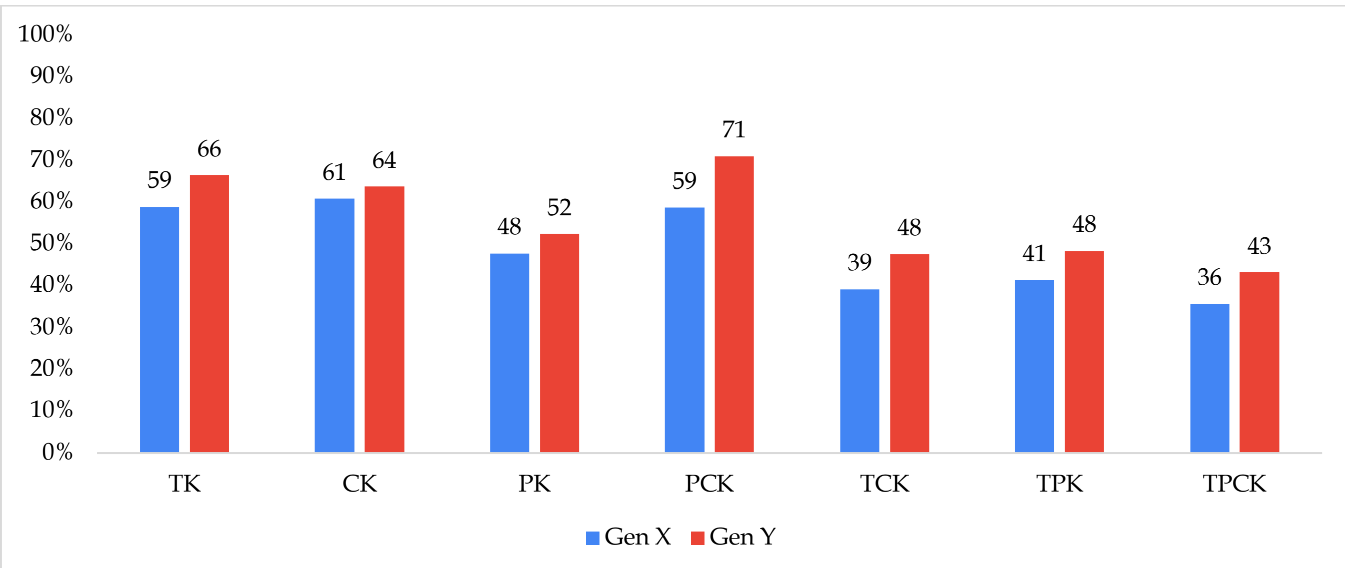

Figure 2. Science teachers' TPACK ability based on generation X and Y

Figure 2 shows that generation Y has a higher percentage than generation X in each TPACK component. Generally, it showed that the biology teachers' TPACK ability of generation Y is better than generation X. The difference in percentage with the most significant value is in the PCK component, which is 12%. This difference cannot be said to be influenced by teaching experience. Because basically, the longer you teach, the better your PCK ability should be (Astuti et al., 2017). The results of the research by Yanti et al. (2019) showed that teachers with more than 10 years of experience show better PCK than teachers who teach more than 5 years and teachers who have taught for less than 5 years. However, the PCK indicator used by these researchers is PCK in general. Meanwhile, this study used PCK indicators that follow the context of 21stcentury learning and meaningful learning. It can be said that the biology teacher from generation X has not adjusted their PCK ability according to the two types of learning.

TPACK components related to technology, such as TK, TCK, TPK, and TPCK, show a percentage difference of 7% - 8%. These results indicate that the biology teachers from generation Y are well-versed in technology. However, the mastery of technology in question is mastery of technology in general, not mastery of technology related to the learning context. This information was obtained from the percentage of TK, which reached 66%, while the percentage of TCK, TPK, and TPK were all below 50%. It shows that just having good technological skills is not enough. If the teacher does not regularly apply technology in learning activities, then this ability will not impact the effectiveness of integrating technology in learning activities. The research results from Yulisman et al. (2020) also showed that the high percentage of technology components does not cause technology-related components to be high. The problem is that teachers have not effectively integrated technology into their learning activities.

Another interesting result is the difference in the percentage of CK and PK components. Each of these components has a difference of 3% and 5%. This data showed that the two generations' content knowledge and pedagogical knowledge of biology teachers are almost the same. In the CK component, both generations have percentages above 60%. It shows that they have good knowledge of biology content. However, in the PK component, both generations have percentages below 60%. They must adjust their pedagogical abilities to suit 21st-century and meaningful learning. Furthermore, this will impact how they determine the right time to use technology. For example, research results from Szeto & Cheng (2017) showed that preservice teachers would only use technology if they cannot practice in the field because of the rain.

Conclusion

Based on the results and discussion, it can be concluded that there are significant differences in the TPACK ability of science teachers based on differences in generations X and Y. Furthermore, the TPACK ability of science teachers of generation Y shows a higher percentage than generation X, especially on the PCK component. The results of this study also provide essential information to students and lecturers at educational institutions, such as FKIP, so that they must update and improve their content knowledge, pedagogical knowledge, and technological knowledge. Because these three components will continuously develop according to the times, furthermore, the teachers should always be active in their professional organizations, for example, MGMP, to share and improve their TPACK abilities.

Author Contributions

Conceptualization, Iswadi and Hendra Yulisman; methodology, Hendra Yulisman; software, Hendra Yulisman; validation, Iswadi and Hendra Yulisman; formal analysis, Hendra Yulisman; investigation, Iswadi; resources, Samsuar and Suryani; data curation, Hendra Yulisman; writing—original draft preparation, Hendra Yulisman; writing—review and editing, Iswadi; visualization, Hendra Yulisman; supervision, Iswadi; project administration, Samsuar and Suryani; funding acquisition, Iswadi. 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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