International Journal of Instruction *October 2022 ● Vol.15, No.4*
e-ISSN: 1308-1470 ● www.e-iji.net *p-ISSN: 1694-609X*
pp. 777-796

Article submission code: 20211231091401
Received: 31/12/2021 Revision: 23/05/2022
Accepted: 16/06/2022 OnlineFirst: 18/08/2022

Technological Pedagogical and Content Knowledge (TPACK): Analysis in Design Selection and Data Analysis Techniques in High School

Bayu Saputra
Universitas Lampung, Indonesia, *bayu.saputra1988@fkip.unila.ac.id*

Uwes Anis Chaeruman
Program Doktor Teknologi Pendidikan Universitas Negeri Jakarta, Indonesia, *uwes@unj.ac.id*

The learning process that is integrated with technology requires teachers who are able to integrate professional skills, pedagogical abilities, and technology in learning. This study uses a content analysis of a number of SCOPUS indexed articles that have been published throughout 2020 with the main focus of the study being TPaCK. This study aims to inform the diversity of research types, research designs, subjects, subjects, data collection instruments and data analysis techniques. The results revealed that the most dominant types of research were quantitative and R&D. In addition, research design methods that are becoming a trend are R&D and survey research. Popular research subjects and subject matter are students with a subject or major in Science and Physics. The most commonly used instruments are questionnaires and tests. Meanwhile, the most widely used data analysis techniques are percentage, n-gain, paired sample t-test and descriptive analysis. In addition, it was also found that several researchers used the same research design but different instruments and data collection. Based on the results of this study, several recommendations have been proposed for future researchers that support TPaCK as the main focus. Some of these recommendations include increasing the diversity of types of research and choosing the right method in conducting research.

Keywords: scopus indexed educational journal, technological pedagogical and content knowledge (TPaCK), data analysis, research methods, high school

INTRODUCTION

Along with the development of the era of life, it has entered the 21st century where the development of the world is oriented towards requiring human resources (HR) to be able to adapt and master science and technology in carrying out activities of daily life, including in the world of education today. As a result of the development of science and technology, education practitioners are required to be able to improve their professional skills. In line with Keengwe et al., (2009), education practitioners must learn how to

Citation: Saputra, B., & Chaeruman, U. A. (2022). Technological pedagogical and content knowledge (TPACK): Analysis in design selection and data analysis techniques in high school. *International Journal of Instruction*, *15*(4), 777-796. https://doi.org/10.29333/iji.2022.15442a

design and develop a technology in order to achieve student success in learning in the 21st century. Education has been recognized as a means to create a competent society in the 21st century (Kivunja, 2014). The integration of technology in the world of education is the right action and very important to be implemented by education practitioners as a tool to develop the learning process in this era (Mishara & Koehler, 2006; McCormick, R., & Scrimshaw, 2001; Srisawasdi, 2012). Technology can be used not only as a means of communication and information processing, but even as a medium to reach students from different backgrounds (Sianjina, 2000) Teachers can connect with students to take new approaches to existing curricula and encourage teaching skills (Schwarz, 2000).

As a professional education practitioner, in this case, the teacher is a teacher who is able to adapt and develop the spirit of self-development to the development of increasingly sophisticated science and technology and is able to apply learning models and methods based on the needs of students (Desilawati & Amrizal, 2014). The use of ICT (Information Communication Technology) in learning can certainly help students in growing interest, achievement, and changes in student behavior (Rusmiyati, 2019). In line with Hasan's research, the use of media in ICT-based learning has an influence on motivation and learning outcomes. ICT-based learning as a means of assisting teachers in the learning process in order to package abstract knowledge into concrete (Halidi & Saehana, 2015).

The learning process that is integrated with technology requires competent teachers. Competent in question is a teacher who is able to integrate professional abilities, pedagogical abilities, and technology in learning. The three abilities according to Koehler et al., (2013) referred to as TPaCK. TPaCK owned by a teacher can be seen from how the teacher's ability to master technology in learning. TPaCK is a theoretical framework for integrating technology, pedagogy, and subject matter in learning. According to Abbitt (2011) the TPaCK model shows that technology-integrated content knowledge and pedagogical skills are important conditions in creating effective and innovative classroom teaching using technology. Ilmi et al., (2020) in their research results show that TPaCK-based learning is able to develop critical thinking skills in learners. Likewise (Fahadi & Khan, 2022) the results of his research on improving technology in learning in the engineering education department by using teacher knowledge construction using the TPaCK framework gave significant results.

The many benefits of using technology in learning that have been described are certainly a consideration for teachers to use technology in learning. But on the other hand, not all teachers are able to operate technology in the learning process. In line with research Sukaesih, S., Ridlo, S., & Saptono (2017) shows that there are still teachers who have not mastered technology, especially using it as a learning resource and medium for achieving basic competencies. Likewise according to Chai et al.,(2010) One of the problems that are often encountered in preparing teachers to use technology and computers is that there are still many teachers who do not have the knowledge of combining pedagogical and technological knowledge. Likewise, Wulansari et al., (2020) the results of their research show that there is a need to increase knowledge and skills in

technology and TpaCK in facing educational challenges in the industrial era 4.0. Along with the rapid development of technology, it is better as a teacher in learning to use the TPaCK approach by preparing, planning learning and guiding students so that educational goals are achieved (Niess, 2011).

Research on TPaCK has been carried out extensively and generally concludes that the perception of TPaCK is very important for teachers to prepare for 21st century education (Masrifah et al., 2018). TPaCK is considered a potential framework that is able to provide new techniques for teachers in Indonesia in solving problems related to the integration of information technology and computers in teaching and learning processes (Bahriah & Yunita, 2019). Several studies have provided a lot of information from their research which is often used as a fundamental basis for government policies and lesson plans designed by education practitioners, namely teachers and lecturers.

In Indonesia, research on TPaCK is widely found, especially in the world of education. Several studies have focused on analyzing teachers' TPaCK abilities (Suyamto et al., 2020; Fuada, Z., Soepriyanto, Y., & Susilaningsih, 2020). Other studies discuss the influence of demographic factors, gender, and age on the perception of TPaCK (Koh & Sing, 2011). Then research on the implementation of technology-based guided inquiry to increase TPaCK in prospective biology teachers (Irdalisa et al., 2020). There is also research that discusses the analysis of thermodynamics textbooks with the TPaCK concept for strengthening student learning competencies (Huda, C., Sulisworo, D., & Toifur, 2017). Furthermore, research on improving problem-solving skills through the development of teaching materials with the STEM-PjBL model integrated with TPaCK (Purwaningsih et al., 2020) as well as research on the role of TPaCK in influencing the ICT integration of language teacher candidates during teaching practice: the Indonesian context (Habibi et al., 2020).

However, among all these studies, there has been no researcher who has reviewed the content analysis of research articles to review the information on the findings that have been reported in all of these studies. This type of research provides concrete recommendations for future research and contributes to demonstrating the identity of education (Choi, S. H., Seo, H. J., & Kim, 2016). In addition, this content analysis method research is also expected to provide an overview and guidance for novice researchers. (Knapp & Schafer, 2009 ; Lin, T. C., Lin, T. J., & Tsai, 2014) and also provides information on what research methods are most often used in educational research (Keselman et al., 2014).

Based on the description above, it is important to conduct a content analysis of article studies that examine the diversity of educational articles on TPaCK. The analysis was carried out by surveying research methods in various articles published in various Scopus indexed journals during 2020. This study aims to collect information on various studies discussing TPaCK in Indonesia to determine the diversity of methods, analytical techniques, and research subjects used by researchers. education whose articles are published in various international journals indexed by Scopus. In more detail, this research is designed to answer the following questions: 1) What types of research are most often used by researchers?; 2) What is the most frequently chosen research

design?; 3) Which research subjects are most often studied by researchers? 4) What subjects/topics are used most often?; 5) What is the most preferred data collection instrument?; 6) What are the most frequently used analytical techniques to analyze research data?

This study has several aspects that distinguish it from several previous studies. First, this research focuses on all articles published in 2020 from international journals indexed by Scopus. Second, this study is devoted to investigating a number of articles on TPaCK. Third, various aspect parameters were used as the basis for content analysis.

METOD

Research design

This research is a qualitative research with content analysis research design or content analysis. The study in this study focuses more on the results of research related to TPaCK from various journal articles published in Scopus indexed international journals, during 2020 and the author's affiliation is from Indonesia. The research method used refers to the research method used by Fauzi & Pradipta (2018).

Data source

Data collection was obtained from the results of the analysis of the contents of the articles downloaded through the database. The database search was carried out using Publish or Perish software with a choice of search sources originating from Scopus, then accessed using the keyword "TPaCK" and the affiliation of authors from Indonesia in the search. This is so that the search for a data can be done more thoroughly. Furthermore, articles that discuss TPaCK are grouped from each of these journals. The articles analyzed in this study are articles published online in 2020. Furthermore, of the 24 available hundreds of articles, two articles cannot be opened, and one article in 2019. So a total of 21 journal articles that examine TPaCK were then analyzed. The list of the 21 journals can be seen in Table 1.

Table 1
List of journal articles in this research

No	Journal	Publisher	Digital Object Identifier (*DOI*)
1	Journal sustainability	Multidisciplinary Digital Publishing Institute	doi:10.3390/su12219050
2	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1440/1/012049
3	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1481/1/012133
4	Journal of Research on Technology In Education	Routledge. Taylor & Francis Group	doi: 10.1080/15391523.2020.1814908
5	Journal of Physics:	IOP Publishing	doi:10.1088/1742-6596/1460/1/012105
6	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1511/1/012027
7	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1511/1/012041
8	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1563/1/012061
9	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1511/1/012043
10	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1521/3/032014
11	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1521/4/042099
12	International Journal of Instruction	Universitas Negeri Yogyakarta	doi.org/10.29333/iji.2020.1323a
13	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1460/1/012135
14	International Conference on Education and Technology	IEEE	doi.org/10.1109/ICET51153.2020.9276555
15	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1663/1/012018
16	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1567/3/032078
17	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1511/1/012034
18	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1521/2/022052
19	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1521/4/042033
20	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1521/4/042069
21	Journal of Physics	IOP Publishing	doi:10.1088/1742-6596/1446/1/012043

The research instrument used is a content analysis guideline that examines the aspects to be analyzed in this research. Each article is reviewed and classified according to six main aspects. These aspects include (1) the type of research; (2) research design; (3) research subjects; (4) subjects selected for research; (5) the data collection instrument used; and (6); data analysis technique. The aspect category used in this study was adapted from (Fauzi & Pradipta, 2018).

Table 2
Categories of research types, research subjects, data collection instruments and data analysis techniques

Aspect	Category		
Types of research	A- Qualitative Research	C- CAR	E. Mix Method
	B- Quantitative Research	D- R & D	
Research design	A.1-The nature of qualitative research		B.3-Survey research
	A.2-Observation and interviewing		B.4-Pre-Experimental Designs
	A.3-Content analysis		B.5-True Experimental Designs
	A.4-Ethnographic research		B.6-Quasi Experimental Designs
	A.5-Historical research		B.7-Ex Post Facto Designs
	A.6-Descriptive qualitative		C. Mix Method Research
	B.1-Observation Studies		D. Research and Development
	B.2-Correlational research		
Research subject	1. Undergraduate Student	3. Class X students	6. Other
	2. Teacher	4. Class VIII students	
Subjects	1. Indonesian 2. Physics 3. Chemistry	4. Biology 5. Mathematics 6. English	7. Natural Science 8. All Folders
Instrument data collection	a-Tests	c-Interview	e-Observation
	b.-Qustionnaire	d-Documents	f-Others
Data analysis technique	a.1-Descriptive analysis a.2-Content analysis a.3-Others Descriptive analysis a.4-Others b.1-Illustrating with Graphics b.2-Mean/SD	b.3-Frequency/Percentage b.4-Gain score/N-Gain b.5-Paired sample t-test b.6-Unpaired sample t test b.7-ANOVA b.8-ANCOVA b.9-MANOVA	b.10-MANCOVA b.11-Correlation b.12-Regression b.13-Factor analysis b.14-Non-parametric tests b.15-Others c.0-Did not mentioned

Data analysis

Each article is classified based on predetermined aspects and categories. Determination of aspects and categories in each article is based on the information shared by the

authors in the abstract, method and discussion. Furthermore, the data that has been collected is presented in the form of a salt.

FINDINGS AND DISCUSSION

This discussion section will discuss content analysis in 21 TPaCK articles based on several aspects, namely the type of research used, the research design used, the research subjects selected, the subject matter that is often used in research, data collection instruments and data analysis techniques used.

Types of Research and Research Design

A graph depicting the percentage distribution of the types of research used in 21 articles on TpaCK. Of the 21 articles analyzed, it can be seen that the majority of the research types are 38.1 % quantitative. Furthermore, the second position is research R&D 28.6%. The third and fourth positions are qualitative and mixed method research, 14.3%, followed by the fifth position, classroom action research, 4.8%, which is the type of research that is least used in content analysis of TPaCK articles.

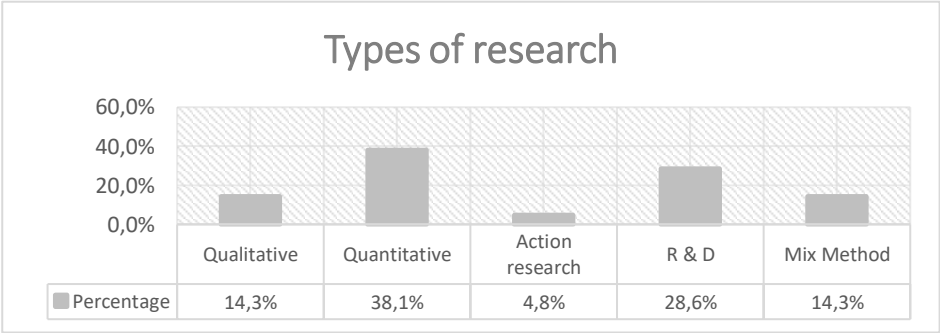

Figure 1
Distribution of the percentage of the type of research used

Based on the type of research used, quantitative research has a higher percentage of results compared to other types of research. The analysis content study in this study informs that this type of quantitative research is becoming a trend in educational research on TPaCK published in Indonesia in 2020. This is in line with several previous studies which revealed that researchers prefer quantitative research to conduct research in the field of education, than qualitative research (Goktas et al., 2012;Uzunboylu & Aşıksoy, 2014). According to (Sharma, 2013) This type of qualitative research is considered to be still common or the lack of attractiveness of researchers to choose this type of research. However, according to Shakouri, (2014) the type of qualitative research began to increase and began to be often used in research related to social, including educational issues (Mohajan, 2018). This condition has a close relationship with qualitative excellence to describe a phenomenon in a comprehensive and detailed manner (Susetyarini & Fauzi, 2020). So that with the lack of interest in the existence of qualitative research, it can be a good opportunity for researchers in the future to use

qualitative designs and focus their research on technological pedagogical and content knowledge.

Furthermore, the percentage of research type R&D occupies the second position after the type of qualitative research with a percentage result of 28.6%. This type of R&D research is a type of research that is quite widely used in research. This is in line with Fauzi & Pradipta (2018) who reported that the type of research R&D was the type of research that was most chosen and published throughout 2017. This R&D research often produces educational products based on the results of research conducted. These products can be in the form of modules, e-learning media in learning (Suciyati & Adian, 2018; Ilmi et al., 2020) or teaching materials in the form of LKPD Kurniasih et al., 2020). Likewise, the type of CAR (Classroom action research) or action research has become a trend in the last few years. Such as the type of CAR based on Lesson Study which has been implemented in several studies (B. M. N. I et al., 2015). However, the content analysis study conducted showed that the smallest percentage of the CAR research type was 4.8%, this indicates that the current CAR research type is less attractive to educational researchers.

In addition to the type of research, this study also aims to provide information related to the research design that is most chosen by researchers. Based on Figure 2 of the 21 articles analyzed, it can be seen that overall the majority of research designs that are widely used are 28% R&D. Furthermore, 19% survey research occupies the second position of the selected research design. The third position is descriptive qualitative, quasi-experimental designs and mix method by 14.3%, the three research designs get the same percentage. Then followed by the fourth position, pre experimental designs 4.7% were the least used research designs in content analysis of TPaCK articles. While several research designs such as, the nature of qualitative research, observation and interviewing, content analysis, ethnographic research, historical research, observation studies, correlational research, true experimental designs and ex post facto designs were not found in articles published in 2020 related to TPaCK.

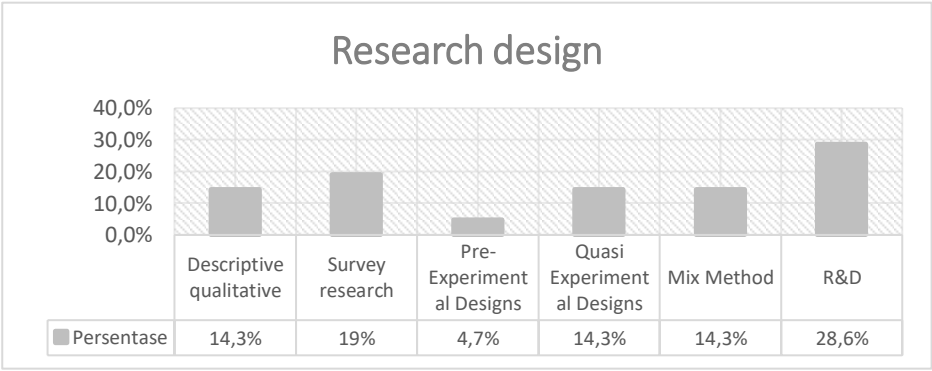

Figure 2
Distribution of the percentage of the research design used

Regarding how and in which direction a research will be carried out, it depends on the selection of research designs which will later become a guide (Grimshaw et al., 2000). In Figure 2, it can be seen that the R&D research design and survey research were the most chosen designs in articles published throughout 2020. The research design in R&D research has its own research design, so it is appointed as a separate category in research design (Fauzi & Pradipta, 2018). This R&D research often produces a product that can be used to achieve a goal in learning. As in the scientific research ilmi et al., (2020) Development of TPACK based-physics learning media to improve HOTS and scientific attitude shows the results that media products are able to develop HOTS and scientific attitudes. Likewise, the research of Oktasari et al., (2020) revealed that the TPaCK framework using a quick response (QR) code has a positive influence in improving students' scientific literacy. Likewise, survey research design is the second trend after R&D research design in 2020. Morrisan (2012) stated that survey research designs attempt to explain or record a condition or attitude in order to explain what is happening. There are several advantages offered to researchers, such as low budget, time efficiency, and a lot of information about the attitudes, beliefs, thoughts, and abilities of the population they will observe (Brewer, 2009). The survey results allow the researcher to examine the relationship among variables and draw conclusions from the relationship. This is in line with several previous studies which revealed that researchers prefer quantitative research with designs offered to conduct research in the field of education (Yanuarto et al., 2020).

Furthermore, in line with the data obtained on the research design aspect, qualitative research designs were found with a descriptive qualitative design of 14.3% in articles published in 2020. These results indicate that qualitative research designs are still rare. This is based on the fact that the nature of qualitative research, observation and interviewing, content analysis, ethnographic research and historical research were not found in the articles analyzed in this study. Likewise, the mix method research design in the study of this article obtained the same percentage as the qualitative research design. Senjaya (2018) revealed that mixed methods research is more often used in the humanities field.

On the other hand, this study also provides information that several studies use the same purpose and type of research, but use different research designs. This is found in several studies that use quantitative research types but the research designs they use are different, such as in the research of Lestari et al., (2020) & Sintawati & Abdurrahman (2020) using quasi-experimental designs, then some other researchers using pre-experimental designs ((Irdalisa et al., 2020) and survey research (Wulansari et al., 2020;Septiandari et al., 2020; Yanuarto et al., 2020). The high frequency of using quasi-experimental compared to quasi-experimental designs explains that researchers must choose the one that best fits what they are going to study (Randler & Bogner, 2008). Pre experimental designs are the rarest compared to other experimental designs (Knapp, 2016). Pre experimental designs were only found in one article in this content analysis study. In addition, observation studies, correlational research, true experimental designs and ex post facto are quantitative research designs that are rarely carried out in articles

published in 2020. Therefore, any information generated and shared in this study is expected to contribute to enriching the research. future related to TPaCK.

Research Subject

The focus of a research in Indonesia is not limited to junior and senior high school levels, but at a higher level, namely students and even teachers. The diversity of research subjects in the research articles analyzed in this study can be seen in Figure 3 below.

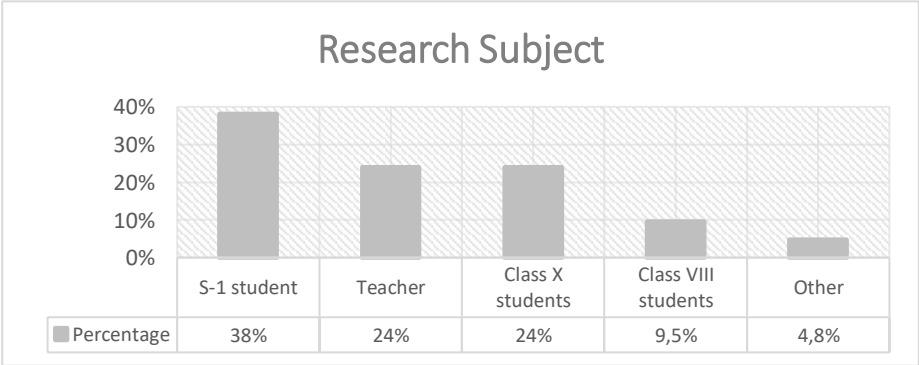

Figure 3
Distribution of the percentage of research subjects used

Based on the distribution diagram of the percentage of research subjects used in the 21 articles analyzed, the most popular research subjects were students, 38%. While teachers and students of high school (SMA) class X get a percentage of 24%. After teachers and high school students, the next position is for junior high school students of class VIII 9.5%. Then 4.8% fall into other categories because the subject used is a collection of articles.

The percentage of research subjects of students and teachers has the highest percentage among other subjects, because in the analysis of the study of articles about TPaCK, on average, it focuses more on the ability of prospective teachers and teachers in mastering TPaCK. So that students and teachers are more often used as subjects to test the researchers' hypotheses. Of course, this is in line with Choi, S. H., Seo, H. J., & Kim (2016) who revealed that students are the most sought after subjects used for educational research. Likewise with Goktas et al., (2012) that the most popular research subjects in Turkish education articles are students and teachers. Meanwhile, high school students get the same percentage as the teacher's research subjects. This is also in line with Lin, T. C., Lin, T. J., & Tsai (2014) that high school students are often used as research subjects by researchers. Meanwhile, the junior high school level gets the smallest percentage compared to students, teachers and high school students. However, based on Figure 3, on the other hand, it can be seen that the higher the level of a class at a certain level of education, the less often that class is chosen as research subjects. As in Figure 3 above, which shows that the research subjects at the high school level are class X and jenang junior high school is class VIII. Meanwhile, class XII and IX were not involved

in the research. This phenomenon is certainly in line with the tendency of school policies to be more selective in granting research permits in grades XII and IX due to the tight preparation for the national exam.

Subjects selected during research

A graph depicting the distribution of the percentage of subjects selected in 21 articles on TPaCK which were then analyzed in this study is presented in Figure 4. Based on Figure 4, of the 21 articles analyzed, it can be seen that overall the majority of subjects selected are physics and science which have a percentage the same is 28.6%. Next is chemistry 14.3%, then biology and mathematics 9.5%. While all the 4.8% folders get the smallest percentage.

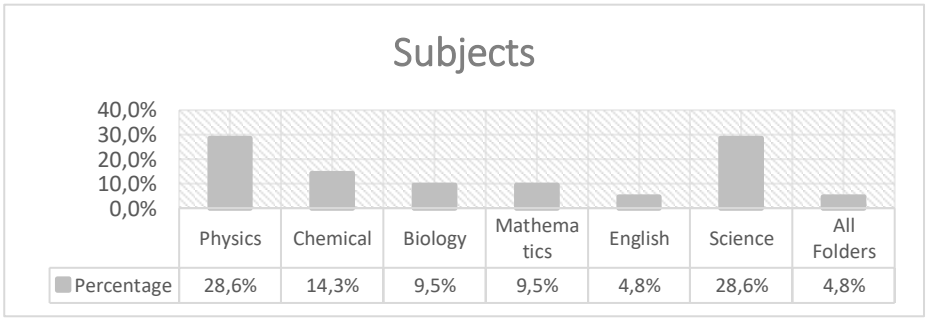

Figure 4
Distribution of the percentage of subjects used

Selection of subjects in a study is an important thing to do. There are several topics that are considered easy and also difficult for students (Fauzi & Fariantika, 2018 ;Fauzi & Mitalistiani, 2018). In the study of this article, the percentage of the most popular subjects is science subjects which include science, physics, chemistry, biology, followed by mathematics, English and all subjects. The large percentage in science, physics, chemistry, biology subjects is due to abstract concepts that need to be conveyed easily to students through media aids in the form of interactive videos and virtual labs. So that some researchers want to know how a teacher's ability to know technology in making and even operating the media will have an impact on student learning outcomes. As in the research conducted by Lestari (2015) analyzing the ability of TPaCK in high school biology teachers in nervous system material. Furthermore (scientific) the development of TPACK-based physics learning media to improve HOTS and scientific attitudes. Then the research of Putri et al., (2020) analysis of technology pedagogical content knowledge (TPACK) of biology teachers in learning the classification of living things and research on the development of TPACK-based physics learning media using VBA macros to improve critical thinking skills were carried out by (Ilmi et al., 2020).

Data Collection Instruments

Based on 21 articles that have been reviewed in the study, various data collection instruments were found. Based on the percentage diagram presented in Figure 5, it can be seen that the most frequently used data collection instruments are 57.1% questionnaires, 38% tests and 4.8% documents.

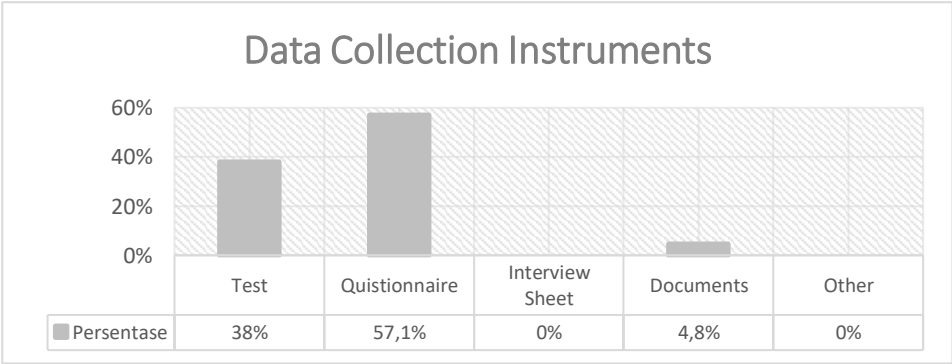

Figure 5
Distribution of the percentage of data collection instruments used

The percentage results, which are presented in Figure 5, show that questionnaires and tests are the most popular data collection instruments used for data collection. The content analysis study of this article also revealed that there were several studies with the same research design but with different data collection techniques. This condition is seen in several studies with quasi-experimental designs, researchers only use test instruments (Lestari et al., 2020) then other researchers not only use tests but also questionnaires (Sintawati & Abdurrahman, 2020). Furthermore, several studies with survey research designs have researchers who use a collection instrument in the form of a questionnaire (Wulansari et al., 2020;Destiani & Purnawarman, 2020; Yanuarto et al., 2020) and some also use a collection instrument in the form of a test (Septiandari et al., 2020)

Referring to the data collection instrument used, this study revealed that there were several articles that did not provide information regarding the validity of the instrument used. Bajpai & Bajpai (2014) Reveal that the key point of a data collection instrument that can be used is that it has passed validity and reliability tests. So it can be concluded that information about the validity of a data collection instrument is considered important in order to convince other researchers if they will adopt an instrument.

Data analysis technique

The variety of data analysis techniques used in the articles that have been analyzed in this study are presented in Figure 6. Based on the percentage diagram presented in Figure 6, the most widely used data analysis techniques are descriptive analysis, percentage, N-Gain and paired sample t-test. test 19%. These four data analysis

techniques have the same percentage value. Furthermore, the next data analysis technique is the 9.5% non-parametric test. While the ANOVA and correlation tests have the same percentage value of 4.8% and 4.8% are included in other categories because they are not explained in detail about what data analysis techniques are used.

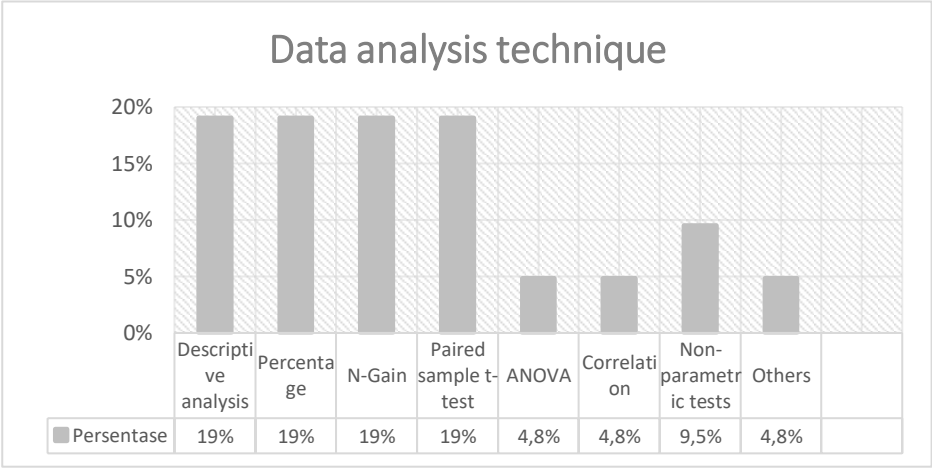

Figure 6
Distribution of the percentage of data analysis techniques used

The selection of the right data analysis method will determine the level of validity of a study. Karadağ (2010) revealed that in general the data obtained in research are more often analyzed using percentages, n-Gain, paired sample t-tests and descriptive analysis rather than inferential statistics. Referring to the graph shown in Figure 6, it shows that the paired sample t-test is a data analysis method that has the same percentage value as descriptive analysis, percentage and N-gain. But it also has the highest value compared to non-parametric tests, ANOVA and correlation. This finding provides information that researchers often use data analysis with paired sample t-test to compare the achievements of two classes or groups.

However, there are two general trends shown by researchers in using the paired sample t-test to test the hypothesis. First, the researcher only took post-test data from each class, then tested it with the paired sample t-test. Second, the researcher refers to the pre-test and post-test data before calculating the n-Gain from the two data. After that, calculate the n-Gain of both classes with t-test. This kind of tendency will reduce the level of research validity. So we need the right data analysis method so that the level of validity of a study is more accurate. The use of this less accurate data analysis method is in line with the findings of the article review research conducted Fauzi & Pradipta (2018).

In addition, based on the analytical study in this study, it was revealed that there are several types of research that are the same but have different data analysis techniques. This condition is seen in the research by taking pretest and posttest data, but the data analysis techniques used are different. There are studies that use non-parametric tests

((Thohir et al., 2020), use descriptive statistics (Septiandari et al., 2020), use paired sample t-test (Sintawati & Abdurrahman, 2020), and use ANOVA (Wulansari et al., 2020)**.** The controversy over the choice of data analysis in experimental design research has been discussed several times (Knapp & Schafer, 2009). In fact, the diversity of data analysis in quasi-experimental research is not only limited to ANOVA data analysis with n-Gain and ANCOVA on pretest-posttest data, but also ANOVA on pretest-posttest data (Dimitrov & Rumrill, 2003).

The diversity of data analysis techniques and research designs in a study with the same procedure and approach will present its own problems for researchers who will conduct meta-analysis studies in educational articles (Knapp & Schafer, 2009). Thus, there are several suggestions that can be given to researchers in further research. The suggestions are as in the results of the research analysis of article studies conducted by Fauzi & Pradipta (2018). First, if the research wants to see the effect of a treatment on one group, then the researcher should take data before and after the treatment is given and then the data is analyzed using paired sample t-test. . Using this data analysis technique, a researcher can determine whether there is a significant increase between before and after the treatment. Then the second is if the research wants to compare two or more classes, the researcher should use a quasi-experimental design. Then the third is if a study has data before and after the treatment is given to each class or group, it is recommended in that study to use ANCOVA as a statistical technique. Instead of having to compare the scores using ANOVA. Finally, multivariate analysis can be used as a data analysis technique if experimental research has more than one dependent variable.

CONCLUSION

This research is a content analysis study on articles in the field of education regarding TPaCk published in SCOPUS indexed journals. There are various types of research, research designs, subjects, selected subject matter, data collection instruments and data analysis techniques used in various articles. Quantitative research and R&D are the most common research found in published articles. Students, Science and questionnaires are the subjects, subjects and data collection instruments that are most chosen by researchers. Several researchers used the same research design but different instruments and data collection. Therefore, based on the results of this study, several recommendations have been proposed for future researchers that support TPaCK as the main focus. Some of these recommendations include increasing the diversity of types of research and choosing the right method in conducting research.

ACKNOWLEDGMENTS

We would like to acknowledge the Government of the Republic of Indonesia, the Education Financing Service Center (Puslapdik) from the Indonesian Education Fund Management Institute (LPDP), for the support of this study.

REFERENCES

Abbitt, J. T. (2011). Measuring Technological Pedagogical Content Knowledge in Preservice Teacher Education: A Review of Current Methods and Instruments. *Journal of Research on Technology in Education*, *43*(4), 281–300.

Bahriah, E. S., & Yunita, L. (2019). Investigating the Competencies of Technological Pedagogical Content Knowledge and Self-Efficacy of Chemistry Teachers. *Journal of Physics: Conference Series*, *1233*(1). https://doi.org/10.1088/1742-6596/1233/1/012021

Bajpai, R., & Bajpai, S. (2014). Goodness of Measurement: Reliability and Validity. *International Journal of Medical Science and Public Health*, *3*(2), 112. https://doi.org/10.5455/ijmsph.2013.191120133

Brewer, E. W. (2009). Conducting survey research in education. In C. X. W. Victor (Ed.),. In *Handbook of research on e-learning applications for career and technical education: Technologies for vocational training* (pp. 519–533). IGI Global.

B. M. N. I., Mite, Y., Fauzi, A., Widiansyah, A. T., & ... (2015). Penerapan pembelajaran cooperative script berbasis lesson study sebagai upaya peningkatan keaktifan lisan dan kecakapan sosial mahasiswa SI …. *Proceedings of the 2nd …*, *October 2015*.

Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2010). Facilitating preservice teachers' development of technological, pedagogical, and content knowledge (TPACK). *Educational Technology and Society*, *13*(4), 63–73.

Choi, S. H., Seo, H. J., & Kim, Y. S. (2016). Analysis of the research trends of the Korean journal of educational research using network text analysis. *International Journal of Software Engineering and Its Applications*, *10*(12), 169-178.

Desilawati, & Amrizal. (2014). Guru Profesional di Era Global. *Pengabdian Kepada Masyarakat*, *20*(77), 1–4. https://jurnal.unimed.ac.id/2012/index.php/jpkm/article/view/3415

Destiani, I., & Purnawarman, P. (2020). Exploring English Teachers' TPACK Level and the Impacts on Strategies of Assessment Practices. *Proceedings - 2020 6th International Conference on Education and Technology, ICET 2020*, 15–20. https://doi.org/10.1109/ICET51153.2020.9276555.

Dimitrov, D. M., & Rumrill, P. D. (2003). Pretest-posttest designs and measurement of change. *Work*, *20*(2), 159–165.

Fauzi, A., & Fariantika, A. (2018). Courses perceived difficult by undergraduate students majoring in biology. *Biosfer*, *11*(2), 78–89. https://doi.org/10.21009/biosferjpb.v11n2.78-89.

Fauzi, A., & Mitalistiani, M. (2018). High School Biology Topics That Perceived Difficult By Undergraduate Students. *DIDAKTIKA BIOLOGI: Jurnal Penelitian*

Pendidikan Biologi, *2*(2), 73. https://doi.org/10.32502/dikbio.v2i2.1242.

Fauzi, A., & Pradipta, I. W. (2018). Research methods and data analysis techniques in education articles published by Indonesian biology educational journals. *Jurnal Pendidikan Biologi Indonesia*, *4*(2), 123–134. https://doi.org/10.22219/jpbi.v4i2.5889.

Fuada, Z., Soepriyanto, Y., & Susilaningsih, S. (2020). Analisis Kemampuan Technological Content Knowledge (TCK) Pada Mahasiswa Program Studi Pendidikan Guru Sekolah Dasar. *Jurnal Kajian Teknologi Pendidikan*, *3*(3), 251–261.

Goktas, Y., Hasancebi, F., Varisoglu, B., Akcay, A., Bayrak, N., Baran, M., & Sozbilir, M. (2012). *Trends in Educational Research in Turkey : A Content*. *12*(1), 455–460.

Grimshaw, J., Campbell, M., Eccles, M., & Steen, N. (2000). Experimental and quasi-experimental designs for evaluating guideline implementation strategies. *Family Practice*, *17*(SUPPL. 1), 10–16. https://doi.org/10.1093/fampra/17.suppl_1.s11.

Habibi, A., Yusop, F. D., & Razak, R. A. (2020). The role of TPACK in affecting pre-service language teachers' ICT integration during teaching practices: Indonesian context. *Education and Information Technologies*, *25*(3), 1929–1949. https://doi.org/10.1007/s10639-019-10040-2.

Halidi, H. M., & Saehana, S. N. H. dan S. (2015). Pengaruh Media Pembelejaran Berbasis TIK Terhadap Motivasi dan Hasil Belajar IPA Siswa Kelas V SDN Model Terpadu Madani Palu. *Jurnal Mitra Sains*, *3*(1), 53–60.

Huda, C., Sulisworo, D., & Toifur, M. (2017). Analisis Buku Ajar Termodinamika dengan Konsep Technological Pedagogical and Content Knowledge (TPACK) untuk Penguatan Kompetensi Belajar Mahasiswa. *Jurnal Penelitian Pembelajaran Fisika*, *8*(1).

Ilmi, A. M., Sukarmin, S., & Sunarno, W. (2020). Development of TPACK based-physics learning media using macro VBA to enhance critical thinking skills. *Journal of Physics: Conference Series*, *1521*(2). https://doi.org/10.1088/1742-6596/1521/2/022052.

Irdalisa, Paidi, & Djukri. (2020). Implementation of technology-based guided inquiry to improve tpack among prospective biology teachers. *International Journal of Instruction*, *13*(2), 33–44. https://doi.org/10.29333/iji.2020.1323a.

Karadağ, E. (2010). nalysis of f Researc ch Method ds and St tatistical Techniqu ues Used d By Doctoral Disserta ation at th he Educat tion Scien nces in T Turkey. *Current Issues in Education*, *13*(4), 1–21. https://cie.asu.edu/ojs/index.php/cieatasu/article/view/439/59.

Keengwe, J., Onchwari, G., & Onchwari, J. (2009). Technology and Student Learning : Toward a Learner- Centered Teaching Model. *Technology*, *17*(1), 11–22. http://www.editlib.org/p/26258.

Keselman, H. J., Huberty, C. J., Lix, L. M., Olejnik, S., Cribbie, R. A., Donahue, B., & Levin, J. R. (2014). Statistical practices of educational researchers: An analysis of their ANOVA, MANOVA, and ANCOVA analyses. *Review of Educational Research*, *68*(3), 350–386.

Kivunja, C. (2014). Innovative Pedagogies in Higher Education to Become Effective Teachers of 21st Century Skills: Unpacking the Learning and Innovations Skills Domain of the New Learning Paradigm. *International Journal of Higher Education*, *3*(4), 37–48. https://doi.org/10.5430/ijhe.v3n4p37.

Knapp, T. R. (2016). Why Is the One-Group Pretest–Posttest Design Still Used? *Clinical Nursing Research*, *25*(5), 467–472. https://doi.org/10.1177/1054773816666280.

Knapp, T. R., & Schafer, W. D. (2009). From gain score t to ANCOVA F (and vice versa). *Practical Assessment, Research and Evaluation*, *14*(6).

Koehler, M. J., Mishra, P., & Cain, W. (2013). What is TPaCK? *Journal of Education*, *193*(3), 13–19. https://doi.org/10.1177/002205741319300303.

Koh, J. H. L., & Sing, C. C. (2011). Modeling pre-service teachers' TPaCK perceptions: The influence of demographic factors and TPACK constructs. *ASCILITE 2011 - The Australasian Society for Computers in Learning in Tertiary Education*, *2011*, 735–746.

Kurniasih, N., Sunyono, S., & ... (2020). Validity of Student Worksheets Based on Socioscientific Issues Towards improve Students' Literacy Skills. *IOSR Journal of …*, *10*(Query date: 2020-08-14 14:24:03), 57–61. https://doi.org/10.9790/7388-1002045761.

Lestari, suci. (2015). Analisis Kemampuan TPACK Pada Guru Biologi SMA di Materi Saraf. *Jurnal Seminar Nasional XII FKIP UNS*, *46*(1), 557–564.

Lestari, W. T., Saputro, S., Masykuri, M., Hastuti, B., Ulfa, M., Mulyani, S., & Yamtinah, S. (2020). Item analysis of teachnological pedagogical content knowledge (TPACK) in pre-service chemistry teachers using the Rasch Model application. *Journal of Physics: Conference Series*, *1511*(1). https://doi.org/10.1088/1742-6596/1511/1/012043.

Lin, T. C., Lin, T. J., & Tsai, C. C. (2014). Research trends in science education from 2008 to 2012: A systematic content analysis of publications in selected journals. *International Journal of Science Education*, *36*(8), 1346–1372.

Masrifah, M., Setiawan, A., Sinaga, P., & Setiawan, W. (2018). Profile of senior high school in-service physics teachers' technological pedagogical and content knowledge (TPACK). *Journal of Physics: Conference Series*, *1097*(1). https://doi.org/10.1088/1742-6596/1097/1/012025.

McCormick, R., & Scrimshaw, P. (2001). Information and communications technology, knowledge and pedagogy. *Education, Communication, and Information*, *1*(1), 39–57.

Mishara, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge Related papers. *The Development of Technological Pedagogical Content Knowledge in a Design Seminar*, *108*(6), 1017–1054.

Mohajan, H. K. (2018). Qualitative research methodology in social sciences and related subjects. *Journal of Economic Development, Environment and People*, *7*(1), 23–48.

Morrisan, M. A. (2012). *Metode penelitian survei*. Kencana.

Niess, M. L. (2011). Investigating TPACK: Knowledge growth in teaching with technology. *Journal of Educational Computing Research*, *44*(3), 299–317. https://doi.org/10.2190/EC.44.3.c

Oktasari, D., Jumadi, Warsono, & Putri, Z. R. (2020). Framework TPACK using Quick Response (QR) code to promote ICT literacy students in learning physics. *Journal of Physics: Conference Series*, *1567*(3). https://doi.org/10.1088/1742-6596/1567/3/032078.

Purwaningsih, E., Sari, A. M., Yuliati, L., Masjkur, K., Kurniawan, B. R., & Zahiri, M. A. (2020). Improving the problem-solving skills through the development of teaching materials with STEM-PjBL (science, technology, engineering, and mathematics-project based learning) model integrated with TPACK (technological pedagogical content knowledge). *Journal of Physics: Conference Series*, *1481*(1). https://doi.org/10.1088/1742-6596/1481/1/012133.

Putri, A. R. A., Hidayat, T., & Purwianingsih, W. (2020). Analysis of TPaCK of biology teachers in classification of living things learning. *Journal of Physics: Conference Series*, *1521*(4). https://doi.org/10.1088/1742-6596/1521/4/042033.

Randler, C., & Bogner, F. X. (2008). Planning Experiments in Science Education Research: Comparison of a Quasi-Experimental Approach with a Matched Pair Tandem Design. *International Journal of Environmental & Science Education*, *3*(3), 95–103. http://files.eric.ed.gov/fulltext/EJ894853.pdf.

Rusmiyati, S. (2019). Upaya Meningkatkan Kompetensi Guru Menggunakan Media Pembelajaran ICT melalui Supervisi dengan Teknik Individual di Sekolah Dasar. *JPI (Jurnal Pendidikan Indonesia): Jurnal Ilmiah Pendidikan*, *5*(1), 138–144. https://doi.org/10.20961/jpi.v5i1.33826.

Schwarz, G. (2000). Renewing teaching through media literacy. *Kappa Delta Pi Record*, *37*(1), 8-12.

Senjaya, A. J. (2018). Campuran (Mixed Method) Dalam Riset Sosial. *Risalah, Jurnal Pendidikan Dan Studi Islam*, *4*(1), 103–118. https://doi.org/10.5281/zenodo.3552026.

Septiandari, W., Riandi, & Muslim. (2020). Technological Pedagogical and Content Knowledge (TPACK) design in learning sound wave to foster students' creativity. *Journal of Physics: Conference Series*, *1521*(4). https://doi.org/10.1088/1742-

6596/1521/4/042099.

Shakouri, N. (2014). Qualitative research: incredulity toward metanarrativeness. *Journal of Education and Human Development*, *3*(2), 671–680. http://jehdnet.com/journals/jehd/Vol_3_No_2_June_2014/40.pdf.

Sharma, S. (2013). Qualitative Approaches in Mathematics Education Research: Challenges and Possible Solutions. *Education Journal*, *2*(2), 50. https://doi.org/10.11648/j.edu.20130202.14.

Sianjina, R. R. (2000). Educational technology and the diverse classroom. *Kappa Delta Pi Record*, *37*(1), 26-29.

Sintawati, M., & Abdurrahman, G. (2020). The effectiveness of blended learning to improve pre-service teacher TPaCK in developing multimedia learning mathematics at elementary school. *Journal of Physics: Conference Series*, *1521*(3). https://doi.org/10.1088/1742-6596/1521/3/032014.

Srisawasdi, N. (2012). The Role of TPACK in Physics Classroom: Case Studies of Preservice Physics Teachers. *Procedia - Social and Behavioral Sciences*, *46*, 3235–3243. https://doi.org/10.1016/j.sbspro.2012.06.043.

Suciyati, A., & Adian, T. (2018). Developing the fun and educative module in plant morphology and anatomy learning for tenth graders. *Jurnal Pendidikan Biologi Indonesia*, *4*(1), 53. https://doi.org/10.22219/jpbi.v4i1.5334.

Sukaesih, S., Ridlo, S., & Saptono, S. (2017). Analisis kemampuan technological pedagogical and content knowledge (TPACK) calon guru pada mata kuliah PP Bio. *In Prosiding SNPS (Seminar Nasional Pendidikan Sains)*, 58–64.

Susetyarini, E., & Fauzi, A. (2020). Trend of critical thinking skill researches in biology education journals across Indonesia: From research design to data analysis. *International Journal of Instruction*, *13*(1), 535–550. https://doi.org/10.29333/iji.2020.13135a

Suyamto, J., Masykuri, M., & Sarwanto, S. (2020). Analisis Kemampuan Tpack (Technolgical, Pedagogical, and Content, Knowledge) Guru Biologi Sma Dalam Menyusun Perangkat Pembelajaran Materi Sistem Peredaran Darah. *INKUIRI: Jurnal Pendidikan IPA*, *9*(1), 46. https://doi.org/10.20961/inkuiri.v9i1.41381.

Thohir, M. A., Jumadi, J., & Warsono, W. (2020). TPaCK of pre-service science teachers: A Delphi study. *Journal of Research on Technology in Education*, *0*(0), 1–16. https://doi.org/10.1080/15391523.2020.1814908.

Uzunboylu, H., & Aşıksoy, G. (2014). Research in Physics Education: A Study of Content Analysis. *Procedia - Social and Behavioral Sciences*, *136*, 425–437. https://doi.org/10.1016/j.sbspro.2014.05.353.

Wulansari, D., Adlim, M., & Syukri, M. (2020). Technological pedagogical and content

knowledge (TPACK) of science teachers in a suburban area. *Journal of Physics: Conference Series*, *1460*(1). https://doi.org/10.1088/1742-6596/1460/1/012135.

Yanuarto, W. N., Maat, S. M., & Husnin, H. (2020). A measurement model of TPaCK in Indonesian senior mathematics teachers' scenario. *Journal of Physics: Conference Series*, *1663*(1). https://doi.org/10.1088/1742-6596/1663/1/012018