Bibliometric Analysis: Research Trends in the Development of the TPACK Instrument in the 2019–2023 Period

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Article Info

Abstract

This research aims to examine scientific trends in instrument development research within the TPACK framework based on the Scopus database from 2019 to 2023 through a bibliometric study. The metadata samples analyzed were 59 articles. Data analysis process using Microsoft Excel, Mendeley, and Vosviewer software. The results of the analysis show that research written by Habibi et al. has the highest number of citations, with 84 times and a ratio of 28.00 per year. Many articles are published in the Journal of Physics: Conference Series. The types of articles published include Journal Articles and Proceedings Articles. Furthermore, the instrumentation developed consisted of 86% non-test instruments and 14% test instruments. Then, 2020 was a year that published a lot of articles. Furthermore, trend analysis on the TPACK instrument has been developed for four subject teachers, namely a science teacher, a mathematics teacher, a biology teacher, and an English teacher. The results of these findings can help researchers in reviewing the development of research trends, especially in the development of instruments for teachers and prospective teachers in other subjects that can assess professional teacher performance, and these findings help in creating novelty for further research.

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INTRODUCTION

Technological developments in the era of the Industrial Revolution 4.0 have generated very rapid world growth in the 21st century. Changes in the 21st century are marked as openness or globalization, meaning that human life in the 21st century is experiencing fundamental changes. In the educational aspect, a teacher is expected to be able to integrate information and communication technology in designing learning, both in the use of media, the selection of teaching materials, learning methods, and the assessment and evaluation process, to increase the success and achievement of the learning process for students. This is in line with how teachers are now required to be able to provide effective, efficient, and innovative learning in order to provide different learning experiences by utilizing existing technological advances and developments (Kurebay et al., 2023, p. 967).

Based on research data presented by Fitroh Setyo Putro Pribowo (2017), 100% of teachers agree that technology makes it easier for teachers to find teaching resources. Apart from that, 92% of teachers expressed the view that technological media is able to provide interesting, varied, and communicative learning. However, this is not in line with the teacher's ability to master and operate communication technology in the learning process, as it is known that 60.35% of teachers are quite proficient in technology, while 39.65% of teachers are unable to use and operate technology.

Thus, it is not surprising that most teachers who use technology in their teaching practice face many challenges and obstacles when integrating technology into their classrooms. These trends reveal that current teacher preparation programs do not provide sufficient experience in technology-based instruction, resulting in cascading effects that negatively impact teachers' use of technology.

Teacher preparation programs typically use the Technology Pedagogical Content Knowledge (TPACK) framework to outline and assess the knowledge that future educators need to use technology in their teaching successfully (Mishra & Koehler, 2006b). The TPACK framework has also been used in many studies related to the use of technology in the classroom. TPACK teacher development reports provide a comprehensive picture. According to Suqi Li et al. (2022, p. 1), the higher the teacher's education level, the better the teacher's TPACK ability, so that educational programs for teachers will be able to form and increase self-confidence in using technology and increase the effectiveness of their learning. Conceptually, the TPACK framework contains three main elements of knowledge in developing skills and competencies as professional teachers, namely content/teaching materials, pedagogy, and technology (Cheng et al., 2022, p. 3). Furthermore, in terms of domains, the TPACK framework is divided into 7 important domains that are integrated with each other, namely Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and Technological Pedagogical and Content Knowledge (TPACK). As depicted in Figure 1 below:
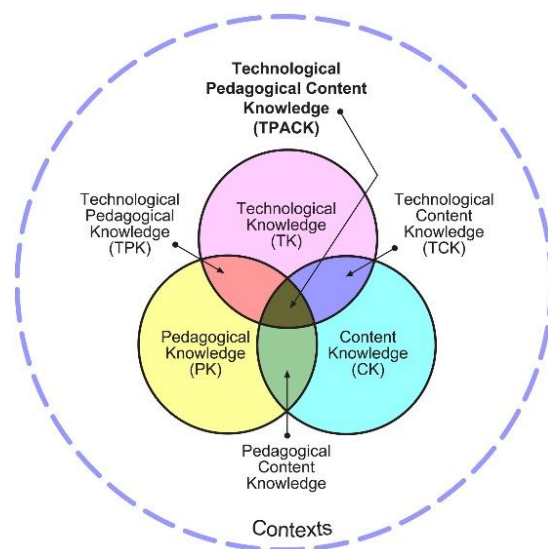

Figure 1. TPACK Framework

The TPACK framework for prospective teachers has become the focus of several countries in improving the curriculum and making technology-related courses a step in developing TPACK abilities (Dalal et al., 2017). Apart from that, a good assessment process can also support the achievement of good learning. The assessment process is a step in measuring learning achievement and collecting student information about learning. According to Nkalane in Yusop (2023, p. 2), the assessment process is carried out with the aim of: first, collecting evidence of achievement results; second, evaluating the results of achievements; third, summing up the list of findings obtained; and fourth, using existing information to determine the direction of learning goals for students. The student assessment process uses assessment instruments, which can take the form of test assessment instruments or non-test assessment instruments (Mustakim et al., 2023, p. 2). According to Docktor and Heller (2009) in Amalia, N. F., & Susilaningsih, E. (2014, p. 1381), assessment instruments are an important unit that needs to be prepared in the process of teaching and learning activities. Assessment is the most important part of teaching and learning activities, which aims to measure learning outcomes by looking at their suitability to learning objectives (Yusop et al., 2022, p. 2). So it is important to have a valid and reliable assessment instrument. As Suraji (2019) explains, a valid and reliable assessment instrument will make it easier to obtain information regarding the accuracy of ongoing learning objectives.

The development of instruments using the TPACK model has become a special attraction since this model was developed and published (Mishra & Koehler, 2006a, p. 1018). In this study, researchers will examine article documents related to trends in the development of TPACK instrument development research from 2019–2023 through bibliometric analysis.

METHODS

This research is analytical research using bibliometric methods. Bibliometric analysis is an analysis process that uses quantitative methods to analyze publication and citation study data (Donthu et al., 2021). The bibliometric analysis process is an appropriate step in analyzing publication studies by looking at the level of influence and contribution value of the research (Ying et al., 2023). Furthermore, this bibliometric analysis process can be termed infometrics or scientometrics. This process becomes a unified evaluation process for research. The application of bibliometric analysis helps to see how much influence the results of article publications have on the study review. This bibliometric analysis study focuses on meta-data from articles discussing the development of assessment instruments within the TPACK framework from the Scopus database. Metadata collection was carried out in July 2023 by searching for article metadata from 2019 to 2023. The initial metadata search process produced data for 120 article documents. The initial analysis process was carried out by providing criteria and limitations to the documents obtained, such as: a) articles that did not explain the instrument development process; b) article types such as review articles and book chapters; and c) incomplete article metadata. The criteria and limitations set by researchers make it easier to focus studies during the process of bibliometric analysis of documents that discuss instrument development within the TPACK framework. Document data obtained from initial analysis using Microsoft Excel and Mendeley software obtained data on 59 article documents with complete metadata and could be further analyzed using bibliometric methods. Bibliometric analysis was carried out with the aim of seeing the development trends and main topics in cases or studies of the development of TPACK database assessment instruments in the last five years by looking at citation levels, publisher journal sources, types of articles published, types of instruments developed, and publication trends by looking at network

visualization, overlay visualization, and density visualization based on the title and abstract of the article document. The publication trend analysis process was carried out with the help of VosViewer analysis software.

RESULTS AND DISCUSSION

Data analysis of article documents with the theme of developing TPACK assessment instruments shows that there are at least 59 article documents published in the Scopus database from 2019 to 2023. The development of publication trends in the world of education makes researchers want to examine how much influence published article documents have on the development of studies in the education world. This analysis is done by looking at the level of citations or citations of article documents as references from several other researchers.

Table 1. Top 10 Articles Cited

No	Authors	Title	Year	Cited
1	A Habibi, F Dina Yusop, R A Razak	The role of TPACK in affecting pre-service language teachers' ICT integration during teaching practices: Indonesian context	2020	84
2	D Miguel-Revilla, J M Martínez-Ferreira, M Sánchez-Agustí	Assessing the digital competence of educators in social studies: An analysis in initial teacher training using the TPACK-21 model	2020	59
3	C S Chai, J Hwee Ling Koh, Y H Teo	Enhancing and Modeling Teachers' Design Beliefs and Efficacy of Technological Pedagogical Content Knowledge for 21st Century Quality Learning	2019	54
4	Y Dong	Exploring the Structural Relationship Among Teachers' Technostress, Technological Pedagogical Content Knowledge (TPACK), Computer Self-efficacy and School Support	2020	47
5	A Habibi, F D Yusop, R A Razak	The dataset for validation of factors affecting pre-service teachers' use of ICT during teaching practices: Indonesian context	2020	35
6	I M Gómez-Trigueros, M Ruiz-Bañuls, D Ortega-Sánchez	Digital literacy of teachers in training: Moving from icts (information and communication technologies) to lkts (learning and knowledge technologies)	2019	31
7	C S Chai, M.S.-Y. Jong, H B Yin, M Chen, W Zhou	Validating and modelling teachers' technological pedagogical content knowledge for integrative science, technology, engineering and mathematics education	2019	26
8	C Kadıoğlu-Akbulut, A Çetin-Dindar, S Küçük, B Acar-Şeşen	Development and validation of the ICT-TPACK-science scale	2020	18
9	M Ozudogru, F Ozudogru	Technological pedagogical content knowledge of mathematics teachers and the effect of demographic variables	2019	16
10	N I B Elas	Development of Technological Pedagogical Content Knowledge (TPACK) for English teachers: The validity and reliability	2019	16

Based on Table 1, it shows that the article written by Habibi et al. was the first article with the highest number of citations, 84 times cited with a ratio of 28.00 per year. Second, an article from Miguel-Revilla et al. with 59 quotes and a ratio of 19.67 per year. Third, Chai et al.'s article has 54 citations and a ratio of 13.50 per year. Fourth, Dong's article has 47 citations and a ratio of 15.67 per year. Fifth, research from Habibi et al. also received 35 quotations and a ratio of 11.67 per year. Furthermore, in terms of development, the topic of TPACK will actually continue to be a study that highlights developments in the world of education. The TPACK concept is one of the 21st century competencies that teachers must have (Nevrita et al., 2020). The TPACK concept is a concept that can answer the demands of 21st century learners, so it can be used as a concept in designing curricula for teacher education (Vera et al., 2023, p. 1799). The TPACK concept, which discusses the use of technology and the ability to integrate technology into student learning, is an important point in the TPACK model study. Therefore, various educational and technology journal sources have become a place for several researchers to publish article documents explaining the phenomenon and studying the TPACK concept.
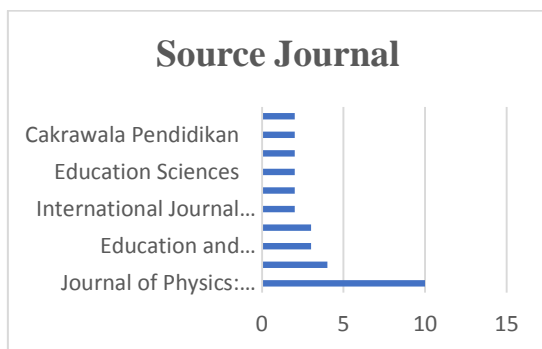

Figure 2. Top 10 journals discuss articles on the topic of instrument development within the TPACK framework

In Figure 2, The TPACK topic is at least evenly published in several educational journal sources. "Journal of Physics: Conference Series" is the place where the most articles are published, with 10 article documents discussing the development of the TPACK instrument. Then the "Journal of Research on Technology in Education" published four article documents, and the journals "Education and Information Technologies" and "AIP Conference Proceedings" published three article documents. Then, from the 59 existing article documents, researchers examined the types of articles published in several journals. It was found that 45 articles were journal articles and 14 documents were proceeding articles, as can be seen in Figure 3.
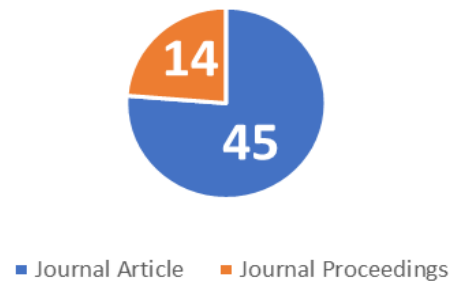

Figure 3. Article Type

The topic of the study of research developments that examine instrument development within the TPACK framework actually makes the model or type of instrument developed become part of the analysis, as can be seen from Figure 4. Regarding the type of instrument developed, 86% of the 59 article documents, or 51 article documents, developed instrument non-tests such as questionnaires, surveys, questionnaires, observations, performance assessments, and self-assessments. Meanwhile, 14%, or 8 article documents, developed test instruments in the form of multiple-choice questions.

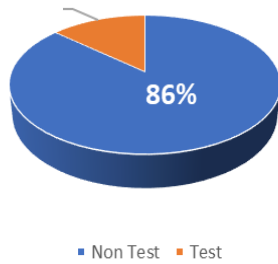## Type of Instrument Developed

Figure 4. The Type of Assessment Instrument Developed

Bibliometric analysis can be done with the help of Vosviewer software. Conceptually, the data mapping analysis process can be carried out in two steps, namely using scaling techniques and grouping techniques. In this study, the author will use data analysis by mapping data according to grouping techniques. The data analysis process through Vosviewer software can help create mapping using a co-occurrence matrix. The data analyzed amounted to 59 article documents. Vosviewer software can be used to draw maps based on keywords from the title and abstract of article data. Apart from that, using Vosviewer software can reveal keywords or word items that are related to each other and can show relationships based on the distance between one word and another (McAllister et al., 2022).

The analysis output from the Vosviewer software produces three separate visualization maps, namely network visualization, overlay visualization, and density visualization. These three output results are depicted in groups of various colors called clusters. According to Aribowo (2021), the mapping of bibliometric analysis results shows several bibliometric network patterns. Meanwhile, the existing cluster pattern is useful for obtaining study groups. As for network visualization, it is depicted in figure 5 below.
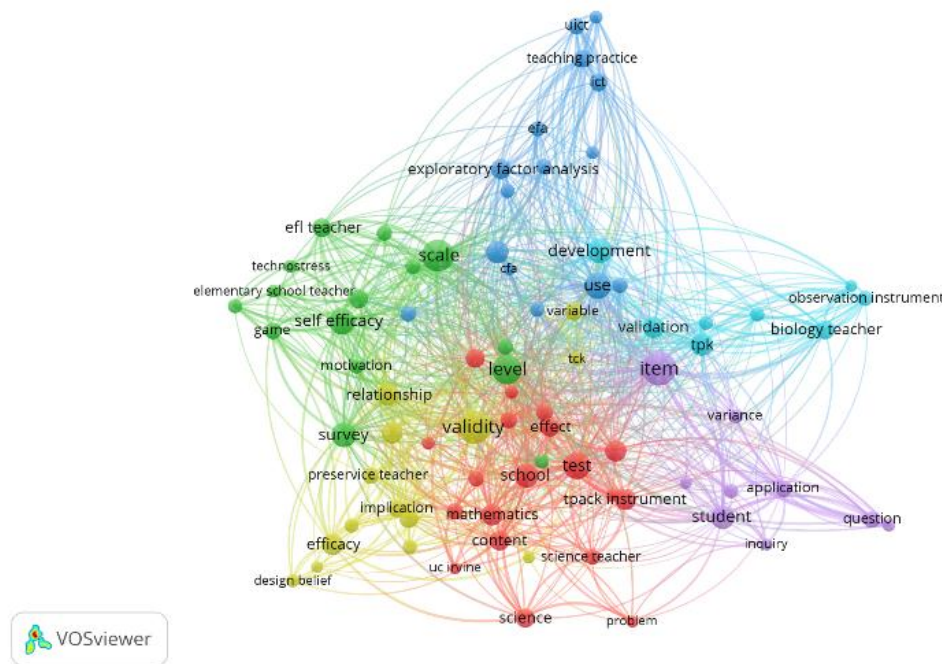

Figure 5. Network Visualization Based on Scopus Database

Based on Figure 5, it explains the network visualization of 59 article documents by displaying nodes or items that are scattered and interconnected. These nodes represent keywords or the frequency of words that appear in the article theme. The size of the circle node represents the number of publications or the relationship between the

keywords and the title and abstract. So from Figure 5, it can be seen that there are several nodes with different colors, which show the density and relationship between keywords. According to Aribowo (2021), the density of bibliometric analysis results using VosViewer software is visible in the primary color pattern of red, green, and blue (RGB). The color differences in Figure 5 show that clusters have formed. The distribution of keywords from this bibliometric analysis resulted in six clusters being formed. The existing keywords are contained in Table 2 below, which contains 80 items.

Table 2. Items in The Cluster

No	Cluster	Items	Elements
1	Cluster1 (Red)	19 Items	Classroom, content, educator, effect, group, instruction, mathematics, mathematics teacher, mean, pedagogical knowledge, problem, school, science, science teacher, test, TPACK instrument, TPACK model, uc irvine, university.
2	Cluster2 (Green)	15 Items	different, efl teacher, elementary school teacher, experience, game, level, motivation, scale, self-efficacy, service teacher, skill, structural equation model, survey, technology integration, technostress.
3	Cluster3 (Blue)	15 Items	CFA, dataset, efa, exploratory factor analysis, gender, ICT, information, participant, perception, pre service science teachers, significant difference, survey instrument, teaching practice, uict, use
4	Cluster 4 (Yelow)	14 Items	design belief, design thinking, efficacy, English teacher, implication, pck, pedagogy, pre service teacher, preservice teacher, relationship, Structural equation model, tck, validity, variable.
5	Cluster 5 (Purple)	9 Items	Ability, Application, inquiry, item, preservice chemistry teacher, professional development, question, student, variance
6	Cluster 6 (Light Blue)	8 Items	Biology teacher, development, empirical validity, face validity, observation instrument, technological pedagogical knowledge, tpk, validation

Based on the metadata analysis of article documents with the theme of instrument development within the TPACK framework, it can be seen that in Figure 5 Network Visualization, there are keywords such as "tpack instrument". These keywords appear to be connected with the development focus on subjects or subject teachers such as science teachers, mathematics teachers, biology teachers, and English teachers, as can be seen in Figure 6.
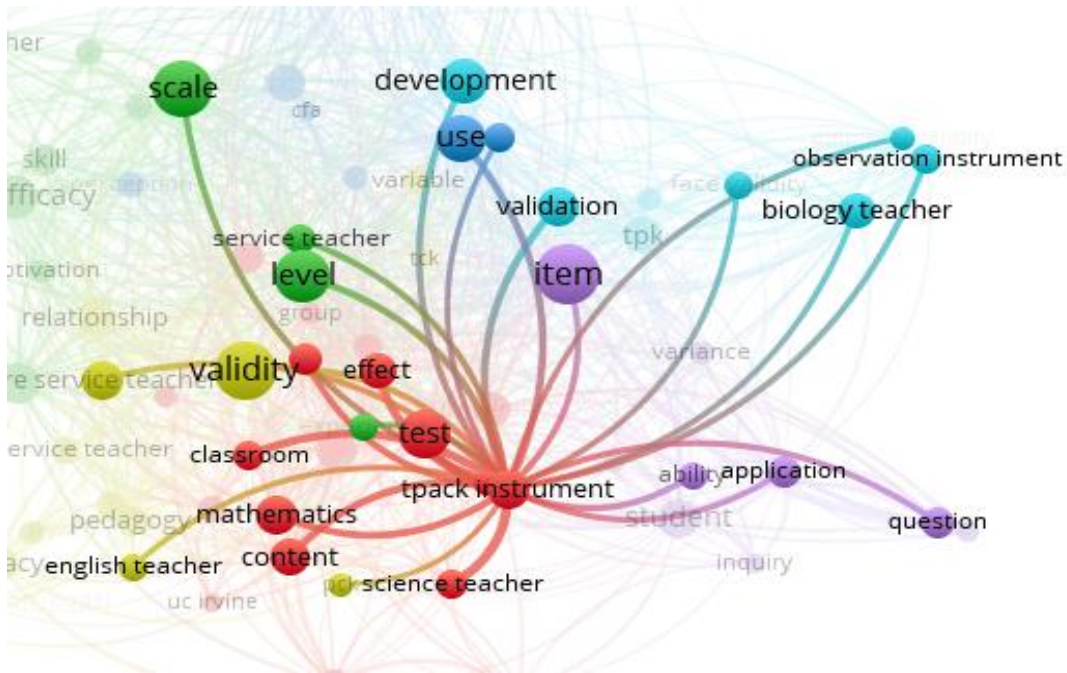
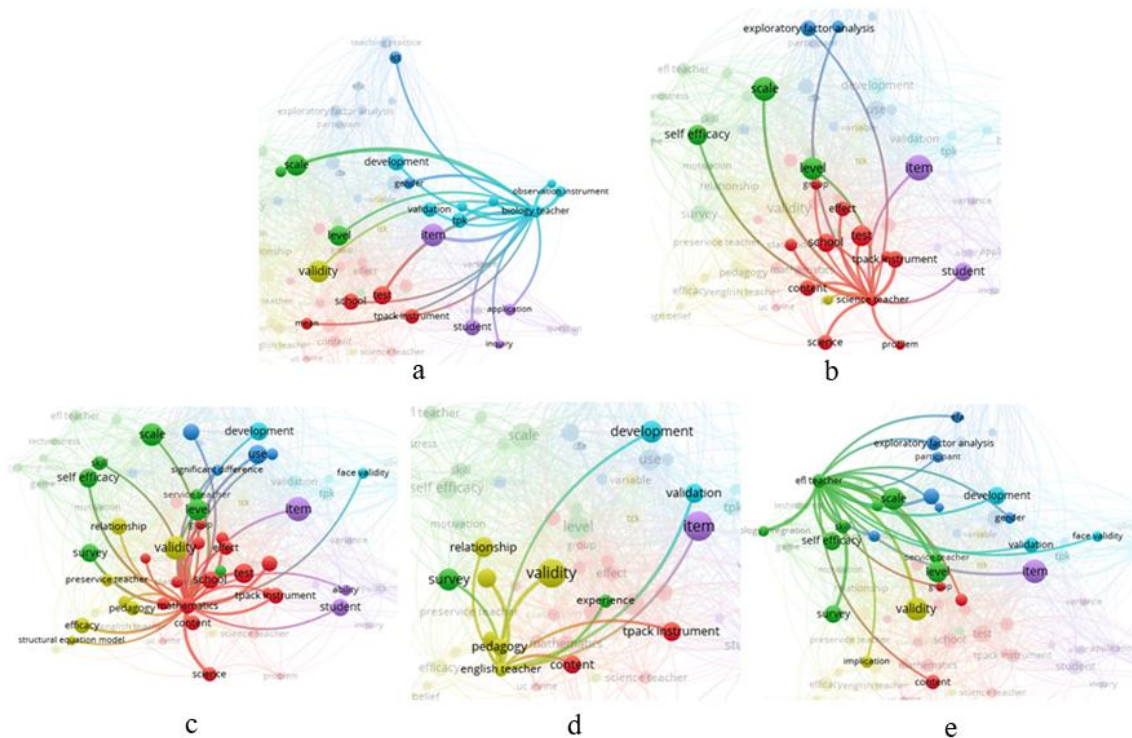**Figure 6.** Network Visualization On items: tpack instrument

Figure 7. Network Visualization On items: Subject Teacher

Figure 7. which depicts network visualization on subject teacher items where the distribution or network visualization on several subject teachers is connected to other keywords such as: a) biology teacher is known to be connected to development items or keywords such as validity, item, gender and observation instruments; b) Science teachers are connected to keywords such as Self Efficacy, Scale, items, and exploratory factor analysis; c) Mathematics keywords which are connected to several keywords such as Self

Efficacy, Scale, validity, item, test, face validity, service teacher, preservice teacher, and Structural Equation Model; d) English teachers are connected to experience, surveys, pedagogy, and validity; and e) EFL teachers are connected to several keywords such as survey, skills, scale, validity, gender, exploratory factor analysis, and face validity.
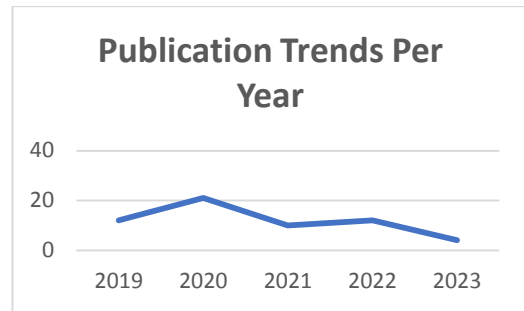

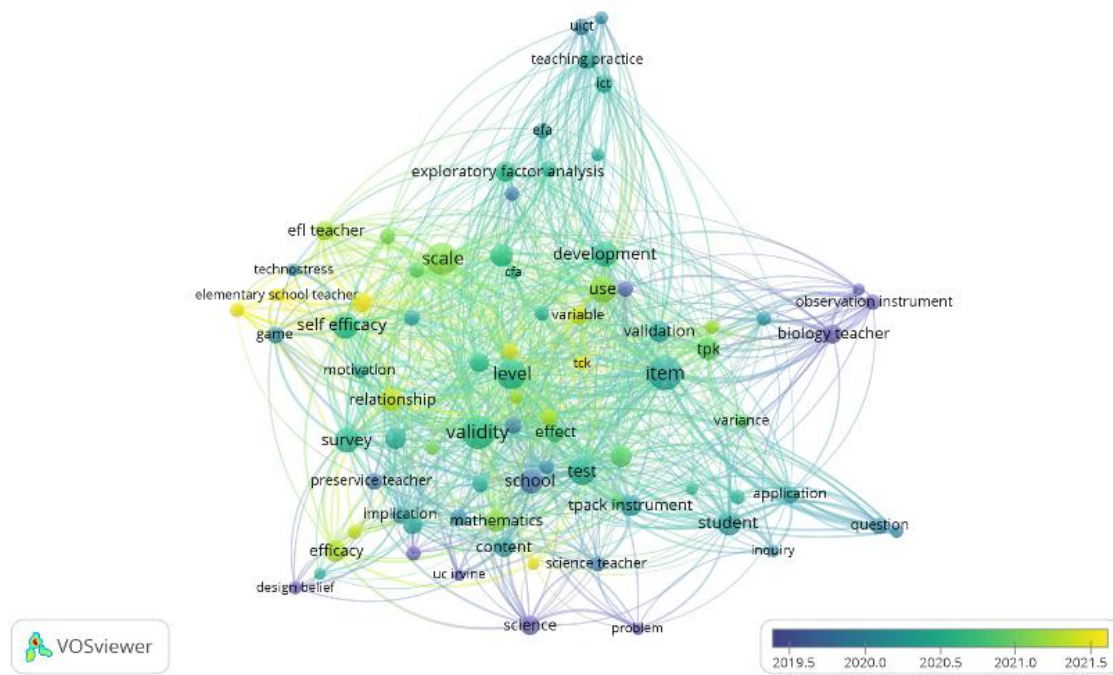**Figure 8.** Trend of a Article Publication per Year

Figure 9. Overlay Visualization Based on Scopus Database

Figure 8, the trend of publication of articles discussing instrument development within the TPACK framework from the database for the last five years, shows a decreasing trend. In 2020, there were 21 published articles, and in 2023, there were 4 research articles published. Then, to see the development of article trends over the last five years, you can see the overlay visualization in Figure 9. which depicts the relationship and distribution of keywords from the time the article document was published. Based on Figure 9, it can be seen that the distribution of keywords at the time the article was published was from 2019 to 2021. In 2019.5, which is

marked with a dark blue node, you can see several keywords that are the subject of discussion, such as instrument observation, biology teacher, science, design belief, English teachers, gender, and empirical validity. Meanwhile, in 2021.5, marked with yellow nodes, there are keywords such as technology integration, elementary school teacher, skills, TCK, PCK, and service teacher.

Based on research studies conducted by several studies depicted in Figure 9, it can be seen that the integration of technology and teacher competence in managing learning is an interesting and relevant topic to study. TPACK is a working framework concept for

teachers in utilizing technology in learning where aspects and constructions of the TPACK framework have a significant influence in developing teacher professionalism (Mailizar et al., 2021). So some of the instrument development research studied focused on several subject teachers. This is in line with the view of (Kadıoğlu-Akbulut et al., 2023, p. 11271) that the TPACK concept has become a topic of discussion in the last two decades, especially for the development of in-service and pre-service teachers. The TPACK concept, which is an integration concept between technology, pedagogy, and teaching materials, is an important point for teacher preparation programs to create professional teachers and improve the quality of interesting and effective learning. Responding to the challenges of the 21st century by improving the quality of student competence, this makes education and training programs for teachers an important part of educational development in every country (Hursen, 2021, p. 1). According to (Njiku, 2023), teacher preparation through collaborative professional teacher development will make it easier to achieve effective teacher development. However, the implementation and development of professional teachers must be accompanied by the creation of relevant technology. Apart from that, the use of good assessment instruments is most useful in teacher training and education (Martín, 2018).

CONCLUSION

The development of the TPACK instrument is actually a very interesting topic and is needed to strengthen teacher competence in learning. This is in line with educational needs in the 21st century, with advances in technology requiring teachers' ability to integrate technology. Based on metadata from the Scopus database, it is known that there are 120 journal articles that examine the topic of TPACK and 59 journal article documents that examine instrument development within the TPACK framework.

It is known that 2020 is the year with the highest number of article publications, with 21 published article documents. Then, of the total article documents, it was discovered that 45 were journal articles and 14 were proceeding articles. Furthermore, of the 59 article documents analyzed, it shows that the TPACK instrument development model was developed in the form of a non-test assessment instrument; 51 documents, or 86% of the documents, and 8 documents, or 14%, developed test instruments. All existing article documents have focused on several subject teachers, such as science teachers, mathematics teachers, biology teachers, and English teachers. The results of this analysis show that it is important to develop instruments within the TPACK framework by focusing on test instruments for several subject teachers and teacher candidates who are still pursuing professional education and training as teachers.

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