Analysis of Competence on “TPACK”: 21st Century Teacher Professional Development

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Abstract. Integrating Technology in the learning process is very important in today's digital era so that educators do not only have a component of content and pedagogical knowledge but also have to be supported by the ability to integrate both components with technology. The purpose of this study was to analyze the competence of Technology, Pedagogy, and Content Knowledge (TPACK) of Education technology alumni in supporting their profession to become professional teachers. The method applied in this study was a Mixed method, using data from alumni who graduated in 2016-2017 through questionnaires and in-depth interviews. The results showed that the variables in TPACK, content knowledge variable and pedagogy content knowledge variable had a high average compared to other variables, namely 73.50 and 73.10. This indicated that from the pedagogic and content side, Education Technology alumni had a good mastery of content and pedagogical knowledge. However, being viewed from the average score in applying technology, their competence was still low. The Technology Pedagogy Knowledge variable achieved 48.30, while the TPACK variable reached 52.40. These results imply that Education Technology alumni still need to improve their TPACK competence in order to become a professional teacher in the era of industrial revolution 4.0.

1. Introduction

Digital Era and 21st century Educational Transformation are eras of change where teachers and students will play an important role in learning activities. The role of teacher is not only as a transfer of knowledge, but also he/she is as a mediator and an active facilitator to develop the active potential of students themselves. This rapid change has consequences for teachers, prospective teachers, and education practitioners to constantly update their abilities in mastering ICT to be used as supporting media in learning activities. This is also in line with the demands on the curriculum (K-13), where teachers are expected to master technology in learning and are able to utilize and apply information technology in the learning process. Therefore, the latest learning issues and trends state that a teacher must have competence on Technological, Pedagogical and Content Knowledge or abbreviated as TPACK [1–6]

However, the reality shows that there are still many teachers who have not used and integrated technology in the learning process in the classroom. Teachers are still preoccupied on classical or conventional learning in delivering learning material, as if they are less willing to get out of comfort zones that demand to continue to innovate and update information (information and data literacy) in the current era of disruption.

For Educational Technology Study Program (S2-TeP) itself, looking at these issues and trends is a challenge to always update the information obtained. It is useful as a source to improve the quality of
learning by creating a strategic design that will eventually be integrated directly into $S2$-TeP curriculum content. This is in accordance with the definition of educational technology in 2018 from http://www.aect.org that, "Educational technology is a study and ethical application of theory, research and best practices to advance knowledge as well as mediating and improving learning and performance through the strategic design, management and implementation of learning and instructional processes and resources."

Most of the Alumni of Educational Technology Study Programs come from multidisciplinary fields, most of whom work as teachers. By seeing these trends in learning means that teachers must be able to integrate technology into their teaching. An approach that requires teaching is needed as an interaction between what teachers know and how they apply what they know in interesting circumstances or contexts in their classrooms. According to [7–9], there is no "one best way" to integrate technology into the curriculum. Conversely, integration efforts must be designed creatively or structured for certain subjects and important ideas in a particular class context.

In order to do so, has the Education technology alumni teacher really had the ability to teach well with technology that requires an understanding of the representation of concepts using technology; the ability of pedagogical techniques that use technology in a constructive way to teach content; the ability of knowledge about what makes the concept difficult or easy to learn and how technology can help to solve some problems faced by students; the ability of students’ initial knowledge and epistemological theory, and knowledge of how technology can be used to build on existing knowledge, and to develop new epistemologies that strengthen the old one ?. This means that learning must be carried out on the basis of what students know and can do as well as how they think and learn to harmonize the learning process with the performance needed, which is in line with their individual needs.'

By taking a close look at this reality, it is clear that the teacher must have excellent characteristics so that he/she can carry out his/her profession seriously in the education process. The development of these excellent characteristics must be done both when the teacher goes through the process of teacher education and when the teacher has carried out his profession as an educator [2,10,11].

Considering this, the researchers are interested in examining issues regarding Technological, Pedagogical, and Content Knowledge especially for teachers who have taken the educational process at the Postgraduate education technology Study Program. How is the implementation of TPACK competence that have been owned after their studyin supporting the profession and will also be a feedback for the Study Program towards the improvement of future study program curriculum content (continuous improvement). This research was conducted with the aim of analyzing the level of TPACK competence possessed by Education technology alumni in supporting their profession as professional teachers.

Modern learning requires 21st century skills that involve communication and collaboration skills and the use of information technology in learning. The development of learning by integrating ICT contributes significantly to the level of pedagogical practices of students. Teachers are also demanded to possess IT literacy skills in teaching with a variety of learning methods and approaches in the classroom. The latest research explains that the success of 21st century learning involves understanding material or content, teaching methods, and utilizing information technology integratedly. The idea of TPACK also has a close relationship with increasing creativity, collaboration, and accountability in learning. TPACK framework is seen in Figure 1.
Figure 1 shows three sets of their combined knowledge which are also considered important in TPACK namely pedagogical content knowledge (PCK), content technology knowledge (TCK) and pedagogical technology knowledge (TPK).

Technological Pedagogical Content Knowledge (TPACK) is a framework for integrating technology in teaching [5,12–16]. They further clarify that the three fundamental knowledge in Technological Pedagogical Content Knowledge (TPACK) are technological knowledge, content knowledge, and pedagogical knowledge and interactions between each of these two knowledges and among all these knowledges.

Technological Knowledge (TK) includes understanding how to use computer software and hardware, presentation equipment, such as presentation documents, and other technologies in the context of education. TK also covers the ability to adapt and learn new technologies. The existence of this capability needs to be held in view of the ongoing developments and technological changes. For example, the development of computers that are constantly changing from the Personal Computer (PC) to the current notebook. Yet, these computers can be used for a variety of pedagogical tasks such as research, communication and others.

Content Knowledge (CK) leads to knowledge or specificity of disciplines or subject matter. CK is different at each level (examples of differences in Primary and Secondary Schools). A teacher is expected to master this knowledge to teach. CK is also important because it determines the specificity of thinking from certain disciplines in each study.

Pedagogical Knowledge (PK) describes the general goal of the specificity of knowledge to teach. It is a collection of skills that the teacher must develop in order to be able to manage and organize teaching and learning activities to achieve the expected learning goals. This knowledge includes (but is not limited to) understanding classroom management activities, the role of student motivation, lesson plans, and learning assessment. PK also describes the knowledge of different teaching methods including knowledge to know how to organize activities in the classroom so that the construction of student knowledge (learning) is conducive.

Pedagogical Content Knowledge (PCK), referring to the statement of Shulman (1986) is that an effective teaching requires more than just a separation of understanding of content and pedagogy [1,12]. PCK also recognizes the fact that different content will match different teaching methods. For example, speaking skills in English is more appropriate with a student-centered approach so that learning is more meaningful. Unlike the lectures on art appreciation seminars, it is more appropriate to
use teacher-centered. PCK has a meaning beyond just content experts or know general pedagogical guidelines, but more about understanding of the reciprocal influences between content and pedagogy. Technological Content Knowledge (TCK) describes knowledge from the reciprocal relationship between technology and content. Technology has an impact on what we know and an introduction to new things about how we can describe content (material) in a different way that was previously impossible. For example, now students can learn the relationship between geometric shapes and angles by touching and playing the concept on the monitor screen by hand on their portable equipment. The same thing happens in visual programming software that allows students to design and create programming on their digital games. Technology enables discovery of new content or an overview of content.

Technological Pedagogical Knowledge (TPK). Technological Pedagogical Knowledge identifies the reciprocal relationship between technology and pedagogy. This knowledge makes it possible to understand what technology is appropriate for achieving pedagogical goals, and allows teachers to choose what equipment is most appropriate based on its feasibility for a particular pedagogical approach. Technology can also provide new methods for teaching that make it easier to apply in class. For example the emergence of online learning requires teachers to develop new pedagogical approaches that are appropriate.

Technological Pedagogical Content Knowledge (TPACK) describes the knowledge synthesized from each field of knowledge that has been described previously (Technological Knowledge, Content Knowledge, Pedagogical Knowledge, Pedagogical Content Knowledge, Technological Content Knowledge, and Technological Pedagogical Knowledge), focusing on how technology can be made specific which is suitable with a pedagogical need to teach the right content in a particular context. Each element of the knowledge field describes a need and the importance of these aspects in teaching. Yet, for effective teaching requires more than each part of it. For teachers with Technological Pedagogical Content Knowledge (TPACK), technology knowledge, pedagogy, and content are synthesized and used to design student learning experiences.

The Technological Pedagogical Content Knowledge (TPACK) framework also functions as a theory and concept for researchers and educators in measuring the readiness of prospective teachers and teachers to teach effectively with technology. TPACK affects teachers. This is due to the relationship between technology, pedagogy, and inherent content. Therefore, teachers face major challenges in shifting technological change, pedagogy, subject matter and the current class context. Teachers should be more active as curriculum designers[1–4,16–18].

In addition to impacting the teacher, TPACKalso affects teacher educators. Among the various learning approaches, a teacher educator should emphasize how teachers integrate technology in their teaching practices rather than emphasizing what teachers integrate into their teaching practices. The approaches that can be taken include technology by design learning and learning technology by activity types. The development of TPACK should begin with a variety of simple technologies which are known to be gradually upgraded to more sophisticated ones.

Preliminary studies have been conducted through the Forum Group Discussion among Educational Learning Technology Study Programs throughout Indonesia under the auspices of Indonesian Educational Technology Study Program Association (APS-TPI) held in Denpasar, March 4th, 2018, which agreed on several things and one of them was the importance of competence on TPACK for teachers, prospective teachers, and education practitioners (including lecturers) in the current digital era to support the improvement of the quality of learning. To reach this mission, it is necessary to have an in-depth study/analysis and get input or feedback from students, especially alumni who are teachers/instructors in improving curriculum content according to the needs of the community or stakeholders. Data on the number of Education technology teacher alumni are obtained from the results of tracer studies conducted in 2016. The data used are alumni who passed in 2016-2017.
Research on TPACK has been carried out by [18]. The study examines around 74 literature including journals and articles related to TPACK. The results of the study indirectly state that teachers need TPACK for effective learning in the classroom, however, more in-depth research on TPACK still needs to be done[1]. Similar research has also been carried out by [19] by analyzing Thermodynamics textbooks with TPACK concept to strengthen student learning competencies. The results obtained show that it is very necessary for TPACK-based thermodynamic modules that support students' conceptual understanding.[4,20] measured the teacher performance quality using TPACK model, which is useful in providing information and knowledge about which variables are most influential in TPACK. The objects of this research are teachers of subjects which are examined nationally (Mathematics, Science, Indonesian, English) in Pasuruan Regency. The results show that Technology knowledge variable with the role of indicators that provide the greatest contribution in the form of technical capabilities in using technology.

The three results of the studies reveal that TPACK has a significant impact on teacher and teacher educators. TPACK framework describes various types of knowledge that teachers need to teach effectively with the help of technology and various complex procedures in the field of interaction of knowledge. Based on this, the researcher was interested in analyzing the competence of TPACK of Educational Technology alumni teachers to support their profession to become professional teachers, as well as indirectly to give feedbacks on the management of Education technology Study Program on curriculum content that should always be updated in accordance with current development era, so that the quality of learning can be improved or even become better.

2. Method
The method applied in this research was a Mixed method using the ex-post facto research design. It’s mean that the researcher did not give treatments to the objects of the study. Researchers only took data without any changes. From all the tracer study data that have been conducted in 2016, the researchers took samples of students who graduated in 2016-2017 consisting of various scientific disciplines such as English language teachers, PPKN (Education on Pancasila and Citizenship), Religion, Social Sciences, Indonesian Language, Mathematics, Natural Sciences, and Economics /Accounting. They filled out the respondent's data. The number of 2016-2017 alumni taken by researchers was based on their willingness to fill in the TPACK instrument adopted from the article by Onal in the Journal of IOJES [20] which was modified by the researchers so that it could be used in multidisciplinary fields. In addition, researchers also conducted in-depth interviews with respondents before giving a questionnaire to be filled out. Table 1 shows the method and instruments to collect data.

| Kinds of Data | Source of Data | Method | Instrument | Time |
|---------------|----------------|--------|------------|------|
| Quantitative & Qualitative Data | Determined Alumni 2016-2017 | In-depth interview | interview guidelines | After filling out the respondents’ biodata |
|                |                | questionnaire | Modified questionnaire | After in-depth interviews |
|                |                | Data processing | SPSS ver 13.0 | After all data were collected and compiled |

Table 1. Methods and Data Collection Instruments

Source: primary data of alumni S2 TeP
### 3. Results and Discussion

Technological Pedagogical Content Knowledge describes the knowledge synthesized from each field of knowledge that has been described previously (Technological Knowledge, Content Knowledge, Pedagogical Knowledge, Pedagogical Content Knowledge, Technological Content Knowledge, and Technological Pedagogical Knowledge), focusing on how technology can be made specific to be relevant with the pedagogical needs to teach the right content in a particular context. Each element of the knowledge field explains the need and importance of these aspects in teaching. But for effective teaching, it requires more than each part of it. For teachers with TPACK, technology knowledge, pedagogy, and content are synthesized and used to design student learning experiences.

The competence of TPACK of the education technology study program can be seen from the results of the questionnaire they filled, in which 55% of teachers stated that they were able to integrate their subject matter with learning strategies and relevant new technologies in their lesson planning, 61.7% of teachers have used technology as a tool to help in evaluating during the learning process. While 45% of teachers stated that they used technology to measure students’ initial knowledge and 38.3% of teachers used technology to identify students' misconceptions. Then, 51.7% of teachers used technology to strengthen students’ skills and understanding. Furthermore, 63.3% of teachers have used technology effectively in providing examples in the textbook, but only 31.7% of teachers were able to meet the demands of their students in online learning. In terms of the competence to integrate technology correctly and effectively, only 60% stated that they were competent, so that it was easier for the students to understand the material. Next, 65% of teachers were able to coordinate with fellow teachers in terms of content, technology and learning strategies in accordance with their subject matters. From all of the statements that have been completed by the respondents, it can be recapitulated the average percentage of each variable measured using the Likert scale as seen on table 3.

| No | TPACK-formed Variable                                      | Average (%) |
|----|-----------------------------------------------------------|-------------|
| 1  | Technological Knowledge (TK)                              | 62.90       |
| 2  | Pedagogical Knowledge (PK)                                | 69.70       |
| 3  | Content Knowledge (CK)                                    | 73.50       |
| 4  | Technological Pedagogical Knowledge (TPK)                 | 48.30       |
| 5  | Technological Content Knowledge (TCK)                     | 68.00       |
| 6  | Pedagogical Content Knowledge (PCK)                       | 73.10       |
| 7  | Technological Pedagogical and Content Knowledge (TPACK)   | 52.40       |

Source: primary data of questionnaire result

The Technological Knowledge (TK) competence possessed by the education technology study program alumni viewed from the recapitulation on table 3 was 62.9%, which means that alumni master the existing technology. This can be seen in the statements written on the evidence or descriptions they made on questionnaires such as, It is usual for them to use simple word, excel, power point, and flash as well as internet technology in virtual classes, such as the quipper application in the learning and assessment process. Teachers of Mathematics, English, ICT and PDP Islamic Studies answered optimistic “almost or very competent [4,5]” on the Technological Knowledge. In contrast, teachers of Economics or Natural Sciences chose “no or slightly competent [1,2]”.

Then the Pedagogical Knowledge (PK) achieved 69.70%. This result was influenced by the length of service as a teacher, the longer they were in service the more honed the pedagogical competence. The respondents involved were nine (9) people who had served more than ten (10) years and three (3) people under ten years, so that experience played an important role in the pedagogical competence of the teacher.

Content Knowledge (CK) reached 73.50% which means that the alumni teachers were very competent in their fields and their placement in the current position is in accordance with their competencies. They have been able to use their knowledge and apply learning strategies to solve
classroom problems. This is in line with the opinion of Harlen & Holroyd [21] stating that strong content knowledge from a teacher will have a positive influence on decision making related to changes in teaching strategies. This is intended to create better learning opportunities. A teacher who has good content knowledge will be able to construct material elements simultaneously in working memory, paying attention to students’ initial knowledge by giving direction, material is not delivered at once or considering prerequisite knowledge.

Whereas the competence of Technological Pedagogical Knowledge (TPK) attained 48.30%, which means that the alumni teachers still have not implemented the technology fully in learning especially online learning. This can be caused by the supporting infrastructure has not been facilitated properly, so that learning which integrates technology is only done off-line.

Furthermore, the competence of Technological Content Knowledge (TCK) yielded 68%. This average was obtained from teachers in the field of mathematics who have used geogebra applications in learning, but for other fields of study such as science and economics, they have not used applications in classroom learning. Internet technology was used only to trace learning resources through Google and Office applications were used only for administrative purposes.

The competence on Pedagogical Content Knowledge (PCK) accomplished 73.10% which implies that the ability of the teacher to integrate content knowledge into the curriculum, teaching and characteristics of students, which can guide teachers to arrange learning situations. They have been able to teach according to the theoretical basis of the curriculum used, able to determine strategies, methods and techniques in learning relevant to their field of study, able to identify difficulties experienced by students such as misconceptions in students and being able to relate certain topic concepts to other concepts. However, there were several different statements from each teacher, namely in terms of conducting research. Apparently not all teachers were able to make research studies according to their knowledge. The experience of the teacher is very influential and plays an important role. This result is reinforced by the statement that PCK of a teacher can be the same as another teacher, but it can also be different, because PCK is personal knowledge [22]. This is influenced by the teacher’s knowledge and beliefs about the subject matter, pedagogical knowledge and beliefs, knowledge and beliefs about the context, including students in it [23]). PCK is also influenced by teacher teaching experience [5,23,24].

The competence of Technological Pedagogical and Content Knowledge (TPACK) gets an average score of 52.40% which means that alumni teachers have not optimally utilized technology that is integrated in the content learning in the classroom. In TPACK instrument, it appears that not all teachers have integrated TPACK in lesson planning, as an evaluation tool during learning, and measuring students’ initial knowledge. The teacher has never done online learning because the facilities are not yet available in their respective schools. However, integrating technology in the classroom to facilitate students in understanding material has been done well such as visualizing abstract material into concrete with simple flash, using video on storytelling material, and using powerpoint in teaching in the classroom.

4. Conclusions and Suggestions
From the results and discussion that has been described above, it can be concluded that the alumni have not implemented TPACK optimally to support their profession as professional teachers. The teaching experience plays a very important role in TPACK. Optimal learning can be obtained if a teacher has a number of knowledge, including the ability to form learning goals, create evaluation tools, select subject matter relevant to learning objectives and relevant to the evaluation tool, design learning experiences, and the ability to lead students to master the subject matter and integrate it into a technology. Facilities and local government support are needed in integrating technology in schools to face the digital era during the 4.0 industrial revolution.
References

[1] Rosyid A 2016 Technological Pedagogical Content Knowledge: Sebuah Kerangka Pengetahuan Bagi Guru Indonesia di Era MEA Semin. Nas. Inov. Pendidik. 446–54
[2] Lestari S 2015 Analisis Kemampuan Technological Pedagogical Content Knowledge (TPACK) pada Guru Biologi SMA dalam Materi Sistem Saraf Semin. Nas. XII Pendidik. Biol. FKIP UNS 2015 1 123–36
[3] Yusuf AY, Engin Karadag M B A 2016 ICT Integration of Turkish Teachers: An Analysis Within TPACK-Practical Model Int. J. Progress. Educ. 12 149–63
[4] Puspitarinı E W and Sunaryo S 2013 Pemodelan Technological Pedagogical Content Knowledge (Tpak) Berbasis Teknologi Informasi Dan Komunikasi (Tik) Dengan Pendekatan Structural Equation Modeling (Sem) 1–8
[5] Rodr J and Montoro M A 2019 Changes in Teacher Training within the TPACK Model Framework: A Systematic Review
[6] Ostrom E 2005 Unlocking public entrepreneurship and public economies (Wider Discussion Papers/World Institute for Development Economics (Unu-Wider))
[7] Ilyas A, Ifdıl I, Ardlı Z, Fadlı R P, Erwinda L, Churnia E, Alızamı A, Dahınsı D, Rangkı İ B, Surantı Ak K and Zolı N 2018 Validation of AUM software: A counselor tool for analyse human problems on counseling and educational practice J. Phys. Conf. Ser. 1114
[8] Elen J and Bishop M J 2014 General instructional strategies Handb. Res. Educ. Commun. Technol. Fourth Ed. 347–248
[9] Cetin-berber D and Erdem A R 2015 An Investigation of Turkish Pre-Service Teachers’ Technological, Pedagogical and Content Knowledge 234–50
[10] Nurdiani N, Rustaman N Y, Setiawan W and Priyandoko D 2019 Reasoning patterns and modes of prospective biology teachers on embryology learning with TPACK framework JPBI (J. Pendidik. Biol. Indones.) 5 93–100
[11] Matthew J.Koehler, Punya Mirsha, Kristen Kereluik, Tae Seob Shin and C R G 2014 The Technological Pedagogical Content Knowledge Framework Handb. Res. Educ. Commun. Technol. Fourth Ed. 347–248
[12] Goradia T 2018 Role of Educational Technologies Utilizing the TPACK Framework and 21st Century Pedagogies: Academics’ Perspectives 6 43–61
[13] A K J, A C F, A D C, A T G and A K W 2018 Developing TPACK of university faculty through technology leadership roles Lo sviluppo di competenze TPACK di docenti 39–55
[14] Lu L 2014 Cultivating Reflective Practitioners in Technology Preparation: Constructing TPACK through Reflection 13–35
[15] Kirchheimer D W 1989 Public Entrepreneurship & Subnational Government Polity 22 119–42
[16] Savec V F 2017 THE OPPORTUNITIES AND CHALLENGES FOR ICT IN SCIENCE 2. Technological Pedagogical Content Knowledge (TPACK) 5 12–22
[17] Çetin İ, Erdoğan A and Educational C 2018 Development, Validity and Reliability Study of Technological Pedagogical Content Knowledge (TPACK) Efficiency Scale for Mathematics Teacher Candidates To cite this article: Çetin, İ. & Erdoğan, A. (2018). Development, validity and reliability study of technological Development, Validity and Reliability Study of Technological Pedagogical Content Knowledge (TPACK) Efficiency Scale for Mathematics Teacher Candidates
[18] Chai, C. S., Koh, J. H. L., & Tsai C C 2011 Exploring the factor structure of the constructs of technological, pedagogical, content knowledge (TPACK). Asia-Pacific Educ. Res. 20(3) 595–603
[19] Huda C, Sulisworo D and Toifur M 2017 Analisis Buku Ajar Termodinamika dengan Konsep Technological Pedagogical and Content Knowledge (TPACK) untuk Penguatan Kompetensi Belajar Mahasiswa J. Penelit. Pembelajaran Fis. 8 1–7
[20] Önal N 2016 Development, validity and reliability of TPACK scale with pre-service mathematics teachers Int. Online J. Educ. Sci. 8 93–107
[21] Harlen, W., & Holroyd C 2007 Primary Teachers’ Understanding Of Concept Of Science: Impact On Confidence And Teaching. *Int. J. Sci. Educ.* **19** 93–105

[22] Berry, A., Friedrichsen, P., & Loughran J 2015 Re-examining Pedagogical Content Knowledge in Science Education.

[23] Rahmat A, Indonesia U P, Purwianingsih W and Indonesia U P 2016 Pedagogical Content Knowledge ( PCK ) Guru dalam Pembelajaran Biologi SMA di Kota Cimahi Pedagogical Content Knowledge ( PCK ) Guru dalam Pembelajaran Biologi SMA di Kota Cimahi.

[24] Anwar Y 2014 Kemampuan Pedagogical Content Knowledge guru biologi yang berpengalaman dan yang belum berpengalaman. *J. Pengajaran MIPA* **19**(1), 69–73

[25] Papanikolaou K, Makri K and Roussos P 2017 Learning design as a vehicle for developing TPACK in blended teacher training on technology enhanced learning