Doctoral Dissertation

Development of the Instrument to Measure Technological Pedagogical Content Knowledge (TPACK) of Pre-Service Science Teacher in Indonesia

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Abstract

This study aims to design and examine an instrument measuring the development of preservice science teachers' Technological, Pedagogical, and Content Knowledge (TPACK) in technology integration of teaching practice program. The study investigates domains i.e.: Content Knowledge (CK), Pedagogy Knowledge (PK), Technology Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and TPACK; where its derivation leads to define indicators and items development of the instruments.

A set of TPACK development instrument is produced, with as many as 116 items in 31 indicators of the TPACK tool with 6–point Likert type scales result initially from this research. Validation process on the instrument applied to 1628 respondents of preservice science teachers in Indonesia. The construct validity of the tool is examined through Confirmatory Factor Analysis using Principal Axis Factor (PFA), and the researcher applying multiple PFA method after selecting items without sharing of factor loading to ensure there is no ambiguous of items respective to the formed elements. Regarding those process, the result shows after the modification and or deletion of 49 of the survey items, the 67 items-survey are considered as a reliable and valid instrument. This instrument would help educators designing studies to assess preservice science teachers' development of TPACK. The finding shows some domain are getting less or smaller indicators and items except for the Technological Content Knowledge.

Some recommendations include in this research for the future investigation, i.e.: (1) Understanding of those preservice science teachers' TPACK affecting their practices during student teaching actions; (2) The teacher preparation program needs to take for improving on development properties of preservice science teachers' TPACK; and (3) identification of significant relationships between preservice teachers' TPACK during the program and their use of technology in their future teaching career.

Table of Content

CHAPTER 1

INTRODUCTION

a. Technology Integration and its packed framework in education

Technology has been recognized by human being before 20th century and also changed significantly over the last two centuries. Initially, term of technology refers to the study of the useful arts (George:1823), to allude technical education (Mannix, et al:2005), then as industrial arts (Schatzber:2006), tool or device (Read:1937), and as applied science or practice the way we do (Franklin:1999), until to be the pursuit of life by means other than life and technology as organized inorganic matter (Stiegler:1998). Nowadays, technology is a similarly broad way as a means to fulfill a human purpose (Arthur:2009) which can be an activity that forms or changes the culture (Borgmann:2006) as the use of scientific knowledge involving a simple or complex piece of equipment (Stylairas et al : 2011).

Technology has transformed the way members of society live and conduct business, yet despite decades of national, state, and local reform initiatives to promote technology in various of aspects, including education (Donovan, Hartley, & Strudler, 2007). Regarding technology using in the educational learning, is defined as the use to achieve learning goals and to empower students learning throughout the instructional program (Cartwright & Hammond, 2003; Koçak-Usluel, Kuúkaya-Mumcu, & Demiraslan, 2007). Even widespread innovative technology use has not evolved in education especially in the classroom (Means, 2010; Sandholtz, Ringstaff, & Dwyer, 1990) but has been proved to bring advantages while applied in learning (Arroyo, 1992; Daher, 2009; Koller, Harvey, & Magnotta, 2006),

Strudler (2010) states that field of education and technological innovations as dynamic and changing and thus contributing to new opportunities and challenges for technology integration in the reform of education. The term of technology integration itself has a broad perspective from practice and study of facilitating and enhancing the learning process (Byrnes and Etter :2008), to systemic design or deliver the instruction and curriculum and resources (Weisberg:2016), through the use of computers and related pieces of equipment in the classroom (Incikabi:2015) in educational setting for effective use in learning, both theory and practice (Delfino & Donatella: 2009; Mulder:2016; Vasin et al:2018)

In fact, educational reformers may aim to encourage technology integration, but imposed reform does not readily transfer into meaningful or authentic practices (Rakes, Fields, & Cox, 2006).Furthermore, Judson (2006) states, “technology integration is not necessarily a pillar of reformed instruction” (p. 592), suggesting that a top-down approach to integrating technology is not sufficient to meet students’ educational needs. It related with Mishra and Koehler (2007) who state that there is no ideal solution to the resulting problems associated with integrating technology into the curriculum. It seems that real educational reform efforts regarding with this technology integration focus on developing appropriate instructional strategies that merge technology use with pedagogical and curricular outcomes to prepare students for the 21st century (Ertmer & Ottenbreit-Leftwich, 2010; Onchwari, & Wachira, 2008a).

According to Lawless and Pellegrino (2007), the rapid rate of technological innovations requires teachers to base technology integration decisions on theories and research related to learning, instruction, and assessment. The emphasis on technology integration should focus on a teachers competence to achieve technological literacy across all content areas, rather than just on technological competence (Rutherford, 2004). Planning for technology integration across the curriculum presents opportunities to examine teaching and learning models which can provide teachers with a pedagogical knowledge base to augment the impact of educational improvement and reform (Shulman, 1986, 1987). Perspectives on efforts to implement effective changes in technology have been a recurring research topic with increased pedagogical emphasis on changing not just what is taught but also how subject matter is delivered (Ertmer & Ottenbreit-Leftwich, 2010; Lawless & Pellegrino, 2007; Mishra & Koehler, 2006; Prensky, 2011). As curriculum designers, teachers decide which pedagogical strategies promote meaningful and strategic technology integration across the curriculum (Harris, 2005), thus contributing to students’ learning (Mundy, Kupczynski, & Kee, 2012). Similarly, Ertmer (2005) suggests, “the decision regarding whether and how to use technology for instruction rests on the shoulders of the teachers” (p. 27). Consequently, these methods and supporting research guide teachers to strategic planning for not only how to use technology, but also “when to use technology, what technology to use, and for what purposes” (Lawless & Pellegrino, 2007, p. 581). Furthermore, the classroom teacher must engage in a pedagogical shift between traditional and new instructional practices to adopt technological changes for 21st- century learners across different contexts (Donovan et al., 2007; Wiske, 2001). Tee and Lee (2011) promote teachers with training and knowledge thoughtfully discern how to choose, apply, and evaluate technological tools to enhance learners’ understanding of the content

Ertmer and Ottenbreit-Leftwich (2010) suggest that context, including content and the school culture, influence a teacher's decision to integrate technology. It is found that changes in how teachers use technology for instruction occur when teachers witness firsthand how technology-supported student-centered activities influence learner outcomes. They also state that for meaningful teaching and learning to occur, teachers must be knowledgeable in how technology, pedagogy, and content can support curricular goals as a package framework. The technological, pedagogical, and content knowledge framework as separate domains is a model which combines a teacher's knowledge, skills, and understanding of the content to transform meaningful learning experiences through pedagogical and technological context-specific solutions (Mishra & Koehler, 2006; Mishra, Koehler, & Henriksen, 2011).

From that passage, the researcher would like to put a base introduction on how essential technology integration in education, primarily focused on instruction level. It relies on teacher's competencies not only on how to use technology, but also when to use technology, what technology to use, and for what purposes as a package of separate knowledge domain, i.e. technology, pedagogy, and content.

b. Framework of Technological Pedagogical and Content Knowledge (TPACK)

Although technology, pedagogy, and content are three different knowledge domains, the interactions of these three domains which consist of the technological, pedagogical, and content knowledge framework, thus representing the knowledge that teachers need to integrate technology effectively. Shulman proposed PCK to describe the relationship between content and pedagogy. Mishra and Koehler (2006) introduced their theory comes after five years of studying teachers at all different grade levels with design experiments to see how their classrooms operated. He argued that modern digital technologies (ICT) had changed the nature of the classroom sufficiently to justify extending Shulman's model to incorporate the intersections of technological knowledge (TK) with both content knowledge (CK) and pedagogical knowledge (PK). It produced three more intersections (TPK, TCK, and TPCK) as represented in Figure 1. Mishra & Koehler (2006) do not argue that the concepts described by the TPACK framework are entirely new, but what distinguishes their approach is their articulation of the relationships and interplay among the three core domains.

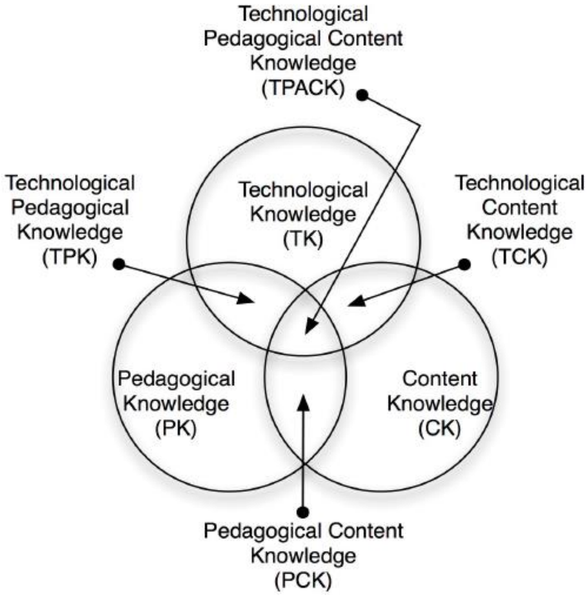


Figure 1. Technological Pedagogical Content Knowledge (TPACK) Framework [Mishra and Koehler (2006)]

The TPACK framework provides teachers with an understanding of how to learn and how to think about technology to meet learner outcomes based on content or pedagogical approaches within specific contexts (Koehler & Mishra, 2005). This type of understanding about teachers' thought processes also provides insight into teaching staff' varying levels of technology use for specific purposes. This framework heightens the teacher's role as a curriculum designer to integrate technology judiciously (Tee & Lee, 2011) through a dynamic relationship among technology, pedagogy, and content knowledge rather than just repurposing existing technological resources (Mishra et al., 2011).

It can be said that TPAK is the set of knowledge that teachers need to teach their students a subject (content), teach effectively(pedagogy), and use technology (Technology). Teachers' TPACK represents three kinds of knowledge for integrating technology across content areas (Mishra & Koehler, 2006, 2007). Flexible planning using these three knowledge components provides teachers with a framework to strategize for technology integration within specific instructional contexts, specifically one-to-one technology-enhanced environment (Koehler & Mishra, 2008). There are increased demands for teachers to integrate technology effectively; providing one-to-one technological access alone is not a practical solution to technology integration (Inan & Lowther, 2010). Mishra et al. (2011) recommend transforming learning by connecting teachers' TPACK with the seven cognitive tools of perception, patterning, abstracting, embodied thinking, modeling, play, and synthesizing. These tools provide teachers with universal applications for repurposing existing tools within different contexts and across content areas for specific pedagogical purposes (Koehler & Mishra, 2008; Mishra et al., 2011).

The teaching and learning context is an integral part of the TPACK framework. Consequently, when teachers integrate one-to-one technology, the setting should also reflect teachers' awareness of an individual learner's physical, linguistic, social, psychological, and cultural aspects for acquiring knowledge as the affordances and constraints of technology in planning for efficient and equitable use (Kelly, 2008). Kelly identifies the following three types of context elements that teachers should consider when integrating technology for individual students:

1. equity issues that apply across content areas such as student preferences or learning styles;
2. equity issues unique to individual students or content areas resulting in miscommunication between the teacher and the learner, particularly in mathematics; and
3. equity issues in which some students' technology use is limited to drill and practice while other students' use is more productive or challenging.

Koehler and Mishra (2008) identify teaching with technology as a complex problem of how best to use technology for learning based on an understanding of flexible and integrated knowledge. Consequently, the technological, pedagogical, and content knowledge framework provides a practical solution for teachers to modify situational variances within teaching and learning contexts for students of diverse backgrounds and learning styles (Koehler & Mishra, 2008).

c. TPACK for Pre-Service Science Teacher

Polly and Brantley-Dias noted what teachers know and how teachers are using technology in the classrooms indicated by using TPACK in association with technology integration in learning environments (Polly and Brantley-Dias, 2009). These studies suggest the need for further research about the ways that pre-service teachers are being prepared to teach using technology tools that are rapidly changing. Thompson and Schmidt provide support for the utilization of the TPACK framework in the development of educational technology among pre-service teachers and others. They describe it as having entered a new phase in its use in research; its focus now being used in research and development, and no longer solely on developing a theoretical definition of the framework itself (Thompson and Schmidt, 2010).

The TPACK framework also has been used by other researchers in the search for insight into technology integration practices. A study by Graham and others in 2009 examined TPACK development among in-service teachers of science. Their focus was on the measurement of the confidence that the participants had in their TPACK knowledge. The TPACK constructs that the measured are TPACK, TPK, TCK, and TK. The results of this study are used to support further development of science program coordinators in strengthening the technology content knowledge (TCK) of science teachers by exposing them to technology tools especially useful in supporting science teaching. Graham (2011) study is related to this research as it suggests the need for exposing pre-service science teachers to specific technology tools that help science teaching and learning.

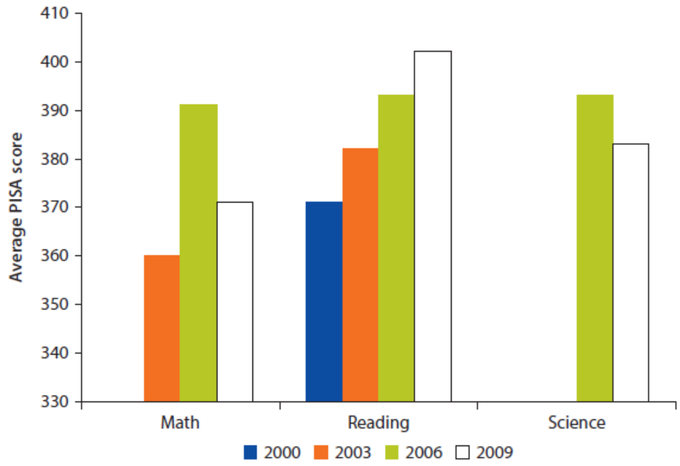
Chai and others studied the perceived development of TPACK among pre-service teachers using an adapted version of the TPACK survey designed by Schmidt and others. The study's findings and implications suggest that the pedagogical component of TPACK should be the focus first when preparing pre-service teachers for the classroom. These researchers also determined that it is important to continually provide opportunities for pre-service teachers to practice combining pedagogy with content and technology throughout their education courses to maintain strong pedagogical skills (Chai et al., 2010).

These studies provide insight into the development of the activity sequence for this study as participants needed to develop of how to best measure an understanding of pre-service science teacher on teaching science pedagogically according to the available technology tools.

d. TPACK Framework for Preservice Science Teacher in Indonesia

Science Teacher Education Programs in Indonesia have been designed by taking into account PCK (MoE:2015) which Shulman described as "the special amalgam of content and pedagogy that is uniquely the province of teachers, their special form of professional understanding" (p. 8). Shulman's work reflected in many of the current to 'content knowledge,' 'pedagogical knowledge,' and 'pedagogical content knowledge'.

The importance of technology framework is started to emphasize as responses of the result of achievement Indonesians' students in mathematics, reading, and science from four cycles of international assessment in TIMSS and PISA (OECD:2010) as follow:



Source: OECD 2010.
Note: PISA = Program for International Student Assessment.

Figure 2. Comparison Result of Mathematics, Reading and Science for Indonesian Student in PISA and TIMSS [OECD:2010]

Directorate of Higher Education (DGHE) of MoE of Indonesia through National Education Priorities on Human Development describe that for mathematics and science learning should be more focused on "Using understandable abstractions, and relationships between concept through mathematics, science impacts countless empiricism decisions students in daily life (MoEC:2015). Furthermore, ICT has been transforming in curriculum and praxis of science not as a specific subject but as Integration support for effective teaching and learning (MoEC:2015).

Nevertheless, the government mention using technology for teaching and learning is made concerning the Teachers Professional Standards for Teachers requiring four National Teacher Standards, i.e., Pedagogy, Personality, Social and Professional Competencies. Regarding with these standards, utilization of technology is mandatory needed as one of the aspects of Professional Competencies only, with less mentioned in the Pedagogy, Social and Personal competencies (MoE: 2013; Pusparini et al.:2017) both in pre-service and in-service levels. According to the Guideline of Curriculum Development of Teacher Education Institute by DGHE, there are no specific references made to TPACK in national curriculum at any subjects (MoE: 2014), but all school highly demanded technology as enrichment in learning support. The government also put pedagogic activities and strategies change in response of ICT and interactive technologies to support knowledge building, consolidation, and application of concepts to new contexts as part of Science Teacher Education Standard (MoE:2013), which emphasize for science teacher to use learning technology using ICT technology functionally, mastering technology related to his/her teaching (MoEC:2013)

Meanwhile, especially for science teachers candidates curriculum, technology integration is emphasized concerning modifying materials including strengthening underlying concepts, interaction during the lesson, students feedback methods, until making a relationship between science concept with daily lives (MoEC:2013).

Furthermore, Indonesian National Qualification Framework Competencies for Higher Education for Pre-Service Teachers demanding for integration of technology concerning utilizing current ICT development and elaborate in the classroom situation to optimize their teaching activities" (MoEC:2015)

From the passage, technology integration is demanded widely not only for science teachers but also pre-service science teacher but less description in which extend the framework of this technology integration. The explication of the frame is an essential part since it will become fundamental for further steps of measurement and skills description.

Regarding with point c and d, the essential step to investigate TPACK development on specific area (local) to pre-service teachers is to identify its properties or characteristics through initial measurement (Koehler and Mishra: 2008), and over 500 studies have been conducted on the TPACK framework and TPACK instruments for in-service teachers but less for pre-service teachers (Hofer & Harris, 2012). Furthermore, in specific case of Indonesia, some researchers investigated TPACK instruments in particular subjects such as Social, English, and including science (Cahyono et al.:2016; Mahdum: 2015; Akmal :2007, Drajati et al.: 2018), but some TPACK instruments designed for in pre-service science teacher level arisen separately such as in chemistry and biology with lack for science as a whole (Riandi:2017, Pusparini et al:2017, Agustin et al.:2018).

So, according to these arguments in the passage, it is crucial to know the characteristic of the pre-service science teacher in Indonesia concerning on TPACK development start from the initial stage through creating and examining an instrument.

e. Research Questions

Based on the background described, the central Research Question (RQ) in this research is "How TPACK as a framework of technology integration is adopted and adapted to be a set of an instrument of measuring technology integration development of pre-service teacher in Indonesia?".

To answer this research question in this case study research for pre-service science level, the researcher needs to steps from investigating the framework of TPACK for the preservice science teacher and its necessity to measure technology integration of preservice science teacher in Indonesia. Furthermore, the stage is defining indicators and items of TPACK instrument, working with validity and findings from this instrument and finally analyzing its the strength and the weaknesses.

f. Statement of the Problem

Students and teachers live in a digital age in which innovative technologies are a part of their daily lives. Nationwide initiatives are in place to expand student access to technologies in the classroom, thus increasing opportunities for teaching and learning with technology enhancement (MoE, 2013). Essentially, technology enhancement settings provide students with access to a technological device. As student access increases, so do opportunities for teachers to integrate technology for a variety of purposes to meet the needs of 21st-century skills learners.

According to Spires, Wiebe, Young, Hollebrands, and Lee (2012), increased technology access has the potential to alter the instructional environment provided the classroom teacher possesses the pedagogical knowledge to facilitate learning in a one-to-one setting. Lawless and Pellegrino (2007) maintain that teachers must stay abreast of instructional strategies for integrating content using new technologies for teaching and learning. Koehler and Mishra (2008) suggest that specific technologies have their affordances or constraints which make them applicable to completing particular tasks. Consequently, teachers must "reject functional fixedness" (p. 17), looking beyond the apparent features of technology to repurpose technologies to provide educational opportunities for 21st-century learners (Koehler & Mishra, 2008).

The context of technology integration environment provides an opportunity to explore science teachers' adaptation of TPACK to integrate technology effectively and advance teachers' decision making processes for curricular design and implementation. Additionally, the lack of technological support and training has been identified as an extrinsic barrier to integrating technology (Ertmer, 2005). Although over 500 studies have been conducted on the TPACK framework (Hofer & Harris, 2012), research about the TPACK framework, preservice science teacher in case of Indonesia, not only in particular subjects, within the same study are essential and have not been explored (Cahyono et al:2016, Mahdum:2015, Pusparini et al: 2017, Riyanti et al:2016, Chai et al:2017). Exploring these three factors may expand practitioners' knowledge of the TPACK framework to affect an educational change for technology integration of preservice science teacher in Indonesia.

According to those brief description, the statement of the problems as followed: There is a bunch research on TPACK framework of teachers to prepare teacher dealing with increased technology which potentially altering instructional environment with affordances, but less followed for pre-service science teacher, and for case of Indonesia pre-service science teacher, it has not been explored.

g. Objectives

The purpose of this case study research is to design and examine an instrument measuring the development of science preservice teachers' Technological, Pedagogical, and Content Knowledge (TPACK) in technology integration. The science curriculum in secondary level (both junior and high school) encompasses a range of content topics that can be taught using technology. In the future, these pre-service science teachers will serve as the curriculum director, selecting activities and resources to fulfill specific goals and objectives.

According to Mishra and Koehler (2006), the incorporation of new technology requires teachers to reconfigure their understanding of how these three elements (technology, pedagogy, and content) interact as knowing a technology does not equate to understanding how to teach using technology. Although the integration of the tools and technologies is often the result of imperatives, the technological, pedagogical, and content knowledge framework provides a language to discuss the educational connections between content and pedagogy through different technological representations and levels of access (Mishra & Koehler, 2006). Mainly for the case of Indonesian pre-service science teacher how the instrument to measure its development would be an essential tool for the understanding of those three elements.

h. Significance of the Study

As technology integration in science learning demand continues to increase, preservice science teachers will need to equip with instructional practices to support meaningful technology integration for 21st-century learners. This study may describe properties for preservice science teachers to integrate technology effectively in the classroom as one of additional reference in Documents of Indonesian National Qualification Framework (MoEC:2015). This case study research might contribute to the body of literature to increase pre-service science teachers' awareness of the TPACK framework which teacher education program directors have recognized to support technology integration endeavors across content areas in the Guideline of Curriculum Development of Teacher Education Institutes (MoEC:2014). This study may also influence the need of standards for future of teacher educator competencies to prepare prospective science teacher' technology integration as an essential component of support for technology integration knowledge.

CHAPTER 2

THEORETICAL REVIEW

This literature review begins with findings the new movement of National Curriculum in Indonesia, where technology integration is one of an essential part, particularly in the science subject. Systematically, the researcher will arrange this chapter as follow:

(a) A brief of Indonesia education system which will be presented into pictures and tables; (b) Short overview about curriculum of Indonesia time to time since independence era to the recent years particularly in terms of general properties, science, technology for schools and technology in pre-service science teachers; (c) comparison of science teacher and pre-service science teacher competencies in Indonesia. For this part of a, b, c the researcher would like to present how the competencies of science-teacher and pre-service science teacher become essential in the localize TPACK Framework in the research. This part is a core to on adoption, adaptation, and creation in the designing process of the instrument describing in chapter 4.

Regarding the TPACK, the researcher then addresses insights on the concept of pedagogical content knowledge (Shulman, 1986,1987) that led to changes in how teachers use pedagogy and content knowledge to improve instructional practices. Additionally, the researcher evaluates the technological, pedagogical, and content knowledge framework (Mishra & Koehler, 2006) through related literature to delineate applications of the TPACK framework, an example of its use in science content, including identifying and measuring TPACK.

Last but not least, the researcher will provide a theoretical review for development of TPACK instruments for the pre-service science teacher, including rational from determined types of instrument obtained. Along with particular situation in Indonesia, this part also will lead to the adoption, adaptation, and creation in the designing process of the instrument in chapter 4. From a plethora of literature review, it leads for the researcher to connect, combine and extract a theoretical review to build the body of knowledge of the instrument for this study

a. Indonesia Education System: A Glance

The Indonesia education system is vast and diverse. With around 60 million students and more than 4 million teachers in some 340 thousand educational institutions, it is the most extensive education system in the Asia region and the in the world after China, India, and the US, where educational improvement in Indonesia will bring substantial impact to Asia as well (World Bank:2014). There are two ministries responsible for managing the education system, with 84% of schools under the Ministry of Education and Culture (MoEC) about 16% under the Ministry of Religious Affairs (MORA) (WorldBank, 2017). Besides public schools, private schools play an essential role. Even only about 7% of primary schools are private, the share increase to 56% of junior secondary schools and 67% of senior secondary schools (MOEC:2013, OECD:2015, ADB:2015). Figure 3 describes the current structure of Indonesia's educational system as an interdependent series.

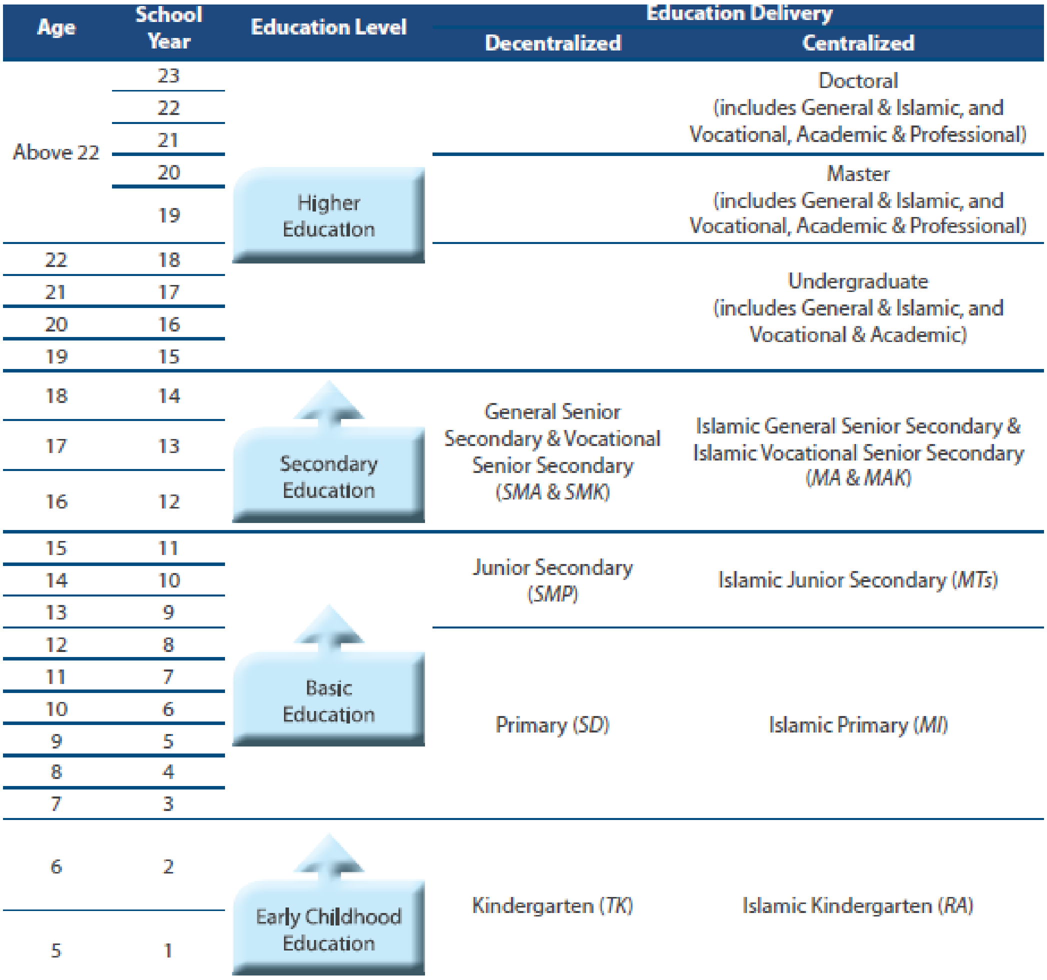


Figure 3. Indonesia education system [MoEC:2013]

Regarding with a very diverse population, geographically dispersed, and with wide variations concerning socio-economic status among the big five islands; it also brings to the distribution of people, students, institutions and teachers at the various educational levels. Table 2 shows the distribution of population, students, educational institutions and teachers in Indonesia.

Age group	Population (millions)	Educational level	Students (millions)	Number of institutions	Teachers/ professors
3-6	18.52	Early childhood*	10.60	162 753	517 858
7-12	26.04	Primary	26.77	148 272	1 682 263
13-15	12.78	Junior secondary	9.65	35 527	587 610
16-18	12.57	Senior secondary	8.46	22 780	452 041
19-23	21.19	Tertiary	5.82	3 189	209 830
Total	91.09		61.30	372 521	3 449 602

Note: * includes Play Groups, Childhood Development and Care Centres, and similar Early Childhood Education and Care programmes

Table 1. Distribution of population, Students, Educational Institutions, and Teachers, by age and level of education, Indonesia, 2013 [Education Statistics of MoEC 2012/2013]

While the share of expenditure on education by level of government is presented as follow:

	Central	Provincial	District
Early childhood	26	3	71
Basic education (primary and junior secondary)	38	1	61
Senior secondary	41	6	53
Higher education	100	0	0

Table 2. Proportion of spending in education by level of government and level of education, Indonesia, 2009 (%) Source Al-Samarrai, S. (2013)

As Table 2 shows, the districts carry the bulk of funding responsibility for primary education (61%) and account for just over half of spending on senior secondary education.

series of reforms in education since 2004 produced some fundamental laws and regulations which provided an overall framework for education sector development in Indonesia. It brings some cheer up progress for citizens generally. First of all is a commitment to allocate 20% of the national budget to education has seen increased almost triple in real terms since 2001, with spending of IDR 310.8 trillion (the US $35.3bn) in 2012 (Tobias et al.: 2014, MOEC: 2005, OECD/ADB: 2015). Furthermore, an upgrading of the teacher workforce where between 2006 and 2010, the percentages of teachers with a bachelor's degree inclined from 17% to 27% at the primary level and from 62% to 76% at the junior secondary level (Tobias et al.: 2014). A NEST is a set of new professional allowances for teachers who have completed the teacher certification process and for those who work in remote areas (MoEC: 2005). Also, a large scale of School Operations Grant program (SOG), as a way of supporting direct-funding into a sub-district level to keep children in classroom activities and provide schools some flexibility in managing their funds (MOEC:2005, OECD: 2014). Also, to support decentralization effort in general, the government has moved to anchor the principles of school-based management, where school considerable transferred decision-making authority to individual schools.

Since 2006, the enrollment for being teachers at Teacher Education Institutes are raised up almost double, school training and teacher association activities are getting bigger, and also some improvement in the quality of education occurred. Indications of Improvements in the quality of education in Indonesian showed in international tests of reading levels, with both PISA (Program of International Science Assessment) and PIRLS (Progress in International Reading Literacy Study) assessments. It reported statistically significant improvements in reading levels across 2000-2012 and 2006-2011, respectively, although there are variations in consecutive years (OECD 2013, IEA 2012). Also, OECD noted that Indonesia was one of the few countries who achieve improvements in reading performance from 2000-2009 and also narrowing gaps between the highest and lowest performance of students (OECD: 2012). This performance in mathematics, still based on PISA scores, has improved overall across 2003-2012, but the annualized change over the period is statistically insignificant.

b. National Curriculum of Indonesia: School Science and Technology and Technology for Science Prospective Teacher

Since educational reform waved in 2004, a dramatic improvement in the education sector have been occurred and could not be better since then. A commitment to spend 20% of the national budget for education brings impact in many aspects of educational improvement, including new movement of the school science national curriculum (MoEC: 2012). This movement is part of the improvement journey from school science curriculums of Indonesia. Indonesia has experienced to revise National Curriculum for 11 times since its independence in 1945. From each period of changes, science and technology also evolved in School Curriculum. In case of School Science in National Curriculum itself is evolved from the period of time as change in national curriculum since 1945 from science directly translated for daily living skills in agriculture and fisheries, increasing science to be science as content, process, and product, until becoming science as part of thinking as scientist in recent curriculum. How main properties of school science curriculum changes over time briefly presented in the following figure 4, i.e.

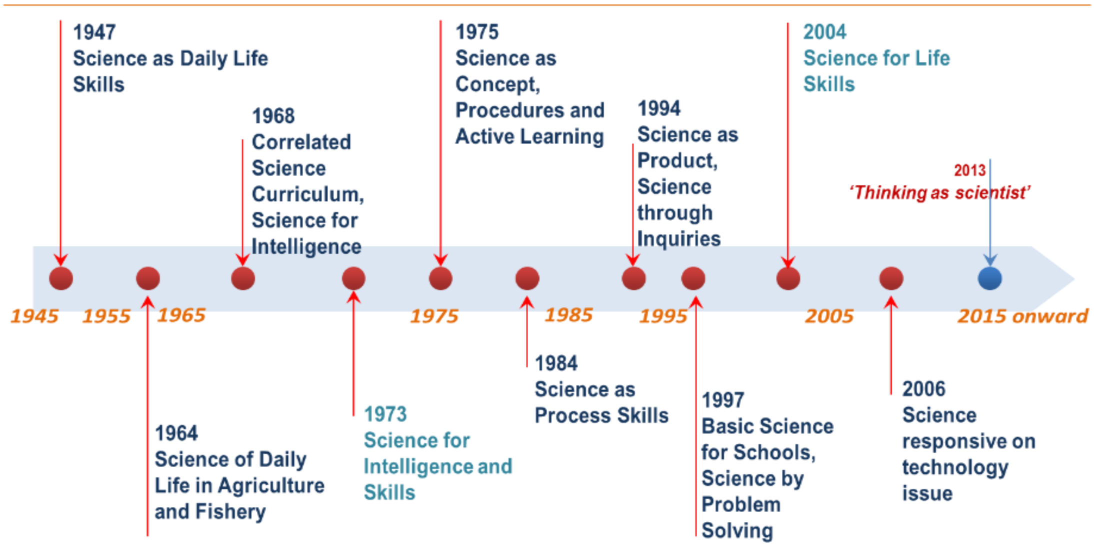


Figure 4. Main Strike of Evolution Science in School Curriculums of Indonesia

According to the overall objectives of a new curriculum, one of science education is aimed at enabling Indonesian children to utilize technology to solve the problem within daily life (MoEC:2013). This objective is matching with demand for science teacher that " . . . Shall able to elaborate technology updates and its application to support learning . . ." (MoEC:2013) This statement means technology integration, which unfortunately there is no precise definition of technology integration on it.

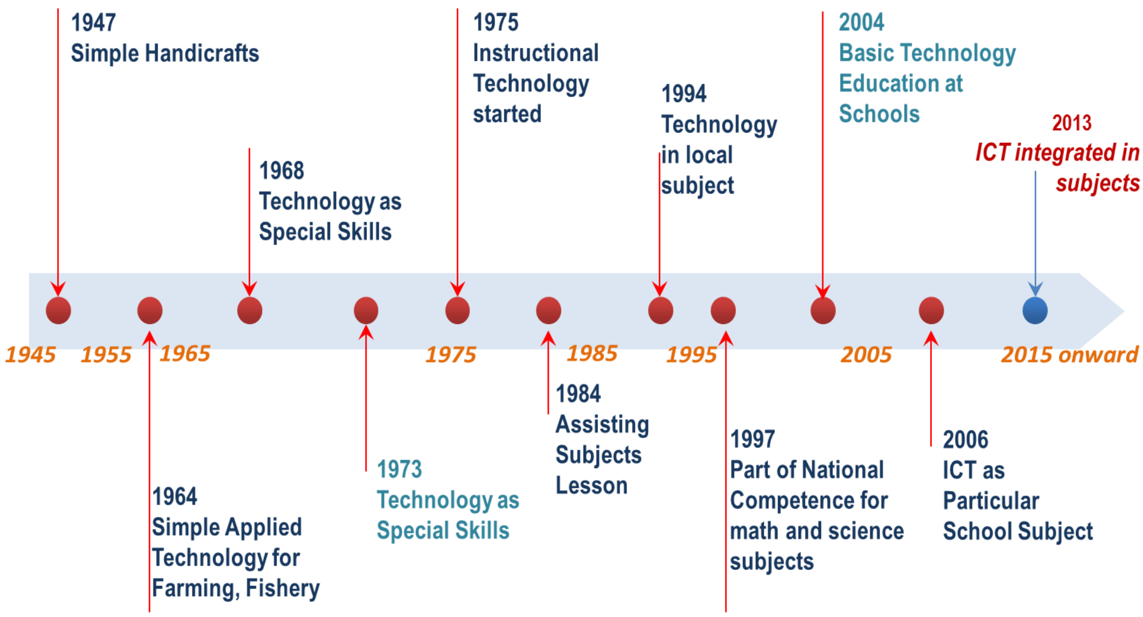


Figure 5. Main Strike of Evolution Technology in School Curriculums of Indonesia

At the same time, the presence of technology in national curriculum as timeframe showed that it evolved from pure handicraft in early practice (1945), translate to technology as unique skills (1968), assisting subject lesson (1984), become technology in local subjects (1995), and introducing primary technology education (2004), until technology means ICT as a particular school subject (2006), and recently ICT integrated into subjects (2015). How main properties of technology briefly changes overtime presented in figure 5.

As it is mandated to fulfill the need of the science teacher at the school, there is also an evolution in pre-service science teacher educators which mostly it changes follow the curriculum changes as well. In level of teacher education institute, not like science which has started to establish since 1947, the presence of technological education in a chronicle of Indonesia curriculum development is unique for technology. It was part of science education at the early existence in the country (1945), regarded as vocational core (1964, 1968), and become two cores both in vocational and science (1975), until it becomes part of pre-service science courses since 1997 until now, and separately has become new identity of ICT (1999 until now). How main properties of technology briefly changes overtime presented in figure 6, i.e.

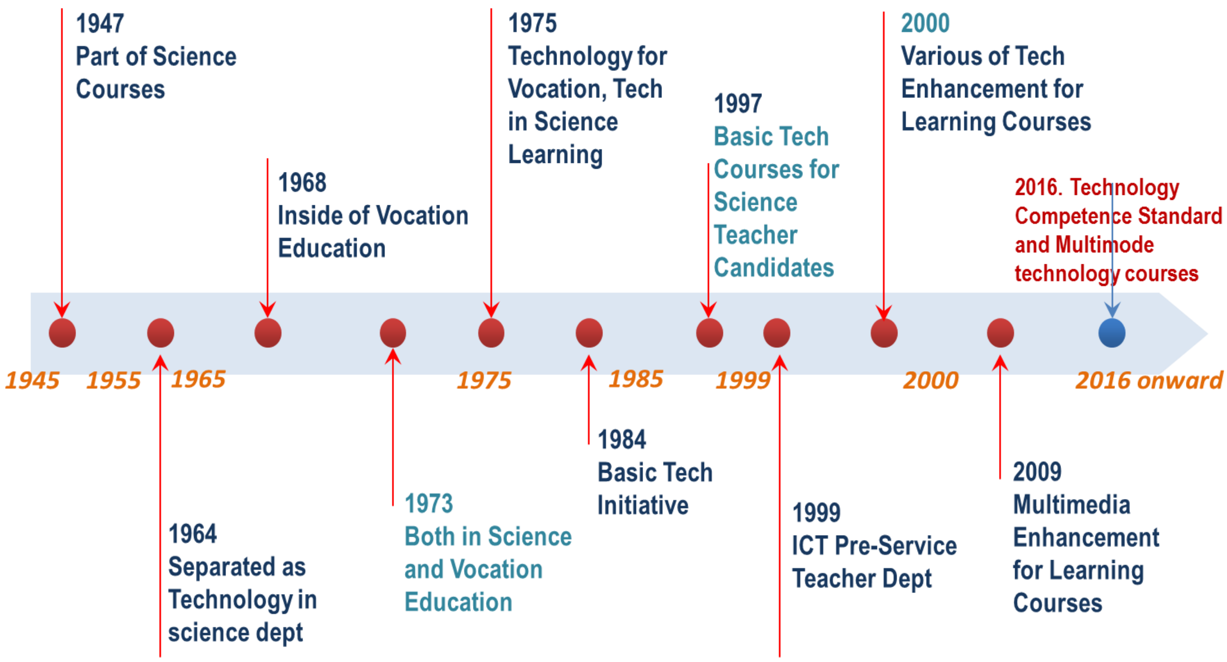


Figure 6. Main Strike of Evolution Technology in Science Curriculums for Pre-Service Science Teacher in Indonesia

c. **Science Teacher Competencies in Indonesia : in-service and pre-service**

Technology integration has not explicitly defined in the national curriculum of Indonesia. However, researchers believe that Indonesian teachers hold strong beliefs that teachers should be designers and students learning should be driven by creating digital artifacts in participatory culture (Chai et al.:2017), and teachers possess strong beliefs that education with technology should move towards the new culture of learning and teachers should be the designer for such learning (Chai et al.:2017).

As mentioned in chapter 1, The elaboration of Teacher Qualifications and Competencies is regulated by the Minister of National Education Regulation No.16 of 2007 on Teachers Qualification and Competency Standards. Teacher Competence according to National Education Articles No.16 of 2007 developed intact from four main competence, covering pedagogic competence, professional competence, personality competence, and social competence. The following table describing Competency Standards for science teachers in detail :

Types of Competences	Competences Indicator
Pedagogy	1. Understanding learners characteristics covering the physical, moral, spiritual, social, cultural, emotional, and intellectual aspects
	2. Mastering learning theories and principles of educational learning
	3. Develop a curriculum related to the subject matter
	4. Organizing educational learning
	5. Utilizing information and communication technologies for the benefit of learning
	6. Facilitate the development of the potential of learners to actualize their potentials
	7. Communicate effectively, empathically, and well mannered with learners
	8. Conducting assessment and evaluation of processes and outcomes of learning
	9. Utilizing assessment and evaluation results for learning purposes
	10. Applying reflective action to improve the quality of learning
Personality	1. The act under the norms of religion, law, social, and national culture of Indonesia
	2. Presenting as an honest person, noble character, and role model for learners and society
	3. Showing a steady, stable, mature, wise, and authoritative person
	4. Demonstrates work ethic, high responsibility, pride in being a teacher, and self-esteem

	5. Uphold the professional code of ethics of teachers
Social	1. Be inclusive, objective, and non-discriminatory due to gender, religion, race, physical, family background, and socioeconomic status
	2. Communicate effectively, empathically, and courteously with fellow educators, education personnel, parents, and the community
	3. Adopt on duty throughout the territory of the Republic of Indonesia which has socio-cultural diversity
	4. Communicate with the professional community itself and other professions orally and in writing or other forms
Professional	1. Mastering the materials, structures, concepts, and scientific mindsets that support the subjects
	2. Mastering the competency standards and foundation competencies of subjects or areas of development.
	3. Developing creative learning materials
	4. Developing professionalism sustainably by taking reflective action
	5. Utilizing information and communication technology to communicate and develop themselves

Table 3. Standard of Competence Indicators for Indonesia Science Teachers

The competences, which explicitly said for pedagogy and professional competences, are demanding pedagogic activities and strategies change in response of ICT and interactive technologies to support knowledge building, consolidation, and application of concepts to new contexts as part of professionalism (MoEC:2007). This technology integration becomes essential for teachers as mandated in Government Regulation No. 74/2008 on Teachers; it declared that teachers should have competencies " . . . . to use learning technology, using ICT technology functionally, mastering technology related with his/her teaching, and part of teacher achievement for being awarded in technology-related competition, and keep updating with technology issues . . ." (MoEC:2008, MoEC:2013).

The researcher critically puts attention about the frameworks adopted or adapted to gain this technology integration and how to obtain technology integration into the classroom learning through designated framework is lack discussed. In this study, the Standard of Competence Indicators for Indonesia Science Teachers would be an essential consideration to make a draft of the instrument of TPACK for pre-service science teachers. Based on the above description, professional competence that can be measured in the TPACK instrument includes the mastery of science materials, concepts and mindset science, master the competency standard and basic competence of science subjects, and the development of science learning materials under the competence to be achieved.

The government designed the Standard of Competence Indicators for Indonesia Science Teachers, but it is a difference in the way of formulating Standard Competence for pre-service science teachers. The competencies transforming into learning outcomes by Indonesia Science Teacher Educator Associations (ISTEA:2018) which devoted into (a) Attitude, (b) Mastery Knowledge, (c) Special Skills, and (d) General Skills as described in the following table:

Types of Competences / Learning Outcomes	Competences / Learning Outcomes Indicator
Attitude	1. Be cautious to God Almighty and able to show religious attitude
	2. Uphold the value of humanity in carrying out duties based on religion, morals, and ethics
	3. Internalize academic values, norms, and ethics
	4. Acting as a proud citizen and love of the country, having nationalism and a sense of responsibility to the state and nation
	5. Respecting cultural diversity, views, religion, and beliefs, as well as the original opinions or findings of others
	6. To contribute to the improvement of the quality of life of society, nation, state, and progress of civilization based on Pancasila;
	7. Cooperate and have social sensitivity and concern for society and environment
	8. Law-abiding and disciplined in social life and state
	9. Internalize the spirit of independence, struggle, and entrepreneurship
	10. Demonstrate a responsible attitude towards the work in the field of expertise independently
	11. Have sincerity, commitment, sincerity to develop an attitude, value, and the ability of learners
Mastery Knowledge	1. Mastering the facts, concepts, principles, laws, theories, and procedures of the science
	2. Mastering the educational foundation, learning theory, characteristics of learners, strategies, planning, and evaluation of science learning comprehensively
	3. Mastering the theoretical concepts of problem-solving in science education procedurally through a scientific approach
	4. Mastering the factual knowledge about the functions and benefits of technology, especially relevant information and communication technology for the development of the quality of science education

	5. Mastering foundation of planning and management of learning resources of classes, laboratories, schools or educational institutions
Special Skills	1. Utilizing science and technology in planning, implementing and evaluating science lesson which according to the standards
	2. Designing and applying learning resources and ICT-based learning media to support science learning
	3. Planning and managing learning resources in the classroom and school and evaluating the lesson comprehensively
	4. Researching by utilizing science and technology to solve problems in science education
General Skills	1. Applying logical, critical, systematic, and innovative thinking to develop the application of science and technology
	2. To examine the implications of the science, technology or art development based on scientific rules, procedures and ethics to produce solutions, ideas, designs, or art criticisms as well as to prepare scientific descriptions of the results of their studies in the form of a thesis or final report
	3. Making decisions appropriately in the context of problem-solving based on the analysis of data and information
	4. Managing self-regulated learning
	5. To develop and maintain networks with counselors, colleagues both within and outside of their institutions

Table 4. Standard of Competence / Learning Outcomes for Indonesia Pre-Service Science Teachers

Regarding with pre-service teachers, technology integration is indicated in the national guidelines of teacher education institutes as “ . . . Essential enhancement for teachers candidate to incorporate their pedagogy and content knowledge to mastering concepts and its contexts in the daily situation and to support teaching to the classroom effectively” (MoEC:2013). Furthermore, among Indonesian National Qualification Framework Competencies for Higher Education especially for pre-service teachers, technology integration is demanded regarding utilizing current ICT development and elaborate in the classroom situation to optimize their teaching activities (MoEC:2015).

TPACK as a framework of technology integration is essential to be adopted and to be adopted in the context of Indonesia since technology integration has been indicated as calls both informal national documents and previously mentioned research. Moreover, besides the TPACK frameworks has not been investigated a lot in Indonesia, as one of most significant education forces in South East Asia, bring TPACK framework to Indonesia would bring impacts in the future to a considerable population of education workforces as well. From these rational, the researcher decided to put on the table Indonesia pre-service teacher as the context to localize TPACK. Regarding with part of a, b, c the researcher would like to present how the competencies of science-teacher and pre-service science teacher become essential in the localize TPACK Framework in order to design and examine TPACK instrument for pre-service science teacher with the following figure:

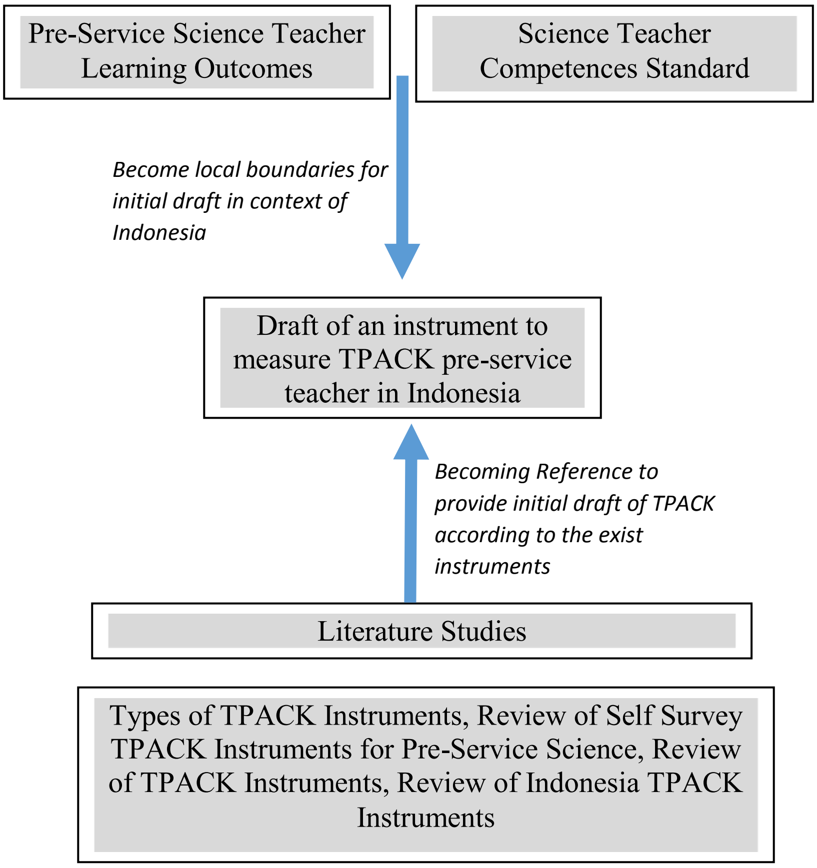


Figure 7. Localize TPACK Framework in order to design and examine TPACK instrument for pre-service science teacher

d. Technology in Pedagogical Content Knowledge (PCK)

The combination of pedagogy and content knowledge evolved into a pedagogical content knowledge framework that has influenced both the educational and research fields (Shulman, 1987). Effective teachers possess a repertoire of pedagogical knowledge skills and content knowledge skills to integrate into the curriculum to meet learners' diverse needs. Shulman (1986) identifies the omission of combined pedagogy and content knowledge as the missing paradigm of how teachers transform subject matter knowledge into various methods of instruction. Shulman (1987) states that the "knowledge base for teachers is not fixed and final" (p. 12), indicating a growth paradigm. He proposes three categories of knowledge which contribute to growing teachers' knowledge base: (a) subject or content knowledge, (b) pedagogical content knowledge, and (c) curricular knowledge (Shulman, 1986).

Shulman (1986) states that teachers should be able not only to understand the content being taught but also to discern why the topic is essential to a given discipline. Shulman identifies pedagogical content knowledge as "an understanding of what makes the learning of specific topics easy or difficult; the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lesson" (p. 9). Shulman describes the curriculum as a range of materials and resources with which a teacher designs are varying pedagogical approaches to represent the content or subject matter for instruction. In addition to knowledge of content, pedagogy, and curriculum, Shulman (1987) also identifies learner knowledge, content knowledge, and knowledge of goals and beliefs as essential to developing a teacher's knowledge base.

The use of technology as tools of teaching to meet the needs of 21st-century learners provides new perspectives for examining changes in teachers' knowledge, specifically teachers' pedagogical beliefs (Ertmer & Ottenbreit-Leftwich, 2010). In fact, the way teachers use technology for instruction has been the topic of interest to researchers, policymakers, and school leaders for several decades. Ertmer and Ottenbreit-Leftwich state, "teaching with technology requires teachers to expand their knowledge of pedagogical practices across multiple aspects of the planning, implementation, and evaluation processes" (p. 260).

Schuck and Kearney (2008) conducted a study to understand teachers' pedagogical practices in two technology-using classrooms: one classroom used digital videos, and the other classroom used an interactive whiteboard. The teachers' roles varied in each classroom depending on the instructional approach for using the technology. For the digital video project, the students experienced increased autonomy during the learning experience with the teacher providing minimal assistance with camera operations and video edits. The teacher maintained primary control using the interactive whiteboard to present content information. The researchers (Schuck & Kearney, 2008) identify this approach as replicating a traditional presentation approach with the addition of using technology.

Schuck and Kearney (2008) suggest that each pedagogical approach was influenced by the technology being used to represent the content. Ertmer and Ottenbreit-Leftwich (2010) maintain that when teachers are introduced to a new pedagogical tool, the decision to use the tool is based on the teacher's belief as to whether the tool aligns with the instructional outcome. Schuck and Kearney note that both teachers expressed using technology to enhance student understanding, increase student motivation, and increase student ownership. The school context, including leadership support for using technology, can also impact a teacher's pedagogical beliefs for integrating technology (Ertmer & Ottenbreit-Leftwich, 2010; Schuck & Kearney, 2008).

It can be inferred that the presence of Technology in PCK not only expanding its domains but also gives a new perspective of teachers' pedagogical beliefs and practices for integrating technology.

e. Technological, Pedagogical, and Content Knowledge (TPACK)

The technological, pedagogical, and content knowledge framework incorporates technology from Shulman's (1987) constructs of pedagogical content knowledge. Koehler and Mishra (2005) developed this framework to represent a pragmatic approach to understanding the teachers' knowledge base essential for integrating technology effectively. The technological, pedagogical, and content knowledge framework consists of a dynamic relationship between three core knowledge areas: technology, pedagogy, and content. Koehler and Mishra (2005, 2008, 2009) and Mishra and Koehler (2006, 2007) identify seven knowledge components of the technological, pedagogical, and content knowledge that comprise an essential knowledge base for teachers. A brief overview of each component of the framework is below:

1. Content knowledge (CK) is knowledge about the subject matter or specific content such as mathematics, science, or social studies. Teachers must know the concepts, theories, and procedures within a given field to teach effectively (Shulman, 1986).
2. Pedagogical knowledge (PK) is knowledge about the processes or methods of teaching and learning including planning; assessment; and cognitive, social, and developmental learning theories (Koehler & Mishra, 2008; Shulman, 1986)

3. Pedagogical content knowledge (PCK) is flexible knowledge about which instructional methods fit with the content and how to represent the content to promote meaningful learning (Koehler & Mishra, 2008; Shulman, 1986).
4. Technology knowledge (TK) is knowledge of both standard and new technologies as the acquisition and adaptation of skills as technological innovations develop (Koehler & Mishra, 2008).
5. Technological content knowledge (TCK) is knowledge about the reciprocal and flexible relationship in which one can use technology to represent content. Both content and technology have affordances and constraints which may prevent possible representations for curricular planning (Koehler & Mishra, 2008).
6. Technological pedagogical knowledge (TPK) is knowledge of the flexible use of technological tools for teaching and learning as knowledge of the affordances and constraints of technologies within a particular context (Koehler & Mishra, 2008).
7. TPACK is knowledge which requires teachers to develop an understanding of the relationships between and among technology, content, and pedagogy to integrate technology productively (Harris, Mishra, & Koehler, 2009; Koehler & Mishra, 2008; Koehler & Mishra, 2009).

Koehler and Mishra (2009) recognize, "no single technological solution applies to every teacher, every course, or every view of teaching" (p. 66). These components as illustrated in the model (Figure 1) comprise an interactive framework which emphasizes the connections among technologies, pedagogy, and content and the complexities of planning for technology integration.

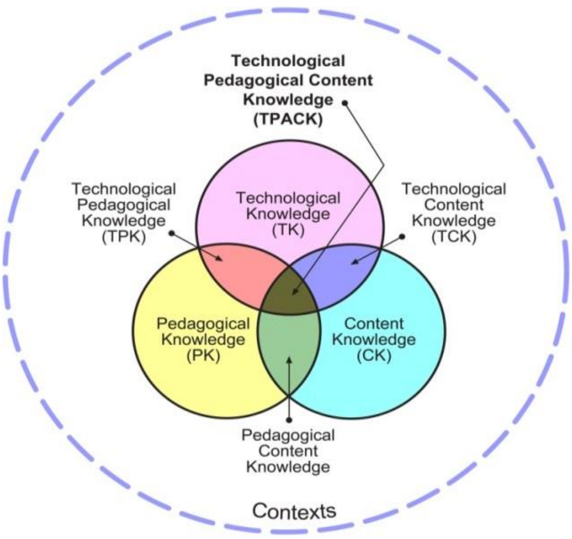


Figure 8. Technological, Pedagogical, and Content Knowledge Framework. Permission to use the technological, pedagogical, and content knowledge image is granted [source: http://tpack.org.]

When making decisions about technology integration, teachers should take into consideration the dynamic relationships between and among these three modes of knowledge rather than simple solutions (Koehler & Mishra, 2008).

Mishra and Koehler (2006) state the following:

[Technological pedagogical content knowledge] is the basis of good teaching with technology and requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones. (p. 1029)

By this framework, one avoids the perception that a single pedagogical approach can be used with digital technologies, instead of considering the ways technologies can support various pedagogies and content areas. Similarly, general technological approaches may not be as useful as considering flexible ways that technology can be integrated into specific content areas. Consequently, the diversity of innovative technologies increases options for teachers to cultivate technological, pedagogical, and content knowledge through thoughtful and meaningful technology integration.

Just as valuable as teacher beliefs about how to integrate technology is a teacher's possession of multiple sources of knowledge which serve as the foundation for those beliefs. Koehler and Mishra (2005) propose that good teaching requires not only introducing technology to teach content material but also possessing the ability to synthesize the core curricular components and make adjustments to instruction based on the different levels of technology integration. Teachers' knowledge of the technological, pedagogical, content knowledge framework provides a range of flexible and fluid use of technologies to provide differentiated learning experiences within a content-based curriculum.

Harris and Hofer (2009, 2011) suggest that teachers' technological, pedagogical, and content knowledge is grounded in using content-specific, technology-enhanced learning activity types for instructional planning. Harris and Hofer (2009) identify five instructional decisions which contribute to a teacher's plan when using learning models as conceptual planning tools:

1. Selecting the learning goals;
2. Making pedagogical decisions based on the learning experiences to achieve the learning goals;
3. Choosing and sequencing activity types to develop the learning experiences;
4. Selecting assessment strategies to identify students' understanding and misconceptions; and
5. Selecting tools and resources to support the learners' acquisition of knowledge, and understanding of the learning experiences and goals.

Harris and Hofer (2009) note that the use of activity types requires teachers to focus on the learning goals and activities specific to instructional content before selecting the technology appropriate for the lesson. Rather than considering the affordances and constraints associated with technology, teachers select the technological tool which best supports students' learning (Harris & Hofer, 2009). This practice of using activity types supports an authentic approach to developing teachers' technological, pedagogical, and content knowledge by considering what students will learn, which activities students will do, and which technologies will support the learning goals.

In contrast, Forssell (2012a) suggests that in-service teachers' typical application of technological, pedagogical, and content knowledge may be restricted because of limited access to technologies. Forssell explains that teachers' technological, pedagogical, and content knowledge is evidenced when teachers employ professional judgment about a technological tool's instructional effectiveness and decide whether or not to use a particular technological tool even within the constraints of limited access. Forssell (2012a, 2012b) contends that a teacher's decision or reasoning not to use instructional technology reflects adaptive expertise with a deliberate focus on process rather than on product.

Harris et al. (2010) "suggest a logical approach to helping teachers to integrate technologies in their teaching is to directly link students' content-based learning activities and related educational technologies that will best support the activities' successful implementation" (p. 575). Educational leaders, pedagogical experts, and technology specialists designed content-based learning activity type taxonomies across six curriculum areas: K-6 literacy, mathematics, science, secondary English language arts, social studies, and world languages (Harris et al.,2010). These activity type taxonomies provide teachers with content-specific standards-based activities to expand and refine traditional instructional planning with meaningful technology integration strategies. Harris et al. note that the taxonomies do not encompass the full range of pedagogical strategies for instructional planning the function of the taxonomies is to expand teachers' range of instructional strategies for curricular planning, thus accommodating the learning styles of 21st-century learners

It can be seen from the framework describes how the framework of TPACK thoroughly presented which make it different from technology-embedded or limited to the application of technology or repurpose technology as part of instructional strategies. It also encountered previous ideas in Shulman (1987) which put technology as part of content knowledge.

f. Identifying and Measuring Technological, Pedagogical, and Content Knowledge

Mishra and Koehler (2006) promoted the technological, pedagogical, and content knowledge framework by adding technology as an additional construct to Shulman's (1987) pedagogical content knowledge framework. The dynamic interplay of the technology-added constructs identified as technological content knowledge; technological pedagogical knowledge; and technological, pedagogical, and content knowledge have gained attention among researchers seeking to clarify the constructs' theoretical foundation or meaning (Angeli & Valanides, 2009; Graham, 2011). Koehler and Mishra (2008) recognize the framework as complex, specifying that teachers' technological content knowledge is "the most neglected aspect of the various intersections of the [technological, pedagogical, and content knowledge framework]" (p. 16). Accordingly, Graham (2011) examines issues surrounding theory development of the technological, pedagogical, and content knowledge framework using Whetten's (1989) three essential elements for theory development. Whetten refers to the following elements as building blocks for theory development:

1. identifying which factors, constructs, or concepts are specific to the phenomenon being studied;
2. exploring how elements are related; and
3. explaining why the factors and relationships are relevant to the phenomenon and broader audience.

Graham (2011) notes that the precise definitions for the interactions of the constructs within the technological, pedagogical, and content knowledge framework lack clarity. In describing the second element, Graham refers to two conditions which may impede a clear understanding of the constructs. Those are (a) the relationship in which pedagogical content knowledge is perceived as either transformative or integrative, thus influencing the researchers' overall synthesis of the technological, pedagogical, and content knowledge framework; and (b) the lack of clarity between individual constructs and among constructs that share boundaries, preventing researchers from distinguishing different constructs. The last element pertains to a rationale or soundness for the theory or model, specifically the constructs of the technological, pedagogical, and content knowledge framework. Graham suggests that researchers have construed the dimensions of the technological, pedagogical, and content knowledge framework to value the core components of technology, pedagogy, and content knowledge rather than the interactive relationships. Graham recommends that future researchers and teacher education programs work together to identify common understandings of the constructs to increase the framework's viability as a theoretical framework.

Varied assessment tools used to determine teachers' technological, pedagogical, and content knowledge have been developed amidst the growing number of researchers exploring teachers' technological, pedagogical, and content knowledge. These tools include self-reported survey instruments, technology integration observation instruments, technology integration assessment rubrics and semi-structured interview protocols. Researchers have used the assessment tools as originally designed or adapted the tools to advance general understanding of the dynamic relationship among teachers' technological, pedagogical, and content knowledge. Abbitt (2011) suggests, "as the methods and instruments for assessing [technological, pedagogical, and content knowledge] are further developed and refined, there is an overarching need for the establishment of meaningful norms for the various instruments to provide additional indices to which these changes can be compared" (p. 297). Hofer and Harris (2012) report a literature base of over 500 studies on the technological, pedagogical, and content knowledge framework with researcher emphasis primarily on preservice teachers rather than in-service teachers as participants. Hofer and Harris analyzed 12 studies that researchers conducted in 2011 to explore experienced teachers' technological, pedagogical, and content knowledge before or during professional development training. A common theme reported in each of the 12 studies was that teachers' technological content knowledge was less evident as compared to technological pedagogical knowledge. Hofer and Harris suggest five reasons for this variance:

1. teachers may attend to pedagogy more than to content;
2. teachers may not separate technological content knowledge from the content or curricular knowledge

3. teachers' technological content knowledge may be a subdomain of pedagogical content knowledge as technological tools become embedded as curricular materials
4. professional development attends to general technology use rather than content-specific use; and
5. teachers may not have access to a variety of tools or are unaware of the content-specific ways to use the tools for instruction.

Consequently, Hofer and Harris recognize a need for the research community to explore and use "more precise instruments, more focused interview prompts, more accurate stimulated recall techniques, and more effective data analysis methods to better understand both the composition and the complexities of teachers' applied [technological, pedagogical, and content knowledge]" (para. 21). The challenge with identifying teachers' technological content knowledge lies in the varying perceptions of researchers' interpretations of the construct continued research should focus on understanding teachers' technology integration practices and in developing professional development experiences that support teachers' developing knowledge base (Hofer & Harris, 2012)

Regarding with instruments to measure TPACK, there five types of TPACK instruments, which briefly description (Borg:2003: Cohen:2006) and its examples present as follow:

1. Surveys

Surveys are a method of collecting information from individuals with the variety of purposes and can be conducted in many ways to gather information through a printed questionnaire, over the telephone, by mail, in person, or on the web. This information obtained through the use of standardized procedures so that every participant is asked the same questions in the same way, with a structured format. Participants were surveyed may be representing themselves, their employer, or some organization to which they belong. Example of the TPACK Instrument in this types are Schmidt et al. (2009), Archambault and Crippen (2009), Jamieson-Proctor et al. (2010),

2. Open Ended Questionnaire

It is an unstructured question in which create any possible answers, and the respondents could answer in their own words. The questions usually begin with a how, what, when, where, and why. Example of the TPACK Instrument in this types are So & Kim (2009); Nies, Sadri, Suharwoto (2006), and Ozgun-Koca (2009)

3. Performance Assessment

It is a test in which the test taker demonstrates the skills the test is intended to measure by doing real-world tasks that require those skills, which including artifact evaluation, document analysis, and pretest-posttest. Example of the TPACK Instrument in this types are Tripp, Graham & Wenworth (2009), Valtonen, Kukkonen, and Wulff (2006), Jonassen, Peck and Wilson (1999), Oster-Levinz and Klieger (2010), Polly et al. (2010)

4. Interviews

It is a formal meeting in person (typically face-to-face), especially one arranged for the assessment of the qualifications of an applicant. Example of the TPACK Instrument in this types are Niess (2009), and Ozgun-Koca (2009)

5. Observations

It is more than just looking or listening; but it is selective, planning what we want to observe, and it has to be recorded to allow the information to be analyzed and interpreted. Example of the TPACK Instrument in this types are Niess, Lee, Sadria, Suharwoto (2006)

Each type of the TPACK instruments have its strengths and weakness, and this usability depends on the context and need of the researcher. Following is types of instruments used in TPACK along with its strengths and weakness as summarized by the researcher

Types of Instruments	Strenghts	Weakness
Surveys	1. High representative. Surveys provide a high level of general capability in representing a large population. 2. Low costs. When conducting surveys, we only need to pay for the production of survey questionnaires. 3. Convenient Data Gathering. Surveys can be administered to the participants through a variety of ways. The questionnaires can directly be sent via e-mail or fax or can be administered through the Internet 4. Good statistical significance. Because of the high representativeness brought about	1. The design is not flexible. The survey that has used by the researcher since early of the research, as well as the method of administering it, cannot be modified all throughout the process of data gathering 2. Not precise for controversial issue. Participants may not precisely answer questions that bear controversies because of the probable difficulty of recalling the information related to them. The

	by the survey method, it is often easier to find statistically significant results and Multiple variables can also be effectively analyzed using surveys. 5. Little or no Observer Subjectivity. Surveys are ideal for scientific research studies because they provide all the participants with a standardized stimulus. With such high reliability obtained, the researcher's own biases are eliminated. 6. Precise Results. As questions in the survey should undergo scrutiny and standardization, they provide uniform definitions to all the subjects who are to answer the questionnaires. Thus, there is a higher precision concerning measuring the data gathered. 7. With survey software, advanced statistical techniques can be utilized to analyze survey data to determine validity, reliability, and statistical significance, including the ability to analyze multiple variables	truth behind these controversies may not be relieved as accurately as when using alternative data gathering methods such as face-to-face interviews and focus groups. 3. Possible inappropriate of questions. The researcher is therefore forced to create general questions because considering the general population. However, these questions may not appropriate for all the participants as they should be. 4. Respondents may not feel encouraged to provide honest answers. They might feel uncomfortable on answers that unfavorably present themselves, or may not aware of reasons for the given answer. 5. Survey question answer options could lead to unclear data because specific answer options may be interpreted differently by respondents
Open Ended Questionnaire	1. It permits an unlimited number of possible answers. 2. respondents can answer in detail and can qualify and clarify responses 3. unanticipated findings can be discovered 4. It permits adequate answers to complex issues 5. It permits creativity, self-expression, and richness of detail 6. It can reveal a respondent's logic, thinking process, and frame of reference	1. different respondents give different degrees of detail in answers 2. responses may be irrelevant or buried in useless detail 3. comparisons and statistical analysis become difficult 4. coding responses is difficult· 5. questions may be too general for respondents who lose direction 6. a more considerable amount of respondent time, thought, and effort is necessary 7. respondents can be intimidated by questions

		8. Answers can take a big space in the questionnaire.
Performance Asssessment	1. The focus is on complex learning outcomes that often cannot be measured by other methods. 2. Performance assessments typically assess process or procedure as well as the product. 3. Well-designed performance assessments communicate the instructional goals and meaningful learning clearly to students. 4. This assessment is meaningful and communicates the learning goal. This performance assessment is an excellent instructional activity and has good content validity - universal with well-designed performance assessments	1. Typically very time consuming for respondents and maker, labor intensive to design and execute. This means that fewer assessments can be gathered so if they are not carefully devised fewer learning goals will be assessed 2. they are hard to assess reliably, which can lead to inaccuracy and unfair evaluation. In this term, inter-rater reliability must address with careful demand training of rater 3. Rating and rubrics can be more subjective 4. Sample of behaviour of performance may not be typical
Interviews	1. Accurate screening. The individual being interviewed is unable to provide false information during screening questions such as gender, age, or race. It is possible to get around screening questions in online and mobile surveys 2. Capture verbal and non-verbal cues. Besides verbal cues, this method also affords the capture of non-verbal cues including body language, which can indicate a level of discomfort with the questions, but is not possible in online or mobile surveys. 3. Keep focus. The interviewer is the one that has control over the interview and can keep the interviewee focused and on track to completion. 4. Capture emotions and behaviors. Face-to-face interviews can no doubt capture an interviewee's emotions and behaviors	1. High-Cost. It requires staff to implement the interviews, which means there will be costs. Personnel is the highest budget, and usually, when it profoundly need, the cost is steep to keep low. 2. Quality of data by interviewer. The interviewers may also have their own biases that could influence the way they input responses. 3. Manual data entry. It can prolong analysis process. 4. The limited size of the sample. It is limited to the size of interviews are conducted, and the number of qualified respondents within that area. It possible to conduct several interviews over multiple areas, which again can increase costs.

Observations	1. It provides direct access to the designated phenomena under consideration. Observation avoids the full range of problems associated with self-report, interview, and questionnaire 2. Observation can take diverse forms, from informal and unstructured approaches through to tightly structured, standardized procedures and can yield associated diverse types of data, both qualitative and quantitative. Observation, therefore, is applicable in a wide range of contexts. 3. observation entails some form of recording to provide a permanent record of such events or behavior, thus allowing further analysis or subsequent comparisons across time or location to be carried out. 4. It can effectively complement other approaches and thus enhance the quality of evidence available to the researcher.	1. it might be time-consuming and resource intensive. Observation may be a very desirable strategy to explore specific research questions, but it may just not be suitable for the researcher with limited time and resources to carry out the observation 2. It is susceptible to observer bias – subjective bias on the part of the observer – thus erode the reliability and hence the validity of the data gathered. This can be because the observer records not what actually happened, but what they either wanted to see, expected to see, or merely thought they saw. 3. The presence of observers in some cases influence the behavior of those being observed

Table 5. Types of TPACK instruments with its Strenghts and Weakness

For a complete and integrated measurement of TPACK of preservice science teachers, all of the instrument used is an ideal case. However, since this study is an initial step to measure TPACK development of science teacher candidates, and considering it will cover a significant number of the respondent to describe their skills regarding TPACK, so the researcher chooses a self-report survey in this research. As the researcher decided to choose a self-report survey instrument, it is essential to review self-survey types of TPACK instruments primarily for the pre-service teachers. Among a bunch of this specific papers, the researcher selected well-examined papers which categorized as most-cited papers or most suitable instruments. Consider the filter methods in this literature study, the reference instruments resulted are coming from Albion et al. (2010), Archambault & Crippen (2009), Schmidt et al. (2009), and Lee &Tsai (2010). The pictorial representative of logic applied in this research regarding with the study literature presenting as follow:

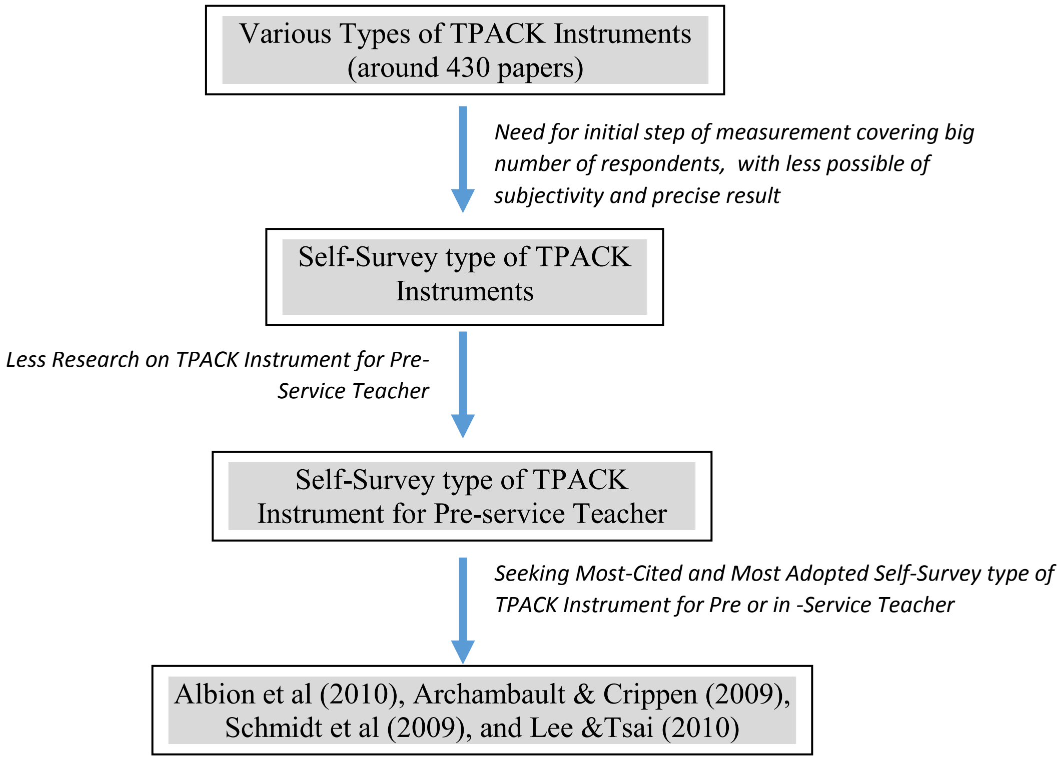


Figure 9. Pictorial Representative for Literature Study on TPACK Instrument for Pre-Service Science Teacher

While the brief review about those four instruments are presented in the Tabel 6 below

No	Authors	Framework	Feature and Methods (e.g: Reliability, Validity or any Statistics employed	Brief Result
1	Albion et al (2010)	TK and TPACK, especially confidence using of computer or ICT into teaching	- Using the 4-point Likert Scale (1: No Competence; 2: Some Competence; 3: Competence; 4: Very Competence) - The study uses Chi-square as a test of non-parametric significance to see a relationship between the pre-service teachers, gender, age, a program of study, their confidence and competence to use computers for both personal and professional (teaching and learning) purposes. - Does not using reliability and validity test	- The participants (Final year of the pre-service teacher) indicated very high levels of computer ownership (99.4%) and regular access to broadband Internet (96.5%) - a non-significant difference between the two universities, ages, for all applications. - Males more confidence than female
2	Archambault &	All TPACK components	- Covered on three domains: pedagogy, content, and knowledge with correlation method.	- From a result of 596 online teachers (K-12 teachers) across the US: highest level for pedagogy, content,

	Crippen (2009)	(seven components)	- Using 5 Likert-scale; 1: Poor until 5: excellent - Reliability testing using Cronbach's alpha coefficient is conducted for each of the subscales to determine the level of internal consistency. - These levels were acceptable, (Gall, Gall, & Borg, 2003) ranging from alpha = .699 for the technology content domain to alpha = .888 for the domain of technology - Employed Construct Validity	and PCK (their knowledge of pedagogy and content are very good), their knowledge on technology is lower than technology. - Teacher tends to the traditional teaching rather than online. There is a high correlation between pedagogy, content, and PCK. Think a load participant difficulties to separate pedagogy and content, because linked each other at day-to-day teaching. - The high correlation found between TC and TP, and TPCK. However, lower correlation on technology-pedagogy and technology-content
3	Schmidt et al (2009)	All TPACK components (seven components)	- Consist of 75 items with 5-level Likert Scale from 1: Strongly disagree to 5: Strongly Agree - Consistency reliability (coefficient alpha) ranging from 0.75 to 0.92 for the seven TPACK subscales. There are additional items on the survey to collect demographic information and education program. - Many scholars have used the TPACK survey as a foundation to assess TPACK knowledge, modify the survey to match their particular needs, including translation, different subject-matters, and different contexts.	- The survey for 124 pre-service teachers has since been revised to modify some of the items. - The result is 54 Likert-type items to assess the seven components of TPACK in four different content areas: Mathematics, Science, Social Studies, and Literacy. - The survey limited for the preservice teacher who become elementary or early childhood teacher
4	Lee &Tsai (2010)		- Web Knowledge replaces technology framework. - A questionnaire consists of 6 sub-scales including attitudes to assess self-efficacy regarding TPACK-W, their attitudes regarding Web-based instruction, and their background variables. 6-point Likert mode	- From 558 teachers from elementary school to high school respondents, older and more experienced teachers were found to have lower levels of self-efficacy concerning TPCK-W, though teachers with more experience of using the web (including for instruction) had higher

		(strongly unconfident to strongly confident, while on TPACK-W using strongly disagree to strongly agree - Validity using exploratory and confirmatory factor analyses (CFA) to measure teacher self-efficacy regarding the use of Web in teaching - Reliability measures using Cronbach alpha around 0.92-0.96 - Using correlation between teachers' self-efficacy concerning their TPACK-W	levels of self-efficacy for TPCK-W. Web attitudes are not TPACK - Teachers used Web only as a source of subject information, which may imply a lack of pedagogical knowledge on how to create interactive exercises on the web - A teacher with more experience of Web use and web-related instruction tend to have high self-efficacy regarding their TPACK-W

Table 6. Review on selected TPACK instruments for pre or in service teacher

Regarding with context of TPACK instruments for pre or in-service teacher in Indonesia, there have been efforts of maintaining TPACK in some particular subjects in such English (Mahdum:2015, Cahyono et al.:2016; Akmal:2017; Drajati et al.: 2018); Biology (Suryawati and Hernandez: 2014, Pusparini et al :2017, Nasution et al:2017), Mathematics (Ariani:2016; Wati et al: 2018) Science (Agustin & Liliasari:2018; Agustin et al :2018), or combination from many subjects (Chai et al :2017) . The brief review about those instruments, which all using framework TPACK as an integrative model, presents in the Tabel 7 below

No	Authors	Feature and Methods (e.g: Reliability, Validity or any Statistics employed)	Brief Result
1	Mahdum (2015)	- The instrument adapted from Schmidt et al. (2009) and Sahin (2011) - Covering 74 in-service senior high school English teachers - 45 items of 7 TPACK sub-domains, 14 TK items, 4 CK items, 7 PK items, 4 PCK items, 4 TCK items, 9 TPK items, and 3 TPACK items. - five-level Likert Scale, Strongly disagree to Strongly agree - validity test through Pearson Correlation, Alpha Cronbach's test showed 0.975	- relatively in 'good' category, especially in sub-domain related to pedagogical and content, PCK with 'very good' category - sub-domains related to technology are still below the other sub-domains - teachers have not been familiar with technology knowledge
2	Cahyono et al (2016)	- Applied on 20 secondary English teachers during teaching practice for master degree - 16-session course including an introduction on TPACK	- More teachers elaborate technological knowledge in their instructional designs

		- Performance assessment and the TPACK questionnaire. No further information about the questionnaire and its validity - -analysis of the teachers' instructional designs made before and after the introduction of TPACK	- positive responses to the introduction of TPACK - low self-efficacy to implement TPACK-oriented instructional designs - teachers need time to do self-contextualization of TPACK framework
3	Akmal, A (2017)	- Local culture and local moral to complete Technological Pedagogical Content Knowledge (TPCK+) within the challenge of the 21st- century skills - 345 pre-service English Teachers through observation, teaching practice, and self-evaluation - No further information about the questionnaire and its validity	- The results show 84.92% of the students were included under the category of "good" and "very good" in pedagogical skills - 77.38 % in pedagogical content knowledge, and 87.53 % in cultural and local wisdom context in content development, but only 51.58% in technological knowledge
4	Drajati et al (2018)	- An online survey of TPACK literacy (Pedagogical Content Knowledge for Multimodal Literacy, Technological Pedagogical Knowledge 21st C Learning, and Knowledge about digital media tools - Adapted the TPACK items from Chai, Ng, Lee, Hong and Koh's (2013) - 100 participant of 46.9% in-service teachers and 53.1% pre-service teachers	- Technology helps them as well as students better in multimodal literacy - 75.90% they can draw out student's initial concepts about the topic of inquiry, 66.30% technology assists them to do it, 73.90% with the help of technology; they could play that role
5	Suryawati and Hernandez (2014)	- Applied to 33 biology high school teachers at - 35 items and is 7 subdomains of TPACK adapted from Schmidt et al. (2009) dan Sahin (2011) with 7 likert scale - Validity using Pearson Correlation and Cronbach Alpha 0.953	- TK good enough (Mean=3,38), PK good (M=4,05), CK good (M=3,92), TPK good (M=3,70), TCK good (M=3,70), PCK very good (M=4,26) and TPCK good (M=3,94). An overall, biology teachers' TPCK is good (M=3,72)
6	Chai et al (2017)	- A newly created instrument examines the teachers' efficacy about their knowledge of using technology for active and constructive learning, authentic learning and collaborative learning instead of adopting the seven factors TPACK model - seven-point Likert scale, ranging from 1 for strongly disagree to 7 for strongly agree, face validity	T- Txhe six factors survey are valid and reliable. All factors are significantly correlated. Path analysis described that two of the teachers' design beliefs (DD and BNCL) predict the teachers TPACK for 21st - century oriented learning.

		- Using exploratory factor analysis (EFA), Cronbach Alpha's - Applied on 187 teachers from various subjects - t-tests and ANOVA to further examine the results base on the demographic	The results imply that it is likely necessary to consider teachers' design beliefs when teacher educators plan to foster teachers' TPACK. - teachers do not possess strong efficacies in designing 21st-century learning with technology
7	Pusparini et al (2017)	- Describe pre-service biology teacher of TPACK during lecture - Using quantitative (survey) and qualitative (lesson plan and teaching simulation) - Adopted Chai et al (2017) Total 35 items covering 6 TK items, 5 CK items, 5 PK items, 6 PCK items, 4 TCK items, 4 TPK items, and 5 TPACK items with 5-level Likert Scale	- Experienced significant gains in all TPACK constructs. - Both of pedagogic and technology treatment is better than others, but pedagogical treatment didn't also increase PCK most of participants
8	Nasution et al (2017)	- Creating Content Representation (CoRes) teachers instrument related to Biology TPACK in descriptive - Less connection with TPACK instruments	- Lack of teachers' ability in TPACK - Less discussion on TPACK and its components
9	Ariani (2016)	- Adopted 32 items survey TPACK survey instrument (Pamuk et al., 2013), five level Likert's scale (from 1—strongly disagree to 5-strongly agree), while reliability using Cronbach Alpha - 173 mathematics teachers from 24 primary schools - Using Structural equation modeling (SEM) and reliability using Cronbach Alpha	- Moderate level of TPACK's components, knowledgeable on TPACK but less capable to deliver for better students understading - significant relationships exist among TPACK components, technological knowledge, pedagogical knowledge and content knowledge were all significant predictors of TPACK
1	Wati et al (2018)	- Identify TPACK of 45 junior high school mathematics teachers using questionnaire and interview - Adopted from Pamuk (2013) and Chai et al (2017). A total 19 items for measuring teachers' self-assessments of the four TPACK domains: 6 PCK items, 4 TPK items, 4 TCK items, and 5 TPACK items, using the five-level Likert scale from strongly disagree to strongly agree - Internal reliability using Cronbach Alphas for all constructs	- Teachers emphasized developing procedural and conceptual knowledge (PCK) - Lower capacity to deal with the general information and communications technologies goals across the curriculum (TPK) - A low standard in teachers' technological skills across a variety of mathematics education goals

1	Agustin & Liliasari (2018)	- Covered 19 pre-service science teachers (PCK) by utilizing content representation (CoRe) with an infusion of technological knowledge (TK) analysis led to the study of TPACK by extending the template with a question in line to TK - two extending CoRe questions related with TPACK but no further information about TPACK Questionnaire	- Contrary value of PCK and TK identified by CoRe template to those measured by self-reported survey. - PSTs perceive their TPACK much higher, that, is 74.74% - Extended CoRe template can be used to capture PSTs PCK and TK
1	Agustin et al (2018)	- More focused on 25 science teachers' TK and TCK through 20 items of a questionnaire (four questions were asking view about technology integration) in the context of teacher professional training - No information of validity and statistics process in the questionairre	- Science teachers still have less TK, yet they have high TCK, concepts as main aspect for implementing technology into science teaching

Table 7. Review on TPACK instruments for pre or in service teacher in Indonesia

All the reviewed papers on the TPACK instruments in Indonesia did not make a connection between adopted or created instruments with particular competencies for Indonesia pre or in-service teachers standards. Furthermore, among all of the reviewed instruments, there are not TPACK instruments which specifically created for pre-service science teachers.

As the summary of this chapter, the researcher put the objectives to highlight studies which were done and were not done on the topic and to show the needs concerning to create a TPACK instrument for the pre-service science teacher in Indonesia. Having reviewed the literature, it concludes that there is a hole in need of TPACK instrument for the pre-service science teacher. The hole is not lies on less TPACK instruments adopted for a particular pre-service science teacher, but also consider the standard for the pre-service science teacher in Indonesia as part of localizing the well-examined and widely used reference of TPACK instrument on the Indonesia context.

CHAPTER 3
METHODOLOGY

The researcher designed this quantitative case study to measure Technological Pedagogical Content Knowledge (TPACK) Development of Pre-Service Science Teacher in Indonesia. Quantitative data is gained through a self-report survey. This chapter is divided into six sections: research design, participants, gaining permission, sampling and recruiting, instruments, and procedures.

a. Research Design

For the quantitative data, the researcher created an instrument called the TPACK development instrument. The researcher conducted a quantitative case study to gain insight into secondary pre-service science teachers' TPACK within the context of before or in the process of teaching practice. The application of a case study design allowed for the focus of the study to be narrowed to pre-service science teachers' understanding of the technology integration of the lesson. Yin (2003) identifies the following five components as essential to a case study research design: (a) a study's question; (b) its propositions, if any; (c) its unit(s) of analysis; (d) the logic linking the data to the proposition; and (e) the criteria for interpreting the findings. These five components comprise a comprehensive research strategy which can be used to frame a case study logically by identifying not only the data to be collected but also how the data will be used following the data collection (Yin, 2003).

The researcher selected the case study design as finding from Indonesian case might similar but also possible to be different from other countries and has not published related to the similar topic. Gaining participants perspectives of reality through quantitative instrument thus enabling the researcher to gain a deeper understanding of the phenomenon being studied (Denzin & Lincoln, 2008; Yin, 2003). The pictorial representative for the research design presenting in figure 8..

b. Participants and Location

The participants are pre-service science teachers in Indonesia. They engaged in responding quantitative instruments through a survey both online or paper version. The researcher selected the members based on their willingness through a personal message, social media, and direct meeting. The instrument provided in print and online mode, while for online instrument provided through Gizmo online application survey.

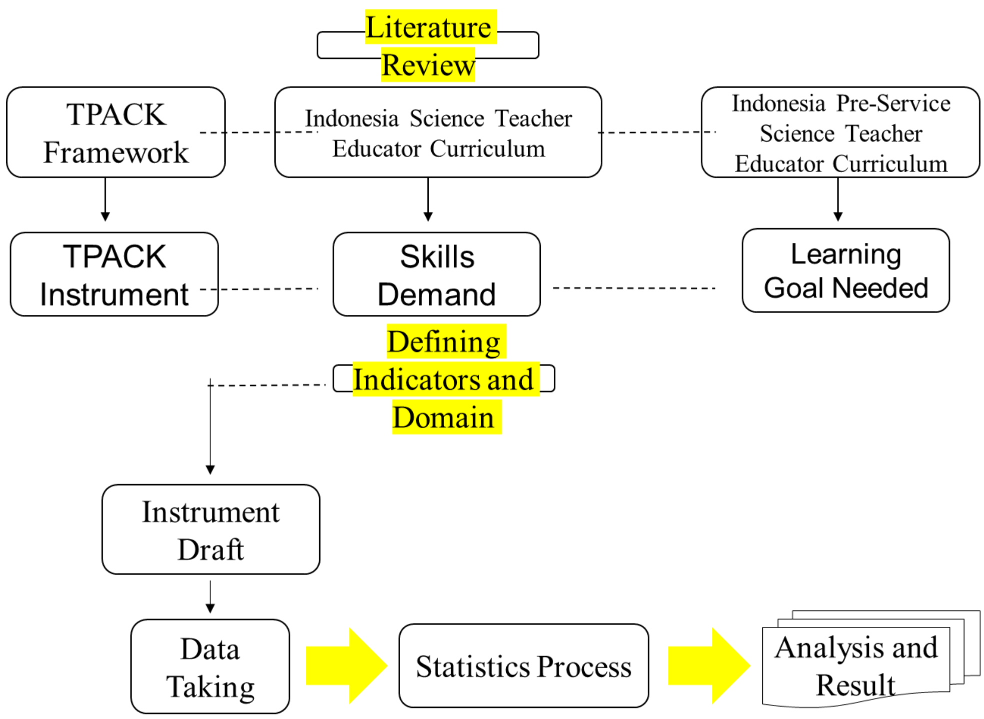


Figure 8. Research Design of the Designing and Examining of the Instrument to measure TPACK of Pre-Service Science Teacher in Indonesia

c. Gaining Permission

Initially, the researcher obtained authorization to proceed with this case study from the Ministry of National Education which has been established to protect the rights of individuals participating in research studies. The Ministry, through the Directorate of Higher Education, granted permission for the researcher to utilize undergraduate students respondents. For quantitative data, all students supported with spread out the survey physically and engaged for online mode as well. Although the researcher enlisted outside assistance, a coding system was used to identify all participants. The coding system was known only to the researcher and do not share with third parties or the public.

The researcher obtained additional permission through the participating school district and the school principal. This step is necessary to reach pre-service science teacher who is in ongoing teaching practice at schools. All participants pre-service science teacher is informed about the purpose of the study and their prospective roles in the study through writing description in the print and online version of the instrument. There is no risk or psychological stress involved in participating in the study. Participants are free to withdraw from the study at any time. For all quantitative data, the researcher gave assurances to maintain confidentiality by using pseudonyms for identification purposes. Data is stored electronically on a secured external hard disk. Additional data collection sources and forms are stored in a secure location at the researcher's home office. Participants are provided contact information for the researcher and university department for conducting research should the participants have any questions or concerns as all these are packed into a statement of research ethics

d. Sampling and Recruiting

The researcher used homogenous sampling, a type of random to attract preservice science teachers in Indonesia. The researcher applied a type of purposeful sampling (Patton, 2002), to select the participants from the preservice science teachers in university and who was conducting teaching practice from any teacher education institute in Indonesia. As many as 100 randomly selected participants who response complete self-report survey received gifts; while for each participant who engage their peers to fulfill the instrument were awarded a special gift as an amount of $50, respectively.

e. Instruments

The use of multiple sources of evidence in a case study strengthens data reporting (Yin, 2003). Varying the data sources provided the researcher with multiple lenses through which to explore and extract aspects of the contextual phenomenon related to the technological, pedagogical, and content knowledge framework teaching practice. However, for this study only, data collection of case study coming from the self-survey instrument, while for various data sources will highlight into further investigation of the dissertation.

The researcher developed the quantitative instrument i.e.: TPACK development instrument, a total of 116 items with a 6–point Likert type scale in 7 domains which consist of 18 items in Content Knowledge (CK), 32 items in Pedagogy Knowledge (PK), 14 items in Technological Knowledge (TK), 20 items in Pedagogical Content Knowledge (PCK), 9 items in Technological Content Knowledge (TCK), 10 items in Technological Pedagogical Knowledge (TPK), and 13 items in Technological Pedagogical Content Knowledge (TPACK). This survey adopted a six-point Likert-type scale designed to allow college respondents to rate their perceptions using the following status: "Extremely Poor," "Poor," "Acceptable," "Good," and "Very Good," and "Excellent" corresponding to 1–6 points, respectively.

f. Data Collection

As many as 1628 respondents filled the quantitative survey, which among of them are total of 1192 respondents who filled complete responses, are recruited from 8 provinces of Indonesia. Because missing responses for any items in a subscale could produce biases in the parameter estimates, the respondent that did not finish the instrument is excluded from the dataset. To avoid double filling from online and paper edition of the instrument, name and participant address are used for the researcher access only, and all paper data submitted online through same online application survey. The address is optional but necessary for the participant who wants to win drawing 100 gifts from the researcher. Double scanning is applied to make sure there is no dual input for similar respondents. All of paper and online mode of survey responses administrated into one package of Microsoft Excel file.

g. Data Analysis Techniques

The TPACK development survey which administered in Microsoft Excel is analyzed for its validity and reliability. The researcher assessed each TPACK knowledge domain subscale for internal consistency using Cronbach's alpha reliability technique. The researcher also investigated construct validity for each knowledge domain subscale using principal axis factor (PFA) of factor analysis with Varimax rotation within each knowledge domain and Kaiser Normalization. Also, multiple PFA method is applied after selecting items without sharing of factor loading to ensure there is no ambiguous of items respective to the above factors. Given that the instrument included 116 items when it was administered for the first time, it was clear that the sample size was adequate to perform a factor analysis on the entire instrument.

CHAPTER 4

INSTRUMENT DEVELOPMENT AND DATA PROCESSING

This chapter is initial core of the research where the researcher elaborate from the literature study into 2 big separate sides. The first side is about TPACK for pre-service science teacher, as written in the chapter two it has steps from the most general issue, i.e. TPACK framworkto be most specific issue, i.e. TPACK instrument for pre-service science teacher in Indonesia. Another side, also as described in the chapter two, more focusing on context of Indonesia, especially standards or learning outcomes of pre-service science teachers. These two sides becoming main cosideration for the researcher to adopt and or to create new TPACK instrument for pre-service science. The chapter four will devote into two different description according to the process of how instrument firstly created and drafted. The first section focusing on the sub-domain development, while the second section will emphasize on the data processing which covering initial validity and realiability of the instrument once drafted.

a. Sub-Domain Development

The researcher following integrative model of the TPACK which is treated as the combination of different knowledge constructs (Graham, 2011). The researcher consider this model as originally TPACK is developed from extending domain technology of PCK of Shulman (1987) which created according to the integrative model from separate Pedagogy and Content Knowledges found in Mishra and Koehler (2006) and Koehler and Mishra (2008). Following the way of TPACK modelled would give understanding for the researcher about how the instruments bring pattern as same as TPACK originally created where emphaize on where equally interactions between and among these bodies of knowledge Mishra and Koehler (2006)

This sub-chapter will describe each sub-domain, indicators and items which coming from adoption and creation according to the analysis of the exist instrumens and need for Indonesia context. As TPACK is built as core from 7 sub-domain, including TPACK it self, a clear rational from those 7 are addressing as follow:

1. Content Knowledge (CK).

Content knowledge is defined as the fundamental tenets of a subject and the organizing and defining principles that define that subject (Shulman, 1986). This knowledge is more about the actual subject matter that is to be learned or taught. As Sulman (1986) noted that this would include:

a. Knowledge of concepts, theories, ideas, organizational framework
b. Knowledge of evidence and proof
c. Knowledge of established practices and approaches towards developing such knowledge

Shulman (1987) defined content knowledge reffered to as the “knowledge, understanding, skill, and disposition that are to be learned (p.9). In case of science, this would include knowledge of scientific facts and theories, the scientific method, and evidence based reasoning. Why this content knowledge is essential because student can receive incorrect information and develop misconception about the content area (NRC:2000) where domain of content knowledge for teachers could be different among subjects

According to the Shulman’s description of the Content Knowledge (CK), the researcher defined the subsets / sub-domain as follow:

1. Curriculum issue; It is related with district or state standards or message from intended curriculum
2. Mapping the concept; It is related with scope of concepts and organizational sequencing
3. Body of knowledge of the subject; It is related with concept, theories, ideas and fundamentals of discipline in which teacher will teach
4. Developing for practices; It is related with established practices and approaches toward developing theories, concept and organizational framework. For this subset, it strong relation with pedagogy and can be regarded as core component for Pedagogical Content Knowledge (PCK)

Table description on how the indicators of Context Knowledge are adopted and or created from the exist TPACK instruments for pre and in-service teachers and need for a TPACK instrument for pre-service science teachers in Indonesia context is follow:

<table>
<tr><th>Adoption and Adaptation from Existed TPACK Instruments</th><th>National Standard on Pre-Service, in-Service Science Teacher</th><th>Sub Domain</th><th>Instrument's Indicators Defined</th></tr>
<tr><td rowspan="8">Archambault & Crippen (2009)
1. My ability to create materials that map to specific district/state standards
This item more focusing on how teacher's content knowledge on curriculum issue since material that declared in attended curriculum might be narrowing in certain part or have emphasize for certain reason as message from standard objectives
2. My ability to decide on the scope of concepts taught within in my class
This item concerned with mapping the concept. Teacher should re-personalize the concept form expert level then re-contextualize the scope of concepts and its deepness for student's level
3. My ability to plan the sequence of concepts taught within my class.
This item also related with mapping the concept, but the item describe more on the how sequencing the concept according to the fulfillment of curriculum objectives. The sequencing might be different with sequencing from the concept structure is self. For example, to teach Forces at primary level, the sequencing starts from forces as push of pull, meanwhile in the concept structure for forces, it is started from understanding of Momentum

Schmidt et al (2009)
1. I have sufficient knowledge about science
This item strongly declare about body of knowledge from particular subject. It is related with concept, theories, ideas, and fundamentals discipline in which teacher will teach. The concept og the teacher might be not same with expert level, but it is necessary to ensure that teacher's concept should not lies on misconception or misinterpretation. Not all the concept would be delivered to students, but teacher deep knowledge of the concept would lead to the proper concept sequencing and mapping</td><td rowspan="8">1. Develop a curriculum related to the subject matter
2. Mastering the materials, structures, concepts, and scientific mindsets that support the subjects
3. Mastering the competency standards and foundation competencies of subjects or areas of development.
4. Developing creative learning materials
5. Mastering the facts, concepts, principles, laws, theories, and procedures of the science
6. Mastering the theoretical concepts of problem-solving in science education procedurally through a</td><td rowspan="2">Curriculum Issue</td><td>Mapping particular standard from curriculum</td></tr>
<tr><td>Sufficient knowledge about science content in curriculum</td></tr>
<tr><td rowspan="2">Mapping the concept</td><td>Sequencing the particular science concept</td></tr>
<tr><td>Knowing scope of concept</td></tr>
<tr><td rowspan="2">Body of knowledge</td><td>Creating materials related with science concept</td></tr>
<tr><td>Sufficient knowledge about certain science concept</td></tr>
<tr><td rowspan="2">Developing for practices</td><td>Planning the sequence of concept</td></tr>
<tr><td>Deciding the scope of essential concept</td></tr>
</table>

2. I can use a science literacy way of thinking This item related with developing for practices in terms of knowledge and nature about subjects. The nature of inquiry differ greatly among fields. In the case of science for example, this would include knowledge of scientific facts and theories, the scientific method, and evidence-based reasoning. In the case of art appreciation, such knowledge would include knowledge of art history, famous paintings, sculptures, artists and their historical contexts	scientific approach 7. Applying logical, critical, systematic, and innovative thinking to develop the application of science and technology		
			Various way developing the understanding of concept
			Using science way of thinking
			Using science way of thinking

Table 8. Rational Adoption and Creation of Indicators of Content Knowledge According to the Referred Instrument and Indonesia Context

The table shows that six items from existed instruments and its rational are adopted , and at the same time also six competences or learning outcomes needed in Indonesia context for science teacher and pre-service science teacher also adopted. These eventually produced 10 indicators which combination and or modification from those two consideration. According to the defined Indicators, the researcher developed the items for the instrument with cosideration that the items shall represent the indicator, and once the indicator has stages to obtain then it can be debrief into variation more than one items. The researcher decided to make variation mostly two since those variation items basically will have same indicator. The items developed for the Content Knowledge presenting as follow:

Indicator(s)	Item(s) My ability to / of . . .
1. Mapping particular standard from curriculum	1. Identify standard of curriculum related with certain concept
	2. Mapping particular standard from curriculum
2. Sufficient knowledge about science content in curriculum	3. know about science content that I want to teach
	4. know the scope of content in curriculum
3. Sequencing the particular science concept	5. make a proper order of science concept according to the standards
	6. sequencing certain science concept
4. Knowing scope of concept	7. Knowing how far / high science concept in certain topic
	8. Know limitation of science concept among other concepts
5. Creating materials related with science concept	9. Identify materials supported with particular science concept

	10. Creating materials related with certain science concept
6. Sufficient knowledge about certain science concept	11. Sufficient knowledge about science concepts in secondary level
7. Planning the sequence of concept	12. Identify ways of concepts'construction
	13. Planning the sequence of concept
8. Deciding the scope of essential concept	14. Identify essential concepts from particular topics
	15. Mapping the scope of essential concepts from particular topics
9. Various way developing the understanding of concept	16. Knowing various ways to understand the particular concept
10. Using science way of thinking	17. Using science way of thinking to develop understanding of science concept
	18. Using science way of thinking in the classroom

Table 9. Adoption and Creation of Item of Content Knowledge According to Defined Indicators

The research mostly created 2 items from each Indicator except for the Indicator number 6 and 9. For the indicator number 6 "Sufficient knowledge about certain science concept", The researcher believe that sufficient knowledge is a minimum requirement for the content mastery as demanded by National Standard for Pre-Service Science Teacher. Creating varition for this item would not produce similar items since reducing the word of sufficient would means less sufficient which no longer as part of the indicator. While for the indicator number 9 "Various way developing the understanding of concept", the keyword lies on the various which means advanced level, so creating additional items which would reduce or change the meaning of the "vaious". For the indicator number 9, The researcher provide verb of "Knowing" since for the pre-service level knowing the various ways to understand the particular concept is basic foundation in the concept. Advanced level from knowing this various way would make intersection with Pedagogy and Technology Knowledge.

For this Content Knowledge, having made careful study toward existed TPACK instruments and National Standard, the researcher produced 10 indicators and 18 Items.

2. Pedagogy Knowledge (PK)

There are three definitions which equals related with pedagogy knowledge

1. The philosophical, theoretical, and practical approaches, sets of events, activities, processes, practices, and methodologies that guide teaching and learning.

2. Knowledge of teaching strategies. For example, a teacher should know when and how to teach with double number lines.
3. Knowledge about teaching, an understanding of "how particular topics, problems, or issues are organized, presented, and adapted to the diverse interests and abilities of learners" and the ways of "representing and formulating the subject that makes it comprehensible to others" (Shulman, 1987 , pp. 8-9).

From this definition, sub-domain of the Pedagogy Knowledge are following:

1. How students learn

   It is related with how students construct knowledge and acquire skills and how they develop habits of mind and positive dispositions toward learning.

2. General classroom management

   refers to the wide variety of skills and techniques that teachers use to keep students organized, orderly, focused, attentive, on task, and academically productive during a class

3. Lesson planning

   It is dealing with instructor's road map of what students need to learn or "learning trajectories" and how it will be done effectively during the class time

4. Students assessment

   It seeks to determine how well students are learning, mainly it is process of gathering and discussing information from multiple and diverse sources in order to develop a deep understanding of what students know, understand, and can do with their knowledge as a result of their learning experiences (Huba & Freed :1999)

5. Teaching methods / techniques

   It is dealing with principles and methods applied for instruction

Adoption and Adaptation from Existed TPACK Instruments	National Standard on Pre-Service, in-Service Science Teacher	Sub Domain	Instrument's Indicators Defined
Archambault & Crippen (2009) 1. My ability to determine a particular strategy best suited to teach a specific concept	1. Mastering the educational foundation, learning	How students learn	Deciding ways of students

<table>
<tr>
<td rowspan="8">It is related with teaching methods or techniques. The strategy could be lead to any teaching methods such as demonstration, discussion, gaming, lectures, etc. the ability to determine means the ability to recognize this strategy which is might be not same with the ability to deliver. The choosing reason is related with specific concept. In this term, the concept characters will determine which strategy would be best used. for example, some hands-on activities could not be done on abstract concepts such as atomic structure, or virtual learning is not recommended for concept which hands on can be delivered easier
2. My ability to use a variety of teaching strategies to relate various concepts to students.
This term is strongly related with the teaching strategy and its using in the classroom to deliver concepts to students. The using of the teaching strategy also should consider general classroom management, lesson planning, and how students learn at the same time. The ability to use reflects is adaptability from theory of the teaching strategy to the practices which sometimes need adjustment in certain aspects
3. My ability to adjust teaching methodology based on student performance/feedback
Again, this term is strongly related with teaching method, but the ability to adjust according student feedback is part of lesson planning prediction, result of student assessment and experience of classroom management
Schmidt et al (2009)
1. I know how to assess student performance in a classroom
It is strongly dealing with student's assessment, which focusing on performance assessment. Knowing how to assess student performance</td>
<td rowspan="8">theory, characteristics of learners, strategies, planning, and evaluation of science learning comprehensively
2. . Mastering foundation of planning and management of learning resources of classes, laboratories, schools or educational institutions
3. Planning and managing learning resources in the classroom and school and evaluating the lesson comprehensively
4. Managing self-regulated learning
5. Understanding learners characteristics covering the physical, moral, spiritual, social, cultural, emotional, and intellectual aspects
6. Conducting assessment and evaluation of processes and</td>
<td rowspan="5"></td>
<td>constructing knowledge</td>
</tr>
<tr><td>Sequencing students acquire skills</td></tr>
<tr><td>Knowing ways of developing habits of mind toward learning</td></tr>
<tr><td>Knowing ways of developing positive disposition toward learning</td></tr>
<tr><td>Indentify students misconception</td></tr>
<tr>
<td rowspan="2">General classroom management</td>
<td>Various ways to keep students organized, orderly and focus during a class</td>
</tr>
<tr><td>Various ways to keep students academically productive during a class</td></tr>
<tr>
<td>Lesson planning</td>
<td>Defining instruction roadmap</td>
</tr>
</table>

<table>
<tr>
<td rowspan="8">mean knowing about which aspects of students learning would be assessed and the method to perform it
2. I can adapt my teaching based upon what students currently understand or do not understand
This terms related with teaching methods and how students learn simultaneously. The keyword adapting teaching based on student understand or not is also part of reflection of teaching. The adaption of teaching method which focusing on whether students understand or not would lead to the creativity to foster most suitable teaching methods at particular chapter
3. I can adapt my teaching style to different learners
This item similar with number 2, but how students learn and student learning style is a main criteria. Since in the classroom might be consist of various learning style of students, so adopting teaching to these situation would be a complex knowledge
4. I can assess student learning in multiple ways
It is related with students assessment and its various type of assessment
5. I can use a wide range of teaching approaches in a classroom setting.
The item similar with number 2 and 3 but the main consideration is classroom management
6. I am familiar with common student understandings and misconceptions
This item strongly related with how student learn subset and classroom management as well because it does not focusing on the single student
7. I know how to organize and maintain classroom management</td>
<td rowspan="8">outcomes of learning
7. Applying reflective action to improve the quality of learning
8. Utilizing assessment and evaluation results for learning purposes
9. Facilitate the development of the potential of learners to actualize their potentials
10. Organizing educational learning
11. Developing professionalism sustainably by taking reflective action</td>
<td rowspan="2"></td>
<td>Predicting students learning trajectories</td>
</tr>
<tr><td>Deciding ways on how it will be done during the class time</td></tr>
<tr><td rowspan="2">Students assessment</td><td>Knowing ways of assessing students perform
ance in a class</td></tr>
<tr><td>Using particular assessment in certain concepts</td></tr>
<tr><td rowspan="4">Teaching methods / techniques</td><td>Knowing ways of teaching methods in class</td></tr>
<tr><td>Determining particular applied teaching strategy in class</td></tr>
<tr><td>Using variety of teaching strategies related with various concepts of students</td></tr>
<tr><td>Adjust teaching according to the students feedback</td></tr>
</table>

It is totally dealing with classroom management			Adjust teaching style to different learners

Table 10. Rational Adoption and Creation of Indicators of Pedagogy Knowledge According to the Referred Instrument and Indonesia Context

The table shows that ten items from existed instruments and its rational are adopted , and at the same time also eleven competences or learning outcomes needed in Indonesia context for science teacher and pre-service science teacher also adopted. These eventually produced 18 indicators which combination and or modification from those two consideration. According to the defined Indicators, the researcher developed the items for the instrument with cosideration that the items shall represent the indicator, and once the indicator has stages to obtain then it can be debrief into variation more than one items. The researcher decided to make variation mostly two since those variation items basically will have same indicator. The items developed for the Pedagogy Knowledge presenting as follow:

Indicator(s)	**Item(s)** **My ability to / of . . .**
1. Deciding ways of students constructing knowledge	19. Adapting teaching based on currently student understand or do not understand
	20. Using range of teaching approaches to construct students knowledge
2. Sequencing students acquire skills	21. Identify students' acquire skills needed from standard
	22. *Planning* sequencing students to acquire targeted skills
3. Knowing ways of developing habits of mind toward learning	23. Knowing habits of mind can be delivered through learning particular concept
	24. Knowing ways of develioping habits of mind toward learning
4. Knowing ways of developing positive disposition toward learning	25. Identifying positive dispotition toward learning from standard
	26. Identifying possible positive dispotition through learning particular concept
5. Indentify students misconception	27. Familiar with common students understanding and misconception
6. Various ways to keep students organized, orderly and focus during a class.	28. Identifying various ways of classroom management to keep student organized, orderly and focus during a class
	29. Adapting various way of classroom management in the classroom to keep student organized, orderly and focus during a class
7. Various ways to keep students academically productive during a class	30. Identifying various ways of teaching to keep student academically productive during a class

	31. Adapting various way of teaching to keep student academically productive during a class
8. Defining instruction roadmap	32. Design a roadmap of lesson plan related with expected objectives
	33. Identify teachers help or facilitation in learning sequences
9. Predicting students learning trajectories	34. Predicting students responses during learning
	35. Preparing responses for possible occurred of predicting students response
10. Deciding ways on how it will be done during the class time	36. Identify time consume for learning sequences
	37. Design possible planning for possible change in the classroom to fit with time
11. Knowing ways of teaching methods in class	38. Knowing teaching methods theoretically
	39. Knowing ways of teaching methods in class
12. Determining particular applied teaching strategy in class	40. Identifying characteristic of various teaching methods
	41. Determining particular applied teaching strategy in the classroom
13. Using variety of teaching strategies related with various concepts of students	42. Identifying various of teaching strategies related with various concept of students
	43. Using variety of teaching strategies related with various concepts of students
14. Adjust teaching according to the students feedback	44. Encouraging students' feedback during classroom
	45. Adjust teaching according to the students' feedback
15. Adjust teaching style to different learners	46. Identifying types of different learners
	47. Adjust teaching style to different learners
16. Knowing ways of assessing students performance in a class	48. Knowing various of students assessment
	49. Knowing ways of assessing students' performance in a class
17. Using particular assessment in certain concepts	50. Using particular assessment in certain concepts

Table 11. Adoption and Creation of Items of Content Knowledge According to Defined Indicators

The research mostly created 2 items from each Indicator except for the Indicator number 5 and 17. For the indicator number 5 "Identify Students Misconception", The researcher believe that Identify student misconception is essential demand for the professional skills and special mastery skills as demanded by National Standard for Pre-Service Science Teacher. The researcher assumed that "Familiar with common students understanding and misconception" is only way in identify steps for the misconception. While for the indicator number 17, the indicator and the item are same as this is application of the particular assesment so indicator itself is already technical term whis less need to be changed. For this Pedagogy

Knowledge, having made careful study toward existed TPACK instruments and National Standard, the researcher produced 17 indicators and 32 Items.

3. Technology Knowledge (TK)

Definition of technology is widely defined as the application of scientific knowledge for practical purposes, dealing with engineering or applied science, or any modification of natural world done to fullfill human needs or desires. In this research, TK which means Fluency of Information Technology (FITness) (NRC:1999) with subsets as follow:

1. Intellectual Capabilities

   Ability to apply information technology in complex and sustained situations and to understand the consequences of doing so. hese capabilities transcend particular hardware or software applications. A great deal of research (and everyday experience as well) indicates that these capabilities do not easily transfer between problem and in general, few individuals are equally adept with these capabilities in all domains. For this reason, these capabilities can be regarded as "life skills" that are formulated in the context of information technology.

2. Contemporary skills

   It is related with to use today computer applications, and apply information technology immediately. Skills refer to the ability to use particular (and contemporary) hardware or software resources to accomplish information processing tasks. Skills embody the intent of the phrase "knowing how to use a computer" as that phrase is colloquially understood. Skills include (but are not limited to) the use of several common software applications. The "skills" component of FITness necessarily changes over time because the information technology products and services available to citizens continually change.

3. Foundational Concepts

   It is related with basic principles of ideas of computers, networking, and information and underpin the technology. It is explain how and why of information technology. Concepts refer to the foundations on which information technology is built. This is the "book learning" part of fluency, although it is highly doubtful that a decent understanding of the concepts can be achieved strictly through the use of textbooks. The concepts are fundamental to information and computing and are enduring in the sense that new concepts may become important in the future as qualitatively new information technologies emerge, but the presented list of fundamental concepts will be augmented with rather than replaced by new concepts.

Intellectual capabilities and fundamental concepts of information technology are instantiated in or relevant to a wide variety of contexts. Intellectual capabilities and skills relate to very practical matters, getting at the heart of what it means to function in a complex technology-oriented world. And all have the characteristic that the acquisition of information technology skills, the understanding of information technology concepts, and the development of intellectual capabilities are lifelong activities. Over a lifetime, an individual will acquire more skills and develop additional proficiency with those skills, understand information technology

<table>
<tr><th>Adoption and Adaptation from Existed TPACK Instruments</th><th>National Standard on Pre-Service, in-Service Science Teacher</th><th>Sub Domain</th><th>Instrument’s Indicators Defined</th></tr>
<tr><td rowspan="7">Albion et al (2010)
1. I am comfortable using digital technologies.
2. I learn about new digital technologies easily.
3. I keep informed about new digital technologies
4. I know how to solve my own technical problems.
5. I have the technological skills I need to use digital technologies to achieve personal goals.
6. I have the technological skills I need to use digital technologies to achieve professional (teaching and learning) goals.
Archambault & Crippen (2009)
1. My ability to troubleshoot technical problems associated with hardware (e.g., network connections)
2. My ability to address various computer issues related to software (e.g., downloading appropriate plug-ins, installing programs)</td><td rowspan="7">1. Mastering the factual knowledge about the functions and benefits of technology, especially relevant information and communication technology for the development of the quality of science education

2. Designing and applying learning resources and ICT-based learning media to support science learning

3. Utilizing information and communication technology to communicate and develop themselves</td><td rowspan="3">Intellectual Capabilities</td><td>Troubleshooting problems associated with hardware</td></tr>
<tr><td>Address various computer issue related to software</td></tr>
<tr><td>Troubleshooting problems associated with sofware</td></tr>
<tr><td rowspan="2">Contemporary skills</td><td>Using today computer application</td></tr>
<tr><td>Applying recently ICT</td></tr>
<tr><td rowspan="2">Foundational Concepts</td><td>Basic principles of computer</td></tr>
<tr><td></td></tr>
</table>

3. My ability to assist students with troubleshooting technical problems with their personal computers. *Schmidt et al (2009)* 1. I know how to solve my own technical problems 2. I can learn technology easily 3. I keep up with important new technologies 4. I frequently play around with the technology 5. I know about a lot of different technologies. 6. I have the technical skills I need to use technology. 7. I have had sufficient opportunities to work with different technologies.	4. Utilizing information and communication technologies for the benefit of learning		Using ideas of networking

Table 12. Rational Adoption and Creation of Indicators of Technology Knowledge According to the Referred Instrument and Indonesia Context

The table shows that sixteen items from existed instruments and its rational are adopted, and at the same time also fourcompetences or learning outcomes needed in Indonesia context for science teacher and pre-service science teacher also adopted. These eventually produced 18 indicators which combination and or modification from those two consideration. According to the defined Indicators, the researcher developed the items for the instrument with cosideration that the items shall represent the indicator, and once the indicator has stages to obtain then it can be debrief into variation more than one items. The researcher decided to make variation mostly two since those variation items basically will have same indicator. The items developed for the Pedagogy Knowledge presenting as follow

Indicator(s)	Item(s) **My ability to / of . . .**
Using today computer application	51. Comfortable using digital technology (cellphone, computer, tablet, etc)
	52. Frequently play around with computer application
Applying recently ICT	53. Learn about new digital technology easily
	54. Keep informed about new digital technologies
	55. Know a lot of about new digital technologies
Basic principles of computer	56. Knowing how to solve problems on my own computer

Using ideas of networking	57. Knowing ideas networkig among computers
	58. Using ideas of networking on data

Table 13. Adoption and Creation of Items of Technology Knowledge According to Defined Indicators

4. Pedagogical Content Knowledge (PCK)

PCK is created through reflection, active processing and the integration of its two contributing components: general pedagogical knowledge and personal pedagogical knowledge. General pedagogical knowledge, gleaned from the research and scholarly literature on classroom organization and management, instructional models and strategies, and classroom communication and discourse, and typically presented in teacher preparation programs, is ultimately combined with personal pedagogical knowledge, which includes personal beliefs and perceptions about teaching (p.5). PCK as a separate domain of knowledge that is iteratively fueled by its component parts: subject matter knowledge, pedagogical knowledge, and knowledge of context (p.6)

PCK which consistent with Shulman (1987) with subsets:

1. Knowledge of representation of subject matter
2. Understanding students conception and its teaching implications
3. General pedagogical knowledge
4. Curriculum knowledge
5. Knowledge of educational context; and
6. Knowledge of the purposes of education

Adoption and Adaptation from Existed TPACK Instruments	National Standard on Pre-Service, in-Service Science Teacher	Sub Domain	Instrument's Indicators Defined
Archambault & Crippen (2009) 1. My ability to distinguish between correct and incorrect problem solving attempts by students. 2. My ability to anticipate likely student misconceptions within a particular topic.	1. Making decisions appropriately in the context of problem-solving based on the analysis of data and information 2. Mastering foundation of planning and management of	Representation of Subject Matter	Knowing various representation in particular science concept
			Determining appropriate (single or multi) representation for certain science lesson

3. My ability to comfortably produce lesson plans with an appreciation for the topic. 4. My ability to assist students in noticing connections between various concepts in a curriculum Schmidt et al (2009) 1. I know how to select effective teaching approaches to guide student thinking and learning in science Lee &Tsai (2010) 1. Know how to apply teaching modules on the Web into courses 2. Be able to use Web technology to enhance teaching 3. Be able to use the Web to enhance students' learning motivation 4. Be able to select proper existing Web-based courses to assist teaching. 5. Be able to apply Web technology to use multiple teaching strategies on a particular course unit 6. Be able to guide students to use Web resources to study a certain course unit 7. Be able to use Web resources to guide students' learning activities for a certain course unit 8. Be able to use Web technology to support teaching for the content of a particular course unit	learning resources of classes, laboratories, schools or educational institutions 3. Mastering the theoretical concepts of problem-solving in science education procedurally through a scientific approach 4. Mastering the competency standards and foundation competencies of subjects or areas of development 5. Mastering the educational foundation, learning theory, characteristics of learners, strategies, planning, and evaluation of science learning comprehensively		Anticipate likely students misconception within a particular topic
		Understanding students conception and its teaching implications	Distinguish correct and incorrect conception of student attempt
		General pedagogical knowledge	Selecting appropriate teaching approaches in science
			Produce lesson plan with an appropriate for the topic
			Apply teaching strategies in particular science concept
		Curriculum knowledge	Knowing limitation of concept related with curriculum
			Adjusting concept sequencing according to the curriculum objectives
		Knowledge of educational context; and	Addressing particular concept with learning objective
			Addressing particular concept with students proximal development
		Knowledge of the purposes of education	Knowing lesson developed in order to gain scientific literacy

Table 14. Rational Adoption and Creation of Indicators of Pedagogical Content Knowledge According to the Referred Instrument and Indonesia Context

The table 14 shows that thirteen items from existed instruments and its rational are adopted, and at the same time also fourcompetences or learning outcomes needed in Indonesia context for science teacher and pre-service science teacher also adopted. These eventually produced 12 indicators which combination and or modification from those two consideration. According to the defined Indicators, the researcher developed the items for the instrument with cosideration that the items shall represent the indicator, and once the indicator has stages to obtain then it can be debrief into variation more than one items. The researcher decided to make variation mostly two since those variation items basically will have same indicator. The items developed for the Pedagogy Knowledge presenting as follow

Indicator(s)	**Item(s)** **My ability to / of . . .**
Knowing various representation in particular science concept	59. Knowing various representation in particular science concept
Determining appropriate (single or multi) representation for certain science lesson	60. Using a better respresentation for particular science lesson
	61. Determining appropriate multi-representation for certain science lesson
Anticipate likely students misconception within a particular topic	62. Predicting likely students misconception within a particular topic
Distinguish correct and incorrect conception of student attempt	63. Distinguish between true concept, not knowing concept and misconception within a particular topic
	64. Distinguish between true concept, not knowing concept and misconception of student attempt within a particular topic
Selecting appropriate teaching approaches in science	65. Identifying various teaching approaches in science
	66. Selecting appropriate teaching approaches in science
Produce lesson plan with an appropriate for the topic	67. Produce lesson plan with an appropriate for the topic
Apply teaching strategies in particular science concept	68. Knowing various teching strategies in particular science concept
	69. Apply teaching strategies in particular science concepts
Knowing limitation of concept related with curriculum	70. Designing concept map related with curriculum
	71. Knowing limitation of concept related with curriculum
Adjusting concept sequencing according to the curriculum objectives	72. Creating concept sequencing according to the topic of grade
	73. Adjusting concept sequencing according to the curriculum objectives
Addressing particular concept with learning objective	74. Addressing particular concept with learning objective

Addressing particular concept with students proximal development	75. Addressing particular concept with students proximal development while they learn individually
	76. Addressing particular concept with student proximal development while they learn collaboratively
Knowing lesson developed in order to gain scientific literacy	77. Identifying scientifi literacy on particular topic
	78. Knowing lesson developed in order to gain scientific literacy

Table 15. Adoption and Creation of Items of Pedagogical Content Knowledge According to Defined Indicators

5. Technological Pedagogical Knowledge (TPK)

It has range of

1. Knowledge of pedagogical affordance and constrains of a range of technological tools; and
2. Knowledge to develop appropriate pedagogical design with technology

Adoption and Adaptation from Existed TPACK Instruments	National Standard on Pre-Service, in-Service Science Teacher	Sub Domain	Instrument's Indicators Defined
Archambault & Crippen (2009) 1. My ability to create an online environment which allows students to build new knowledge and skills 2. My ability to implement different methods of teaching online 3.My ability to moderate online interactivity among student 4. My ability to encourage online interactivity among students Schmidt et al (2009) 1. I can choose technologies that enhance the teaching approaches for a lesson	1. Designing and applying learning resources and ICT-based learning media to support science learning 2. Researching by utilizing science and technology to solve problems in science education 3. Mastering foundation of planning and management of learning resources of classes, laboratories, schools or educational institutions 4. Understanding learners characteristics covering the physical,	Knowledge of pedagogical affordance and constrains of a range of technological tools	adapt the use of the technologies learnied to different teaching activities
			choosing technologies that enhance the teaching approaches for a lesson
			choosing technologies that enhance students' learning for a lesson
		Knowledge to develop appropriate pedagogical design with technology	creating an online environment which allows students to build new knowledge and skills

2. I can choose technologies that enhance students' learning for a lesson 3. My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom 4. I am thinking critically about how to use technology in my classroom. 5. I can adapt the use of the technologies that I am learning about to different teaching activities	moral, spiritual, social, cultural, emotional, and intellectual aspects 5. Utilizing information and communication technologies for the benefit of learning		 Determining different methods of teaching online Encourage interactivity among student using ICT Moderating interactivity among student using ICT

Table 16. Rational Adoption and Creation of Indicators of Pedagogical Content Knowledge According to the Referred Instrument and Indonesia Context

The table 16 shows that 14 items from existed instruments and its rational are adopted, and at the same time also fourcompetences or learning outcomes needed in Indonesia context for science teacher and pre-service science teacher also adopted. These eventually produced 7 indicators which combination and or modification from those two consideration. According to the defined Indicators, the researcher developed the items for the instrument with cosideration that the items shall represent the indicator, and once the indicator has stages to obtain then it can be debrief into variation more than one items. The researcher decided to make variation mostly two since those variation items basically will have same indicator. The items developed for the Pedagogy Knowledge presenting as follow

Indicator(s)	**Item(s) My ability to / of . . .**
creating an online environment which allows students to build new knowledge and skills	79. Dealing with online environment to build new knowledge and skills
	80. Creating an online environment which allows students to build new knowledge and skills
Determining different methods of teaching online	81. Determining different methods of teaching online
Encourage interactivity among student using ICT	82. Communicating online with students in particular online environtment
	83. Encourage interactivity among student using ICT

Moderating interactivity among student using ICT	84. Moderating interactivity among student using ICT

Table 17. Adoption and Creation of Items of Technological Pedagogical Knowledge According to Defined Indicators

6. Technological Content Knowledge (TCK)

Technology can constrain the types of possible representations, but also can afford the construction of newer and more varied representations. Furthermore, technological tools can provide a greater degree of flexibility in navigating across these representations. While TCK subsets/subdomain are

1. Choosing of technologies affords and constrains the types of content ideas that can be taught
2. flexibility in navigating across content representations
3. Manner in which the subject matter can be changed by the application of particular technologies.

It is essentual to understand which specific technologies are best suited for addressing subject-matter learning in each domains and how the content dictates or perhaps even changes the technology—or vice versa

Adoption and Adaptation from Existed TPACK Instruments	National Standard on Pre-Service, in-Service Science Teacher	Sub Domain	Instrument's Indicators Defined
Archambault & Crippen (2009) 1.My ability to use technological representations (i.e. multimedia, visual demonstrations, etc.) to demonstrate specific concepts in my content area). 2.My ability to implement district curriculum in an online environment. 3.My ability to use various courseware programs to deliver instruction (e.g., Blackboard, Centra). Schmidt et al (2009) 1.I know about technologies that I can use for understanding and doing in science /	1. Utilizing information and communication technologies for the benefit of learning. 2. Utilizing information and communication technology to communicate and develop themselves 3. Mastering the materials, structures, concepts, and scientific mindsets	Choosing of technologies affords and constrains the types of content ideas that can be taught	Selecting proper content concerned with technology Enhancing the scope of body of knowledge dealing with technology

Lee &Tsai (2010) 1.Know that Web technology can provide various materials to enrich course content This term related with enhancing the scope of body of knowledge and also mapping the concept, but there is no guarantee that various material would lead to the proper concepts. 2.Know how to search online resources for course content. This term is strongly related with understanding of keyword of concept to find particular resources related with the course content, it can be classified as many subset depends on the purposes of searching. The searching could be related with curriculum issue, mapping the concept, enhance body of knowledge or to develop practices 3.Know how to select proper content from Web resources This item emphasize on selecting proper content, which concerned with combination of 4.Be able to search related online materials for course content 5. Be able to search for various materials on the Web to be integrated into course content	that support the subjects. 4. Designing and applying learning resources and ICT-based learning media to support science learning 5. Applying logical, critical, systematic, and innovative thinking to develop the application of science and technology 6. To examine the implications of the science, technology or art development based on scientific rules, procedures and ethics to produce solutions, ideas, designs, or art criticisms as well as to prepare scientific descriptions of the results of their studies in the form of a thesis or final report	flexibility in navigating across content representations	Understandin g of representation s of concepts dealing with available technology
		Manner in which the subject matter can be changed by the application of particular technologies	Knowing specific technologies best suited in students domain
			Knowing how content dictates or even perhaps changes the technology or vice-versa

Table 18 Rational Adoption and Creation of Indicators of Technological Content Knowledge According to the Referred Instrument and Indonesia Context

The table 18 shows that 9 items from existed instruments and its rational are adopted, and at the same time also fourcompetences or learning outcomes needed in Indonesia context for science teacher and pre-service science teacher also adopted. These eventually produced 5 indicators which combination and or modification from those two consideration. According to the defined Indicators, the researcher developed the items for the instrument with cosideration that the items shall represent the indicator, and once the indicator has stages to obtain then it can be debrief into variation more than one items. The researcher decided to make variation mostly two since those variation items basically will have same indicator. The items developed for the Pedagogy Knowledge presenting as follow

Indicator(s)	Item(s) My ability to / of . . .
Selecting proper content concerned with technology	85. Selecting proper content of science related with technology needed (multimedia, visual demo, apps)
Enhancing the scope of body of knowledge dealing with technology	86. Selecting exist technology (multimedia, visual demo, apps) that can be used related with enchancement of content
	87. Selecting exist technologies as application of body of knowledge
Understanding of representations of concepts dealing with available technology	88. Identify various representations of particular concepts of a topic
	89. Understanding of representations of concepts dealing with available technology
Knowing specific technologies best suited in students domain	90. Knowing specific technologies suited in classroom using
	91. Knowing specific technologies best suited in students domain
Knowing how content dictates or even perhaps changes the technology or vice-versa	92. Identify content dictates the technology
	93. Identify technology dictates particular content in a science topic

Table 19 Adoption and Creation of Items of Technological Pedagogical Knowledge According to Defined Indicators

7. Technological Pedagogical Content Knowledge (TPACK)

TPACK centers on the nuanced interactions among three doamins of knowledge: content, pedagogy, and technology (Koehler & Mishra, 2008). Because if defined on its inception, the TPACK framework has been at the center of efforts to inform and transform teacher preparation programs (Abbitt, 2011; Chai, Koh, & Tsai, 2010; Harris & Hofer, 2009)It has subdomains i.e.:

1. Effective teaching with technology
2. Representation of concept using technology
3. pedagogical techniques that use technologies in constructive ways to teach content

4. knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face
5. knowledge of students' prior knowledge and theories of epistemology; and
6. how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones

From those three definition, indicators are defined as displayed in the appendix

Adoption and Adaptation from Existed TPACK Instruments	National Standard on Pre-Service, in-Service Science Teacher	Sub Domain	Instrument's Indicators Defined
Albion et al (2010) In my class, I could support students' use of ICT to: 1. Acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change 2. Develop functional competencies in a specified curriculum area. 3. Synthesize their knowledge 4. Actively construct their own knowledge in collaboration with their peers and others. 5. Actively construct knowledge that integrates curriculum areas. 6. Develop deep understanding about a topic of interest relevant to the curriculum area(s) being studied.	1. To examine the implications of the science, technology or art development based on scientific rules, procedures and ethics to produce solutions, ideas, designs, or art criticisms as well as to prepare scientific descriptions of the results of their studies in the form of a thesis or final report	Effective teaching with technology	Acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change
			Using strategies that combine content-technologies-teaching approaches in classroom
7. Develop a scientific understanding of the world. 8. Provide motivation for curriculum tasks. 9. Plan and/or manage curriculum projects. 10. Integrate different media to create appropriate products 11. Engage in sustained involvement with curriculum activities	2. Researching by utilizing science and technology to solve problems in science education 3. Mastering the factual knowledge about the functions and benefits of	Representation of concept using technology	Using appropriate technology for better representation of content for the lesson
			Modify exsist technology related with

<table>
<tr>
<td rowspan="6">12. Support elements of the learning process
13. Demonstrate what they have learned.
14. Undertake formative and/or summative assessment.
15. Acquire awareness of the global implications of ICT-based technologies on society.
16. Gain intercultural understanding
17. Critically evaluate their own and society's values
18. Communicate with others locally and globally
19. Engage in independent learning through access to education at a time, place, and pace of their own choosing
20. Understand and participate in the changing knowledge economy.
Archambault & Crippen (2009)
1. My ability to use online student assessment to modify instruction
2. My ability to use technology to predict students' skill/understanding of a particular topic
3. My ability to use technology to create effective representations of content that depart from textbook knowledge
4. My ability to meet the overall demands of online teaching

Schmidt et al (2009)
1. I can teach lessons that appropriately combine literacy, technologies and teaching approaches
2. I can use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom.
3. I can choose technologies that enhance the content for a lesson.</td>
<td rowspan="6">technology, especially relevant information and communication technology for the development of the quality of science educatioN

4. Designing and applying learning resources and ICT-based learning media to support science learning

5. Understanding learners characteristics covering the physical, moral, spiritual, social, cultural, emotional, and intellectual aspects

6. Utilizing assessment and evaluation results for learning purposes</td>
<td></td>
<td>representation of certain concept</td>
</tr>
<tr>
<td rowspan="2">pedagogical techniques that use technologies in constructive ways to teach content</td>
<td>Modify teaching strategies in terms of involving technology at particular concept</td>
</tr>
<tr>
<td>Using teaching strategies in term of particular concept using certain technology</td>
</tr>
<tr>
<td rowspan="2">knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face</td>
<td>Identifying students obstacles on certain concepts which can be improved by technologies</td>
</tr>
<tr>
<td>Adjusting technologies for possibility reduce student conception problem</td>
</tr>
<tr>
<td>Using of technology to build on existing knowledge to develop new epistemologies</td>
<td>Adjusting technology to describe better existing knowledge of concept</td>
</tr>
</table>

4. I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn 5. I can teach lessons that appropriately combine science, technologies, and teaching approaches 6. I can teach lessons that appropriately combine social studies, technologies, and teaching approaches 7. I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school and/ or district. 8. I can teach lessons that appropriately combine mathematics, technologies, and teaching approaches		or strengthen old one	Adjusting technology to describe new epistemologie s in particular concept

Table 20. Rational Adoption and Creation of Indicators of Technological Pedagogical Content Knowledge According to the Referred Instrument and Indonesia Context

The table 20 shows that 32 items from existed instruments and its rational are adopted, and at the same time also fourcompetences or learning outcomes needed in Indonesia context for science teacher and pre-service science teacher also adopted. These eventually produced 9 indicators which combination and or modification from those two consideration. According to the defined Indicators, the researcher developed the items for the instrument with cosideration that the items shall represent the indicator, and once the indicator has stages to obtain then it can be debrief into variation more than one items. The researcher decided to make variation mostly two since those variation items basically will have same indicator. The items developed for the Pedagogy Knowledge presenting as follow

Indicator(s)	Item(s) My ability to / of . . .
Acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change	94. Acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change
Using strategies that combine content-technologies-teaching approaches in classroom	95. Develop functional competencies in a specified curriculum area
	96. use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom

Using appropriate technology for better representation of content for the lesson	97. Identfying various technology for representation of content for the lesson
	98. Using appropriate technology for better representation of content for the lesson
Modify exsist technology related with representation of certain concept	99. Modify exsist technology related with representation of certain concept
Modify teaching strategies in terms of involving technology at particular concept	100. Modify teaching strategies in terms of involving technology at particular concept
Using teaching strategies in term of particular concept using certain technology	101. Using teaching strategies in term of particular concept using certain technology
Identifying students obstacles on certain concepts which can be improved by technologies	102. Able to synthesize students knowledge
	103. Identifying students obstacles on certain concepts which can be improved by technologies
Adjusting technologies for possibility reduce student conception problem	104. Adjusting technologies for possibility reduce student conception problem
Adjusting technology to describe better existing knowledge of concept	105. Adjusting technology to describe better existing knowledge of concept
Adjusting technology to describe new epistemologies in particular concept	106. Adjusting technology to describe new epistemologies in particular concept

Table 21. Adoption and Creation of Items of Technological Pedagogical Content Knowledge According to Defined Indicators

In step of defining items, researher was collecting, analysing, adopting and adapting items which have been defined by previous researchers according to the component of TPACK / Sub-domain and its description. Personal academic consideration are applied in this stage to ensure that items are reflecting indicatotors which truly predicted describing the description of each sub-domains. Some items plotted associate with the sub-domain and its description according to the existed items of populated instruments, while the presence items from literature study could not fit with with demanding sub-components defined by researcher. In that occasion, researcher as trying to create and define items by himself. Eventually, regarding its origin, items produces are mixed between adoption and adaptation from previous instrument with self-creation of the researcher.

Domain	Sub-Domain	Indicator(s)	Item(s) My ability to / of . . .
Content Knowledge **(CK)**	Curriculum Issue	Mapping particular standard from curriculum	107. Identify standard of curriculum related with certain concept
			108. Mapping particular standard from curriculum
		Sufficient knowledge about science content in curriculum	109. know about science content that I want to teach

			110. know the scope of content in curriculum
	Mapping the Concept	Sequencing the particular science concept	111. make a proper order of science concept according to the standards
			112. sequencing certain science concept
		Knowing scope of concept	113. Knowing how far / high science concept in certain topic
			114. Know limitation of science concept among other concepts
	Body of Knowledge	Creating materials related with science concept	115. Identify materials supported with particular science concept
			116. Creating materials related with certain science concept
		Sufficient knowledge about certain science concept	117. Sufficient knowledge about science concepts in secondary level
	Developing for Practice	Planning the sequence of concept	118. Identify ways of concepts'construction
			119. Planning the sequence of concept
		Deciding the scope of essential concept	120. Identify essential concepts from particular topics
			121. Mapping the scope of essential concepts from particular topics
		Various way developing the understanding of concept	122. Knowing various ways to understand the particular concept
		Using science way of thinking	123. Using science way of thinking to develop understanding of science concept
			124. Using science way of thinking in the classroom
Pedagogical Knowledge (**PK**)	How Students Learn	Deciding ways of students constructing knowledge	125. Adapting teaching based on currently student understand or do not understand
			126. Using range of teaching approaches to construct students knowledge
		Sequencing students acquire skills	127. Identify students' acquire skills needed from standard
			128. *Planning* sequencing students to acquire targeted skills
		Knowing ways of developing habits of mind toward learning	129. Knowing habits of mind can be delivered through learning particular concept
			130. Knowing ways of develioping habits of mind toward learning
		Knowing ways of developing positive disposition toward learning	131. Identifying positive dispotition toward learning from standard
			132. Identifying possible positive dispotition through learning particular concept
		Indentify students misconception	133. Familiar with common students understanding and misconception
			134. Identifying various ways of classroom management to keep

	General Classroom Management	Various ways to keep students organized, orderly and focus during a class.	student organized, orderly and focus during a class
			135. Adapting various way of classroom management in the classroom to keep student organized, orderly and focus during a class
		Various ways to keep students academically productive during a class	136. Identifying various ways of teaching to keep student academically productive during a class
			137. Adapting various way of teaching to keep student academically productive during a class
	Lesson Planning	Defining instruction roadmap	138. Design a roadmap of lesson plan related with expected objectives
			139. Identify teachers help or facilitation in learning sequences
		Predicting students learning trajectories	140. Predicting students responses during learning
			141. Preparing responses for possible occurred of predicting students response
		Deciding ways on how it will be done during the class time	142. Identify time consume for learning sequences
			143. Design possible planning for possible change in the classroom to fit with time
	Teaching Methods / Techniques	Knowing ways of teaching methods in class	144. Knowing teaching methods theoretically
			145. Knowing ways of teaching methods in class
		Determining particular applied teaching strategy in class	146. Identifying characteristic of various teaching methods
			147. Determining particular applied teaching strategy in the classroom
		Using variety of teaching strategies related with various concepts of students	148. Identifying various of teaching strategies related with various concept of students
			149. Using variety of teaching strategies related with various concepts of students
		Adjust teaching according to the students feedback	150. Encouraging students' feedback during classroom
			151. Adjust teaching according to the students' feedback
		Adjust teaching style to different learners	152. Identifying types of different learners
			153. Adjust teaching style to different learners
	Students Assessment	Knowing ways of assessing students performance in a class	154. Knowing various of students assessment
			155. Knowing ways of assessing students' performance in a class
		Using particular assessment in certain concepts	156. Using particular assessment in certain concept

Technological Knowledge (**TK**)	Intellectual Capabilities	Troubleshooting problems associated with hardware	157. Able to handle troubleshooting problems related with hardware (e.g. network connection)
			158. Able to assist students with hardware problems witht their PC or laptops
		Address various computer issue related to software	159. Addressing various computer issue related to software (e.g. installing program, dowloading)
			160. Able to assist students with hardware problems witht their PC or laptops
		Troubleshooting problems associated with sofware	161. Able to handle troubleshooting problems related with software (e.g. network connection)
			162. Able to assist students with networking problems witht their PC or laptops
	Contemporary skills	Using today computer application	163. Comfortable using digital technology (cellphone, computer, tablet, etc)
			164. Frequently play around with computer application
		Applying recently ICT	165. Learn about new digital technology easily
			166. Keep informed about new digital technologies
			167. Know a lot of about new digital technologies
	Foundational Concept	Basic principles of computer	168. Knowing how to solve problems on my own computer
		Using ideas of networking	169. Knowing ideas networkig among computers
			170. Using ideas of networking on data
Pedagogical Content Knowledge (**PCK**)	Representation of Subject Matter	Knowing various representation in particular science concept	171. Knowing various representation in particular science concept
		Determining appropriate (single or multi) representation for certain science lesson	172. Using a better respresentation for particular science lesson
			173. Determining appropriate multi-representation for certain science lesson
		Anticipate likely students misconception within a particular topic	174. Predicting likely students misconception within a particular topic
	Understanding Student Conception and its Teaching Implications	Distinguish correct and incorrect conception of student attempt	175. Distinguish between true concept, not knowing concept and misconception within a particular topic
			176. Distinguish between true concept, not knowing concept and misconception of student attempt within a particular topic
	General Pedagogy	Selecting appropriate teaching approaches in science	177. Identifying various teaching approaches in science
			178. Selecting appropriate teaching approaches in science
		Produce lesson plan with an appropriate for the topic	179. Produce lesson plan with an appropriate for the topic

		Apply teaching strategies in particular science concept	180. Knowing various teching strategies in particular science concept
			181. Apply teaching strategies in particular science concepts
	Curriculum	Knowing limitation of concept related with curriculum	182. Designing concept map related with curriculum
			183. Knowing limitation of concept related with curriculum
		Adjusting concept sequencing according to the curriculum objectives	184. Creating concept sequencing according to the topic of grade
			185. Adjusting concept sequencing according to the curriculum objectives
	Educational Context	Addressing particular concept with learning objective	186. Addressing particular concept with learning objective
		Addressing particular concept with students proximal development	187. Addressing particular concept with students proximal development while they learn individually
			188. Addressing particular concept with student proximal development while they learn collaboratively
	Purpose of education	Knowing lesson developed in order to gain scientific literacy	189. Identifying scientifi literacy on particular topic
			190. Knowing lesson developed in order to gain scientific literacy
Technological Content Knowledge (**TCK**)	Choosing Technologies Affords, Constrains, and Types of Content Ideas that can be taught	Selecting proper content concerned with technology	191. Selecting proper content of science related with technology needed (multimedia, visual demo, apps)
		Enhancing the scope of body of knowledge dealing with technology	192. Selecting exist technology (multimedia, visual demo, apps) that can be used related with enchancement of content
			193. Selecting exist technologies as application of body of knowledge
	Flexibility in Navigating Across Content Representation	Understanding of representations of concepts dealing with available technology	194. Identify various representations of particular concepts of a topic
			195. Understanding of representations of concepts dealing with available technology
	Manner in which the subject matter can be changed by the application of particular technologies	Knowing specific technologies best suited in students domain	196. Knowing specific technologies suited in classroom using
			197. Knowing specific technologies best suited in students domain
		Knowing how content dictates or even perhaps changes the technology or vice-versa	198. Identify content dictates the technology
			199. Identify technology dictates particular content in a science topic
Technological Pedagogical Knowledge (**TPK**)	Pedagogical affordance and constrains of a range of	adapt the use of the technologies learnied to different teaching activities	200. Identify using of technologies learned during the course period
			201. adapt the use of the technologies learnied to different teaching activities

	technological tools	choosing technologies that enhance the teaching approaches for a lesson	202. Choosing technologies that enhance the teaching approaches for a lesson
		choosing technologies that enhance students' learning for a lesson	203. Choosing technologies that enhance students' learning for a lesson
	Developing appropriate pedagogical design with technology	creating an online environment which allows students to build new knowledge and skills	204. Dealing with online environment to build new knowledge and skills
			205. Creating an online environment which allows students to build new knowledge and skills
		Determining different methods of teaching online	206. Determining different methods of teaching online
		Encourage interactivity among student using ICT	207. Communicating online with students in particular online environtment
			208. Encourage interactivity among student using ICT
		Moderating interactivity among student using ICT	209. Moderating interactivity among student using ICT
Technological Pedagogical Content Knowledge (TPACK)	Effective teaching with technology	Acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change	210. Acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change
			211. Develop functional competencies in a specified curriculum area
		Using strategies that combine content-technologies-teaching approaches in classroom	212. use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom
	Representation of concept using technology	Using appropriate technology for better representation of content for the lesson	213. Identfying various technology for representation of content for the lesson
			214. Using appropriate technology for better representation of content for the lesson
		Modify exsist technology related with representation of certain concept	215. Modify exsist technology related with representation of certain concept
	Pedagogical techniques that use technology in constructive ways to teach content	Modify teaching strategies in terms of involving technology at particular concept	216. Modify teaching strategies in terms of involving technology at particular concept
		Using teaching strategies in term of particular concept using certain technology	217. Using teaching strategies in term of particular concept using certain technology
	Knowledge what makes concept difficult or easy and related technolgy can reduce students problem	Identifying students obstacles on certain concepts which can be improved by technologies	218. Able to synthesize students knowledge
			219. Identifying students obstacles on certain concepts which can be improved by technologies
		Adjusting technologies for possibility reduce student conception problem	220. Adjusting technologies for possibility reduce student conception problem

	Using of technology to build on existing knowledge to develop new epistemologies or strengthen old one	Adjusting technology to describe better existing knowledge of concept	221. Adjusting technology to describe better existing knowledge of concept
		Adjusting technology to describe new epistemologies in particular concept	222. Adjusting technology to describe new epistemologies in particular concept

Table 22. Full of Draft TPACK Instrument Resulted

It is obvious that the resercher obtained the first draft of the instrument TPACK for Preservice Science Teacher in Indonesia. This draft then shall be initially validated through expert view. In this the instrument consulted with 3 Professors which has background from Physics Education, Biology Education and Chemistry Education

b. Factor Analysis

To reduce items from the initial instrument, Factor Analysis is chosen. Aim of Factor analysis:

1. To reveal any latent variables that cause the manifest variables to cover.
2. To explore the underlying pattern of relationships among multiple observed variables,
3. For assessing the dimensionality of questionnaire scales that measure underlying latent variables (baglin:2014)

There are many methods of Factor analysis with short description as follow

Factor Analysis Methods	Short description
Principal Component Analysis (PCA)	Some argue for severely restricted use of components analysis in favor of a true factor analysis method (Bentler & Kano, 1990; Floyd & Widaman, 1995). Others disagree, and point out either that there is almost no difference between principal components and factor analysis, or that PCA is preferable (Guadagnoli and Velicer, 1988; Steiger, 1990; Velicer & Jackson, 1990). Components analysis is only a data reduction method. It became common decades ago when computers are slow and expensive to use; it was a quicker, cheaper alternative to factor analysis (Gorsuch, 1990). It is computed without regard to any underlying structure caused by latent variables; components are calculated using all of the variance of the manifest variables, and all of that variance appears in the solution (Ford et al., 1986; Baglin:2014) However, researchers rarely collect and analyze data without an a priori idea about how the variables are related (Floyd & Widaman, 1995).

Unweighted Least Squares / Ordinary Least Squares (ULS)	Minimizing the residuals between the input correlation matrix and the reproduced (by the factors) correlation matrix (while diagonal elements as the sums of communality and uniqueness are aimed to restore 1s) Minimizing the sum of the squared differences between the observed and reproduced correlation matrices (ignoring the diagonals). In a good factor model, most of the off-diagonal elements will be small. The measure of sampling adequacy for a variable is displayed on the diagonal of the anti-image correlation matrix
Generalized Least Square (GLS)	Correlations between variables with high uniqueness (at the current iteration) are given less the weight. This method is used if the researcher want the factors to fit highly *unique* variables (i.e. those the weakly driven by the factors) worse than highly *common* variables (i.e. strongly driven by the factors).
Maximum Likelihood (ML)	If data are relatively normally distributed, maximum likelihood is the best choice Fabrigar, Wegener, MacCallum and Strahan (1999) Benefit of using ML is that in addition to the correlational estimates, it produces significance tests for each item as the well as fit statistics for the structure (Pett et al., 2003)
Principal Axis Factoring	If the assumption of multivariate normality is "severely violated" it recommends one of the principal factor methods; in SPSS this procedure is called "principal axis factors" (Fabrigar et al., 1999) because it requires no distributional assumptions and may be used if data are not normally distributed (Fabrigar et al., 1999). The items are believed to reflect the underlying structure. These factor loadings are used to estimate new communalities that replace the old community estimates in the diagonal.
Alpha Factoring	A factor extraction method that considers the variables in the analysis to be a sample from the universe of potential variables. This method maximizes the alpha reliability of the factors.
Image Factoring	A factor extraction method developed by Guttmann and based on image theory. The common part of the variable, called the partial image, is defined as its linear regression on remaining variables, rather than a function of hypothetical factors.

Researcher chosen principal axis factor analyses rather than confirmatory factor analysis (CFA) to identify integral constructs underlying the items on the Survey of Preservice Teachers' Knowledge of Teaching and Technology (Schmidt et al., 2009). Some studies empirically provides evidence that CFA may be a less favorable method for determining the number of factors measured by a data set. Correct population model somehow could not uncover by particular searches in correlation matrices using this method (MacCallum, Roznowski, & Nowrwitz, 1992). Moreover, researcher employed principal axis factor analysis since it gives superior recovery of weak factors (Briggs & MacCallum, 2003).

A brief resume of data processing in SPSS using factor analysis is shown below:

Sample Size: 1380

Case Processing Summary

		N	%
Cases	Valid	1192	100.0
	Excluded[a]	0	.0
	Total	1192	100.0

Excellent (Comrey & Lee, 1992)

Type of FA: Exploratory Factor Analysis (EFA) / Principal Component Analysis with Anti-Image Correlation test and Varimax if needed.

1. **Content Knowledge (CK)** for item number 1 – 18

Features	Brief description Data Statistical Processing
correlation matrix	Inter-item correlations score: 6 Strong (4%), 76 moderate (47%), 80 weak (49%)
Measures of sampling adequacy (MSAs)	KMO > .5 and significance,
Anti-image matrices	No variables with diagonal anti-image correlations of less than .5 means no one variables should be excluded
Total variance explained test	Two factors identified (F1 and F2) with initial eigenvalue ≥1
Communalities	The biggest score is .670 which more than .5 (item number 12)
Component Matrix	Found 1 component factor which F1, F1 > .5; re-analyze with Varimax is used
Cronbach's Alpha Reliability	Since *Cronbach's alpha if item deleted* are less than .930, no one items deleted

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.929
Bartlett's Test of Sphericity	Approx. Chi-Square	11544.903
	df	153
	Sig.	.000

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.930	.930	18

Factor I Content Standards in the Curriculum	Factor loading
1. Identify standard of curriculum related with certain concept	.729
2. Mapping particular standard from curriculum	.751
3. Make a proper order of physics concept according to the standards	.649

5. Sequencing certain physics concept	.732
6. Know about physics content that I want to teach	.700
17. Using physics way of thinking in the classroom	.765
18. Mapping the scope of essential concepts from particular topics	.705
4. Planning the sequence of concept	.536
Factor II Developing Concept for Practice	Factor loading
7. Knowing how far / high physics concept in certain topic	.667
8. Know limitation of physics concept among other concepts	.650
9. Sufficient knowledge about physics concepts in secondary level	.643
10. Creating materials related with certain physics concept	.542
11. Identify essential concepts from particular topics	.649
12. Knowing various ways to understand the particular concept	.801
13. Using physics way of thinking to develop understanding of physics concept	.742
14. Knowing the scope of content in curriculum	.601
15. Identify materials supported with particular physics concept	.671
16. Identify ways of concepts construction	.765

2. **Pedagogical Knowledge (PK)** for Item number 19 – 50

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.927
Bartlett's Test of Sphericity	Approx. Chi-Square	25149.003
	df	496
	Sig.	.000

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.948	.948	28

Features		Brief description Data Statistical Processing
correlation matrix		Inter-item correlations score: 1 Very Strong (0.19%); 18 Strong (3.51%), 204 Moderate (39.8%), 287 weak (56%)
Measures of sampling adequacy (MSAs)		KMO > .5 and significance,
Anti-image matrices		No variables with diagonal anti-image correlations of less than .5 means no one variables should be excluded
Total variance explained test		Six components indicated with initial eigenvalue ≥1
Communalities		The biggest score is .804 which more than .5 (item number 49)
Component Matrix	- - - 	Found 3 component factors which 2 Factors > .5; re-analyze with Varimax is used After the varimax-once: Items 43, 36 and 42 are no one more than 0.5 on one of 6 factors; The items are deleted and data is re-analyzed After Varimax-second: Item number 37 is no one more than 0.5 on one of 6 factors; The item is deleted and data is re-analyzed
Cronbach's Alpha Reliability	- -	Since *Cronbach's alpha if item deleted* are less than .948, no one items deleted. Deleted items from Component Matrix process are excluded

Factor I Students Classroom Management	Factor loading
31. Adapting various way of teaching to keep student academically productive during a class	.719
30. Identifying various ways of teaching to keep student academically productive during a class	.592
28. Identifying various ways of classroom management to keep student organized, orderly and focus during a class	.663
29. Adapting various way of classroom management in the classroom to keep student organized, orderly and focus during a class	.710

46. Identifying types of different learners	.554
47. Adjust teaching style to different learners	.535

Factor II Teaching for Student Learning	Factor loading
19. Adapting teaching based on currently student understand or do not understand	.590
20. Adapting teaching based on currently student understand or do not understand	.506
22. Planning sequencing students to acquire targeted skills	.563
44. Encouraging students feedback during classroom	.710
45. Adjust teaching according to the students feedback	.769

Factor III How Students Learn	Factor loading
21. Identify students acquire skills needed from standard	.563
23. Knowing habits of mind can be delivered through learning particular concept	.673
24. Knowing ways of developing habits of mind toward learning	.568
25. Identifying positive disposition toward learning from standard	.604
26. Identifying possible positive disposition through learning particular concept	.616
27. Familiar with common students understanding and misconception	.530

Factor IV Lesson Design	Factor loading
32. Design a roadmap of lesson plan related with expected objectives	.671
33. Identify teachers help or facilitation in learning sequences	.661
34. Predicting students responses during learning	.640
35. Preparing responses for possible occurred of predicting students response	.642
Factor V Teaching Methods	**Factor loading**
38. Knowing teaching methods theoretically	.794
39. Knowing ways of teaching methods in class	.673
40. Identifying characteristic of various teaching methods	.748
41. Determining particular applied teaching strategy in the classroom	.541
Factor VI Students Assessment	**Factor loading**
48. Knowing various of students assessment	.763
49. Knowing ways of assessing students' performance in a class	.825
50. Using particular assessment in certain concept	.703

3. **Technological Knowledge (TK)** for Item number 51 – 64

Features	Brief description Data Statistical Processing
correlation matrix	Inter-item correlations score: 0 Very Strong (0%);13 Strong (13.2%), 53 Moderate (54%), 30 weak (30.6%), 2 none (2%)
Measures of sampling adequacy (MSAs)	KMO > .5 and significance,
Anti-image matrices	No variables with diagonal anti-image correlations of less than .5 means no one variables should be excluded
Total variance explained test	Three components indicated with initial eigenvalue ≥1
Communalities	The biggest score is .841 which more than .5 (item number 63)
Component Matrix	- Found 3 items (64, 58, 63) which 2 Factors > .5; re-analyze with Varimax is used - After the varimax-once: Item no 55 is less than 0.5 of 6 factors; The items are deleted and data is re-analyzed - After Varimax-second, all item number fulfilled .5 on one of three factors
Cronbach's Alpha Reliability	- At Cronbach's alpha if item deleted, only if item 57 deleted, the alpha would be are .916 which is less significance from .915; so no one items deleted. - Deleted items from Component Matrix process are excluded

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.915	.917	13

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.885
Bartlett's Test of Sphericity	Approx. Chi-Square	11760.711
	df	91
	Sig.	.000

Factor I Intellectual Capabilities	Factor loading
51. Able to handle troubleshooting problems related with hardware (e.g. network connection)	.785
52. Able to assist students with hardware problems with their PC or laptops	.854
53. Addressing various computer issue related to software (e.g. installing program, dowloading)	.685
54. Able to assist students with hardware problems with their PC or laptops	.708
56. Able to assist students with hardware problems with their PC or laptops	.849
Factor II Contemporary Skills	**Factor loading**
57. Comfortable using digital technology (cellphone, computer, tablet, etc.)	.774
58. Frequently play around with computer application	.790
59. Learn about new digital technology easily	.811

60. Keep informed about new digital technologies	.757
61. Know a lot of about new digital technologies	.692

Factor II Foundational Concept	Factor loading
62. Knowing how to solve my own computer	.640
63. Knowing ideas networking among computers	.885
64. Using ideas of networking on data	.871

4. **Pedagogical Content Knowledge (PCK)** for Item number 65 – 84

Features	Brief description Data Statistical Processing
Correlation matrix	Inter-item correlations score: 1 Very Strong (0.5%);30 Strong (15%), 152 Moderate (76%), 15 weak (30.6%), 2 none (2%)
Measures of sampling adequacy (MSAs)	KMO > .5 and significance,
Anti-image matrices	No variables with diagonal anti-image correlations of less than .5 means no one variables should be excluded
Total variance explained test	Three components indicated with initial eigenvalue ≥1
Communalities	The biggest score is .831 which more than .5 (item number 68)
Component Matrix	- Found 2 items (69, 70) which 2 Factors > .5; re-analyze with Varimax is used - After Varimax-First, all item number fulfilled .5 on one of three factors
Cronbach's Alpha Reliability	Since Cronbach's alpha if item deleted are less than .954, no one items deleted.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.954	.955	20

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.944
Bartlett's Test of Sphericity	Approx. Chi-Square	17983.661
	df	190
	Sig.	.000

Factor I Teaching concept according standards	Factor loading
71. Identifying various teaching approaches in physics	.636
72. Selecting appropriate teaching approaches in physics	.711
73. Produce lesson plan with an appropriate for the topic	.693
74. Knowing various teaching strategy in particular physics concept	.728
75. Apply teaching strategies in particular physics concepts	.708
76. Designing concept map related with curriculum	.640
77. Knowing limitation of concept related with curriculum	.670
78. Creating concept sequencing according to the topic of grade	.642
79. Adjusting concept sequencing according to the curriculum objectives	.705

80. Addressing particular concept with learning objective	.759
Factor III Students' Conception	Factor loading
68. Predicting likely students misconception within a particular topic	.619
69. Distinguish between true concept, not knowing concept and misconception within a particular topic	.834
70 Distinguish between true concept, not knowing concept and misconception of student attempt within a particular topic	.819

Factor IV Representation of Subject Matters	Factor loading
65. Knowing various representation in particular physics concept	.743
66. Using a better representation for particular physics lesson	.731
67. Determining appropriate multi-representation for certain physics lesson	.688
Factor II Purpose of Science Education	Factor loading
82. Addressing particular concept with student proximal development while they learn collaboratively	.644
83. Identifying scientific literacy on particular topic	.728
84. Knowing lesson developed in order to gain scientific literacy	.627

5. **Technological Content Knowledge (TCK**) for Item number 85 – 93

Features	**Brief description Data Statistical Processing**
- correlation matrix	- Inter-item correlations score: - 0 Very Strong (0%);18 Strong (50%), 18 Moderate (50%), 0 weak (30.6%), 0 none (2%)
- Measures of sampling adequacy (MSAs)	- KMO > .5 and significance,
- Anti-image matrices	- No variables with diagonal anti-image correlations of less than .5 means no one variables should be excluded
- Total variance explained test	- One component indicated with initial eigenvalue ≥1
- Communalities	- The biggest score is .726 which more than .5 (item number 92)
- Component Matrix	- all item number fulfilled ≥.5 on one of three factors - and only producing one factor
- Cronbach's Alpha Reliability	- Since Cronbach's alpha if item deleted are less than .928, no one items deleted.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.900
Bartlett's Test of Sphericity	Approx. Chi-Square	7606.458
	df	36
	Sig.	.000

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.928	.928	9

Factor I Navigating Applied Technology for Representation	Factor loading
85. Selecting proper content of physics related with technology needed (multimedia, visual demo, apps)	.733
86. Selecting exist technology (multimedia, visual demo, apps) can be used related with enhancement of content	.711
87. Selecting exist technologies as application of body of knowledge	.838
88. Identify various representations of particular concepts of a topic	.784
89. Understanding of representations of concepts dealing with available technology	.806
90. Knowing specific technologies suited in classroom using	.820
91. Knowing specific technologies best suited in students domain	.809
92. Identify content dictates the technology	.852
93. Identify technology dictates particular content in a physics topic	.825

6. Technological Pedagogical Knowledge (TPK) item number 94 – 103

Features	Brief description and Result
- correlation matrix	- Inter-item correlations score: - 0 Very Strong (0%);6 Strong (13,3%), 15 Moderate (33.3%), 24 weak (53.3%), 0 none
- Measures of sampling adequacy (MSAs)	- KMO > .5 and significance,
- Anti-image matrices	- No variables with diagonal anti-image correlations of less than .5 means no one variables should be excluded
- Total variance explained test	- Two component indicated with initial eigenvalue ≥1
- Communalities	- The biggest score is .749 which more than .5 (item number 96)
- Component Matrix	- all item number fulfilled ≥.5 on one of 2 factors
- Cronbach's Alpha Reliability	- Since Cronbach's alpha if item deleted are less than .878, no one items deleted.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.878	.884	10

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.900
Bartlett's Test of Sphericity	Approx. Chi-Square	7606.458
	df	36
	Sig.	.000

Factor I Pedagogical Design with Technology	Factor loading
99. Creating an online environment which allows students to build new knowledge and skills	.747
100. Determining different methods of teaching online	.734
101. Communicating online with students in particular online environment	.796

102. Encourage interactivity among student using ICT	.792
103. Moderating interactivity among student using ICT	.849
Factor II Pedagogical range for technological tools	Factor loading
94. Identify using of technologies learned during the course period	.755
95. adapt the use of the technologies learned to different teaching activities	.751
96. Choosing technologies that enhance the teaching approaches for a lesson	.849
97. Choosing technologies that enhance students' learning for a lesson	.814

7. **Technological Pedagogical Content Knowledge (TPACK)** for Item number 104 – 116

Features	Brief description and Result
- correlation matrix	- Inter-item correlations score: - 2 Very Strong (0%);28 Strong (38,8%), 37 Moderate (47.4%), 11 weak (14.1%), 0 none
- Measures of sampling adequacy (MSAs)	- KMO > .5 and significance,
- Anti-image matrices	- No variables with diagonal anti-image correlations of less than .5 means no one variables should be excluded
- Total variance explained test	- Two components indicated with initial eigenvalue ≥1
- Communalities	- The biggest score is .775 which more than .5 (item number 116)
- Component Matrix	- Found 2 items (105, 104) which 2 Factors > .5; re-analyze with Varimax is used - all item number fulfilled ≥.5 on one of 2 factors
- Cronbach's Alpha Reliability	- At Cronbach's alpha if item deleted, only if item 104 deleted, the alpha would be .947 which is less significance from .943; so no one items deleted .

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.923
Bartlett's Test of Sphericity	Approx. Chi-Square	12072.778
	df	78
	Sig.	.000

.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.943	.943	13

Factor II Effective teaching with technology	Factor loading
104. Acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change	.882
105. Develop functional competencies in a specified curriculum area	.823

106. use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom	.660
Factor I Technology in pedagogy for knowledge building	Factor loading
107. Identifying various technology for representation of content for the lesson	.704
108. Using appropriate technology for better representation of content for the lesson	.743
109. Modify exist technology related with representation of certain concept	.758
110. Modify teaching strategies in terms of involving technology at particular concept	.767
111. Using teaching strategies in term of particular concept using certain technology	.795
112. Able to synthesize students' knowledge	.724
113. Identifying students obstacles on certain concepts which can be improved by technologies	.702
114. Adjusting technologies for possibility reduce student conception problem	.829
115. Adjusting technology to describe better existing knowledge of concept	.829
116. Adjusting technology to describe new epistemologies in particular concept	.837

All the result from each construct give loading factor which larger than 0.5 which means each factor could not be abandoned for the next statistical consideration. At this rate there are big possibility that the factor loadings are share each other, so that to avoid ambigous factor loading, a multiple PFA Factor Analysis should be applied. The researcher doing so in the chapter 5

CHAPTER 5

RESULT DESCRIPTION

The researcher created the TPACK survey using an online survey development tool and posted it on Gizmo site for participants to access. When the preservice teachers accessed the survey online the first time, they are presented with an informed consent document that described the study's purpose and are told that their participation in the study was voluntary as attached in the appendix I. Practically, this research ethics come later as some respondents were missed to fill in, then in some cases, researcher asking their approval of explanatory statement after filling the survey.

All participants completed the survey during break session of the semester. The survey took approximately 15–20 minutes for participants to complete. The majority of responses (79.0%) are from students majoring in physics education, whereas 14.5% of the responses are from biology education majors and 6.5% of the respondents are enrolled in science major such as chemistry and general science. While final result from this online survey can be seen as follow:

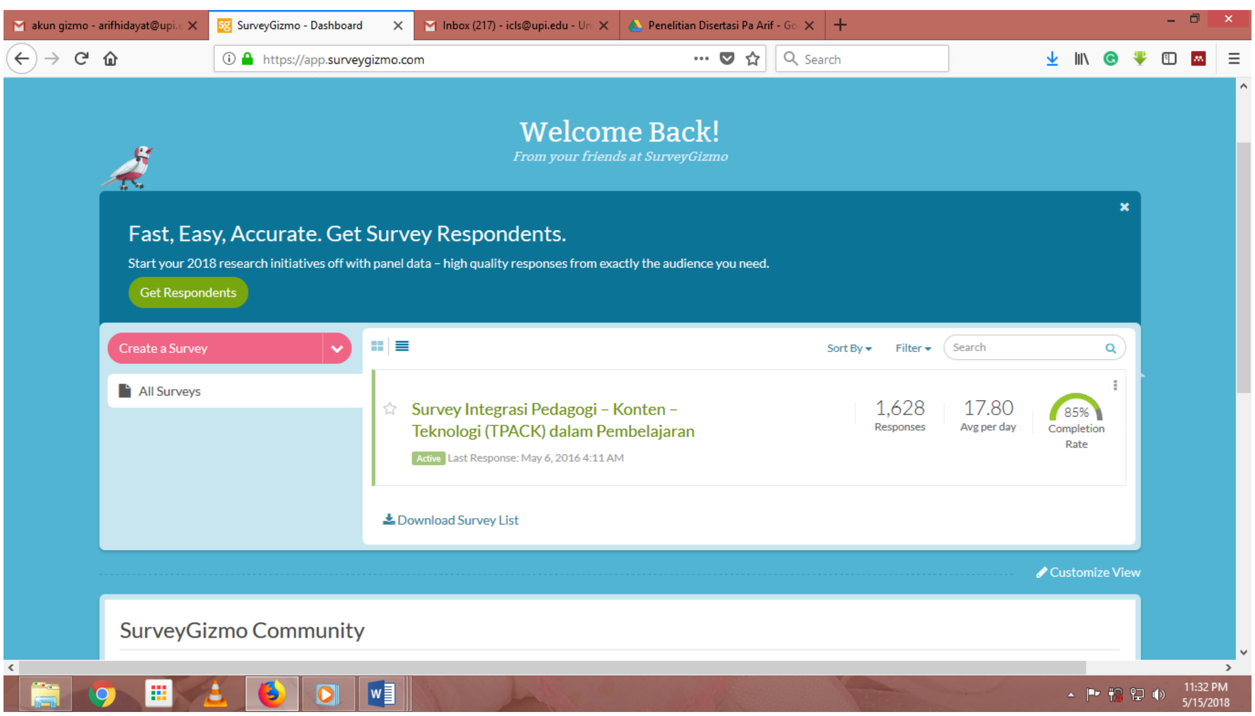


Figure 11. Display Result of TPACK Survey (into Bahasa Indonesia) indicated that it has been responded by 1,628 responses and 85% Completion rate

Even though this survey has been answered by about 1,600 responded but researcher selected to be 1380 pre-service who completed the survey, (70.5%) are female and (29.5%) are male, respectively.

All responses from the survey then imported into Microsoft Excel, and simply researcher separate complete and incomplete responses to gain eligible data for next step. This excel data then converted into Statistical Package for the Social Sciences (SPSS) software for further analyses. Factor analysis involved in term of series of analyses used to develop a rigorous instrument. For this purpose, the first step involved running a factor analysis on the items within each subscale to ascertain the covariation among the items and whether the patterns fit well into the TPACK constructs. The researchers used the Kaiser-Guttmann rule (which states that factors with Eigen values greater than 1 should be accepted) to identify a number of factors and their constitution based on the data analysis. In addition, the researcher calculated reliability statistics for items in each subscale to identify problematic items. The researcher examined questionable items for each TPACK domain subscale and eliminated those that reduced the reliability coefficient for the subscales. The researcher also eliminated those items because it seemed they are not measuring the preservice science teachers' knowledge of the related construct. Thus, the researcher dropped the individual items that affected the reliability and construct validity of each knowledge domain subscale. As a result, 48 items are deleted from the survey, including 4 TK items, 9 CK items, 16 PK items, 9 PCK items, 4 TCK items, 3 TPK items, and 3 TPACK items.

After eliminating problematic items, the researcher ran a second factor analysis on the remaining survey items within each of the seven subscales, and those results are presented in this section. The resulting TPACK instrument exhibited strong internal consistency reliability and included 64 items. Reliability statistics are then repeated on the remaining items within each knowledge domain. The internal consistency reliability (coefficient alpha) ranged from.915 to .948 for the seven TPACK subscales.

According to George and Mallery (2001), this range is considered to be acceptable to excellent. The researcher report the final items for the TPACK subscales, along with their reliabilities, in the sections as follow:

Content Knowledge (CK)

The first knowledge domain, content knowledge (CK), It is widely known that knowledge concerned with about the actual subject matter that is to be learned or taught. However, as Sulman (1986) noted that this would include: (1) Knowledge of concepts, theories, ideas, organizational framework (2) Knowledge of evidence and proof, and (3) Knowledge of established practices and approaches towards developing such knowledge. In case of science, this would include knowledge of scientific facts and theories, the scientific method, and evidence based reasoning. Why this content knowledge is essential because student can receive incorrect information and develop misconception about the content area (NRC:2000). Shulman (1987) then defined content knowledge referred to as the “knowledge, understanding, skill, and disposition that are to be learned (p.9)

Developing items domain of content knowledge for teachers could be different among subjects. The factor analysis of the 18 items of this domain extracted two factors. Each of the 2 factors extracted with 46.11% of variance for factor 1 and 8,5% of variance for factor 2 with Cronbach alpha .930. Some items with sharing factor loadings are expelled from the analysis, and multiple analysis applied to avoid this bias producing 9 items with classified into two factors where factor 1 loaded 6 items, and factor 2 loaded 3 items as mentioned in the table:

Content Knowledge (CK)	**Items**	**Factors ad its factor loadings**	
		1	2
Factor 1 Developing Concept for Practice	7. Knowing how far / high science concept in certain topic	0.67	0.25
	4. knowing the scope of content in curriculum	0.54	0.43
	11. Sufficient knowledge about science concepts in secondary level	0.69	0.29
	16. Knowing various ways to understand the particular concept	0.76	0.19

	17. Using science way of thinking to develop understanding of science concept	0.76	0.15
	18. Using science way of thinking in the classroom	0.71	0.17
Factor 2: Content Standard in the Curriculum	1. Identify standard of curriculum related with certain concept	0.25	0.73
	3. know about science content that I want to teach	0.24	0.65
	6. sequencing certain science concept	0.25	0.70

Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.Cronbach's Alpha .930

Item number 2,5,8,9,10,12,13,14, and 15 are dismissed from the resulted items of factors because of various reason of statistical processes and adjustment. Item number 2,5,8 are deleted for adjustment since their loading factors are smaller than loading factors of their pair item in the same indicators, even >.50; while item number 9,10, 12, 13, 14, 15 are vanished after multiple factor analysis to separate shared factor loading as shown in the table.

Content Knowledge Items	**Factors ad its factor loadings**		**Deleted reason**
	1	**2**	
2. Mapping particular standard from curriculum	.452	.707	< .730 of no 1 (same indicator)
5. make a proper order of science concept according to the standards	.482	.670	< .710 of no 6 (same indicator)
8. Know limitation of science concept among other concepts	.663	.475	< .680 of no 7 (same indicator)
9. Identify materials supported with particular science concept	.684	.523	Deleted for shared factor loadings after several Factor Analysis applied
10. Createing materials related with certain science concept	.566	.442	
12. Identify ways of concepts construction	.805	.480	
13. Planning the sequence of concept	.785	.559	
14. Identify essential concepts from particular topics	.663	.547	
15. Mapping the scope of essential concepts from particular topics	.686	.491	

Pedagogical Knowledge (PK)

Pedagogical knowledge (PK), the second subdomain, refers to the methods and processes of teaching and would include fundamental knowledge in areas such as classroom management, assessment, lesson plan development, and student learning. The factor analysis of the 32 items of this domain extracted five factors. Each of the 5 factors extracted with 42.12% of variance for factor 1; 6,429 % of variance for factor 2; 4,67% of variance for factor 3, 4,11% of variance for factor 4, and 3,76% of variance for factor 5; with Cronbach alpha .948. Some items with sharing factor loadings also are deleted from the analysis, and similar PAF applied to avoid this bias producing 16 items with classified into five factors i.e.: Factor 1 (3 items), Factor 2 (3 items), Factor 3 (2 items), Factor 4 (2 items), and Factor 5 (4 items) as described in the following table.

Pedagogy Knowledge (PK)	Items	Factors				
		1	2	3	4	5
Factor 1 Student Classroom Management	29. Adapting various way of classroom management in the classroom to keep student organized, orderly and focus during a class	0.70	0.23	0.12	0.15	0.31
	31. Adapting various way of teaching to keep student academically productive during a class	0.69	0.16	0.22	0.18	0.34
	46. Identifying types of different learners	0.64	0.22	0.13	0.15	0
Factor 2 Teaching for Students Learning	19. Adapting teaching based on currently student understand or do not understand	0.39	0.59	0.17	0.07	0.26
	22. Planning sequencing students to acquire targeted skills	0.14	0.62	0.12	0.2	0.36
	45. Adjust teaching according to the students feedback	0.29	0.71	0.06	0.07	0.06

Factor 3 How Students Learn	32. Design a roadmap of lesson plan related with expected objectives	0.14	0.05	0.66	0.36	0.19
	35. Preparing responses for possible occurred of predicting students response	0.33	0.37	0.63	0.01	0.07
Factor 4 Teaching Methods	38. Knowing teaching methods theoretically	0.16	0.11	0.04	0.78	0.16
	40. Identifying characteristic of various teaching methods	0.22	0.15	0.22	0.75	0.06
Factor 5 Lesson Design	21. Identify students acquire skills needed from standard	0.06	0.39	0.11	0.28	0.53
	23. Knowing habits of mind can be delivered through learning particular concept	0.26	0.15	-0.02	0.04	0.69
	26. Identifying possible positive dispotition through learning particular concept	0.07	0.08	0.38	0.31	0.6
	27. Familiar with common students understanding and misconception	0.37	0.13	0.22	-0.06	0.55
Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization. Cronbach's Alpha .948						

As amount of 16 items are dismissed from the resulted items of factors because of various reason of statistical processes and adjustment. Item number 25, 28, 36, and are deleted since adjustment of their loading factors are smaller than loading factors of their pair item in the same indicators, even >.50; while item number 20, 24, 30, 33, 34, 41, 44, 47, 42, 43, 48, 49, and 50 are vanished after multiple factor analysis to separate shared factor loading even both they are in the same indicators or the only item in certain indicators as shown in the following table:

Pedagogy Knowledge Items	Factors					Deleted Reason
	1	2	3	4	5	
20. Using range of teaching approaches to construct students knowledge	.558	-.246	-.447	.561	-.362	Shared factor loadings after several Factor Analysis applied
24. Knowing ways of developing habits of mind toward learning	.569	-.377	-.391	.609	-.328	
25. Identifying positive disposition toward learning from standard	.387	-.352	-.106	.574	-.480	< .608 of no 26 (same indicator)
28. Identifying various ways of classroom management to keep student organized, orderly and focus during a class	.747	-.310	-.343	.443	-.419	< .680 of no 29 (same indicator)
30. Identifying various ways of teaching to keep student academically productive during a class	.746	-.356	-.245	.420	-.578	Shared factor loadings after several Factor Analysis applied
33. Identify teachers help or facilitation in learning sequences	.434	-.532	-.128	.405	-.648	
34. Predicting students responses during learning	.500	-.352	-.431	.372	-.761	
36. Identify time consume for learning sequences	.395	-.465	-.425	.431	-.499	< .50
39. Knowing ways of teaching methods in class	.473	-.440	-.273	.444	-.397	< .780 of no 38 (same indicator)
41. Determining particular applied teaching strategy in the classroom	.555	-.527	-.272	.335	-.585	Shared factor loadings after several Factor Analysis applied
44. Encouraging students feedback during classroom	.528	-.363	-.652	.366	-.453	
47. Adjust teaching style to different learners	.622	-.423	-.635	.297	-.405	
42. Identifying various of teaching strategies related with various concept of students	.609	-.540	-.261	.429	-.600	
43. Using variety of teaching strategies related with various concepts of students	.634	-.536	-.362	.433	-.541	
48. Knowing various of students assessment	.396	-.833	-.207	.260	-.602	Shared factor loadings after several Factor Analysis applied
49. Knowing ways of assessing students performance in a class	.386	-.915	-.267	.680	-.380	

50. Using particular assessment in certain concept	.666	-.759	-.241	.420	-.418

Technological Knowledge (TK)

The third knowledge domain, technology knowledge (TK), refers to understanding how to use various technologies. The factor analysis of the 14 items of this domain extracted into two factors. Each of the 2 factors extracted with 50.47% of variance for factor 1; 12,07 % variance of for factor 2 with Cronbach alpha .915. Some items with sharing factor loadings also are deleted from the analysis, and similar PAF applied to avoid this bias producing 7 items with classified into three factors i.e.: factor 1 (3 items), Factor 2 (2 items), and Factor 3 (2 items) as described in the following table.

Technological Knowledge (TK)	Items	Factors		
		1	2	3
Factor 1 Intellectual Capabilities	52. Able to assist students with hardware problems witht their PC or laptops	0.85	0.16	0.17
	54. Able to assist students with hardware problems witht their PC or laptops	0.71	0.36	0.24
	56. Able to assist students with hardware problems witht their PC or laptops	0.85	0.09	0.28
Factor 2 Contemporary Skills	58. Frequently play around with computer application	0.22	0.79	0.11
	59. Learn about new digital technology easily	0.24	0.81	0.17
Factor 3 Foundation Concept	62. Knowing how to solve my own computer	0.41	0.29	0.66
	63. Knowing ideas networkig among computers	0.23	0.13	0.88
Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.Cronbach's Alpha .915				

As amount of 4 items are dismissed from the resulted items of factors 51,53,55,and are deleted since adjustment of their loading factors are smaller than loading factors of their pair item in the same indicators, even >.50; while item number 61 and 64 are vanished after multiple factor analysis to separate shared factor loading even both they are in the same indicators as follow:

Technology Items	Factors			Deleted Reason
	1	2	3	
51. Able to handle troubleshooting problems related with hardware (e.g. network connection)	.767	.457	.461	< .850 of no 52 (same indicator)
53. Addressing various computer issue related to software (e.g. installing program, dowloading)	.738	.533	.516	< .714 of no 54 (same indicator)
55. Able to handle troubleshooting problems related with software (e.g. network connection)	.628	.518	.565	< .850 of no 54 (same indicator)
61. Know a lot of about new digital technologies	.547	.773	.506	Shared factor loadings after several Factor Analysis applied
64. Using ideas of networking on data	.503	.381	.854	

Pedagogical Content Knowledge (PCK)

The fourth knowledge domain, pedagogical content knowledge (PCK), refers to the content knowledge that deals with the teaching process. The process of factor analysis of initial 20 items of the domain extracted into three factors. Each of the 3 factors extracted with 52.04% of variance for factor 1; 4,84 % of variance for factor 2; and 4,10% of variance for factor 3,; with Cronbach alpha .954. Some items with sharing factor loadings also are deleted from the analysis, and similar PAF applied to avoid this bias producing 12 items with classified into three factors i.e.: Factor 1 (6 items), Factor 2 (4 items), and Factor 3 (2 items).

Pedagogical Content Knowledge (PCK)	items	Factors		
		1	2	3
Factor 1 Teaching Concept According to the Standard	72. Selecting appropriate teaching approaches in science	0.71	0.34	0.26
	73. Produce lesson plan with an appropriate for the topic	0.69	0.21	0.21
	74. Knowing various teaching strategy in particular science concept	0.73	0.36	0.15
	77. Knowing limitation of concept related with curriculum	0.67	0.34	0.28
	79. Adjusting concept sequencing according to the curriculum objectives	0.71	0.11	0.27
	80. Addressing particular concept with learning objective	0.76	0.36	0.2
Factor 2 Representation of Subject Matters	65. Knowing various representation in particular science concept	0.18	0.74	0.27
	66. Using a better representation for particular science lesson	0.37	0.73	0.21
	82. Addressing particular concept with student proximal development while they learn collaboratively	0.48	0.64	0.12
	83. Identifying scientific literacy on particular topic	0.34	0.73	0.16
Factor 3 Students' Conception	68. Predicting likely students misconception within a particular topic	0.35	0.32	0.62
	69. Distinguish between true concept, not knowing concept and misconception within a particular topic	0.24	0.28	0.83
Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.Cronbach's Alpha .954				

As amount of 8 items are dismissed from the resulted items of factors because of various reason of statistical processes and adjustment. Item number 67,70,78, 81, 84 are deleted since adjustment of their loading factors are smaller than loading factors of their pair item in the same indicators, even >.50; while item number 71,75, 76, 81, and 84 are vanished after multiple factor analysis to separate shared factor loading even both they are in the same indicators or the only item in certain indicators as follow:

Pedagogical Content Knowledge items	Factors			Deleted Reason
	1	2	3	
67. Determining appropriate multi-representation for certain science lesson	.480	.488	.712	< .730 of no 66 (same indicator)
70. Distinguish between true concept, not knowing concept and misconception of student attempt within a particular topic	.589	.792	.541	< .830 of no 69 (same indicator)
71. Identifying various teaching approaches in science	.730	.454	.565	Shared factor loadings after several Factor Analysis applied
75. Apply teaching strategies in particular science concepts	.765	.333	.599	
76. Designing concept map related with curriculum	.723	.439	.564	
78. Creating concept sequencing according to the topic of grade	.617	.523	.497	< .701 of no 79 (same indicator)
81. Addressing particular concept with students proximal development while they learn individually	.683	.415	.702	Shared factor loadings after several Factor Analysis applied
84. Knowing lesson developed in order to gain scientific literacy	.685	.435	.741	

Technological Content Knowledge (TCK)

The fifth knowledge domain, technological content knowledge (TCK), refers to teachers' understanding of how using a specific technology can change the way learners understand and practice concepts in a specific content area. The process of factor analysis of initial 9 items of the domain extracted into one factor with 59.39% of variance for the and Cronbach alpha .928. Some items with sharing factor loadings also are deleted from the analysis, and similar PAF applied to avoid this bias producing 5 items with classified into one factor i.e.: Factor 1 (5 items).

Technological Content Kowledge (TCK)	Items	Factor 1
Factor 1 Navigating Applied Technology for Representation	85. Selecting proper content of science related with technology needed (multimedia, visual demo, apps)	0.73
	87. Selecting exist technologies as application of body of knowledge	0.84
	89. Understanding of representations of concepts dealing with available technology	0.81
	90. Knowing specific technologies suited used in the classroom	0.82
	92. Identify content dictates the technology	0.85
Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.Cronbach's Alpha .928		

As amount of 4 items are dismissed from the resulted items of factors because of various reason of statistical processes and adjustment. Item number 86, 88, 91 and 93 are deleted since adjustment of their loading factors are smaller than loading factors of their pair item in the same indicators, even >.50and after multiple factor analysis to separate shared factor loading even they are in the same indicators.

Technological Content Knowledge Items	Factor 1	Deleted Reason
86. Selecting exist technology (multimedia, visual demo, apps) can be used related with enchancement of content TCK	.665	< .807 of no 87 (same indicator)
88. Identify various representations of particular concepts of a topic TCK	.751	< .801 of no 89 (same indicator)
91. Knowing specific technologies best suited in students domain TCK	.781	< .820 of no 90 (same indicator)
93. Identify technology dictates particular content in a science topic TCK	.803	< .850 of no 92 (same indicator)

Technological Pedagogical Knowledge (TPK)

Technological pedagogical knowledge (TPK) refers to teachers' knowledge of how various technologies can be used in teaching and understanding that using technology may change the way an individual teaches. The process of factor analysis of initial 10 items of the domain extracted into two factors. Each of the 2 factors extracted with 44,80 % of variance for factor 1; and 11,20% of variance for factor 2; with Cronbach alpha .9878 is the highest. Some items with sharing factor loadings also are deleted from the analysis, and similar PAF applied to avoid this bias producing 7 items with classified into two factors i.e.: Factor 1 (4 items), and Factor 2 (3 items).

Technological Pedagogical Knowledge (TPK)	Items	Factors	
		1	2
Factor 1 Pedagogical Design with Technology	99. Creating an online environment which allows students to build new knowledge and skills	0.75	0.21
	100. Determining different methods of teaching online	0.73	0.32
	101. Communicating online with students in particular online environtment	0.80	0.25
	103. Moderating interactivity among student using ICT	0.85	0.15
Factor 2 Pedagogical Range for Technological Tools	94. Identify using of technologies learned during the course period	0.20	0.76
	96. Choosing technologies that enhance the teaching approaches for a lesson	0.17	0.85
	97. Choosing technologies that enhance students' learning for a lesson	0.22	0.81

Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.Cronbach's Alpha .9878

As amount of 3 items are dismissed from the resulted items of factors because of various reason of statistical processes and adjustment. Item number 95, 98, and 102 are deleted since adjustment of their loading factors are smaller than loading factors of their pair item in the same indicators, even its loading factors are >.5 and coming from same indicators.

Technological pedagogical knowledge Items	Factors		Deleted Reason
	1	2	
95. adapt the use of the technologies learnied to different teaching activities	.427	.686	< .760 of no 94 (same indicator)
98. Dealing with online environment to build new knowledge and skills	.474	.535	< .750 of no 99 (same indicator)
102. Encourage interactivity among student using ICT	.760	.423	< .800 of no 101 (same indicator)

Technological Pedagogical Content Knowledge (TPACK)

The seventh and final knowledge domain, technological pedagogical content knowledge (TPACK), refers to the knowledge teachers require for integrating technology into their teaching—the total package. Teachers must have an intuitive understanding of the complex interplay between the three basic components of knowledge (CK, PK, TK) by teaching content using appropriate pedagogical methods and technologies. The process of factor analysis of initial 13 items of the domain extracted into two factors. Each of the 2 factors extracted with 57,01 % of variance for factor 1; and 5,07% of variance for factor 2; with Cronbach alpha .943. Some items with sharing factor loadings also are deleted from the analysis, and similar PAF applied to avoid this bias producing 7 items with classified into two factors i.e.: Factor 1 (5 items), and Factor 2 (2 items)

Technological Pedagogical Content Knowledge (TPACK)	items	Factors	
		1	2
Factor 1 Effective Teaching with Technology	108. Using appropriate technology for better representation of content for the lesson	0.74	0.37
	110. Modify teaching strategies in terms of involving technology at particular concept	0.77	0.33
	114. Adjusting technologies for possibility reduce student conception problem	0.83	0.20

	115. Adjusting technology to describe better existing knowledge of concept	0.83	0.20
	116. Adjusting technology to describe new epistemologies in particular concept	0.84	0.27
Factor 2 Technology in Pedagogy for Knowledge Building	104. Acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change	0.19	0.82
	106. use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom	0.44	0.66
Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.Cronbach's Alpha .943			

As amount of 6 items are dismissed from the resulted items of factors because of various reason of statistical processes and adjustment. Item number 105, 107 are deleted since adjustment of their loading factors are smaller than loading factors of their pair item in the same indicators, even its loading factors are >.5; while item number 109, 111, 112, and 113 are vanished after multiple factor analysis to separate shared factor loading even both they are in the same indicators or the only item in certain indicators.

Technological Pedagogical Content Knowledge Items	Factors 1	2	Deleted Reason
105. Develop functional competencies in a specified curriculum area	.522	.787	< .820 of no 104 (same indicator)
107. Identfying various technology for representation of content for the lesson	.722	.621	< .744 of no 108 (same indicator)
109. Modify exsist technology related with representation of certain concept	.754	.516	Shared factor loadings after several Factor Analysis applied)
113. Identifying students obstacles on certain concepts which can be improved by technologies	.739	.555	
112. Able to synthesize students knowledge	.742	.542	
111. Using teaching strategies in term of particular concept using certain technology	.821	.571	

The comparison of instrument before and after the process of factor analysis as domain by domain explanation are shown below:

a. Content Knowledge (CK)

Before Factor Analysis			**After Factor Analysis**	
Sub-Domain	**items**		**items**	**New Sub-domain**
Curriculum Issue	1. Identify standard of curriculum related with certain concept	→	1. Identify standard of curriculum related with certain concept	Content Standard in Curriculum
	2. Mapping particular standard from curriculum	→	deleted	
	3. know about science content that I want to teach	→	3. know about science content that I want to teach	
	4. know the scope of content in curriculum	→	4. know the scope of content in curriculum	
Mapping the Concept	5. make a proper order of science concept according to the standards	→	deleted	Developing Concept for Practice
	6. sequencing certain science concept	→	6. sequencing certain science concept	
	7. Knowing how far / high science concept in certain topic	→	7. Knowing how far / high science concept in certain topic	
	8. Know limitation of science concept among other concepts	→	deleted	
Body of knowledge	9. Identify materials supported with particular science concept	→	deleted	
	10. Creating materials related with certain science concept	→	deleted	
	11. Sufficient knowledge about science concepts in secondary level	→	11. Sufficient knowledge about science concepts in secondary level	
Developing for practice	12. Identify ways of concepts construction	→	deleted	
	13. Planning the sequence of concept	→	deleted	
	14. Identify essential concepts from particular topics	→	deleted	

	15. Mapping the scope of essential concepts from particular topics	→	deleted	
	16. Knowing various ways to understand the particular concept	→	16. Knowing various ways to understand the particular concept	
	17. Using science way of thinking to develop understanding of science concept	→	17. Using science way of thinking to develop understanding of science concept	
	18. Using science way of thinking in the classroom	→	18. Using science way of thinking in the classroom	

In this domain, as result of the multiple PFA four factors are reduced to be 2 factors, where remain items are filled with same colors among before and after multiple PFA. As mentioned previously that item number 2,5,8 are deleted for adjustment since their loading factors are smaller than loading factors of their pair item in the same indicators, even those contain factor loading >.5 while item number 9,10, 12, 13, 14, 15 are vanished after multiple factor analysis to separate shared factor loading. Three items constructing of the factor I are emphasized on the *standards of curriculum*, *secquencing concepts*, and *science content* which actually can be fit with two sub domain in initial instrument, i.e. Curriculum Issu and Mapping the Concept, and Body of Knowledge. The researcher decided to combine this 3 aspects in one wording of the factor as Content Standard in the Curriculum. The researcher believe that Curriculum contain concepts and its mapping for students, and the concepts as standardized in the curriculum is part of body of knowledge. Considering Indonesia Curriculum which no longer focusing on the content-based but rather than competence, the researcher put science content as adoptive from its body of knowledge from scientist to be transformable through objectives in the curriculum.

The second factor contains six items or double comparing the items in the first factor. Reading each items and comparing with initial items it can be found that some items are exactly same with the old version, and others are different. For item *Knowing various ways to understand the particular concept*, *Using science way of thinking to develop understanding of science concept*, and *Using science way of thinking in the classroom* are similar with 3 consecutive items (no 16, 17 and 18) in the sub Domain of Developing Practice. So for this reason, the researcher put Developing Practice as main keyword for the naming this second factor. Furthermore, for items *knowing how far / high science concept in certain topic*, *how far / high science concept in certain topic*, and *various ways to understand the particular concept*; researcher believe that those 3 items are strong related with concept, both as part of the body of knowledge and its mapping in the curriculum. Combining these keywords resulting Developing Concept for Practice as naming of the second factor.

b. Pedagogy Knowledge (PK)

Before Factor Analysis			After Factor Analysis	
Sub-Domain	**items**		**items**	**New Sub Domain**
How Students learn	19. Adapting teaching based on currently student understand or do not understand	→	19. Deleted	How Students learn
	20. Using range of teaching approaches to construct students knowledge	→	20. Using range of teaching approaches to construct students knowledge	
	21. Identify students acquire skills needed from standard	→	21. Deleted	
	22. Planning sequencing students to acquire targeted skils	→	22. Deleted	
	23. Knowing habits of mind can be delivered through learning particular concept	→	23. Deleted	
	24. Knowing ways of develioping habits of mind toward learning	→	24. Knowing ways of develioping habits of mind toward learning	
	25. Identifying positive dispotition toward learning from standard	→	25. Identifying positive dispotition toward learning from standard	
	26. Identifying possible positive dispotition through learning particular concept	→	26. Deleted	

	27. Familiar with common students understanding and misconception	→	27. Deleted	
General Classroom Management	28. Identifying various ways of classroom management to keep student organized, orderly and focus during a class	→	28. Identifying various ways of classroom management to keep student organized, orderly and focus during a class	General Classroom Management
	29. Adapting various way of classroom management to keep student organized, orderly and focus during a class	→	29. Deleted	
	30. Identifying various ways of teaching to keep student academically productive during a class	→	30. Identifying various ways of teaching to keep student academically productive during a class	
	31. Adapting various way of teaching to keep student academically productive during a class	→	31. Deleted	
Lesson Planning	32. Design a roadmap of lesson plan related with expected objectives	→	32. Deleted	Lesson Design
	33. Adapting various way of teaching to keep student academically productive during a class	→	33. Adapting various way of teaching to keep student academically productive during a class	
	34. Predicting students responses during learning	→	34. Predicting students responses during learning	
	35. Preparing responses for possible occurred of predicting students response	→	35. Deleted	
	36. Identify time consume for learning sequences	→	36. Identify time consume for learning sequences	

	37. Design possible planning for possible change in the classroom to fit with time	→	37. Deleted	
Teaching Methods / Techniques	38. Knowing teaching methods theoretically	→	38. Deleted	Teaching for Student Learning
	39. Knowing ways of teaching methods in class	→	39. Knowing ways of teaching methods in class	
	40. Identifying characteristic of various teaching methods	→	40. Deleted	
	41. Determining particular applied teaching strategy in the classroom	→	41. Determining particular applied teaching strategy in the classroom	
	42. Identifying various of teaching strategies related with various concept of students	→	42. Identifying various of teaching strategies related with various concept of students	
	43. Using variety of teaching strategies related with various concepts of students	→	43. Using variety of teaching strategies related with various concepts of students	
	44. Encouraging students feedback during classroom	→	44. Encouraging students feedback during classroom	
	45. Adjust teaching according to the students feedback	→	45. Deleted	
	46. Identifying types of different learners	→	46. Deleted	
	47. Adjust teaching style to different learners	→	47. Adjust teaching style to different learners	
Students Assessment	48. Knowing various of students assessment	→	48. Knowing various of students assessment	Students Assessment
	49. Knowing ways of assessing students performance in a class	→	49. Knowing ways of assessing students performance in a class	

	50. Using particular assessment in certain concept	→	50. Using particular assessment in certain concept	

For the Pedagogy Knowledge (PK) the multiple PFA provides with same 5 factors but reducing items, where remain items are filled with same colors among before and after multiple PFA. As amount of 16 items are dismissed from the resulted items of factors because of various reason of statistical processes and adjustment. Item number 25, 28, 36, and are deleted since adjustment of their loading factors are smaller than loading factors of their pair item in the same indicators, even >.50; while item number 20, 24, 30, 33, 34, 41, 44, 47, 42, 43, 48, 49, and 50 are vanished after multiple factor analysis to separate shared factor loading even both they are in the same indicators or the only item in certain indicators.

For the sub-domain *How Students Learn*, practically naming is similar as all the new items are coming from the same sub domain, since the deleted items - both from adjustment or multiples PFA – still sharing same indicators. In the second factor, the *general classroom management* is changed *to be student classroom management.* This name raising since item *identifying types of different learners* which coming from sub-domain *Teaching Methods* are wrapped together. Reading carefully those 3 items, the researcher decided that this second factor shall be *Student Classroom Management* rather than *General Classroom Management*. The term of *student classroom* and *general classroom* are distinguished by consider that the first term more likely on the specific subject adaptive learner-oriented classroom management rather than the second term.

For the third factor, since there are quite significance of the deleting items which mostly emphasize on teaching and students response and leaving other two items which bold to the design and its preparation, the researcher think that *Lesson Design* is more represent the items rather than *Lesson Plan*.

Furthermore, in the factor number 4, the PFA and adjustment remaining three items of teaching methods which describes relation of teaching action with students learning as the target. In that case, the researcher finds that name of Teaching for Students Learning is more appropriate. Last but not least, for the fifth factor, even there is one items deleted but the rest two items still strong indicated about students assessment, so the name of the sub domain is not change.

C. Technology Knowledge (TK)

Before Factor Analysis				
Sub-Domain	**items**		**items**	**New Sub Domain**
Intellectual Capabilities	1. Able to handle troubleshooting problems related with hardware (e.g. network connection)	→	Deleted	Intellectual Capabilities
	2. Able to assist students with hardware problems witht their PC or laptops	→	Able to assist students with hardware problems witht their PC or laptops	
	3. Addressing various computer issue related to software (e.g. installing program, dowloading)	→	Deleted	
	4. Able to assist students with software problems witht their PC or laptops	→	Able to assist students with software problems witht their PC or laptops	
	5. Able to handle troubleshooting problems related with software (e.g. network connection)	→	Deleted	
	6. Able to assist students with networking problems witht their PC or laptops	→	Able to assist students with networking problems witht their PC or laptops	
Contemporary skills	7. Comfortable using digital technology (cellphone, computer, tablet, etc)	→	Deleted	Contemporary skills

	8. Frequently play around with computer application	→	Frequently play around with computer application	
	9. Learn about new digital technology easily	→	Learn about new digital technology easily	
	10. Keep informed about new digital technologies	→	Deleted	
	11. Know a lot of about new digital technologies	→	Deleted	
Foundational Concept	12. Knowing how to solve my own computer	→	Knowing how to solve my own computer	Foundational Concept
	13. Knowing ideas networkig among computers	→	Knowing ideas networkig among computers	
	14. Using ideas of networking on data	→	Deleted	

The factor analysis of the 14 items of this domain extracted into three factors. As amount of 4 items are dismissed from the resulted items of factors 51, 53, 55, are deleted since adjustment of their loading factors are smaller than loading factors of their pair item in the same indicators, even >.50; while item number 61 and 64 are vanished after multiple factor analysis to separate shared factor loading even both they are in the same indicators

In this domain, what really interesting is the same number and factor but there is guarantee that naming shall be same. The name of each factor shall be considered based on its constructed items. However, in TK even though some items are deleted but the indicators are remain same, so in that case the researcher think that the name is similar with a previous, as name of the sub domain is perfectly described into its indicators.

c. Pedagogical Content Knowledge (PCK)

Before Factor Analysis			After Factor Analysis	
Sub-Domain	**items**		**items**	**New SubDomain**
Representation of Subject matter	65. Knowing various representation in particular science concept	→	Knowing various representation in particular science concept	Representation of Subject matter
	66. Using a better respresentation for particular science lesson	→	Using a better respresentation for particular science lesson	
	67. Determining appropriate multi-representation for certain science lesson	→	Deleted	
	68. Predicting likely students misconception within a particular topic	→	Predicting likely students misconception within a particular topic	Students' Conception
Understanding student conception and ist teaching implications	69. Distinguish between true concept, not knowing concept and misconception within a particular topic	→	Distinguish between true concept, not knowing concept and misconception within a particular topic	
General pedagogical	70. Identifying various teaching approaches in science	→	Deleted	Teaching Concept According to the Standard
	71. Selecting appropriate teaching approaches in science	→	Deleted	
	72. Produce lesson plan with an appropriate for the topic	→	Produce lesson plan with an appropriate for the topic	
	73. Knowing various teching strategy in particular science concept	→	Knowing various teching strategy in particular science concept	
	74. Apply teaching strategies in particular science concepts	→	Apply teaching strategies in particular science concepts	
Curriculum	75. Designing concept map related with curriculum	→	Deleted	
	76. Knowing limitation of concept related with curriculum	→	Deleted	
	77. Creating concept sequencing according to the topic of grade	→	Creating concept sequencing according to the topic of grade	
Educational context	78. Adjusting concept sequencing according to the curriculum objectives	→	Deleted	
	79. Addressing particular concept with learning objective	→	Addressing particular concept with learning objective	
	80. Addressing particular concept with students	→	Addressing particular concept with students	

	proximal development while they learn individually		proximal development while they learn individually	
Purpose of education	81. Identfying scientific literacy on particular topic	→	Deleted	
	82. Knowing lesson developed in order to gain scientific literacy	→	Knowing lesson developed in order to gain scientific literacy	

The fourth knowledge domain, pedagogical content knowledge (PCK), refers to the content knowledge that deals with the teaching process. The process of factor analysis of initial 20 items of the domain extracted into three factors. As amount of 8 items are dismissed from the resulted items of factors because of various reason of statistical processes and adjustment. Item number 67,70,78, 81, 84 are deleted since adjustment of their loading factors are smaller than loading factors of their pair item in the same indicators, even >.50; while item number 71,75, 76, 81, and 84 are vanished after multiple factor analysis to separate shared factor loading even both they are in the same indicators

For first factor which consist of 5 items, where 4 items were belong to the *General Pedagogies*, one item was belong to *Curriculum*¸ and other 2 items belong to the *Educational Context*. Also, those 3 items located from *General Pedagogies* are more focusing on the teaching concept, and consider that in educational context, curriculum basically contain the concept according its standards so the Researcher put term *Teaching Concept according Standards* which means curriculum in educational context.

The situation is slightly same with the second factor where name of student's conception mainly coming from that the items reflects educational context, understanding students' conception and teaching implication, subject matter representative, and purpose of education. The researcher believe that the term students conception is a most suitable since it can covers those mentioned aspects from its items. While for the 3rd factor, all the items are coming from the same sub domain, i.e. representation subject matter. Even there is another item of this sub domain is belonged to the other new factor but it does not change the meaning of these remain 2 items, so the researcher took similar name for the third factor

d. Technological Content Knowledge (TCK)

Before Factor Analysis			After Factor Analysis	
Sub-Domain	**items**		**items**	**New Sub Domain**
Choosing technologies affords and constrains the types of content ideas that can be taught	83. Selecting proper content of science related with technology needed (multimedia, visual demo, apps)	→	Deleted	
	84. Selecting exist technology (multimedia, visual demo, apps) can be used related with enchancement of content	→	Deleted	
	85. Selecting exist technologies as application of body of knowledge	→	Selecting exist technologies as application of body of knowledge	Navigating Applied Technology for Representation
Flexibility in navigating across content representation	86. Identify various representations of particular concepts of a topic	→	Deleted	
	87. Understanding of representations of concepts dealing with available technology	→	Understanding of representations of concepts dealing with available technology	
Manner in which the subject matter can be changed by the application of particular technologies	88. Knowing specific technologies suited in classroom using	→	Deleted	
	89. Knowing specific technologies best suited in students domain	→	Knowing specific technologies best suited in students domain	
	90. Identify content dictates the technology	→		

	91. Identify technology dictates particular content in a science topic	→	Identify technology dictates particular content in a science topic	

As amount of 4 items are dismissed from the resulted items of factors because of various reason of statistical processes and adjustment. Item number 86, 88, 91 and 93 are deleted since adjustment of their loading factors are smaller than loading factors of their pair item in the same indicators, even >.50and after multiple factor analysis to separate shared factor loading even they are in the same indicators.

The interesting point from this factor is the number of factor generated by the process of statistics is only one, and in this case the researcher should check the items thoroughly to ensure its representative name. All new items in this domain coming from three previous factors which has keywords on navigation, applied technology, and representation. So, the researcher think that combination of these keywords can be arranged as Navigating Applied Technology for Representation

e. Technological Pedagogical Knowledge (TPK)

Before Factor Analysis			**Before Factor Analysis**	
Sub-Domain	**items**		**items**	**New Sub-Domain**
Pedagogical affordance and constrains of a range of technological tools	94. Identify using of technologies learned during the course period	→	Identify using of technologies learned during the course period	2 Pedagogical Range for Technological Tools
	95. adapt the use of the technologies learnied to different teaching activities	→	Deleted	
	96. Choosing technologies that enhance the teaching approaches for a lesson	→	Choosing technologies that enhance the teaching approaches for a lesson	

	97. Choosing technologies that enhance students' learning for a lesson	→	Choosing technologies that enhance students' learning for a lesson	
Developing appropriate pedagogical design with technology	98. Dealing with online environment to build new knowledge and skills	→	Deleted	
	99. Creating an online environment which allows students to build new knowledge and skills	→	Creating an online environment which allows students to build new knowledge and skills	Pedagogical Design with Technology
	100. Determining different methods of teaching online	→	Determining different methods of teaching online	
	101. Communicating online with students in particular online environtment	→	Communicating online with students in particular online environtment	
	102. Encourage interactivity among student using ICT	→	Deleted	
	103. Moderating interactivity among student using ICT	→	Deleted	

As amount of 3 items are dismissed from the resulted items of factors because of various reason of statistical processes and adjustment. Item number 95, 98, and 102 are deleted since adjustment of their loading factors are smaller than loading factors of their pair item in the same indicators, even its loading factors are >.5 and coming from same indicators.

For the TPK the number of factors are same with the old one, i.e. two factors, but still there is no guarantee that the naming of the factors shall be same. It is mostly determined by its loading items. For the first factor, the items coming from two factors, both from its pedagogy design-oriented and pedagogy affordance-oriented. Having seen the items tends to the pedagogical design related with the technology, so the researcher believe that the suitable name is Pedagogical Design with Technology. While for the second factor, the case is similar where the new items is shared from two previous factor. Consider the keywords of items on range of pedagogy in context to be integrated with appropriate technological tools, so the researcher took name for this factor as Pedagogical range for technological tools

f. Technological Pedagogical Content Knowledge (TPACK)

Before Factor Analysis			After Factor Analysis	
Sub-Domain	**items**		**items**	**Sub-Domain**
Effective teaching with technology	104. Acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change	→	Acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change	Technology in Pedagogy for Knowledge Building
	105. Develop functional competencies in a specified curriculum area	→	Deleted	
	106. use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom	→	use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom	
Representation of concept using technology	107. Identfying various technology for representation of content for the lesson	→	Deleted	
	108. Using appropriate technology for better representation of content for the lesson	→	Using appropriate technology for better representation of content for the lesson	1 Effective Teaching with Technology
	109. Modify exsist technology related with representation of certain concept	→	Deleted	
Pedagogical techniques that use technology	110. Modify teaching strategies in terms of involving technology at particular concept	→	Modify teaching strategies in terms of involving technology at particular concept	

in constructive ways to teach content	111. Using teaching strategies in term of particular concept using certain technology	→	Deleted	
Knowledge what makes concept difficult or easy and related technolgy can reduce students problem	112. Able to synthesize students knowledge	→	Deleted	
	113. Identifying students obstacles on certain concepts which can be improved by technologies	→	Deleted	
	114. Adjusting technologies for possibility reduce student conception problem	→	Adjusting technologies for possibility reduce student conception problem	
Using of technology to build on existing knowledge to develop new epistemologies or strengthen old one	115. Adjusting technology to describe better existing knowledge of concept	→	Adjusting technology to describe better existing knowledge of concept	
	116. Adjusting technology to describe new epistemologies in particular concept	→	Adjusting technology to describe new epistemologies in particular concept	

There are 6 items are dismissed from the resulted items of factors because of various reason of statistical processes and adjustment. Item number 105, 107 are deleted since adjustment of their loading factors are smaller than loading factors of their pair item in the same indicators, even its loading factors are >.5; while item number 109, 111, 112, and 113 are vanished after multiple factor analysis to separate shared factor loading even both they are in the same indicators or the only item in certain indicators

The items of the first factor are shared from all previous factors except *Effective Teaching with Technology*, and having seen its items keywords, it seems that essential points from those items lies on knowledge building due to integration of technology in pedagogical situation. So the researcher took the name as Technology in pedagogy for knowledge building. While for the second item, all items coming from the factor of Effective Teaching with Technology, ans as the indicators are not changed as well so the researcher took same name fot the second factor.

Briefly, it can be seen changes of the indicator and items as follow:

Each Domain Factor Analysis – CFA - Varimax					
Domain	Before Factor Analysis	After Factor Analysis		Adjustment	After Adjustment items
		Factors and items	reduced		
Content Knowledge (CK)	4 factors	2 factors	2 factors	Items with same indicators are merged in one item with certain modify sentence or one sentence with higher of factor loading	9 items
	18 items	18 items	-		
Pedagogical Knowledge (PK)	5 factors	2 factors	3 factors		16 items
	32 items	28 items	4 items		
Technological Knowledge (TK)	3 factors	3 factors	Factors		8 items
	14 items	13 items	1 items		
Pedagogical Content Knowledge (PCK)	6 factors	3 factors	2 factors		11 items
	20 items	19 items	1 items		
Technological Content Knowledge (TCK)	3 factors	1 factor	2 factors		5 items
	9 items	9 items	-		
Technological Pedagogical Knowledge (TPK)	2 factors	2 factors	factors		7 items
	10 items	9 items	Items		
Technological Pedagogical Content Knowledge (TPACK)	5 factors	2 factors	factors		10 items
	13 items	13 items	-		

These reduction of items and factors results independent latent variables as expected in using this statistical method for unobserved variables called factors. There are reduction of number of variables, such as combining two or more variables into less or single factor (Dennis:2006). For example, in Content Knowledge (CK), curriculum issue and mapping the concept conbined to be content standard in curriculum, while body of knowledge and developing for practice are reduced to be developing concept for practice.

In this study, the TPACK instrument was developed and validated with 1382 pre-service science teachers from teacher education programs across 12 different universities in Indonesia. PFA and multiple PFA were conducted in two different samples for reducing ambigious items. The final version of the scale consists of 67 items and eight subscales: PCK (11 items), TK (8 items), CK (9 items), PK (16 items), TPK (7 items), TPACK (10 items), and TCK (5 items). Cronbach's alpha coefficient for internal consistency reliability of the subscales and whole scale were found to be high in both samples (Alpar, 2003).

The reliability and validity analyses showed high correlations between TPACK and its constructs, which support TPACK as a distinct form of knowledge-transformative model. TPACK is identified as an ill-structured, complex, and messy concept (Koehler & Mishra, 2008; Mishra & Koehler, 2006; Wilson & Wright, 2010). There has not been a consensus among researchers regarding the constructs of the TPACK framework (Graham, 2011). Researcher adapted Gess-Newsome's (1999) transformative approach and Magnusson et al's (1999) PCK model to explicitly define the elements of TPACK in our TPACK framework. The findings of this study also support the transformative TPACK framework, this TPACK instrument is different from other previous TPACK instruments in several ways.

First, the items were written following the transformative approach. Second, unlike many previous instruments (e.g. Mishra & Koehler, 2005), this TPACK instrument not includes items to measure a teacher's CxK in component of science subjects but an integrative as science. According to Koehler and Mishra (2009), TPACK and its components are highly influenced by CxK as integrative, which in this case CxK refers to subjects in science such as physics, chemistry and biology.

From this method as well, researcher identify groups of inter-related variables, which indicates how they are related to each other. For example from above items, there is findings that factor called "knowing the content scope in curriculum" in CK relates withhow good preservice science teacher knowing the universe of the content in curriculum. Researcher also found that factor called "knowing limitation of concept related with curriculum" in PCK is dealing with scope minimum of the content in curriculum. This is global factor called "g" or general intellegence that relates to both “knowing the content scope in curriculum” and “knowing limitation of concept related with curriculum”. This mean a respondent of preservice science teacher with a high “g” seems to have both high “knowing the content scope in curriculum” and “knowing limitation of concept related with curriculum” capabilites, and this “g” will explain reason why a preservice science teacher has a good or less on CK and PCK domains. This findings leads to further analysis of cognitive ability of three-stratum theory (Carroll; 1993) which developed according to factor-analytic investigation.

Regarding with factor analysis method, researcher estimated communalities through squared multiple correlations and iterated them to produce final communality estimates (Gorsuch 2003). For both theoretical and empirical reasons, researcher assumed that retained factors would be correlated. Consequently, researcher employed a Promax rotation with $k = 1$. One of the more critical decisions in an EFA is to determine the correct number of factors to retain and rotate (Fabrigar et al., 1999). The most common rule is to retain factors when eigenvalues are > 1.0. This solitary criterion is the default procedure in most statistical packages. The shortcoming is that implementation of solitary criteria tends to under or overestimate the number of true latent dimensions (Velicer, Eaton, & Fava, 2000) or later defined as domains in TPACK.

Tables in the chapter 4 presents results from Bartlett’s Test of Sphericity (Bartlett, 1954) indicated that the correlation matrix was not random, let say case of TPK items ($\chi2 = 7606.6$; df = 36; Sig = .000). The Kaiser-Meyer-Olkin (KMO; Kaiser, 1974) statistic was .900, well above the .60 minimum that Kline (1994) suggested. PA suggested that two factors should be retained, same with Kaiser’s criterion suggested. Similarly, scree pointed performed to the 2 factors as well while confirmed in the same process. Researcher interpreted the factors according to the magnitude and meaning of their salient pattern coefficients or factor loading. Certain reference consider that all coefficients greater than or equal to .40 were considered appreciable (Tabachnick & Fidell, 2007).

This research adescribes the field of teacher education (including pre-service teacher) and part of bunch of research efforts reporting on the development and assessment of TPACK (Archambault & Barnett, 2010; Archambault & Crippen, 2009; Chai et al., 2010). Much of this study aimed at equipping empirical evidence for the TPACK framework and validating assessment strategies and instruments used to measure TPACK (e.g., Chai et al., 2010). Finally, this TPACK was developed to measure only pre-service science teacher's TPACK while most of the previous surveys applied for pre-service and inservice teachers (e.g., Graham et al, 2009).

CHAPTER 6

IMPLICATION FOR PRACTICE

These results indicate that this is a promising instrument for measuring preservice science teachers' self-assessment of the TPACK knowledge domains. With the sample size around 1000, the researcher has good indications that the survey, as revised, is a reliable measure of TPACK and its related knowledge domains. Future work will include further refinement of the instrument through obtaining a larger sample size so a factor analysis can be performed on the entire instrument and then further validation of the instrument using classroom observation procedures.

This survey instrument was designed with a specific purpose in mind: examining preservice science teachers' development of TPACK. Over ten years, many instruments have been developed for measuring constructs like teachers' technology skills, technology integration, access to technology, and teachers' attitudes about technology (Becker & Riel, 2000; Keller, Bonk, & Hew, 2005; Knezek & Christiansen, 2004). Although advances are made in developing valid and reliable instruments for these purposes, this instrument is different from others because it measures preservice teachers' self-assessment of their development of TPACK rather than pre-service teachers' attitudes or pre-service teachers' technology use and integration. It extends the work of Mishra and Kohler (2005) and Archambault and Crippen (2009) with the creation of another robust survey that targets explicitly preservice teachers and thoroughly examines their knowledge development in each of the seven TPACK domains.

Readers are reminded that this survey was designed explicitly for preservice science teachers who are preparing to become secondary school (PK–7) or high school teachers (PK–12). Thus, the content knowledge domain includes physics, chemistry, biology and general science. Because PK–7 and PK–12 teachers generally teach these subjects in their classrooms, having separate factors for each content area seems most appropriate and supports the idea that the TPACK framework is content dependent (AACTE Committee on Innovation and Technology, 2008; Mishra & Kohler, 2006).

Future work in this TPACK instrument will benefit from efforts that specifically address measuring secondary teachers' self-assessment in the content areas of science. According to the results from this study, it seems realistic that there would be an instrument designed specifically for each secondary content area.

Regarding with answering most crucial part of this study, i.e., research question: "How TPACK framework is adopted and adapted to be a set of the instrument of measuring technology integration development of pre-service teacher in Indonesia?"; It can be answered as follow: The research investigating the framework of TPACK for the preservice science teacher and its necessity to measure technology integration of preservice science teacher in Indonesia. As among of 31 Indicators and 116 items of TPACK instrument initially formed which coming from adopted and adapted indicators and items from series of literature review and researcher synthesis of thinking, while having applied with validity and findings from this instrument on 1382 completed responses it resulted in 67 examined items to measure TPACK of preservice science teacher.

The instrument developed for this study provides a starting point for work designed to examine and support preservice science teachers' development of TPACK. The researcher plan on conducting a study to examine the development of TPACK after completing content area methodology courses and teaching practice. Research plans also involve following these preservice teachers during their induction years of teaching. Perhaps most important, the researcher plan to process qualitative data of classroom observations of student teachers and conduct observation for an induction year teachers to evaluate the level of TPACK demonstrated in their classrooms and then investigate how scores on the TPACK instrument predict classroom behaviors. Besides, the authors plan studies designed to validate further and revise the instrument.

The researcher is also in the process of completing a study of pre- and posttest scores using the instrument with preservice teachers currently enrolled in the teaching practice course to determine what effect the class has on the early development of TPACK (Schmidt et al., 2009). Use and modification of this instrument should encourage a line of research on measuring the development of TPACK in preservice teachers and ultimately help preservice teacher education programs design and implement approaches that will encourage this development. The researcher plan to administer the survey periodically throughout teacher education programs, using the results to inform researchers of specific times or events when each knowledge domain is developed. This information will provide valuable insight into the development of TPACK and provide program feedback on practical approaches in encouraging this development.

Further Development

Shulman (1986, 1987) proposed refers to an integrative set of knowledge not just merely composed of subject content and pedagogy but also with experience-based knowledge offering a bridge connecting knowledge of content and pedagogy. Under the same rationale, Mishra and Koehler (2006) added the element of technology to the knowledge system of PCK and proposed TPACK as an essential knowledge set that contemporary teachers should develop. Represented in a three-circle Venn diagram composed of CK, pedagogical knowledge (PK) and technological knowledge (TK), TPACK refers to the mutually overlapping area of composite knowledge sets of PCK, technological pedagogical knowledge (TPK) and technological content knowledge. Similar to how teachers are encouraged to engage their PCK in instruction, teachers also are encouraged to engage their TPACK dynamically in order to enhance the quality of their content delivery through the proper use of pedagogical strategies and technological resources.

Based on the framework of TPACK, researchers in the past few years have devoted themselves to discussing whether other critical factors are contributing to teacher instruction in the digital age. Rooted in the framework of TPACK (Mishra & Koehler, 2006), Kabakci Yurdakul et al (2012) pointed out other competencies that teachers with TPACK should develop, including design (ie, designing instruction), exertion (ie, implementing instruction), ethics (ie, ethical awareness) and proficiency (ie, innovativeness, problem-solving and field specializations). Other competencies include designing and engaging in proper evaluations, setting information and communication technology (ICT)-friendly learning environments and retaining positive personal beliefs (Guzman & Nussbaum, 2009).

Regarding the local application of Indonesia, especially standards for the pre-service and in-service science teacher, other competencies are potentially to add

Self Critique

However, there is no “one best way” to integrate technology into the curriculum (Koehler & Mishra: 2013).

There have been several critiques of the notion that TPACK is the integration of separate component knowledge as well as mutually integrated knowledge. First, Shulman’s separation of PCK into three distinct categories of knowledge has been trying to validate (McEwan & Bull, 1991; Segall, 2004). Even experienced in-service teachers may feel perplexed when trying to figure out the differences between content and pedagogy (Archambault & Crippen, 2009). Second, adopting Whetten's (1989) definition of solid theory, Graham (2011) criticizes the integrative concept of TPACK and argues that it lacks a firm theoretical foundation, stable construct validity, and actual value for educational technology. His critique is based on previous research findings regarding fuzzy definitions of PCK (Gess-Newsome, 2002; Magnusson, Krajcik & Borko, 1999) and TPACK (Cox, 2008), an intuitive analysis of the component knowledge involved in TPACK (Angeli & Valanides, 2009) and an unacceptable validity level of TPACK components (Archambault & Barnett, 2010; Archambault & Crippen, 2009; Burgoyne, 2010; Schmidt et al, 2009). These theoretical concerns could threaten the construct validity of a framework that recognizes TPACK as merely an accumulation of knowledge sets. Because knowledge is doomed to reach consilience after numerous rounds of unification and disciplinary boundaries are "replaced by shifting hybrid domains" (Wilson, 1998, p. 11), it would probably be more meaningful to discuss TPACK globally and pay attention to the features of the unified construct. A transformative perspective to measuring TPACK will not require that researchers measure all the knowledge subconstructs, but rather identify items that capture TPACK as a unique knowledge base

However, even every factors and item are accepted equally according to the mathematical methods; researcher found that certain factors did not seem to be useful in distinguishing among domains and unfortunately researcher could identify casualties using this method.

A critical question might up arise from this research about the instrument of TPACK is what's next? While the instrument already designed and well-examined, the step for creation is completed. From this step, we are in the start line to use this instrument to the pre-service science teacher in Indonesia in the context of specific Teacher Education Institute as a case or nationwide. Another step is using this instrument as the component of other non-self report instruments to measure TPACK development of preservice science teachers such as an interview of performance instruments which will give a more comprehensive pictures

Future research recommendations for the investigation are: (1) understanding of those preservice science teachers' TPACK affected their practices during student teaching actions (2) the teacher preparation program needs to take for improving on development properties of preservice science teachers' TPACK and (3) identification of significant relationships between preservice teachers' TPACK during the program and their use of technology in their future teaching career. Other things are whether preservice science teachers perceive that they are being prepared to teach 21st-century skills by integrating technology into teaching and learning by the Study Program

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APPENDICES

APPENDIX A

Examples of TPACK in the science classroom learning

Analyzing forces on Amusement Park Rides with Mobile Device

Content Knowledge (CK):

- Force diagram
- G- forces
- Acceleration
- Circular motion

Pedagogical Knowledge (PK)

- Annual activity of school for outside learning
- Grouping of students with at least one student with internet access and unlimited data plan on his / her cellphone

Technological Knowledge (TK)

- Cellphone
- Tablets
- Gaming controllers

Pedagogical Content Knowledge (PCK)

- Conceptual difficulties associated with understanding centripetal force
- Qualitative experience for understanding about energy tranformation, circular motion

Technological Pedagogical Knowledge (TPK)

- Amusement Park Ride

Technological Content Knowledge (TCK)

- Mobile device accelerometer

- Gyroscope
- Acceleremeter software

TPACK:

Using Physics toolbox accelerometer for android at one of group leader to collecct real data on at least one ride of amusement park and put it into google drive to analyse at the following day. The data easly imported into excell or logger pro

APPENDIX B

Demographic Information

1. Gender

    Female . . . . Male . . . .

2. Age

    a. Under 18
    b. 18 - 20
    c. 20-22
    d. 22-24
    e. More than 24

3. Please indicate your formal teaching experience

    a. None
    b. Less than 3 months
    c. 3 – 6 months
    d. 6 – 12 months
    e. 1 – 2 years
    f. Other (specify ________________________________)

4. Please indicate your informal teaching experience

    a. None
    b. Less than 3 months
    c. 3 – 6 months

d. 6 – 12 months
e. 1 – 2 years
f. Other (specify ________________________________)

5. Please indicate the grade of students that you would like to teach
    a. Primary school (lower grade)
    b. Primary school (upper grade)
    c. Secondary school
    d. High School
    e. Have not decided
6. Hour(s) average of using computers at home or outside campus (in a week)
    a. None
    b. 1-2 hours
    c. 2-5 hours
    d. more than 5 hours
7. Hour(s) average of using computers at campus (in a week)
    a. None
    b. 1-2 hours
    c. 2-5 hours
    d. More than 5 hours
8. Please list the formal courses taken at undergraduate in computer technology or related to the computer technology

Name of course	Content	Duration	Year taken

9. Please list the informal courses or activities at undergraduate in computer technology or related to the computer technology

Name of course / activities	Content	Duration	Year taken

10. Which technologies do you use personally? (check all that apply)

□ Chat / instant messaging (Whatsapp, LINE, WeChat)

- □ Blogging / microblogging (blogspot, blogger, twitter)
- □ VoIP audio conference (Skype, Google Hangout, Gizmo)
- □ Social Bookmarking (Delicious, Digo, Digg)
- □ Wiki (Wikispaces, PB Wiki)
- □ Social Networking (Facebook, Niki)
- □ Others ____

11. May we contact you about your input at a later date?
    If so, please provide your e-mail address. ______________________________

APPENDIX C

Initial Instrument Indicator and Items TPACK For pre-service science teacher on Teaching Practice Program

Objective: To obtain the background of the science pre-service teacher in terms of their knowledge on teaching and learning, physics, and technology before Teaching Practice Program

Extremely Poor	Poor	Acceptable	Good	Very Good	Excellent
A	**B**	**C**	**D**	**E**	**F**

Domain	Sub-Domain	Indicator(s)	Item(s)

			My ability to / of . . .
Content Knowledge (**CK**)	Curriculum Issue	Mapping particular standard from curriculum	1. Identify standard of curriculum related with certain concept 2. Mapping particular standard from curriculum
		Sufficient knowledge about science content in curriculum	3. know about science content that I want to teach 4. know the scope of content in curriculum
	Mapping the Concept	Sequencing the particular science concept	5. make a proper order of science concept according to the standards 6. sequencing certain science concept
		Knowing scope of concept	7. Knowing how far / high science concept in certain topic 8. Know limitation of science concept among other concepts
	Body of Knowledge	Creating materials related with science concept	9. Identify materials supported with particular science concept 10. Creating materials related with certain science concept
		Sufficient knowledge about certain science concept	11. Sufficient knowledge about science concepts in secondary level
	Developing for Practice	Planning the sequence of concept	12. Identify ways of concepts'construction 13. Planning the sequence of concept
		Deciding the scope of essential concept	14. Identify essential concepts from particular topics 15. Mapping the scope of essential concepts from particular topics
		Various way developing the understanding of concept	16. Knowing various ways to understand the particular concept

		Using science way of thinking	17. Using science way of thinking to develop understanding of science concept 18. Using science way of thinking in the classroom
Pedagogical Knowledge (**PK**)	How Students Learn	Deciding ways of students constructing knowledge	19. Adapting teaching based on currently student understand or do not understand 20. Using range of teaching approaches to construct students knowledge
		Sequencing students acquire skills	21. Identify students' acquire skills needed from standard 22. Planning sequencing students to acquire targeted skills
		Knowing ways of developing habits of mind toward learning	23. Knowing habits of mind can be delivered through learning particular concept 24. Knowing ways of develioping habits of mind toward learning
		Knowing ways of developing positive disposition toward learning	25. Identifying positive dispotition toward learning from standard 26. Identifying possible positive dispotition through learning particular concept
		Indentify students misconception	27. Familiar with common students understanding and misconception

	General Classroom Management	Various ways to keep students organized, orderly and focus during a class.	28. Identifying various ways of classroom management to keep student organized, orderly and focus during a class 29. Adapting various way of classroom management in the classroom to keep student organized, orderly and focus during a class
		Various ways to keep students academically productive during a class	30. Identifying various ways of teaching to keep student academically productive during a class 31. Adapting various way of teaching to keep student academically productive during a class
	Lesson Planning	Defining instruction roadmap	32. Design a roadmap of lesson plan related with expected objectives 33. Identify teachers help or facilitation in learning sequences
		Predicting students learning trajectories	34. Predicting students responses during learning 35. Preparing responses for possible occurred of predicting students response
		Deciding ways on how it will be done during the class time	36. Identify time consume for learning sequences 37. Design possible planning for possible change in the classroom to fit with time
	Teaching Methods / Techniques	Knowing ways of teaching methods in class	38. Knowing teaching methods theoretically 39. Knowing ways of teaching methods in class

		Determining particular applied teaching strategy in class	40. Identifying characteristic of various teaching methods 41. Determining particular applied teaching strategy in the classroom
		Using variety of teaching strategies related with various concepts of students	42. Identifying various of teaching strategies related with various concept of students 43. Using variety of teaching strategies related with various concepts of students
		Adjust teaching according to the students feedback	44. Encouraging students' feedback during classroom 45. Adjust teaching according to the students' feedback
		Adjust teaching style to different learners	46. Identifying types of different learners 47. Adjust teaching style to different learners
	Students Assessment	Knowing ways of assessing students performance in a class	48. Knowing various of students assessment 49. Knowing ways of assessing students' performance in a class
		Using particular assessment in certain concepts	50. Using particular assessment in certain concept
Technological Knowledge (**TK**)	Intellectual Capabilities	Troubleshooting problems associated with hardware	51. Able to handle troubleshooting problems related with hardware (e.g. network connection) 52. Able to assist students with hardware problems witht their PC or laptops
		Address various computer issue related to software	53. Addressing various computer issue related to software (e.g. installing program, dowloading)

			54. Able to assist students with hardware problems witht their PC or laptops
		Troubleshooting problems associated with sofware	55. Able to handle troubleshooting problems related with software (e.g. network connection) 56. Able to assist students with networking problems witht their PC or laptops
	Contemporary skills	Using today computer application	57. Comfortable using digital technology (cellphone, computer, tablet, etc) 58. Frequently play around with computer application
		Applying recently ICT	59. Learn about new digital technology easily 60. Keep informed about new digital technologies 61. Know a lot of about new digital technologies
	Foundational Concept	Basic principles of computer	62. Knowing how to solve problems on my own computer
		Using ideas of networking	63. Knowing ideas networkig among computers 64. Using ideas of networking on data
Pedagogical Content Knowledge (**PCK**)	Representation of Subject Matter	Knowing various representation in particular science concept	65. Knowing various representation in particular science concept
		Determining appropriate (single or multi) representation for certain science lesson	66. Using a better respresentation for particular science lesson 67. Determining appropriate multi-representation for certain science lesson

		Anticipate likely students misconception within a particular topic	68. Predicting likely students misconception within a particular topic
	Understanding Student Conception and its Teaching Implications	Distinguish correct and incorrect conception of student attempt	69. Distinguish between true concept, not knowing concept and misconception within a particular topic 70. Distinguish between true concept, not knowing concept and misconception of student attempt within a particular topic
	General Pedagogy	Selecting appropriate teaching approaches in science	71. Identifying various teaching approaches in science 72. Selecting appropriate teaching approaches in science
		Produce lesson plan with an appropriate for the topic	73. Produce lesson plan with an appropriate for the topic
		Apply teaching strategies in particular science concept	74. Knowing various teching strategies in particular science concept 75. Apply teaching strategies in particular science concepts
	Curriculum	Knowing limitation of concept related with curriculum	76. Designing concept map related with curriculum 77. Knowing limitation of concept related with curriculum
		Adjusting concept sequencing according to the curriculum objectives	78. Creating concept sequencing according to the topic of grade 79. Adjusting concept sequencing according to the curriculum objectives
	Educational Context	Addressing particular concept with learning objective	80. Addressing particular concept with learning objective

		Addressing particular concept with students proximal development	81. Addressing particular concept with students proximal development while they learn individually 82. Addressing particular concept with student proximal development while they learn collaboratively
	Purpose of education	Knowing lesson developed in order to gain scientific literacy	83. Identifying scientifi literacy on particular topic 84. Knowing lesson developed in order to gain scientific literacy
Technological Content Knowledge (**TCK**)	Choosing Technologies Affords, Constrains, and Types of Content Ideas that can be taught	Selecting proper content concerned with technology	85. Selecting proper content of science related with technology needed (multimedia, visual demo, apps)
		Enhancing the scope of body of knowledge dealing with technology	86. Selecting exist technology (multimedia, visual demo, apps) that can be used related with enchancement of content 87. Selecting exist technologies as application of body of knowledge
	Flexibility in Navigating Across Content Representation	Understanding of representations of concepts dealing with available technology	88. Identify various representations of particular concepts of a topic 89. Understanding of representations of concepts dealing with available technology
	Manner in which the subject matter can be changed by	Knowing specific technologies best suited in students domain	90. Knowing specific technologies suited in classroom using 91. Knowing specific technologies best suited in students domain

	the application of particular technologies	Knowing how content dictates or even perhaps changes the technology or vice-versa	92. Identify content dictates the technology 93. Identify technology dictates particular content in a science topic
Technological Pedagogical Knowledge (**TPK**)	Pedagogical affordance and constrains of a range of technological tools	adapt the use of the technologies learnied to different teaching activities	94. Identify using of technologies learned during the course period 95. adapt the use of the technologies learnied to different teaching activities
		choosing technologies that enhance the teaching approaches for a lesson	96. Choosing technologies that enhance the teaching approaches for a lesson
		choosing technologies that enhance students' learning for a lesson	97. Choosing technologies that enhance students' learning for a lesson
	Developing appropriate pedagogical design with technology	creating an online environment which allows students to build new knowledge and skills	98. Dealing with online environment to build new knowledge and skills 99. Creating an online environment which allows students to build new knowledge and skills
		Determining different methods of teaching online	100. Determining different methods of teaching online
		Encourage interactivity among student using ICT	101. Communicating online with students in particular online environtment 102. Encourage interactivity among student using ICT

		Moderating interactivity among student using ICT	103. Moderating interactivity among student using ICT
Technological Pedagogical Content Knowledge (TPACK)	Effective teaching with technology	Acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change	104. Acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change 105. Develop functional competencies in a specified curriculum area
		Using strategies that combine content-technologies-teaching approaches in classroom	106. use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom
	Representation of concept using technology	Using appropriate technology for better representation of content for the lesson	107. Identfying various technology for representation of content for the lesson 108. Using appropriate technology for better representation of content for the lesson
		Modify exsist technology related with representation of certain concept	109. Modify exsist technology related with representation of certain concept
	Pedagogical techniques that use technology in constructive ways to teach content	Modify teaching strategies in terms of involving technology at particular concept	110. Modify teaching strategies in terms of involving technology at particular concept
		Using teaching strategies in term of particular concept using certain technology	111. Using teaching strategies in term of particular concept using certain technology

	Knowledge what makes concept difficult or easy and related technolgy can reduce students problem	Identifying students obstacles on certain concepts which can be improved by technologies	112. Able to synthesize students knowledge 113. Identifying students obstacles on certain concepts which can be improved by technologies
		Adjusting technologies for possibility reduce student conception problem	114. Adjusting technologies for possibility reduce student conception problem
	Using of technology to build on existing knowledge to develop new epistemologies or strengthen old one	Adjusting technology to describe better existing knowledge of concept	115. Adjusting technology to describe better existing knowledge of concept
		Adjusting technology to describe new epistemologies in particular concept	116. Adjusting technology to describe new epistemologies in particular concept

APPENDIX D

Examined Instrument Indicator and Items TPACK For pre-service science teacher on Teaching Practice Program

Objective: To obtain the background of the science pre-service teacher in terms of their knowledge on teaching and learning, physics, and technology before Teaching Practice Program

Extremely Poor	Poor	Acceptable	Good	Very Good	Excellent
A	**B**	**C**	**D**	**E**	**F**

New Instrument Produced from this method

Domain	**Sub-Domain**	**Item(s)** My ability to / of . . .
Content Knowledge (**CK**)	Content Standards in the Curriculum	1. Identify standard of curriculum related with certain concepts
		2. Sequencing certain science concept
		3. Knowing about science content that I want to teach
	Developing Concept for Practice	4. Knowing how far / high science concept in certain topic
		5. Sufficient knowledge about science concepts in secondary level
		6. Knowing various ways to understand the particular concept
		7. Using science way of thinking to develop understanding of science concept
		8. Knowing the scope of content in curriculum
		9. Using science way of thinking in the classroom

Pedagogical Knowledge (**PK**)	Students Classroom Management	10. Adapting various way of teaching to keep student academically productive during a class
		11. Adapting various way of classroom management in the classroom to keep student organized, orderly and focus during a class
		12. Identifying types of different learners
	Teaching for Studets Learning	13. Adapting teaching based on currently student understand or do not understand
		14. Planning sequencing students to acquire targeted skills
		15. Adjust teaching according to the students' feedback
	How Students learn	16. Identify students' acquire skills needed from standard
		17. Knowing habits of mind can be delivered through learning particular concept
		18. Identifying possible positive disposition through learning particular concept
		19. Familiar with common students understanding and misconception
	Teaching Methods	20. Knowing teaching methods theoretically
		21. Identifying characteristic of various teaching methods
	Lesson Design	22. Design a roadmap of lesson plan related with expected objectives
		23. Preparing responses for possible occurred of predicting students response
	Students Assessment	24. Knowing ways of assessing students' performance in a class
		25. Using particular assessment in certain concept
Technological Knowledge (**TK**)	Intellectual Capabilities	26. Able to assist students with hardware problems with their PC or laptops
		27. Able to assist students with software problems with their PC or laptops
		28. Able to assist students with networking problems with their PC or laptops
		29. Frequently play around with computer application

	Contemporary skills	30. Learn about new digital technologies easily
		31. Know a lot of about new digital technologies
	Foundational Concept	32. Knowing how to solve problems on my own computer
		33. Knowing ideas networking among computers
Pedagogical Content Knowledge (**PCK**)	Teaching concept according standards	34. Selecting appropriate teaching approaches in science
		35. Produce lesson plan with an appropriate for the topic
		36. Knowing various teaching strategy in particular science concept
		37. Knowing limitation of concept related with curriculum
		38. Adjusting concept sequencing according to the curriculum objectives
		39. Addressing particular concept with learning objective
	Purpose of Science Education Students' Conception	40. Addressing particular concept with student proximal development while they learn collaboratively
		41. Identifying scientific literacy on particular topic
		42. Predicting likely students misconception within a particular topic
		43. Distinguish between true concept, not knowing concept and misconception within a particular topic
	Representation of Subject Matters	44. Knowing various representation in particular science concept
		45. Using a better representation for particular science lesson
Technological Content	Navigating Applied	46. Selecting proper content of science related with technology needed (multimedia, visual demo, apps)
		47. Selecting exist technologies as application of body of knowledge

Knowledge (**TCK**)	Technology for Representation	48. Understanding of representations of concepts dealing with available technology
		49. Knowing specific technologies suited in classroom using
		50. Identify content dictates the technology
Technological Pedagogical Knowledge (**TPK**)	Pedagogical Design with Technology	51. Creating an online environment which allows students to build new knowledge and skills
		52. Determining different methods of teaching online
		53. Communicating online with students in particular online environment
		54. Moderating interactivity among student using ICT
	Pedagogical range for technological tools	55. Identify using of technologies learned during the course period
		56. Choosing technologies that enhance the teaching approaches for a lesson
		57. Choosing technologies that enhance students' learning for a lesson
Technological Pedagogical Content Knowledge (**TPACK**)	Technology in pedagogy for knowledge building	58. Using appropriate technology for better representation of content for the lesson
		59. Modify exist technology related with representation of certain concept
		60. Modify teaching strategies in terms of involving technology at particular concept
		61. Using teaching strategies in term of particular concept using certain technology
		62. Able to synthesize students' knowledge
		63. Adjusting technologies for possibility reduce student conception problems
		64. Adjusting technology to describe better existing knowledge of concept
		65. Adjusting technology to describe new epistemologies in particular concept
	Effective teaching with technology	66. Acquire the knowledge, skills, abilities, and attitudes to deal with ongoing technological change

		67. Use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom

Appendix E

English –translated version

EXPLANATORY STATEMENT

(Responded Pre-Service Science Teachers)

Dissertation Research: Study of Measuring Technological Pedagogical Content Knowledge (TPACK) Development of Pre-Service Science Teacher in Indonesia

Arif Hidayat

Science Education, Graduate School of International Development and Economy Cooperation (IDEC) - Hiroshima University, JAPAN

Phone: +81-80- 4262-2873

email: arifhidayat@upi.edu

You are invited to take part in this study. Please read this Explanatory Statement in full before deciding whether or not to participate in this research. If you would like further information regarding any aspect of this research, you are encouraged to contact wes via the phone numbers or email addresses listed above.

What does the research involve?

If you consent to participate in this study, you will be invited to contribute data in the following ways:

- In the beginning of the research, you will spend your time about 15 – 20 minutes to read and answer the survey
- You will continue to be a pre-service science teacher in your usual courses / classroom. You will have an interview and participate in one whole-school teaching practice session before the research tarts. You will conduct (in total 2) lessons of your subject for observation. All the observed lessons and reflection sessions will be videotaped and audiotaped. In each lesson, two groups of children will be audiotaped at random as they participate in group discussions.
- At the end of the research, you will be interviewed about your reflection upon lessons as well as your experience with integration of technology. The interview will be for about 20 minutes and audio and or video recorded. The transcripts of your own interviews will be sent to you for feedback and amendment if you believe such changes are necessary. Tentative findings of the research will be also sent to you for your feedback.

Why were you chosen for this research?

You have been invited to participate in this study because you are pre-service teacher of science in a secondary school chosen and you are interested in taking part in the research as a way of learning and creating new knowledge for your own. We are seeking pre-service science teachers with a range of teaching experiences. We will select people according to these criteria in order of receipt of consent forms.

Source of funding: MEXT Scholarship

This research study is supported by the MEXT Scholarship, which is a Japan-based formal body devoted to the research, and implementation of education in Japan. This scholarship is awarded to pursue PhD degree in Hiroshima University

- **Consenting to participate in the project and withdrawing from the research**

  Your participation in this study is completely voluntary and you may choose to withdraw up until you have answered the survey. If you wish to withdraw from the study, you can contact wes via email arifhidayat@monash.edu, or through phone number +81-80-4263-2873. If you choose to withdraw, the data collected from you will be destroyed and will not be included in the findings.

Possible benefits and risks to participants

Benefits of Participating

You will benefit from being part of this study as you may grow your understanding and capacity and become more aware of your interactions with students using integration of technology to enhance student learning. You may also develop a different view of yourself as a teacher that helps to inform your professional practice. Your participation will contribute to a deeper understanding of how pre-service teachers TPACK development.

Risks of Participating

There are no foreseeable risks of being part of this study beyond those of teaching practice or course routine as normal. The risks of participant identification and confidentiality have been addressed. Please see the following paragraph. The only inconvenience will be giving us some of your time for reading and answering the survey.

Confidentiality

- We will not name the school and you will be referred to by a pseudonym in the data. This may include research publications, reports, and/or presentation.

- **Storage of data**

  All data collected in this study will be stored securely on a password protected computer hard drive and will only be accessed by we.

- **Results**

  If you would like to a copy of the research papers that we would publish in due course, please contact wes via email arifhidayat@upi.edu, or by phone +81-80-4263-2873.

  Complaints

  Should you have any concerns or complaints about the conduct of research of this dissertation, you are welcome to contact the Arif Hidayat, Indonesia University of Education:

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Thank you,

Arif Hidayat