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Slamet Suyanto, Heru Nurcahyo & Ixora Mercuriani Ixora

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## Comparative Study on the Development of Technological, Pedagogical and Content Knowledge (Tpack) of Biology Teacher Through Academic and Professional Program

Slamet Suyanto<sup>1</sup>  
Heru Nurcahyo<sup>2</sup>  
Ixora Mercuriani<sup>3</sup>

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### Abstract

Suyanto, Slamet et al., 2018. The development of teacher and lecturers in Indonesia follows two main programs: academic and professional. The academic program is a 4-year bachelor program (S-1) and master (S-2) program. The profession program is a 4-year bachelor program (S-1) followed by 1-year Teacher Professional Program (PPG). Both programs must develop Technological knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK). This survey research was aimed at measuring the TK, PK, and CK the student of those programs. The subjects were 75 people, including 25 S-1 students, 25 PPG students, and 25 S-2 students. The instrument was objective tests. The data were analyzed using descriptive and analysis of variance statistic. The results indicated that the TK profile of S1, PPG, and S-2 was 70.57, 71.40, and 72.44 in a 100 scale. The profile of PK was 68.73, 74.33, and 73.84. The profile of CK was 69.07, 69.67, and 72.40. There was a significant difference on CK between S1 and S2 students, but no difference on CK between S-1 and PPG students. There was a significant difference on PK and CK profiles between S-1 and PPG students; but there was no difference on CK between S-1 and PPG students. Therefore, PPG was developing more on PK, but not on CK. For magister program, it should provide students more with field experience on schooling.

**Keywords:** tpack, content knowledge, pedagogical knowledge, technological knowledge, biology teacher

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<sup>1</sup> Graduate Program, Universitas Negeri Yogyakarta, Email: [slamet\\_suyanto@uny.ac.id](mailto:slamet_suyanto@uny.ac.id)

<sup>2</sup> Graduate Program, Universitas Negeri Yogyakarta, Email: [heru\\_nurcahyo@uny.ac.id](mailto:heru_nurcahyo@uny.ac.id)

<sup>3</sup> Graduate Program, Universitas Negeri Yogyakarta, Email: [ixora\\_mercuriani@uny.ac.id](mailto:ixora_mercuriani@uny.ac.id)

## Background

### Low HDI

Human quality is a critical factor for the development of a country, specifically for a developing country like Indonesia. According to UNDP (2017), Human Development Index (HDI) of Indonesia is 0,694 or in the medium category, it ranks 116 among 189 countries. The problem in Indonesia is that the HDI is not equal through the regions. Yogyakarta and Jakarta Province, for example, rank high with HDI score 85.49 and 80.06 in 100 scale. However, 6.23% of other regions (regency) have a low HDI. Nduga regency, for example, scores the lowest with HDI 27.87 (BPS 2017). Therefore the HDI is still need improvement.

HDI is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living (UNDP, 2017). HDI is affected by several factors, such as education, health, and economic. In term of education, Indonesia faces several problems. The first one is the length of schooling. According to Bapenas (2017) the average length of schooling of Indonesian is 7.46 years or it is equal to junior high school level in 2010. It increases to 8.10 years of schooling in 2017, lower than the expected length 12.85 years (Figure 1).



Sumber : Badan Pusat Statistik

Figure 1. The length of schooling of Indonesian from 2010-2017. HL: Expected Length of Schooling and RLS: Real Length of Schooling. (Source: Center of Statistic Biro (BPS), 2017)

HDI is also affected by the quality of education. Education is the most powerful and strategic institution to educate people. Education in Indonesia is facing a problem with the teachers, both in their quantity and quality. Indonesia lacks numbers of teachers. Data from Depdikbud (2016) shows that Indonesia deficits of 146.987 teachers, in particular in elementary schools lack of 90.618 teachers, special education 3.596 teachers, high school 160.661 teachers, and vocational schools 108.249 teachers.

In addition, education is also facing a problem with the quality of teachers. According to BPS (2015), Indonesia has 3.073.159 teachers; 93% of them are considered eligible and 6.89% are ineligible to teaching. The uneligibility is caused by the absence of teaching certificate, and compulsory education for teaching (4-years of undergraduate or 4-year diploma program). The performance of teachers in teaching is also low; that is 74.83% for elementary school teachers, 79.16% for Junior high school teachers and 81.16% for High school teachers.

### Teacher competence

According to Indonesian Decree number 14-year 2005 on teacher and lecturer, the competence

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of teachers consists of four aspects (1) pedagogical competences, (2) professional competence, (3) personality competence, and (4) social competence. In these competences, there is no specific competence on understanding and using ICT in education. It is only a part of pedagogic competence. This competence is slightly different from TPACK proposed by Shulman (1986).

To improve the quality of teachers, Indonesia's government increases the education requirement of teachers. First, to become a teacher, one must hold the certificate of 2-year diploma of teacher education. Then, it increased to 4-year teacher education (S-1, Bachelor). Now, to be a teacher one must follow teacher professional education (PPG), one year after S-1. To be a lecturer, one must follow 2-year master education program (S-2).

### **Teacher profile in TPACK**

There are some emerging researches on the profile of TPACK of Indonesian teachers. The researches mainly measure the component of TPACK partially. Teachers' performance test (UKG) done by DSE (2015) showed that teachers scored low. The average of national score was 55 in a-100 scale. Seven provinces score moderate i.e. DI Yogyakarta (62.58), Middle Java (59.10), DKI Jakarta (58.44), East Java (56.73), Bali (56.13), Bangka Belitung (55.13), and West Java (55.06). Only D.I. Yogyakarta's teachers passed the threshold (56.91) for pedagogical competence, (DSE, 2015). The scores above showed that the ability of teachers to understand pedagogical and professional competence were low.

Cahyono, *et al.* (2016) measured the TK, PK, and CK of English as Foreign Language in-service teachers. They found that the EFL teachers score highest on CK, and less in TK, and PK. The profile of TK, PK, and CK developed through the teaching practice. The other researcher, Nurul Kusuma Wardani, *et al.*, (2014) also identified the interaction of TK, PK, and CK of physic teachers. They found that the highest to the lowest scores were PCK, TCK, and TPCK.

Related to CK, according to NSTA (2017), there are five life science topics in high school: (1) Structure and Function, (2) Inheritance and Variation of Traits, (3) Matter and Energy in Organisms and Ecosystems, (4) Interdependent Relationships in Ecosystems, and (5) Natural Selection and Evolution. The performance expectations for high school life sciences blend core ideas with science and engineering practices and crosscutting concepts to support students in developing useable knowledge that can be applied across the science disciplines.

### **The importance of the research on TPACK**

The teacher Performance Test done by DSE (1915) did not measure TK, just measuring PK and CK. This research measures TK, PK, and CK of the pre-service and in-service teachers. The results of this research will be valuable to teacher education programs, specifically in Indonesia and other developing countries. According to PDDIKTI (2017), there were 3.276 higher education institutions in Indonesia; 122 are publics and 3.154 are privates; with 20.516 study programs and 6.924.511 students. The number of accredited study programs is 53% (8,638 study programs) and the unaccredited is 47% (8.139 study programs) (Kemendiknas, 2013). Educational study programs score highest with 3.585 unit (Kompas, 01/29/2015). Research on TPACK profile will be useful to the development of curriculum, teaching practice, evaluation, and other standards to get the best qualified teachers specifically for educational study programs.

### **Research questions**

From the background, the research questions are:

1. What is profile of PK, CK, and TK of S-1, PPG, and S-2 students of biology education program?

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2. What is the best profile of PK, CK, and TK of S-1, PPG, and S-2 students of biology education program?

### **Literature Review**

#### **Teacher Competence**

It is described above that Indonesia's teacher competence consists of four aspects (1) pedagogical competence, (2) personality competence, (3) social competence, and (4) professional competence (MoE-ae, 2014). Pedagogical competence includes the ability to plan, to do, and to evaluate instructional programs; to understand and use the characteristics of the students; to understand educational and instructional theories and the applications; to develop and use media and learning resources; and to use ICT in learning process. Personality competence comprises the attitudes of teachers including maturity, fairness, justice, wisdom, and democracy. The competences are not included in the TPACK. The social competence includes the ability of teachers to interact and to work cooperatively with students, parents, colleges, and society as well. The last competence is professional competence, constitutes the mastery of teachers in the contents of the subject taught, and the procedures related to the inquiry process of the subject.

According to the Government Act number 19 Year 2017 on Teacher, verse 1 says that teacher is a professional with primary jobs are educating, teaching, guiding, directing, training, assessing, and evaluating the learners. The qualification of teacher must be bachelor (S-1) or D-4 with an inline subject.

#### **National Standard of Teacher Education Program**

According to the MoHE act number 55-year 2017, verse 1, says that the standard of teacher education program is minimum criteria of teacher education program, consisting standard of competence of the graduates, standard of content, standard of process, standard of educators, standard of management, standard of facility, and standard of finance. The teacher education institution (LPTK) is higher education institutions appointed by the government to deliver teacher education program (PPG). PPG is a program to educate under graduates who want to become teachers.

#### **Teacher competence according to Indonesian Qualification Framework (IQF)**

According to presidential Decree number 8, year 2012, professional teachers rank level seventh of the IQF from nine levels where the 7<sup>th</sup> level is considered "professional". The nine levels respectively are classified into three categories:

- a. Level 1- 3 is operator;
- b. Level 4- 6 is technician or analyst,
- c. Level 7- 9 is expert.

According to the IQF, teacher is a profession level 7 (Figure 2)

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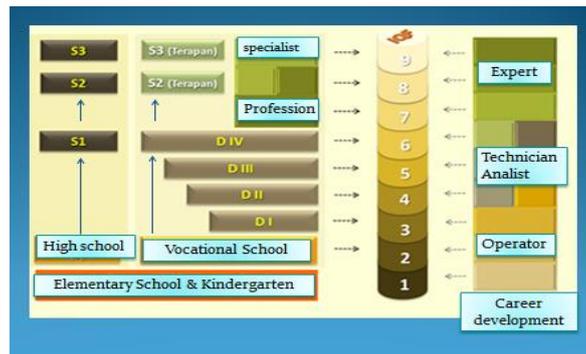


Figure 2. The nine levels of the IQF, teacher ranks seven

**TPACK**

Teacher’s understanding on TPACK depicts their mastery on the subject, pedagogy, and technology related to the subjects and its education (Vela & Medrano, 2015; Koehler & Mishra 2009; Yeh at al., 2017). Historically, TPACK has been proposed by Shulman in 1986. According to him, teacher’s content knowledge and its pedagogy interacts each other in teaching and learning process. He said “...the content and the pedagogical knowledge worked out the pedagogical content knowledge as “the special amalgam of content and pedagogy”.” (Shulman, 1987, p.8). Later, that content knowledge is called CK, and the pedagogy is called PK, and the interaction is called pedagogical content knowledge (PCK). Shulman (1987) said that PCK was “subject matter knowledge for teaching”.

TPACK consists of Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK). The three elements blend each other and form TPK, PCK, and TCK (Mishra, Spiro, & Feltovich, 1996; Spiro & Jehng, 1990), and finally they form TPACK. In other words, TPACK has seven elements including (1) PK, (2) CK, (3) TK, (4) PCK, (5) TCK, (6) TPK, and (7) TPACK (Figure 3 ).

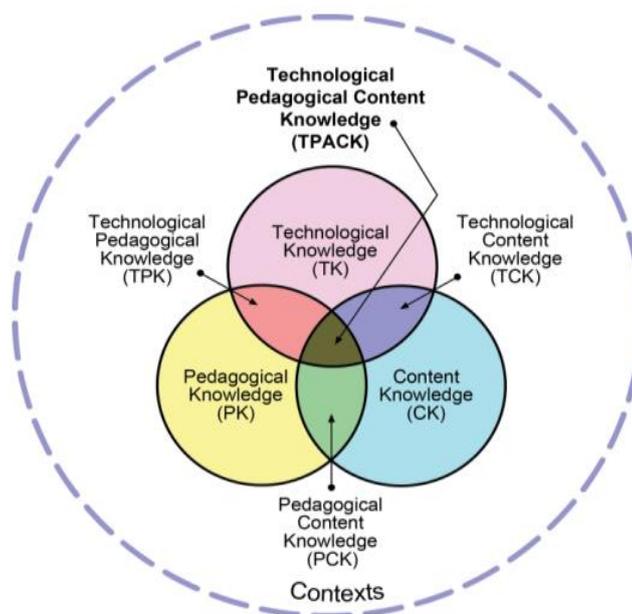


Figure 3. The structure of TPACK from Shulman (Koehler & Mishra, 2009: 63)

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### Pedagogical Knowledge (PK)

PK is the science of pedagogy, including knowledge on curriculum, student's development, learning theories, instructional theories, teaching materials, media, evaluation, and motivation techniques (Jang and Chen; 2010; Finger, Jamieson-Proctor, and Albion, 2010). Koehler & Mishra, (2009) stated "Teachers should have deep knowledge about the processes and practices or methods of teaching and learning. This generic form of knowledge applies to understanding how students learn, general classroom management skills, lesson planning, and student assessment." Can, Erokten, & Bahtiyar (2017) said "Pedagogical knowledge (PK) is the knowledge about teaching and learning process and its application such as students' learning process, classroom management, developing lesson plan, applying and evaluating."

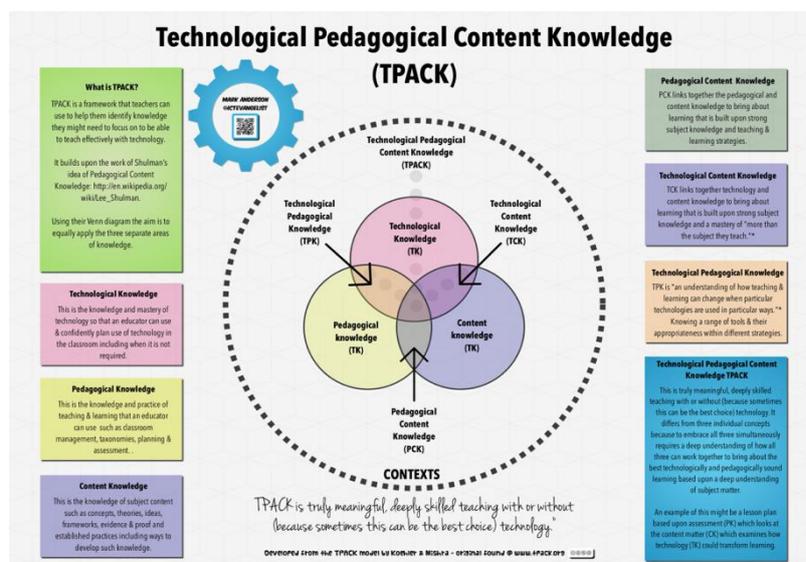


Figure 5. TPACK and its interactions among the elements (Koehler & Mishra, 2009:p. 65)

### Technological Knowledge

Technological Knowledge (TK) is knowledge about technology related to teaching a subject (Mishra and Koehler 2006; Finger, Jamieson-Proctor, and Albion 2010; Shin et al. 2009). Koehler & Mishra (2009) explained "TK is knowledge about certain ways of thinking about, and working with technology, tools and resources, including information and communication technology". Therefore, in biology, TK is technology used in the laboratory to do research or teaching biology and technology related to ICT used in biological classes.

### Content Knowledge

The concept of Knowledge (CK) comprises the science of a subject (Shulman, 1986; Vela & Medrano, 2015; Koehler & Mishra 2009; Yeh et al., 2017). For biology teachers, CK is knowledge about biology and its application. Koehler & Mishra (2009) explain more detail the element of TPACK and the interactions among those elements (Figure 5). In this figure they explain more detail on its element of the TPACK.

PCK is called subject specific knowledge, that is the science of teaching a specific subject matter (Jang & Chen, 2010; Archambault & Oh-young, 2009). For biology teacher, PCK is the pedagogical knowledge to teach a specific concept on biology. In order to be able to teach the concept of cell biology to high school students, for example, the teacher must understand the concept of cell, prokaryotic and eukaryotic cell, cell organelles, and biological process in the cell (CK), the teacher must also understand learning and instructional theories relevant to teaching cell (PK), the psychological development of the students who learn the cell (PK), and

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the technology relevant to teaching the concept (TK). Next, the teacher must be able to motivate students to learn, and evaluate the students' achievement.

Prior research results indicated that the better the teacher in TPACK, the higher students' performance is (Timostsuk 2015; Gurses et al., 2015; Hattie, 2009). Gurses (2015) measured TPACK of elementary school teachers specifically in designing lesson plans and teaching. He found that the ability of designing lesson plans and teaching has significant impact on the students' achievement. Carel and Hamed (2017) relate the TPACK mastery with students' achievement. They found that the TPACK score of teachers, specifically TK, has a significant effect on students' achievement in English class.

### **Measuring TPACK**

Measuring TPACK has been done by several researchers (Graham et al. 2009; Abbitt, 2011; Burgoyne, Graham, and Sudweeks, 2010), by using some ways, such as tests, questioners, and observation (Burgoyne, Graham, and Sudweeks, 2010). Kratz & Schaal (2015) measured PCK elementary pre-service teachers in the United States. They develop instruments that are valid to measure TPACK. Kiray, S.A. (2016) developed instruments to measure primary teacher efficacy on TPACK. He used Confirmatory Factor Analysis to find fit factors of TPACK.

### **Method**

#### **Design**

This research was a survey, using a quantitative method. The data concerning the profil of PK, CK, and TK of S-1, PPG, S-2 biology education students were obtained by using tests. The tests were validated by expert judgment and field tests. The research was done in Yogyakarta State University. The S-1 students were in semester six from a 4-year program. The PPG students were teachers who were enrolled in a 2-semester of teacher professional development program. The S-2 students were second semester of the master program of biology education.

#### **Population dan Sample**

The population of this study was 2 classes (70 S-1 students), 27 PPG students, and 47 S-2 students. The sample was taken using cluster random sampling and the availability of the respondents, comprises 75 people, including 25 a-4 year undergraduate students (S-1); 25 PPG students (5-year teacher education program), and 25 S-2 students (6-7 years master program) in biology education.

#### **Data gathering & Instrument**

Data on PK, CK, TK was obtained by using objective test. First, the team developed the PK test by the biology expert. The test was focus on physiological processes on human beings, the main focus of high school biology materials. The test was constructed based on elements of TPACK identified by Seyit Kirey Ahmed's (1916) previous research. It was included 50 elements of TPACK. The instrument was developed and then reviewed by an expert of biology education evaluation. The test was then validated by using a field test. There were 40 valid items based on the field test. The test then applied to the respondent to get data of TK, PK, and CK.

#### **Data analyses technique**

Data on PK, CK, and TK first were analyzed by using descriptive statistic of total, mean, maximum and minimum score, and standard of deviation. The difference of PK, CK, and TK among levels (s-1, PPG, and S-2) was analyzed using analysis of variance after tested using homogeneity and normality test.

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**Results and Discussion**

**Results**

**PK, CK, and TK Profile**

	CK	PK	TK
S-1	69.07	70.57	70.57
PPG	69.67	71.40	71.40
S-2	72.40	72.44	72.44

**PK profile**

The profile of PK of the students of S-1, PPG, and S-2 was presented in the following Figure 7.

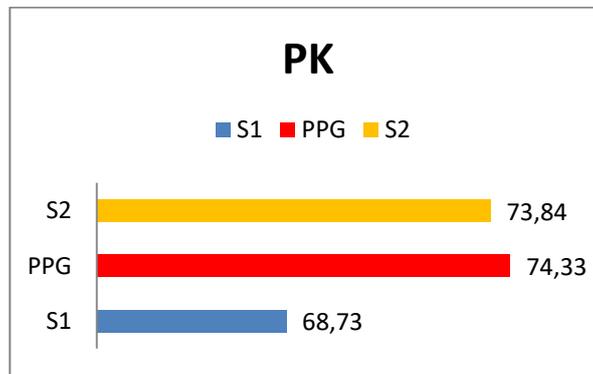


Figure 7. PK profile of S-1, PPG, and S-2 student

Figure 7 above indicated that the best PK was PPG students. The result was logical, since the participants of PPG involved in this research were teachers that have at least five years' experience teaching in schools.

**TK Profile**

The data of TK profile of S-1, PPG, and S-2 students were presented in Figure 8 bellow. S-2 students ranked the highest. There was no difference of TK score between S-1 and PPG students. Teachers did not really aware of the website URL, they mostly just asked students to get information on internet, but they did not tell the appropriate websites.

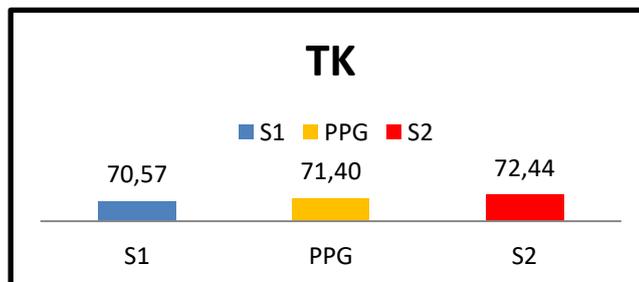


Figure 8. TK Profile of S-1, PPG, and S-2 students

**CK Profile**

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The CK profile of S-1, PPG, and S-2 students was presented in Figure 9. S-2 students score highest on CK profile. However, there was no difference of TK between S-1 and PPG students. Copriady, et all (2018) have done a research on the effect of teaching practice on the mastery of the content in chemistry for pre-service teachers. He found that teaching practice significantly improved the mastery of chemistry content (CK). However, the effect of teaching on in-service teachers' CK was questionable. If the teachers did not updating their knowledge in lifelong learning mode, their knowledge would be expired.

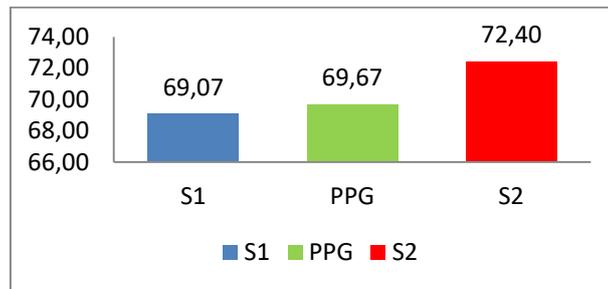


Figure 9. CK profile of biology in-service teachers

**General profile**

Generally, the PK, TK, and CK profile of S-1, PPG, and S-2 students were in moderate category. In addition, the PK profile was theoretically better than the CK and TK. The profile depicted the knowledge or the understanding on PK, TK, and CK, not the application in teaching. .

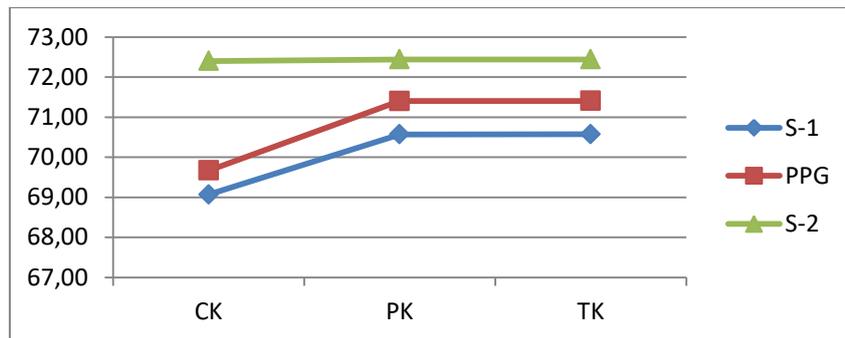


Figure 10. General profile of TK, PK, and CK among S-1, PPG, and S- students

**Inferential Test**

Analysis of variance was used to measure the difference among S-1, PPG, and S-2 on TPACK profile. The results presented in the following tables (Table 1).

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**Table 1.** Descriptive statistic analysis and Anova

**Descriptives**

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
S-1	25	62.1336	7.63003	1.52601	58.9841	65.2831	46.67	73.33
PPG	25	66.3996	7.32296	1.46459	63.3768	69.4224	53.33	80.00
S-2	25	73.3316	3.84804	.76961	71.7432	74.9200	66.67	80.00
Total	75	67.2883	7.91566	.91402	65.4670	69.1095	46.67	80.00

**ANOVA**

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1597.055	2	798.527	18.915	.000
Within Groups	3039.611	72	42.217		
Total	4636.666	74			

**Discussion**

**Profile PK, TK, and CK**

The profile of PK was highest than TK and CK. This meant that UNY for being a university of education played important roles in educating the students with pedagogical knowledge (PK). This evidence was reasonable since UNY had been known previously as a teacher education institute with the main business was to educate teachers. PPG students scored highest on PK meant that being a teacher in school and schooling experience gave significant contribution to the PK score. Nikolaros, J. (Nikolaros, 2014) studied the effect of the length of teaching experience to the effectiveness of instruction strategy. He divided the length of teaching 1-10 years, 10-20 years, and 20-30 years. He found the longer the teaching experience, the better the teaching strategy. In this research the teaching experience of the teacher spun 1-10 years and it had an effect on their PK profile. Using anova test, there was no difference between S-2 students and PPG students on their profile of PK although the PK profile of S-2 students is lower than PPG students. Therefore, it would better if S-2 students were provided with teaching experience in schools.

The results of PK and CK in in a medium category. This results were almost the same with the results of Teacher Performance Test (UKG) done by The DGSE (Arieq, 2017) where the

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average result was 55.0 the highest score was Yogyakarta teachers who was 62.8, followed by Jawa Tengah (59,10), DKI Jakarta (58,44), Jawa Timur (56,73), Bali (56,13), Bangka Belitung (55,13), dan Jawa Barat (55,06).

The profile of PK, CK, and TK was also affected by the geography of participants. S-1 students of biology UNY came from 10 best students in his or her school. They were very good students. The enrollment competition was 1: 48; from 1.120 candidates only 23 students were accepted through the national enrollment system (SBMPTN, 2017). The enrollment competition was even higher through campus selection system. PPG students were graduated from many universities, either public or private. Therefore, the CK between S-1 and PPG students had no significant difference (UNY, 2017).

### **The difference profile of PK, TK, and CK**

The Anova showed that there were differences on the TPACK profiles, among S-1, PPG, and S-2 program. S-2 program scored highest, followed by PPG, and S-1. However, for PK profile, PPG students scored highest, it meant that teaching experience in school as a teacher for more than 5 years developed their PK. The S-2 students mostly came from fresh graduates who had no teaching experience. In this case, for being teachers in schools has a good contribution in developing PK, including understanding of curriculum, characteristic of students, teaching methods, teaching media, and evaluation (Finger et al., 2015; Nikolaros, 2014; Mutvei and Mattsson, 2015).

The profile of TK and CK, the highest score was S-2 biology education. Theoretical bases of S-2 program were good in improving the TK and CK. In S-2 program, there was a course of Media and Learning materials where students develop media and learning materials using computer and internet. In addition there some courses with higher level difficulty of biology such as cellular and molecular biology. Those courses were likely increased the TK and CK of the S-2 students. This results were resemble with the results of the Teacher Performance Test, that teachers holding S-2 certificate scored higher than PPG and S-1 (Arieq, 2017; Bambang Yudi Cahyono, 2016).

Overall, the results indicate that the profile of TPACK of S-1, PPG, and S-2 students were in moderate category. It meant that the profile of PK, CK, and TK of the students needed improvement. The improvement should be made at least reached the mastery learning score: 75. Some students had already scored higher than 75, but some others scored below it. To improve the CK students should be involved in using the technology related to laboratory works and field works. In the laboratory students used many kinds of devices and tools such as PCR, SEM, digital pH meter, and other measurement devices. They also should learn more on the use of ICT in teaching and learning purposes (Margaret, 2001; Anwar, Rustaman, & Widodo, 2016).

In order to get higher score in PK, students should go to school to have experience in teaching and interacting with students. School experience is very important to decontextualize teaching and learning theories.

### **Acknowledgments**

The authors express gratitude and thanks to those respondents of this research, including S-1, PPG, and S-2 students of UNY who have been willing to participate in this research.

### **Conclusion and Suggestion**

#### **Conclusion**

Based on the data and discussion, conclusions can be made concerning the profile of PK, CK, and TK of S-1, PPG, and S-2 students in this research were as follow.

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1. The profile of PK, CK, and TK was in moderate category, with the scores in a row was 72.44, 70.57, 71.40 in a 100-scale.
2. There was a significant differences the score of PK between PPG and S-1 and S-2 students, where PPG scored highest ( $p < 0.05$ ). There was a different score of CK between S-1, PPG, and S-2 students, where the S-2 students scored highest. There was no difference on CK between S-1 and PPG students. Therefore PPG must accommodate content mastery rather than workshop on teaching materials only to increase the CK profile. In addition, was suggested that S-2 students would better if they are provided with school experience to increase their PK profile.

### **Suggestion**

1. The Profile of TK, PK, and CK in a medium category, therefore it should be improved to reach mastery learning criteria of 75 by giving more hands on activities in schools, in the biology laboratory, and in using ICT.

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