Differentiation between TPACK level in junior and senior pre-service teacher to design science lesson

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Abstract. Technological development provides enormous opportunities for efficient and active learning. Advance in technology-based learning should be inline with the ability of teachers to teach science using technology. Preservice teachers should be equipped with an appropriate college curriculum. TPACK can be used to see the abilities of prospective science teachers. This study was examining different TPACK levels at junior and senior-level. This study involved a sample of students majoring in a bachelor's degree in science teacher program. The results of the questionnaire showed that junior-level students have higher TPACK than senior-level. Based on the results of a lesson plan analysis, junior-level students tend to use technology in the classroom. Students at the senior-level have been experienced in classroom teaching. However, classroom management and time management skills of maybe affects the TPACK level in junior and senior-level students.

1. Introduction
Technology in education is developing, along with the development of technology and communication. To deal with the industrial revolution 4.0, it requires the role of technology in carrying out various activities in daily life. Information and communication technology abbreviated as ICT is a terminology that includes all technical equipment for processing and delivering information. In the digital era, the use of technology can certainly provide significant opportunities in improving teaching and learning. Computer and instructional technologies give huge benefits to teachers. Integrating technology in the classroom could make their students more interested in the subject. Within the literature, experienced teachers in educational computer use maintain higher expectations for student learning. Additionally, using computers and other technology in education could help the student to increase their performance [1].

Science explains natural phenomena, which include facts, concepts, principles, and laws through scientific methods. Difficulties experienced by some science teachers in teaching can lead to the inability of students to understand science concepts. Upper Primary Science teachers lack in conceptual understanding of the subject Science. This lack leads them to many difficulties while teaching science concepts. Science teachers also faced difficulties in teaching some science concepts at the upper primary level of education [2]. Technology can make it easier for science teachers to teach science, such as displaying videos, pictures, or using simulation learning. Science also could be taught with interactive classrooms such as cloud classroom [3]. The learning process can also be done from blended learning to increase interaction [4] or fully online learning using e-learning, Moodle, and Edmodo. It only requires
adequate facilities and infrastructure. Students can learn and get more information, not only from the teacher. Using technology wisely can broaden student’s knowledge, from gifted student to the student who needs a different medium to learn [5].

Before TPACK was introduced, there are several terminology that had been introduced, such as PCK [6]. Technology is infused in PCK, and several kinds of researches about it had been known as information and communication-related-PCK [7] and technologically-enhanced-PCK [8]. This framework elaborated later by [9] as Technology, Pedagogy, and Content Knowledge or abbreviated by TPACK. TPACK is used for preservice teachers to plan how integrating technology into their lessons. TPACK component as written here.

![Figure 1. TPACK components [10].](image)

The teacher believes that technology could be applied to all educational levels [11]. Teacher also believes that they have to learn educational strategies to teach with technology [11]. The majority of the teacher workforce currently has not mastered much in the field of technology. More research is needed to examine the teacher preparation programs in teacher belief [12]. Preparations that can be made by teachers or prospective teachers to be able to master the technology in achieving successful implementation of the science curriculum by developing teacher professionalism in obtaining knowledge, pedagogic, and technological content. Teacher knowledge has a significant impact on their decision in teaching. A development program for in-service teachers has a positive impact on teachers [13] and also for preservice [14]. To helps teachers change their practice, the curriculum has to help teacher to expand and explain their knowledge systems, such as subject knowledge (content knowledge, CK), knowledge of teaching methods and strategy and also classroom management (pedagogical knowledge, PK), and knowledge of how to teach specific content to specific learners in specific contexts (pedagogical content knowledge, PCK) [15]. It also has to be done in the curriculum for the teacher preparation program.

This study focused on how a curriculum in science teacher preparation program affects their TPACK level. The TPACK level could be measured with a questionnaire adapted from [16]. The questionnaire contains nine categories; there are technology, way of thinking, way to develop understanding, sufficient knowledge, pedagogical knowledge, content knowledge, technological knowledge, TPACK, and learning experience.

1.1 Task

Students have to make a lesson plan for the science lesson. The science content can be divided into chemistry, biology, and physics. The lesson plan consists of objectives, teaching methods, and steps.
1.1.1 Chemistry content
One of the chemistry content that has to be discussed is acid and base. They have to know the definition of acid-base based on the Arrhenius Theory. Acid is a substance that produces $H^+$ when dissolved in water. The base is a substance that produces $OH^-$ when dissolved in water. The dissociation of acid is written below.

$$HX \ (acid) \rightarrow H^+ \ + \ X^- $$  \hspace{1cm} (a)

In example, $HCl \rightarrow H^+ \ + \ Cl^-$  \hspace{1cm} (b)

The dissociation of the base is written below.

$$YOH \ (base) \rightarrow Y^+ \ + \ OH^- $$  \hspace{1cm} (c)

In example, $MgOH_2 \rightarrow Mg^{2+} \ + \ 2OH^- $  \hspace{1cm} (d)

Based on Arrhenius Theory, acid and base undergo neutralization reaction produces water and salt.

$$HX \ + \ YOH \rightarrow H_2O \ + \ XY \ (salt) $$  \hspace{1cm} (e)

Gastric acid or stomach acid is a fluid formed in the stomach that consists of hydrochloric acid (HCl), potassium chloride (KCl), and sodium chloride (NaCl). High gastric acid can cause stomachache. It can be neutralized using medicine contains the base.

1.1.2 Biology content
The human circulatory system and human excretory system are learning content that has to be taught by the teacher. The human circulatory system consists of the heart, lungs, and arteries, veins, coronary, and portal vessels. The system is responsible for the flow of blood, nutrients, oxygen, and other gases, and as well as hormones to and from cells. The average adult has 4.7 to 5.6 liters of blood, consists of 60 % of plasma, and 40% for red blood cells, white blood cells, and platelets [17]. The systemic circulation is a network of veins, arteries, and blood vessels transport oxygenated blood from the heart, delivers oxygen and nutrients to and from the body's cells, and then returns deoxygenated blood back to the heart.

The human excretory system is a process to discharge wastes in the human body. Parts in the human body that are involved in this process are sweat glands, the liver, the lungs, and the kidney system. Human has two kidneys. Each kidney has a renal cortex, renal medulla, and renal pelvis. The blood enters kidney via the renal artery, which splits into many afferent arterioles. These arterioles go to the Bowman's Capsules of nephrons. The wastes are taken out of the blood by pressure filtration. The renal cortex is the outer layer of the kidney, and the medulla is the inner layer of the kidney. The renal pelvis takes urine away from the kidney via the ureter. Both of the ureters lead the urine into the body's only urinary bladder, which expands and sends nerve impulses when full. From there, urine is expelled through the urethra and out of the body.

1.1.3 Physics content
Heat and energy are content that has to teach. One of the topics is the law of conservation of energy. The law states that the total energy of an isolated system remains constant. It means that energy can neither be created nor destroyed; instead, it can only be transformed or transferred from one form to another. For instance, when a bomb explodes, chemical energy is converted to kinetic energy. It is also happening in fireworks. If one adds up all forms of energy that were released in the explosion, such as the kinetic energy and potential energy of the pieces, as well as heat and sound, one will get the exact decrease of chemical energy in the combustion of the dynamite.
2. Methodology
This mixed-method study is use questionnaire is used to examine TPACK in preservice teachers, both junior and senior-level. Twenty-four students in junior-level and twenty-four students in the senior-level science teacher preparation program are willing to get surveyed. They also asked to design a TPACK based science lesson for secondary school. Junior-level have never been taught at school. Senior-level have taught at school for their teaching practice course. This questionnaire consists of nine categories (technological skill, way of thinking, way to develop understanding, sufficient knowledge, pedagogical knowledge, content knowledge, technological knowledge, and learning experience). The data are valid and reliable after analyzed quantitatively. Then their lesson plan also analyzed by content analysis to understand if it is in line with data from the questionnaire. The methods are graphed below.

![Figure 2. Research methods to examine the TPACK level in junior and senior preservice teachers.](image)

3. Result
TPACK questionnaire level from junior and senior-level as resulted below.

![Figure 1. TPACK Questionnaire Result](image)
The average of TPACK in junior-level is 4.6. It is higher than the senior-level at 3.6. Every aspect of the junior-level is higher than the senior-level. Junior-level is in the range between 4.4 – 4.6. Senior-level is in range between 3.4-3.6. The lowest aspect of junior-level is sufficient knowledge (4.6). Meanwhile, the lowest aspect of senior-level is technology and TK (3.4). Six aspects at junior-level have the highest value (4.6), such as technology, way of thinking, way to develop understanding, content knowledge, TPACK, and learning experience. Lesson plan from junior-level as described below. In senior-level, only five aspects have the highest value 3,6), such as the way of thinking, way to develop understanding, pedagogical knowledge, content knowledge, and TPACK.

4. Discussion

4.1 Lesson plan from junior-level

4.1.1 Chemistry
They demonstrate a Sparkol animation about acid and base in the human digestion system. This simulation video is about consuming medicine to neutralize excess gastric acid. Pedagogical knowledge is about they gave a chance for students to make groups and discussed about Sparkol animation about acid and base. Content about acid and base, which described, is about gastric acid composition and neutralization.

   Content knowledge in this lesson plan is level in content that has to be taught about acid-base and neutralization of gastric acid. Gastric acid contains mostly of hydrochloric acid (HCl). In some conditions, this acid could be higher than the normal range. It is causing ulcers or stomachache. Medicines are taken to neutralize high stomach acid. The medicine contains bases, such as magnesium hydroxide, MgOH₂ and aluminium hydroxide, Al(OH)₃. Pedagogical knowledge is how teachers using demonstration methods and then make student discussion groups. Technology knowledge is how teachers use Sparkol animation videos in a demonstration.

4.1.2 Biology
They design a lesson plan about the human circulatory system. They use video as a learning media for students. Their technological knowledge is seen in what media they used. Pedagogical knowledge is how they give a chance for student to do roleplay about the human circulatory system. Content about the human circulatory system is about how blood transports in the human body.

   Content knowledge is what the teacher taught about blood transportation, function of heart and lung, and arteries, veins, coronary and portal vessels (systemic). Pedagogical knowledge is how teachers design a lesson using demonstration and then instruct student to do roleplay about the human circulatory system. Technological knowledge is when teachers using video as learning media.

4.1.3 Physics
They design lesson plan about heat and energy. They combine powerpoint presentations and Phet simulation. They use Discovery Learning as a learning model. Content about heat and energy, which described, is about the law of conservation energy. Content knowledge is about the law of conservation energy, temperature change, and heat change related to energy. Pedagogical knowledge is how teachers using learning media to explain and doing simulation. The teacher also uses discovery learning to teach this content. Technology knowledge is the teacher choose powerpoint presentation and Phet simulation.

4.2. Lesson plan from senior-level

4.2.1 Chemistry
They design a lesson plan about acid and base. Student learns from practice. The teacher explains it directly, not from digital media. Content knowledge is the same as a lesson plan in the junior-level. Pedagogical knowledge is how teachers choose to practice as a method to teach acid-base neutralization.
In this practice, the student can react hydrochloric acid as a substituent of gastric acid and magnesium hydroxide as a substituent of medicine. Technology knowledge is not seen here because the teacher does not use any digital learning media.

4.2.2 Biology

They design a lesson plan about the human excretory system. They use powerpoint presentations only as learning media. They also use cooperative learning as a learning strategy. Content about the human excretory system, which described is about the human excretory system, especially in kidneys. Content knowledge is about how waste is discharged from blood and excreted in the urine. Pedagogical knowledge is how teachers use cooperative learning as a learning strategy. Technology knowledge is using powerpoint presentations as learning media.

4.2.3 Physics

They design a lesson plan about the wave. They use powerpoint presentations as learning media. After that, students make groups and practice. They practice using a pendulum to learn. It is also an example of cooperative learning as a learning strategy. Content about wave, which described, is about frequency, wave period, and wavelength by practice with pendulum. Content knowledge is about frequency, wave period, and wavelength. Pedagogical knowledge is how teachers use learning media and choose a practice to learn. Pendulum is used to measure frequency, wave periods, and wavelength. Technological knowledge is when teachers using powerpoint presentations as learning media.

4.3 Differentiation in lesson plan and relation with questionnaire

TPACK's self-rated score in this questionnaire is related to learning [18]. In this case is how they design their lesson plan. They have different perceptions on how to teach content and make students learn. Every aspect of TPACK, such as technology knowledge, content knowledge, and pedagogical knowledge, are explained below.

Senior-level has a lower level of technology knowledge. It is in line with the lesson plan in chemistry. Senior-level’s lesson plan does not use technological learning media. Junior-level use Sparkol animation in the course. In biology, senior-level use powerpoint presentations. Meanwhile, junior-level use video. It is a different kind of technology they used. In physics, senior-level use powerpoint presentations. Meanwhile, junior-level use powerpoint presentations and Phet simulation. Powerpoint often used in teaching because it gives long-term learning retention for students [19].

Content knowledge at the junior-level has a higher value than the senior-level. In the same course field, they have different content to teach and design a lesson plan. In biology, a junior-level design lesson plan for the human circulatory system, similar to senior-level that design for the human excretory system. There are two processes in the human body. If they have the same content, as have to be seen in chemistry, they have different objectives. In physics, heat and energy are taught by the senior-level. Meanwhile, a junior-level design lesson plan to teach about the wave.

Pedagogical knowledge at junior-level has a higher value than the senior-level. Senior-level use practice in physics and chemistry field. Demonstration using media is only happening in physics and biology lesson plan. Lesson plan designed by junior-level, student also doing simulation in biology. Pedagogical knowledge relates to how teachers describe goals of learning and also getting and maintaining student focus [20], and simulation is a way to engaging students [21].

Factors that affect the lesson plan are organizing the classrooms and the teaching materials and time management predict the variable of the teacher’s practical planning skills [22]. Students in junior-level may not have experience in teaching or organizing classrooms. They design a lesson plan based on what they have experience in learning. It is inline with aspects of the learning experience. Junior-level has a higher value than the senior-level. It is related to time management skills. Both junior and senior-level have to predict how much time student needs to learn content and reach objectives. A useful lesson plan will differ in every class they taught.
5. Conclusion
This study shows that the junior-level has a higher level of TPACK score than the senior-level. It is also proven by analysis in their lesson plan. Junior-level tend to use technology for learning media to teach content. The findings cannot be generalized because of the limited number of students in this study. Further research should specify kinds of aspects that affect in TPACK and the lesson plan. It is crucial to explore how each student design their lesson plan based on their TPACK. All these are essential to explore and understand, but it is well beyond the scope of this study.

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