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Innovative Education Program for Science Preservice Teachers: Technological, Pedagogical, and Science Knowledge - Contextual (TPACK - C) Approach

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Improving teacher quality is crucial in education and remains a challenge in Indonesia. These challenges require teachers to master concepts, technologies, and pedagogics, including the Nature of Science (NoS) for science preservice teachers. While the facts show that an understanding of the NoS is a given in certain subjects, these subjects do not emphasise mastery of the content and its method of teaching. Most students still have difficulty connecting natural phenomena and science, and face challenges in determining the appropriate form of learning technology to represent the object of science being studied. The understanding of NoS of prospective natural science teacher students is still wrong. Thus, it is important to design an educational program for the professional development of teachers. The question is why is the design of the educational program for the professional development of teachers with TPASK-C important? What are the characteristics of the educational program for the professional development of teachers with TPASK-C based on the views of experts and the lecturers?

Key words: *Nature of Science, education program, TPASK-C approach*

Introduction

The key to success in improving education quality lies in the preparation and placement of professional teachers, who have the capacity and responsibility to plan for future education

Haseena & Mohammed (2015); Roofe & Cook (2017). The teacher is a dominant factor in influencing student achievement as demonstrated by a study with 60000 students (Marzano et al, (2003). These statements emphasise that teachers have a strategic and vital role in determining educational success.

The National Science Teacher Association (NSTA, 2003) sets ten standards for the preparation of science teachers, including content standards, Nature of Science (NoS), inquiry, science issues, general skills of teaching, curriculum of science, science in the community, assessment, safety and welfare, and professional growth (professional development). The NSTA (National Science Teacher Association) updated the standards for the preparation of natural science teachers, which were released in NSTA (NSTA, 2012) to six standards that reflect the competence of natural science teachers, especially prospective science teachers.

Teachers now and in the future are also required to prepare themselves to face generation Z by using technology to educate and prepare high-quality learning that is integrated into the preparation of learning practices in the classroom (Srisawasdi, 2012). Technology mastery becomes vital in creating unlimited access to the global community and creating new methods for self-development and problem solving in learning (Arnentis, 2017). Teachers are also required to focus on learning activities that provide skills and knowledge to students so that students can contribute to the global community (Mupa & Chinooneka, 2015). Therefore, learning by using technology becomes a necessity for teachers to teach Generation Z, who are already familiar with the technology. Thus, teachers must have the ability to integrate technology in learning. This is because education, teacher training, and the teacher training process, the most important component of education, cannot be considered without considering social developments and changes (Tukkahraman, 2015).

Improving teacher quality is crucial in education and is still a challenge in Indonesia. For example, teachers taking the Teacher Competency Test or UKG in science subjects in 357 schools in the Province of DI Yogyakarta received an average UKG score of 62.16 (Centre for Education and Culture Data and Statistics, Kemdikbud, 2016). The UKG results reflect the current low quality of Indonesian teachers.

These challenges require teachers to master concepts, technologies, pedagogics or what is called Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006). TPACK encourages 21st-century teacher competence and becomes an essential knowledge base for high-quality science teachers (Triyono, 2017).

As revealed by Widowati et al, (2015) most students of Yogyakarta City Junior High School have an understanding that NoS is still lacking in regard to the process and product aspect, while being good in terms of attitude. These facts confirm that understanding NoS is an issue in international education. The implication of this research is that the development of NoS understanding is important for teacher candidates.

LPTK has a big challenge to describe the figure of graduates of the Strata 1 (S1) professional teacher candidates. This challenge includes having to compile a curriculum that is able to guarantee the achievement of the 6th qualification of KKNI qualification graduates. However, the quality of LPTK is a separate issue in Indonesia. The Centre for Education and Culture Data and Statistics, Kemdikbud (2016), documents that 422 LPTKs in Indonesia are still experiencing a quality disparity. There are around 1,600 study programs from approximately 3,300 LPTK study programs that have been accredited, which has produced an over-supply of graduates in education. Most LPTKs do not yet have a good partnership system with schools without laboratories. Also, there is the challenge of industrial revolution 4.0, which changes expertise into something that combines multiple technologies for automation and digitalisation systems in various fields (Triyono, 2017)..

Based on the standards for the preparation of natural science teachers in NSTA, TPACK's ability must be mastered so that prospective teachers can become quality science teachers. Also, science teachers should have the ability to effectively present NoS teaching. Teachers must also have an understanding of NoS themselves and knowledge of pedagogical content regarding NoS teaching (Mokshein, et al, 2015). However, the facts show that the majority of prospective teachers lack adequate pedagogical skills, despite being familiar with the technology. This is because prospective teachers do not have sufficient opportunities to apply technological knowledge associated with pedagogy (Liu et al, 2015); (Lee & Lee, 2014). As a result, such lectures also failed to help teachers to integrate technology into the classroom. (Goktas et al, 2008).

Based on the various reviews above, it is important to design an educational program for the professional development of teachers, especially prospective science teachers. It is vital to use an approach in the development of science teacher preparation that integrates science, teaching, and learning with technology (which hereafter will be referred to as TPACK) and NoS subject matter. Additionally, the context must also be linked with content (contextual learning) in line with TPASK-C. This is so that the prospective Natural Sciences teacher can meet the demands of future teachers and can learn Natural Sciences as the nature of Natural Sciences. In relation to this, the question is why is the design of the educational program for the professional development of teachers with TPASK-C important? What are the characteristics of the educational program for the professional development of teachers with TPASK-C based on the views of experts and the lecturers?

Research Method

This research type is R and D (Research and Development) as indicated by the model Four-D and Borg and Gall. Procedure development of prototype consists of four main phases (phase define, design, develop, and disseminate) and an additional phase (preliminary testing fields, main product revision, playing field testing, and operational product revision) which are taken from the Borg and Gall procedure. In this paper, the define and the design are loaded.

The type of data in this study is qualitative. The research instruments used were: (1) Observation and questionnaire sheets to collect data about need assessment and to explore information about the lecture program in science education at a Bachelor level that has taken place so far; (2) NoS C+ questionnaire (Buarapan, 2013) to gain an understanding of the NoS for a preservice science teacher; (3) Sheet interviews for the experts and the lecturers for developing an innovative education program in science education at a Bachelor level. This research data was analysed descriptively.

The Result and Discussion

The results of the preliminary study show that:

a. The implementation of lectures in courses that facilitate content and learning has been programmed quite well. However, based on observations during the Natural Sciences 2 lecture, there were significant differences in the lecture's orientation. One class emphasised mastery of content and teaching methods, while another class stressed mastery of content and said little regading how to teach the content, let alone how to determine the appropriate learning technology. Natural science 1, natural science 2, natural science 3 or the basic teaching ability to teach NoS is still implicit.
b. The results of the student need assessment questionnaire show that understanding of the NoS is a given in certain subjects (subjects that have competence rather than emphasising mastery of content and how to teach science).
c. The results of the student need questionnaire indicate that the lecture systems of Science 1, Science 2, Science 3, and Basic Teaching Ability (KDM) have been carried out by grouping 5-6 students into one group. Monitoring the progress of group assignments is less than optimal.
d. The results of observations of lecture teaching show that most students still have difficulty connecting natural phenomena and science content as well as difficulties in determining the appropriate form of learning technology to represent the object of science being studied.
e. The results of the survey on the understanding of NoS of prospective natural science teachers show that the understanding of NoS of prospective natural science teacher

students is still wrong, for example, that science is not socially and culturally affected, that scientific theories do not change, and that designing investigations does not involve imaginative and creative thinking.

Based on standards regarding the preparation of science teachers in NSTA, in addition to the ability of TPACK, it was stated that the primary role of teachers in science education reform focuses on the conception of the NoS and classroom practice (Lederman, 2007). Cobern & Loving argue that NoS is an important subject even though it is difficult to teach meaningfully and effectively to prospective teachers. Mercado et al (2015) state that the prospective teacher lecture method (preservice teacher) must develop an understanding of NoS. It is given that if natural science teachers can effectively present NoS teaching, teachers must have an understanding of NoS themselves, as well as knowledge of pedagogical content about NoS teaching. Buarapan (2013) also states that to help students have an adequate understanding of NoS, the science teacher must first have an adequate understanding of NoS. Teachers' understanding of NoS will be more adequate if it has been prepared since they are still prospective teachers.

Teacher education programs in Indonesia have not been designed based on a specific framework for professional development. This is not synchronous with the National Research Council (1996), which stated that in learning how to teach science teachers need a component of analysis about Pedagogical Content Knowledge (PCK), which is referred to as science, learning, and teaching. Some tertiary educational institutions implicitly use Shulman's PCK. Of course, this is inadequate in building the professional abilities of future teachers to use technology integration to improve learning and teaching in the 21st century. Therefore, there needs to be a shift about to the more contemporary conceptualisation of the Technological Pedagogical Content Knowledge (TPCK), or what is now known as TPACK.

Smetana & Bell (2012) suggested that TPACK offers a framework for understanding how teachers' flexible knowledge of content, pedagogy, and technology interacts and enables them to apply effective instructional practices during technology integration in teaching. TPACK as an approach involves technology integration in learning: teachers teach with technology, and use technology to design the education curricula, as well as in the classroom. Of course, this is following the standard process for teacher education also stated in Permenristekdikti (Minister of Research, Technology, and Higher Education Regulation) number 55 of 2017 article 9, section 3, paragraph 4, which states that learning in teacher education should apply the principles of (a) Lecturers as models, wherein teachers act as role models for prospective teacher students, and (b) Authentic experience, which encourages direct learning as early as possible in real situations.

The TPACK approach for teachers and science candidates needs to be combined with NoS and contextual matters so that the TPACK ability obtained by teachers and prospective science teachers is specific for teaching science as it is. The combination approach between the TPACK, NoS, and contextual approaches, hereafter referred to as the Technological Pedagogical And Science Knowledge-Contextual approach, or as TPASK-C. The TPASK-C approach is unique because it has a specific subject matter in the form of science and is oriented towards learning science by raising issues and phenomena in the surrounding environment, including that of family, school, and community. Most of the research that has been carried out with the TPACK approach emphasise the elements of technology. The development of the TPACK approach lectures in combination with the NoS and contextual approaches or TPASK-C has never been developed before. The education program is designed by starting from the contextual exploration that is presented in nature (as an object of natural science). The prospective science teacher (undergraduate student in Natural Sciences Education) is able to elevate these things into science based learning that encourage active students and integrate NoS content. The ability to teach in a constructivist and contextual way makes the use of technology more effective. Students are required to build knowledge through their reciprocal with objects, phenomena, experiences, and the environment (Meng & Idris, 2015).

Based on the discussion with the experts and the lecturers, there are some suggestions as shown in Table 1.

Table 1: The Suggestion from The Experts and The Lecturers

Source	**Activities**
Experts 1	The characteristics of the TPASK-C program are detailed enough to realise the figure of the TPASK-C program as intended by the developer based on the theories studied.
Experts 2	If TPASK-C developed today is still an approach, and each stage is clear, the theoretical foundation can be developed as a model.
Experts 3	a. Clear the theoretical foundation that underlies the development of lecture programs and their targets. b. Avoid conflicting theories c. Add a description of the lecture program
Lecturer 1	Clarify the stages of the TPASK-C program and the content of the NoS so that lecturers will understand the TPASK and NoS.
Lecturer 2	Understanding about NoS should be more clear.
Lecturer 3	The mechanism to apply the approach must be systematic.

Next, a product developed in the form of a lecture program approaching TPASK-C, with the development stages as shown in Table 2.

Table 2: Stages of Development of Learning Programs with *Technological Pedagogical and Science Knowledge-Contextual* (TPASK-C) Learning Approach.

Variable	**Theory**	**Description**	**Step**	**Purpose**	***Classroom Management***
TPASK-C approach	Constructivism Theory, Vygotsky's Cognitive Development Theory, Andragogi Theory	The way the child adapts and interprets with the objects and surrounding events through reflection and coordination of what is thought, not from structuring the reality from the outside, by processing information. Learners are considered to have an active ability to plan learning directions, have materials, think of the best way to learn, analyse and conclude and can benefit from learning or from an educational process.	*Orientation* *Design* *Develop* These three steps as a whole load TPASK components and contextual learning.	TPASK capacity building, which includes: SK, PK, TK, TPK, TSK, PSK, TPASK, and self-efficacy	Semester Learning Plan Student Worksheet Teaching Materials Evaluation Instruments
TPASK ability	Maslow's Motivation Theory, Erikson's Psychosocial Theory, Bandura's Theory	Students need for self-actualisation and can determine interest as well.			
NoS					
Self-efficacy					

The development of a lecture program involving TPASK-C connects to the theory of constructivism, which emphasises that knowledge is actively constructed by students (Schunk, 2012). Vygotsky's theory emphasises that learning activities are the result of social interaction between students (Salkind, 2004), and the theory of andragogy which emphasises that students have the readiness to learn (Tolstoy & Miloslavskaya, 2019). The target of the TPASK-C lecture program is in the form of TPASK's ability and self-efficacy, which is based on Erikson's psychosocial theory (Salkind, 2004). This states that pubescent individuals will be able to have an interest in something (in this case work as a science teacher). Bandura's theory emphasises that individuals can learn by mimicry and choose the behaviour that is exemplified (Chaer, 2016). Maslow's motivational theory emphasises that individuals have the highest need in the form of self-actualisation (Saeednia & Nor, 2010). As for the broad outline of the lecture program approach, TPASK-C is as shown in Table 3.

Table 3: Description of TPASK-C Adjacent Lecture Program

Phase	Activities	TPASK-C Approach's Component
1st Phase: Orientation	Introduce students to the lecture program with the TPASK-C approach and its achievement targets	
2nd Phase: Design	Design mapping products as a basis for developing collaborative learning tools, in the form of a map of natural potential, a table of links between the curriculum and natural potential and their learning activities, a mind map or concept map as well as the NoS content map	Contextual, TK, PK, and SK
3rd Phase: Develop	Developing constructivism-based active learning tool products based on the results of the collaborative design phase.	PSK, TSK, TPK, TPASK

Conclusion

In teacher education courses, it is important to use innovative approaches to meet the needs and demands of future teachers. The TPASK-C approach is an innovative approach that should be applied in the lecture program for prospective science teachers. It is designed to start from the exploration of contextuality that is presented in nature (as an object of natural science). The prospective science teacher (undergraduate student of Natural Sciences Education) is then encouraged to develop these things into a science learning scenario that is based on student active learning and is integrated with NoS content.

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