Technological Pedagogical and Content Knowledge (TPACK) design in learning sound wave to foster students’ creativity

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Abstract. One of the purposes of science education is to create a better future generation who is able to face and solve globalization’s problems in order to improve their quality of life. Being creative is one of the efforts to achieve that purpose which creativity is one of 21st century skill that should to develop. As a science teacher is needed to have responsibility provide students with an excellent education in the 21st century. There is framework for teacher and prospective teacher called TPACK. Therefore the aim of this study is to analyze TPACK teacher to foster students’ creativity. This study was conducted in one of junior high schools in Bandung. The subject of this study was 45 students. The learning approach to foster students’ creativity used by teacher was STEM. Students asked to make solution with creating product that will solve the problem given. Creative product made by students measured by using rubric based on Bessemer and O’Quin. The result of the study show for novelty aspect A class gain 81% and B class gain 75%, effective aspect gain 75% for A class and 76% gain 75% and whole aspect both of class gain 87%. The process of fostering students' creativity has been facilitated well it can be seen from the learning process experienced by students, through suitable implementation of strategies and approaches in the classroom.

1. Introduction
One of the purposes of science education is to create a better future generation who is able to face and solve globalization’s problems in order to improve their quality of life. Being creative is one of the efforts to achieve that purpose which creativity is one of 21st century skill that should to develop. As a science teacher is needed to have responsibility provide students with an excellent education in the 21st century. Teachers are expected to act effortlessly, fluidly, to take risks, be adventurous, and develop pedagogy in order to develop their own knowledge and skills [1]. In addition according to [2], teachers play a key role in developing creativity for students and they need to be aware of creativity, (both positive and negative) to educate their students to be happy, well rounded, well-adjusted creators who fit in well with their communities, giving and taking and contributing to others. They must have a wide domain and interdisciplinary knowledge as well as have the skills to teach for creativity. There is framework for teacher and prospective teacher called TPACK, it can be used to improve quality and skills for teaching. TPACK stands for Technological Pedagogical Content Knowledge, and it is
regarded as the new model of teachers’ expertise for the 21st century classroom [3] TPACK as the “interaction between content, pedagogy and technology”. With TPACK, teaching learning activity required the use of technology, an understanding of how to represent concepts using technology. Teachers need to apply pedagogical techniques that use technologies in a constructive way to teach content. This results in an optimal learning situation where the science teacher succeeds in capturing the attention of learners (using technology, for example) and where learners are motivated to concentrate on the learning task [4]. It is important for every teacher to understand the concepts of TPACK, because our world is becoming more and more technologically advanced. Students are used to having technology in their daily lives and the constant stimulation they provide. Therefore, if technologies need to be integrated in today classroom, its importance in STEM education is even more acute. In the TPACK framework, these technologies can be regarded as technological content knowledge (TCK). Integral to both TPACK and STEM education is technology. It is now commonly accepted that teachers need to develop TPACK to integrate technology and it seems likely that STEM education would require teachers to activate and expand their TPACK for STEM lesson design. In addition, TPACK and STEM are both targeted at developing students’ 21st century capacities [5].

Creativity is one of the abilities that must be possessed by students from STEM learning activities [6]. By participating in STEM learning, students will learn how to overcome problems and grow to become an innovator. Creativity and innovation are strategic tools that enable us to overcome various difficulties in preparing for the future [7]. Moreover, to improve the quality of human resources future is needed to fostering students’ creativity in learning activity. Beyond personal demands to be able to think creatively, demands on educational institutions to prepare graduates to be able to develop their creativity are also increasingly prominent. The progress of digital technology and globalization has an impact on how students do work, think and create something [8]. Digital devices and available applications provide new opportunities where students can use their imagination to create and share them in creative ways. In addition, noted that creativity is including as important aspect of innovation and change. There has also been increasing educational research to support the importance of creativity in fields of thinking and learning. Therefore the aim of this study is to analyze TPACK teacher to foster students’ creativity in learning sound wave and measured students’ creativity in learning sound wave.

2. Methods
The research method used in this research is descriptive method. Descriptive method is a research method that aims to describe the situation or a phenomenon as it is, thoroughly and it does not manipulate independent variables [9]. This study was not require a control class because the researcher was not provide treatment, but measures, analyses, and describes the aspects studied in real conditions. Descriptions of this condition are individuals (teachers) and groups (students) in descriptive and numerical forms. The process of preparing learning activity was prepared by teacher without intervention from the researcher. The location of this study was one of Junior High School in Bandung. The samples were 8th grades students from two different classes at the Junior High School in Bandung. The first class (VIII-D) is a sample class in which the class is taught directly by professional teachers (teacher B) in the relevant subject (fully responsible teacher) in the school, while the second class (VIII-E) is a sample class taught by students who are pre-service teacher (teacher A). Content Representative (CoRe) is one of instrument used to access teacher TPACK consisting of several questions. The researcher analysed CoRe’s teacher answer and learning activity to describe TPACK teacher and how teacher fostering students’ creativity. In learning activity that designed by teacher to foster creativity, students asked to make product creative in learning sound wave in group. The creative product made by student measured by rubric based on Bessemer and O’Quin.
3. Result and Discussion
3.1 TPACK Teachers in Designing Learning Activity to Foster Students’ Creativity

Teacher A was teachers who teach in VIII-D while Teacher B was teachers who teach in VIII-E class. In the selection of the concept or idea both of teachers choose two big ideas, which are the definition of the sound wave and characteristic of the sound. The reasons both of teachers choose that idea was because to achieve learning objective, this concept appear on National Examination question, there are so many technology which created by applying sound wave concept, this concept will motivated students to create solution to solve real problem faced by developing technology and this concept will help student to understand their surroundings. Therefore, the teacher's orientations to choose concepts that provide opportunities to develop students' creativity. This condition is essential in determining the success of learning [10]. The teacher understands the scope and depth of the concept to be delivered by considering the abilities and conditions of the students. The teacher tries to balance the teacher's knowledge related to the concept with the knowledge that must be mastered by students in learning therefore be able to determine material boundaries clearly [11]. In addition, teacher A not only considered about the concept structure but also has consideration regarding what students need and teaching materials based on the demand knowledge, curriculum and students’ prior knowledge and misconception. However, Teacher B only considering about the arrangement of the concept that need to be taught. Learning experience will motivating and give more meaning to the students thus guide students towards engagement in content and help them learn new skills [12]. By encouraging students to relate their personal experience to the classroom, teachers help students make learning relevant and advance their skills across academic settings.

In this lesson, students will learn that sound is energy and has the ability to do work. Sound is produced by a vibration, and a vibration is when objects or air molecules rapidly move back and forth. When a vibration occurs, it produces sound. When the vibration stops, the sound produced stops as well. Sound travels in waves from one place to another. Students can visualize this by imagining a person dropping a rock in a pond. The impact of the rock upon the surface of the water produces a ripple effect. Sound waves “ripple” from a vibration in a similar way. Sound waves need a medium or material to travel through and this material can be a solid, liquid, or gas. When a sound hits a material, it is either absorbed, reflected, transmitted, or a combination of all three. When a sound is absorbed, the waves are essentially disrupted by the material, making the sound dissipate. When a sound is reflected, it bounces off of the material and comes back to the person or object making the sound. When a sound is transmitted, the sound travels through the object (Figure 1).

Figure 1. How the sound made by a speaker reaches ears

The proses of delivering content or ideas related to the step of learning activity, the way teacher in delivering the concept of sound wave to foster student’ creativity. Both of teacher applying STEM approach to foster students’ creativity. The aim of STEM education is to improve students’ understanding of science, technology, engineering and mathematics, thus to be able to apply that knowledge to solve complex problems [5]. Creativity is one of the abilities that must be possessed by students from STEM learning activities [13]. By participating in STEM learning, students will learn how to overcome problems and grow to become an innovator. Teacher asked student to make product
to express their creativity through learning activity. According to both of teacher this activity will encourage students to think spatially, increase fine motor abilities, and hone crucial problem solving skills all while using imagination and artistic creativity.

In the learning activity students are presented with the following challenge, their new school is under construction and the architect accidentally put the music room next to the library. Students need to design a room that will absorb the most amount of sound so that the music does not disturb the library. Students use a box as a proxy for the room need to create a design that will decrease the sound that is coming from the outside of the box. To evaluate this challenge, students use a speaker within the box and a decibel meter outside the box to measure the effectiveness of their design. Students relate science to engineering as they examine properties of sound and apply this knowledge in order to design a soundproof room a practical application that acoustical engineers may perform in their work. The students employ the engineering design process and are given a range of materials to choose from. As students design their soundproof rooms, they are also limited by several constraints that acoustical engineers may encounter. Engineering design involves identifying and solving problems in a literacy process. In this process student’s look for various solutions using concepts of science, mathematics and technology, through thinking processes, making a model, and analysing solutions that might be realized to answer existing problems. Creativity is considered an important element in solving problems. Students’ product can be assessed to measure the creativity which affect on students’ creativity. According to Bessemer and O’Quin the term product in this case is not limited on commercial products, but involve the variety of the objects or ideas. Additionally, stated that creative product can be grouped into three categories, those are novelty, whole and effective [14].

Technology used in learning activity was animation flash about sound wave, video and power point slide about sound reflection and the tools and materials to design creative product. According to observation pre-service teacher (teacher B) used ICT better than teacher A. It showed when teacher A could not solve the problem when the video didn’t display on the screen however teacher B able to solve the problem by resetting the display setting on the laptop, additionally teacher B always tries to solve the problem by themselves. In using the power point media, teacher B explores power point features such as inserting the video in power point where it will be more practical to display. Pre-service teacher have better knowledge about technology it might because teacher with ten year teaching experience are not adequately trained to explore the use of digital technology[15].

3.2 Students’ Creativity
The product of students’ can be assessed quantitatively based on creativity rubric that was judge by expert judgment. The rubric to measure the creativity product refer to the rubric was designed by Bessemer and O’Quin According to them, the criterion used to measure product of creativity classified into three main aspects, those are novelty, whole, and effective, meanwhile each dimension has certain criterion to measure the students’ creativity product. In general the result of students’ creativities in making creativity product based on the creativity domain, show in Figure 2.

![Figure 2. Graphic of the Comparison of the Average (%) every Creativity Aspect in teacher A class and Teacher B class](image-url)
Based on Figure 2 the product that was made by student noticed the highest percentage in both of class were in whole aspect, with a percentage of 88%. It show that student in general student are able to make product that all parts function properly thus able to solve the problem given. In addition, students able to create the product with short time and easy to recreate if there is a problem to fix. Creative solutions often go beyond more novelty and functionality to include a strong aesthetic quality. Creative products and solutions are deeply bound to the context within which they occur [14]. In whole creativity it will measured the organic of the product, organic means that the product has a harmonious sense of completeness to it and all the part work well together. Then the product should well-crafted, means the product has been worked and reworked with care to develop it to its highest possible level for this point in time (quality). According to observation during learning activity and the result of the product made, both of teachers able to foster creativity in whole aspect.

Novelty aspect consists of original, which means the product is unusual or infrequently seen in a universe of products made by people with similar experience. Moreover, there is surprising aspect in novelty which means the product present unaccepted or unanticipated information to the user, listener or viewer [14]. In teacher A class novelty aspect with percentage 81% higher than in teacher B class who gained 75% in average. In general, the percentage can be said to be quite good in supporting students' original thinking skills. The teacher has been able to encourage students to produce new ideas that have not been thought of by his friends, guide students to find innovative ideas, and encourage students to think using different methods. Growing and developing innovative student thinking is not an easy thing. One way to develop student creativity is by encouraging students to believe in their ability to create innovative things. Reflecting on the learning process carried out, both teachers have been good enough in building students' confidence to produce innovative ideas. This is supported by the teacher's suitable strategy in giving rewards to students who are able to provide innovative answers or ideas, so that students are more confident not to hesitate in thinking of new ideas or possibilities that has never been revealed or thought about. Therefore, it helps students in creating creative product. Whereas, for the effectiveness aspect in teacher is a class with percentage 76% and in teacher B class with 75%. Effective aspect consists of logical, useful, valuable; understandable that should appear on product made by student. The result from both class include as good with that percentage gain. It showed that students able to create the product focus to create product to solve the problem by applying the concept of sound wave then the product is made according to design and can reduce noise, able to produce meaning product and understandable. Product of creativity does not have to be new but have to be approved as valuable and meaningful one. A useful criterion show that the product made should be applied practically.

The process of fostering creativity which is manifested in the form of interaction between teachers and students is certainly able to encourage and spur improvement in student creativity. Improvement can occur because of several reasons. First, the combination of teacher guiding behaviour, type and number of questions raised, and positive feedback given by the teacher, as well as the closeness that exists between teachers and students can be a supporting factor in increasing students' creative thinking skills. Second, clear and easy-to-understand learning intrusion, the selection of teaching materials and topics, good teaching preparation, and the types of evaluations that teachers use can also have positive implications for student creativity. Teachers who are able to stimulate and develop the ability of creativity will make students feel brave in taking various risks both in the learning process and in working on the tasks given [16]. Additionally, students are more motivated in using creative ways of thinking when the teacher uses creative ways of learning activity with clear instructions and understood by students, giving freedom of thought and showing diverse perceptions and alternative perspectives for students in carrying out their tasks.

4. Conclusion

Based on the results of the discussion, it can be concluded that the process of fostering students' creativity has been facilitated well, which can be seen from the learning process experienced by students, through the implementation of strategies and approaches in the classroom. The teacher...
understands the scope and depth of the concept to be delivered by considering the abilities and conditions of the students. The teacher tries to balance the teacher's knowledge related to the concept with the knowledge that must be mastered by students. The process of fostering creativity showed in the form of interaction between teachers and students is certainly able to encourage and spur improvement in student creativity. Moreover, teacher brought clear and easy-to-understand learning intrusion, the selection of teaching materials and topics, good teaching preparation, and the types of evaluations that teachers use can also have positive implications for student creativity. By participating in STEM learning, students will learn how to overcome problems and grow to become an innovator because creativity is one of the abilities that must be possessed by students from STEM learning activities.

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