K-12 Science Learning: Designing a Lesson on Nearpod to Teach Projectile Motion

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ABSTRACT

The development of technology has not only brought changes to our lifestyle but also affected our way of thinking. When it comes to education, technology has brought great opportunities to change the way of teaching and learning. Utilizing technology when teaching increases students' motivation, engagement, and achievement. Furthermore, online learning is common nowadays. Therefore, teachers' ability to integrate technology into teaching to enhance students' learning is becoming increasingly important. However, many teachers struggle with effectively using technology to promote students' learning. In this case, the Technological Pedagogical Content Knowledge (TPACK) framework has been widely used to combine the knowledge of content, pedagogy, and technology and support teachers in teaching with technology. This research designs and develops a science lesson for 10th-grade students to learn projectile motion. The lesson is developed on Nearpod, an online teaching platform with abundant technology, and is able to support students' self-paced learning. The lesson can be divided into eight parts, including pre-assessment, motivational introduction, open inquiry. Each part contains technology-based activities, including interactive games, interactive simulation, Google Docs worksheets . The research takes the lesson as an example to see how technology can be fully integrated into teaching science and analyses how content knowledge, pedagogical knowledge, and technological knowledge are combined to enhance students' learning based on the TPACK framework. In the end, the research gives suggestions on teachers integrating technology into teaching to promote students' logical thinking skills, problem-solving ability, and passions for the subject while making sure learning objectives are achieved.

Keywords: *TPACK, Technology Integration, Lesson Design, Online Education, K-12.*

1. INTRODUCTION

The rapid development of technology has not only brought significant changes to our lifestyle and improved productivity but also deeply affected our way of thinking. Utilized to support both teaching and learning, technology is able to increase students' motivation, engagement, and thus enhance students' learning. In this case, teachers' ability to integrate technology into the classroom is becoming increasingly important. However, many teachers feel confused about integrating technology into their teaching [1].

The Technological Pedagogical Content Knowledge (TPACK) framework was proposed by Mishra and Koehler, which has become a widely used framework to dynamically combine the knowledge of content, pedagogy, and technology and support teachers in teaching their subject matter with technology [2].

This research designed a science lesson for 10th-grade students to learn projectile motion using the online teaching platform Nearpod and a few kinds of technology. This research analyses the TPACK framework and how the lesson is designed and developed based on the TPACK framework for the combination of content knowledge, pedagogy, and technology. Furthermore, this research provides insights for lesson designing on Nearpod for teachers and gives suggestions on integrating technology into teaching science classes.

2. LITERATURE REVIEW

The TPACK framework contains technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK), and offers a productive approach to the dilemmas that teachers face in implementing educational technology in teaching.

According to the TPACK framework, the three types of knowledge (i.e., TK, PK, and CK) are combined and dynamically co-constrain each other [3]. Technological pedagogical knowledge (TPK) describes relationships and interactions between technologies and pedagogical strategies, while pedagogical content knowledge (PCK) shows the same between pedagogical strategies and subject content. Then, technological content knowledge (TCK) reveals relationships and intersections among technologies and subject content. Therefore, these triangulated areas constitute TPACK, which considers the relationships among all three areas and acknowledges that teachers are acting within this complicated area.

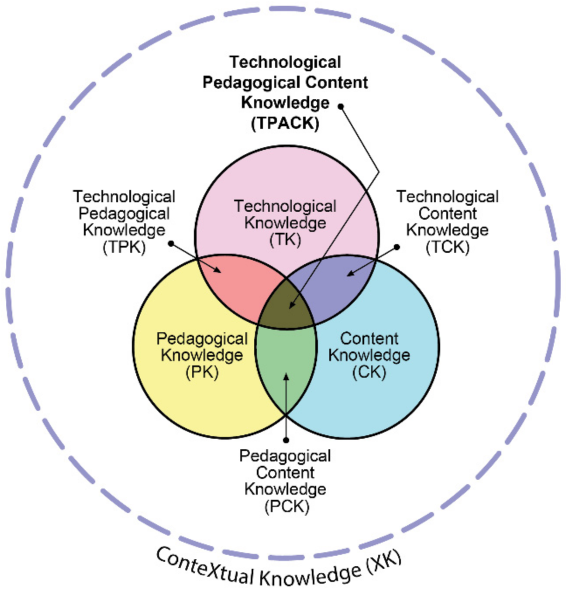

Figure 1. The TPACK Framework

As shown in figure 1, TPACK lies in the centre, which is the kind of knowledge teacher needs in teaching. TK means technological knowledge that teachers should master such as how to use the projector. Pedagogical knowledge refers to teachers' foundations on pedagogy or teaching methods so that they are able to teach students professionally. And content language is about teachers' knowledge of specific content. Teachers should be familiar with the content knowledge in this class and teach students. However, there are some overlaps in this figure such as TCK, TPK PCK, which are overlaps that require more than one knowledge. A well-designed lesson should reflect the teacher's TPACK. Therefore, the TPACK framework can not only provide guidance for teachers to design a technology-based lesson but also serve as a criterion to judge whether the lesson is well-designed.

Kaplon-Schilis and Lyublinskaya developed the TPACK Levels Rubric for better assessing teachers' TPACK levels and supporting teachers to design and develop technology-based lessons [4]. The TPACK Levels Rubric is a validated instrument that has been used in a variety of studies to assess teachers' abilities to integrate technology into teaching by clear indicators and criteria. It proposes three aspects of teachers' great application of integrating technology into a lesson, which includes subject content fidelity, pedagogical strategies, and technology affordances. Therefore, teachers should consider these three aspects while designing and developing a lesson.

According to Niess et al., applying the TPACK framework to pedagogy is necessary, as people merely knowing how to use technology is not the same as knowing how to teach with it [5]. In accordance with problem solving theory, participating in the design of educational technology makes teachers develop their TPACK.

3. RESEARCH METHODS

The lesson is designed and developed on the online teaching platform Nearpod. The qualitative research takes this lesson as an example to see how technology can be fully integrated into teaching science on Nearpod.

The whole lesson can be divided into eight parts, including pre-assessment, motivational introduction, open inquiry, teacher explanations, formative assessment, application, summative assessment, and summary. Formative assessment means an activity conducted in class to check students' understanding of knowledge, whereas summative assessment is in the form of an open-ended question and a quiz.

The pre-assessment includes a brief quiz for students to review previous knowledge, which helps build connections between knowledge. The motivational introduction contains an online interactive game, serving as a hook to motivate students to learn today's lesson. Then, the open inquiry is composed of an interactive simulation and a working sheet to work on in groups. In this period, students will need to use the simulation to design a physical experiment to explore the questions that they are interested in and record their data and observations on the working sheet. Then the next step is teacher explanations, which provide text and visuals to explain a few variables related to projectile motion to enhance students' understanding of the topic. After that, formative assessment is conducted where students will need to draw a projectile path online to show their understanding of knowledge in their way. Then, the application part includes giving examples of real-life projectile motion and distinguishing the differences between projectile motion in real life and in an ideal physical situation. An inspiring video is provided in this part to help improve their cognition. Next, summative assessment is implemented as students are given a situation where a man is missing his target with an arrow and students will need to give suggestions to this man using what they've learned. Also, they will need to complete a quiz that tests their understanding and application of knowledge. By the end, after the teacher gives a summary of current lessons, students will need to fill in exit tickets, which promotes their self-feedback and reflections.

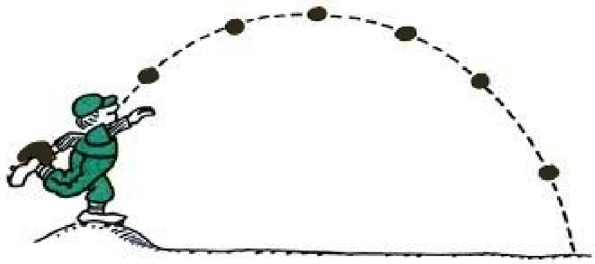

Figure 2. An Example of Projectile Motion in Real Life

4. RESULTS

4.1. Subject Content Fidelity

The subject of the Nearpod lesson is science and the topic is projectile motion. It is a very important module in high school science lessons. Projectile motion is the motion of an object thrown or projected into the air, subject to only the acceleration of gravity. The object is called a projectile, and its path is called its trajectory. To effectively learn projectile motion, students need to conduct experiments on their own, observe the phenomena, and make conclusions about the law of projectile motion. Nearpod is an online teaching platform with abundant technology, which enables it to support students' efficient and effective learning of projectile motion. Therefore, this lesson is designed and developed on Nearpod.

The target students are in grade 10. In this lesson, students will explore and know the phenomenon of projectile motion as well as how varying initial conditions affect a projectile path. Moreover, students will be able to describe the trajectory of an object in projectile motion using physical terms as well as give real-life examples of projectile motions with physical explanations.

Projectile motion involves a lot of physical terms and concepts. Then it is possible that students feel bored and struggle to understand new knowledge as well as connect it with previous knowledge when learning it. Therefore, the ultimate goal of this lesson is to promote their logical thinking skills, problem-solving ability, and their passions for physics while making sure to achieve students' learning objectives.

4.1.1. Discovery Learning

At the beginning of the lesson, students will need to play the online interactive game Angry Birds and answer the open-ended question on Nearpod, including how they describe the motion of the Angry Birds after they have left the slingshot and how the way they fling the Angry Birds changes the arc of the trace path.

Many physical principles are discovered from normal phenomena in daily life. By playing the game and drawing conclusions from their observations during the game, students are fully engaged in discovery learning and experience the basic process of studying science.

4.1.2. Physical Experiments

The principles and formulas of projectile motion are originally concluded from physical experiments. Therefore, it is necessary for students to conduct experiments themselves to explore projectile motion and form their own perspective of projectile motion. An interactive simulation is implemented in this part to let students design and conduct their own physical experiments. Then, they will record their data and observations on a working sheet provided for them. This process also shows the method of studying science. Doing experiments and then drawing conclusions is the basic process of studying science problems. Therefore, this experiment activity helps them develop a scientific view in exploring things deeply [6].

4.1.3. Application

According to Narasimharao and Wright, students often feel disconnected from science and are unable to find its relevance to their daily lives [7]. Therefore, the activities "Collaborate Board" where students will post their examples of projectile motion in real life, and "Drag & Drop" where students will need to distinguish the differences between projectile motion in real life and ideal physical condition are used for knowledge application. These activities help them build connections between physical conceptions and real-life situations, and they can share their perspectives on real-life projectile motion by collaboration.

4.2. Pedagogical Strategies

4.2.1. Open Inquiry

Open inquiry is a kind of inquiry-based task where students can form their own questions that they are interested in and decide the methods on their own to achieve it. In this process, the teacher plays a role who supports students' learning by inspiring and commenting instead of giving direct teaching.

The open inquiry in this lesson is supported by the interactive simulation and Google Docs, which provides an environment for students to take scientifically meaningful actions freely on their learning objects and immediately see the meaningful consequences of these actions. For example, by changing the variables such as initial velocity or the weight of the cannonball in the simulation, students will see different trajectories after launching the cannonball. Therefore, the simulation provides intuitive results and makes it easy for students to understand how those variables affect the trajectory of a projectile. Also, the open inquiry provides opportunities for them to discover whatever they prefer to explore, which will promote their ability of problem-solving, discovery learning, and collaboration [8].

4.2.2. Group Work

A few group work activities are included in this lesson. During the motivational introduction, students need to discuss with the neighbour their inspirations from the interactive game. Also, students are paired in groups to conduct experiments using the interactive simulation and work on worksheets together. Moreover, they need to post their own examples of projectile motion in real life on “Collaborative Board” and discuss the examples posted by others. All these group work activities provide chances for students to learn from others and exchange ideas to actively engage in the class, and thus creating meaningful learning for them.

4.2.3. Assessment and Feedback

Assessment in this lesson includes pre-assessment, formative assessment, and summative assessment.

According to Schema Theory by Anderson et al., knowledge is based on past experience and accessed to guide current understanding [9]. Therefore, previous knowledge of a few physical terms and concepts about motion should be reviewed at the beginning of the class to make it easier for students to understand new knowledge. Pre-assessment assesses what knowledge and skills students already have about content to be learned. In this case, the pre-assessment takes the form of a “Matching Pairs” activity where students will need to match the physical terms. They have learned the meanings of these physical terms before, so this activity helps them build connections between knowledge as well as get adapted to the new lesson.

The formative assessment is conducted by the “Draw It” activity during the lesson, providing a full picture of students’ current understanding and thus helping the teachers modify their lesson and improve themselves for having a better understanding of the subject content and pedagogy [10].

The summative assessment of the lesson includes an open-ended question and a quiz. The open-ended question provides a situation where students will need to give suggestions on a man who cannot hit the target with his arrow. The open-ended question develops students’ problem-solving ability and keeps students’ motivation level high even at the end of the class because it is an interesting question to work on. Meanwhile, the quiz includes a few multi-choice questions focused on the variables related to projectile motion, providing instant feedback once the quiz is finished by students. By doing the quiz, students are engaged in self-assessment and able to identify areas of improvement with their results, thus improving their ability of self-regulation and autonomic learning [11].

For the feedback, students need to fill in an exit ticket before class ends. In this step, students will need to summarize their learning and accomplishments by answering the exit ticket, which leads to their self-feedback as well as encourages reflections [12].

4.3. Technological Affordances

4.3.1. Online Game

The interactive online game Angry Birds is used at the beginning of the class, motivating students to actively participate in class and arousing their curiosity about the knowledge to be taught. Furthermore, games help simplify difficult conceptions to be taught in class. Therefore, students feel more confident for learning new knowledge and thus are willing to take the lead in class [13].

4.3.2. Interactive Simulation

Students need to design and conduct experiments using the interactive simulation for self-exploration. This activity is an open inquiry of high cognitive demand. In this inquiry-based task, students are only given the simulation and a document helping them to record their steps, data, and observations during the experiments. They are asked to propose questions that they want to explore and then design their own experiments without the teacher’s direct guidance. Therefore, students investigate questions that are formulated according to their own interests and through self-designed procedures. In this process, they are experiencing cooperative learning, discovery learning, and actively engaged in the learning process, and thus their motivations, critical thinking, and problem-solving abilities are greatly improved [14].

4.3.3. Draw It

A “Draw It” activity is utilized for formative assessment. In this activity, students need to draw a projectile path of whatever projectile they like and label all the terms on their drawing. This activity provides opportunities for students to review previous learning and present their understanding of knowledge in their own way. Also, visual learning contributes to deep learning. Therefore, students will deeply memorize what they have learned and develop their cognitive level of understanding [15].

4.3.4. Multimedia and Network Resources

Multi-media resources and websites are utilized to enrich the lesson. Based on dual coding theory, students learn through verbal associations and visual imagery [16]. Multi-media resources and websites allow the separate encoding of information in memory both in visual and propositional form, thus making learning easier.

5. DISCUSSION

In this lesson, content knowledge, pedagogical knowledge, and technological knowledge are combined to show the full integration of technology into the lesson to enhance students' learning.

Content fidelity is fully shown in the design of this science lesson as many activities provided in the lesson have their physical meaning, which makes students not only learn about the current topic but also get to understand how to study scientific problems and develop their passions for physics.

For pedagogy, a few instructional strategies are used in the lesson, while technology-based activities are built around learning objectives and explicitly promote students' learning abilities and learning effects. The activity design of this lesson shows multiple instructional strategies that support students' deep learning of science.

Various kinds of technology are utilized in the lesson which fully shows technology affordances. By doing technology-based activities of high cognitive demand, students will develop higher-order thinking skills, leading to a deep understanding of science [17]. In short, technological affordances are given full consideration in this Nearpod lesson.

A few inspirations are given from this science lesson. First, teachers are highly recommended to use inquiry-based tasks, especially open inquiry to improve students' discovery learning and problem solving abilities. Also, it gives students an opportunity to explore by themselves and learn at their own pace, not only enhancing their cognitive levels but also improving their chances to achieve success on the topic they learned.

Second, the sequence of tasks should be given careful consideration when designing a lesson. If students get the chance to explore on their own before the teacher gives explanations, students will have a better understanding and memorizing of subject matter as well as their cognitive levels will be developed. Otherwise, teacher explanations appearing first would leave little room for students to think independently and discover on their own. In this lesson, an inquiry-based task is set before teacher explanations, leading to students' self-exploration and improving their learning effects as well as learning abilities.

Moreover, interactive games and simulations are welcomed among students because they are vivid and motivational. As for K-12 students, their motivation is highly determined by fun and easy activities which promote their active participation in class and confidence to learn.

Last but not least, assessment is indispensable and it can be taken into different forms such as quizzes, fun activities, open-ended questions, discussion, and so on. Different kinds of assessment improve the richness of a lesson and also help teachers modify the lesson according to the assessment results of the students.

6. CONCLUSION

In this lesson, subject content, technology, and pedagogy dynamically connect with each other according to the TPACK framework, altogether contributing to providing students with a deep conceptual understanding of the subject, promoting their abilities to use technology to explore and solve problems, and developing their high cognitive thinking skills.

With the increasing popularity and accessibility of the Internet and Internet-based technologies, integrating technology into teaching is more and more necessary. Suggestions are given to teachers on effectively using and integrating technology into teaching K-12 students science lessons to enhance their learning. Moreover, the TPACK framework has become a widely used framework to provide a systematic and meaningful way of preparing teachers for technology integration to address the needs of all students.

Therefore, it is highly recommended that teachers design and develop technology-based lessons according to the TPACK framework, paying attention to the subject content fidelity, pedagogical strategies, and technological affordances of their lessons. Besides, constantly applying the TPACK framework to pedagogy is necessary, as merely knowing how to use technology is not the same as knowing how to teach with it, which needs a lot of practice. In accordance with problem solving theory, participating in the design of educational technology makes teachers develop their TPACK.

To sum up, it is necessary to keep exploring the effectiveness of integrating technology into teaching to enhance students' learning.

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