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Computer Simulation Integration in Secondary Physics: Understanding its Nature, Impacts, and Challenges

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ABSTRACT

This paper explored the teaching experiences of physics teachers in integrating computer simulations in their pedagogy to promote a constructivist learning environment. Its objectives are to determine how physics teachers describe computer simulations based on how they are used, how these are embedded in the teaching-learning process, their impact on the teaching-learning process, and the challenges of integrating these into physics teaching. Using the phenomenological design, two themes emerged for the first objectives, which are process-based and system-based. First, the teacher-manipulated with sub-themes of engaging, demonstrating, elaborating, and evaluating, and student-manipulated emerged on how the simulations are used. Second, the impact to teaching generated knowledge-based, skill-based, and value-based learning-based primarily on the three learning domains. Also, respondents emphasized that the integrations of computer simulations are convenience, efficacy, and heterogeneity. Finally, the challenges in the integration process are classified as teacher and school-related. The results showed that teachers are integrating computer simulations differently depending on their resources and the TPACK knowledge.

INTRODUCTION

Physics is considered one of the complex subjects in primary and higher education because it relies profoundly on quantitative skills and relationships between concepts. In addition, its empirical nature entails the importance of observation, measurement, and experimentation in its development (Ocampo et al., 2015). This extreme level of difficulty students associate with physics has led to students' diminishing interest in physics. Teachers feel that students consider physics abstract and complex to understand (Oon & Subramaniam, 2011). This apparent decline in students' interest in physics or science, in general, is reflected in the performance of Filipino students in national and international assessments. The result of the 2018 Programme for International Student Assessment (PISA) showed that Filipino students are ranked significantly lower than the average participating countries in terms of scientific literacy (Department of Education [DepEd], 2019). Data from the World Economic Forum's "Global Competitive Index" on the quality of science education further reveal that the Philippines ranked 76th in the year 2017-2018, a drop from the 2015-2016 ranking of 67th place (World Economic Forum [WEF], 2019). Furthermore, grade 10 and 12 students performed poorly in science and mathematics in the 2018 National Achievement Test (NAT), as indicated by the low mean percentage scores across the different dimensions of 21st-century skills (DepEd, 2019). Based on these existing data, it can be stated

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that the quality of science education in the country still lags behind neighboring countries in the ASEAN region.

Several factors can be attributed to the current state of science education in the country. The Science Education Institute, Department of Science and Technology [SEI-DOST] & University of the Philippines National Institute for Science and Mathematics Education Development [UP NISMED] (2011) identified these as shortage of qualified science teachers, lack of quality textbooks, incongruent teaching assignments with teachers' educational background, mismatch of teacher education curriculum and the philosophy of science education at the primary education, and lastly, the predominance of teacher-centered classrooms and teaching practices. These factors have been previously identified and categorized by Orleans (2007) as teacher-related and school-related factors when he assessed physics instruction conditions in secondary schools. All these factors are considered problems and issues that require educational reforms and actions from the government and the education sector. Hence, in 2016, the government formally implemented the K to 12 curricula to improve the quality of education in the country, emphasizing developing scientific literacy among learners.

One of the apparent factors attributed to students' inferior performance in science or physics, particularly that teachers can address, is the type of classroom learning environment. The teacher-centered classroom mostly dominates the learning environment due to teachers' lack of technological, pedagogical, and content skills suited to science teaching. Hence, most teachers turn to the lecture method, rarely providing students with engaging and challenging activities to explore and develop creative ideas (SEI-DOST & UP NISMED, 2011). In addressing this concern, it is recommended that teachers use established multiple approaches driven by constructivism to facilitate the acquisition of the three learning domains. These approaches include but are not limited to contextual learning, problem-based learning, inquiry-based approach, science-technology approach, and multidisciplinary approaches. This recommendation is based primarily on the fact that science education's theoretical and philosophical foundation is constructivist. It has been recognized that constructivism improves the quality of teaching and ensures a positive contribution to the development of scientific thinking skills (Altun & Yücel-Toy, 2015). Dudduan et al. (2015) emphasized that science needs different critical thinking methodologies to regularly involve experimentation and practice. Science is a close interplay of ideas and experimentation geared towards understanding the theory with accompanying exterminations.

In implementing constructivism as both pedagogy and philosophy, effective instructional technologies and learning materials appropriate in evaluating a curriculum's components are necessary. Information and Communication Technology (ICT) in science education has created a revolutionary change in the teaching and learning process that resulted in the emergence of a new educational paradigm (Boopathiraj & Chellamani, 2015). Previously, Salameh Al-Rsa'i (2013) pointed out that Information and Communication Technology (ICT) provides many tools and patterns that can be utilized through constructive learning strategies in teaching science. The students can perform several tasks and activities and be responsible for their learning. Also, Hennessy et al. (2007) explained that science teachers are shifting towards commonly available interactive technologies in many practical ways and devising new pedagogic strategies and forms of classroom activity accordingly. One of the emerging interactive tools is computer simulations which have been frequently used in the different fields of science. The systematic review of D'Angelo et al. (2014) on the effect of computer simulations on students is classified into achievements, scientific inquiry, reasoning skills, and non-cognitive outcomes. This classification validates the review of Rutten et al. (2012) when they found that most studies point that the impacts of computer simulations on students can be observed generally in the three domains of learning. Previous studies also suggest that simulations are more effective than traditional teaching practices in promoting the science content, developing process skills, and facilitating conceptual change (Smetana & Bell, 2012).

Numerous studies concerning the integration of computer simulations focus mainly on the impact or effect on students' cognitive, psychomotor, and affective learning domains. Based on the literature review of Rutten et al. (2012), there is a scarcity of studies concerning the effect of computer simulations on teachers since most of the studies have investigated the effectiveness of these simulations without regards to the influence of the teacher, the curriculum, and other such pedagogical factors. They added that recognizing the role of teachers will establish a pedagogical framework for integrating computer simulations in science education. With the integration of computer simulations in science teaching, limited studies have dwelled into understanding the lived experiences of science teachers who manage and control the learning environment. Mostly, related studies are quantitative and are fixated on determining its effect on students' achievement, skills, and attitudes. Hence, this study focuses on physics teachers' experiences in utilizing computer simulations to promote a constructivist learning environment. It considers how these simulations are being used and how they are embedded in the teaching-learning process.

Banking on existing data acknowledges that primary science education in our country is not comparable to international standards. Thus, this study's findings may contribute partly to the improvement of primary science education in our country by realizing the science education framework of the K to 12 curricula. In addition, this study will encourage physics teachers and other science teachers to utilize computer simulations in their teaching, whether in classroom discussion or laboratory settings. Generally, the primary goal of this study is to improve science instruction through the integration of computer simulations in the teaching-learning process to promote a constructivist learning environment.

METHODS

Research Design

This study was carried out within the breadth of "phenomenology" since it aims to understand why and describe how science teachers integrate computer simulations in their classes. Van Manen (2017) characterized phenomenology as the way to access the world as we experience it reflectively. Besides, Schram (2003) stated that this design studies people's conscious experience of their life-world, focusing on the experience itself and how experiencing something is transformed into consciousness (Merriam & Tisdell, 2015). Thus, this study focused on the experiences of physics teachers who have integrated computer simulations in their classes to promote a constructivist learning environment.

Setting and Participants

The participants are three junior and three senior high school physics teachers within Benguet and Baguio, Philippines. The participants were selected purposively because they all have integrated computer simulations in their physics classes. This criterion was set by the phenomenological framework, which requires a relatively homogenous group of participants (Creswell, 2008). A letter of invitation containing a brief description of the purpose and nature of the study was forwarded to them electronically before the interview.

Ethical Considerations

In ensuring that the study adheres to conducting qualitative research, ethical considerations were strictly employed. These considerations primarily centered on protecting research participants are autonomy, beneficence, and justice (Orb et al., 2001). Following these established principles, participants were carefully informed beforehand about the nature of the study and the extent of their participation. A consent form was accomplished containing the details and nature of the survey emphasizing that they have the right to decide whether to participate in this study freely and withdraw without any consequences. In the same manner, confidentiality and anonymity were likewise observed. Participants were given pseudonyms and assured that the data gathered were treated with strict confidentiality. Lastly, the principle of justice, which refers to equal share and fairness, was given importance. The researcher recognized participants' vulnerability; thus, considerations into their availability and convenience during this study's conduct were prioritized. Also, their contributions in this study were greatly acknowledged and emphasized.

Data Gathering Procedure

This study utilized the two stages of data gathering, the preliminary and final stages. In realizing the essence of the participants' lived experiences, different tools were used to collect the data during these stages. These include invitation letters, consent forms, and unstructured interviews. In the preliminary stage, the selection of participants and sending of invitation letters were implemented. Then, informal and casual interviews were conducted to determine their awareness of integrating computer simulations, which were the basis for selecting participants. The final stage was collecting data through in-depth semi-structured interviews since it provides specific and detailed descriptions of a study's topic. The purpose of the interview is to describe the meaning of a phenomenon that the participants share (Marshall & Rossman, 2006). The researcher designed the interview form with the essential questions on their usage of computer simulations in their teaching to achieve this. Open-ended questions were asked to enable the respondents to provide as sufficient details as possible. Follow-up questions were also asked, encouraging participants to freely expound their answers and even provide more details if necessary. Such freedom is essential as it allows the researcher to gather comprehensive descriptions of the teachers' experiences in their science classes (Pecay, 2017). All interviews were recorded and manually transcribed by the researcher.

Data Analysis

The usual procedure observed in data analysis includes preparing data for analyses, reducing the data phenomenologically, engaging in imaginative variation, and uncovering the essence of the experience (Yüksel & Yıldırım, 2015). Generally, the procedure begins with bracketing or "epoche" to clarify the researcher's preconception throughout the study, thereby setting aside his prejudgments and predispositions towards the phenomenon. Subsequently, phenomenological reduction follows, starting with horizontalizing or listing all relevant expressions, reducing experiences to the invariant constituents, thematic clustering to create core themes, and comparing multiple data sources to validate the constant components crafting of individual textural descriptions of participants. The textual descriptions of participants were then subjected to imaginative variations that allow the researcher to incorporate the textual description into a structure explaining how the experience occurred. Writing the composite description that presents the "essence" of the phenomenon comes last. Finally, the composite structural description is combined into the composite textural description to explain the investigated phenomenon universally. Verbatim files, including themes that emerged from the data, were then sent back to the participants to validate and verify the researchers' understanding of the result.

RESULTS AND DISCUSSION

The data collected from the participants' responses were analyzed, and the results showed diverse themes for each of the questions asked (Figure 1). However, findings were primarily based on the four research questions, which were also the basis in formulating the interview questions.

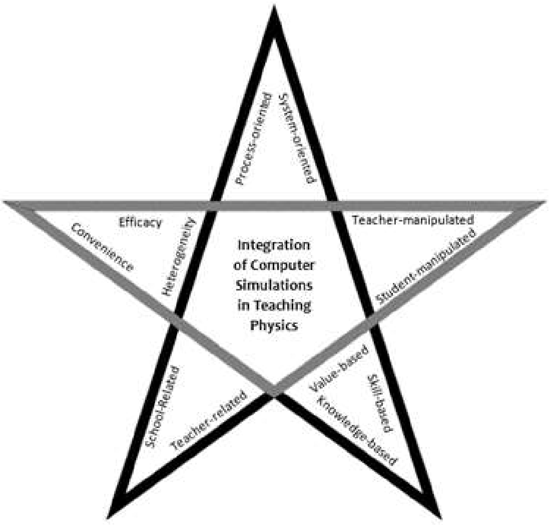

Figure 1. The five-point stellar model for the integration of computer simulations in teaching physics.

The Function of Computer Simulations in Teaching Physics

Based on the findings, two themes have emerged on how Physics teachers describe the role or function of computer simulations. These are process-oriented and system-oriented.

Process-oriented

All the respondents have stated that one of the essential functions of computer simulations in teaching physics is visualizing a process. Process refers to a series of steps undertaken to achieve a particular task or goal. As one participant elucidated, it is difficult for students to visualize a specific physics process, such as determining the image formed by convex and concave mirrors (optics). Accordingly, with computer simulations, the students can see the animated process sometimes coupled with audio and even the corresponding mathematical form of the presented concept. The definition of computer simulations provided by De Jong and Van Joolingen (1998) confirms this finding that computer simulations are programs that contain a model of a system (natural or artificial) or a process. As previously studied, web-based and multimedia resources that include simulations with features like prediction, manipulation, and explanation help visualize abstract knowledge (Hennessy et al., 2007). The computer simulations are particularly effective in helping students understand the abstract and counterintuitive concepts of certain physics areas (Adams et al., 2008) because of the critical features of visualization, interactivity, context, and practical computations. Moreover, the surveyed students enjoyed the simulations and emphasized visualizing the internal and complex physics processes. For example, in chemistry, computer-based simulations with animated color and graphic images can present the dynamic nature of electrolysis through a multi-sensory approach that lacks the traditional methods (Mihindo et al., 2017).

System-oriented

The participants revealed that they use computer simulations to show or demonstrate a particular system or structure. One participant specifically mentioned that he uses the atom simulation model to explain its nature (composition, arrangement, shape, and more.). This simulation allows the students to explore the atom more realistically as it helps visualize specific structures not visible to the naked eye. Numerous studies, archaic and recent, have consistently described computer simulations as models of a dynamic system. Consequently, computer simulations are defined similarly as representations or models of an event, object, or some phenomenon, use of the computer to simulate dynamic systems of objects in a real or imagined world, representation or model of a real or imagined specific object, system or phenomenon and as a model of a process or a system (De Jong, 2011). More importantly, these computer simulations allow students to visualize objects and processes usually beyond the user's control in the natural world (De Jong et al., 2013). Osborne and Hennessy (2003) also argued that simulation offers idealized, dynamic, and visual representations of physical phenomena. The study conducted by Ayasun and Karbeyaz (2007) revealed that the integration of a MATLAB/Simulink in undergraduate machinery courses aid students in their understanding of DC motor characteristics and the dynamic behavior of this system beyond the use of textbooks and classroom discussion. In their survey, Adams et al. (2008) found that integrating computer simulations in quantum mechanics resulted in positive feedback from students. One particular student mentioned that the computer simulations were excellent and helpful in quantum mechanics where it is not ordinarily possible to observe the described phenomena directly.

Process of Integrating Computer Simulations

Two themes emerged on how the teacher-respondents integrate computer simulations. First, these are teacher-manipulated and student-manipulated. Second, under teacher- manipulation, the four sub-themes derived were engaging, demonstrating, elaborating, and evaluating.

Teacher-manipulated

This theme emerged as the central mechanism employed by physics teachers in integrating computer simulations in their classes. Within this theme are sub-themes dependent on what specific part of the instruction these simulations are integrated to; Engaging, Demonstrating, Evaluating, and Elaborating. Familiar with all respondents, they all specified that they use computer simulations at the beginning of the lesson to motivate, catch attention and focus the learners in preparation for the day's lesson. One respondent mentioned that "*Isun ti motivation na, lesson proper na. Kasla example dyay ususarek nga Phet ket adda part nga pang motivation*" [Translation: It is for motivation or lesson proper, like the Phet that I am currently using]. Another respondent likewise mentioned that "simulations could also be used to catch students' attention or even anchor them to your discussion. In the literature review conducted by Kranjc (2011), it is generalized that most of the simulations attract attention and interest as revealed by students who often talk about it, indicating that some degree of motivation has been reached. Garard et al. (1998) surveyed undergraduate students further revealed that games and simulations increase student motivation and cognitive learning beyond traditional instructional methods. Durán et al. (2007) also investigated the effects of a computer simulation on students' motivation and interaction. Results showed that simulations appeared to foster discussions among the students and the teacher during the brainstorming session, further validating the claim that it affects students' affective domain. Similarly, though not a simulation but rather a video-sharing platform, YouTube videos are used to motivate students, as stated by science teachers in the phenomenological study of Pecay (2017).

Another sub-theme that emerged from two respondents is demonstrating. They have specified that the use of computer simulations is necessary for demonstrating or as a guided inquiry. Notably, one respondent mentioned that he uses simulations to show chemical reactions instead of risking hazards due to chemicals in the laboratory. Based on this statement, he used the simulation to substitute for a laboratory experiment that poses a risk due to the chemicals. Smetana and Bell (2008) suggested that simulations may be integrated into lectures as a teacher-led demonstration. It further implied that when simulations are teacher-led, students must be actively engaged through different means such as questioning, predicting outcomes (POE), generalizing, and explaining. Several studies have looked into the effect of computer simulation integration in teaching physics and other sciences as a teacher-led demonstration for the last decade. In their research, Durán et al. (2007) have emphasized that real-time simulations during the lecture resulted in a significant change in students' motivation and interaction. Adams et al. (2008) used the simulations in various contexts, including interactive lecture demonstrations to demonstrate critical phenomena and then ask students to make predictions. This method allowed students to ask deep questions similar to those probed by the founders of quantum mechanics hence concluding that the visualization provided by the simulation allowed students to see the heart of the issue and ask deep questions earlier in the learning process.

The third emerging theme, which is evaluating, is only manifested by one teacher-respondent. Explicitly, the teacher said, "In some cases, I use simulations to let the students validate their learning by integrating concepts to virtual applications and examples." From our perspective, the respondent stated that he uses simulations to gauge students learning or whether the students gained the concepts related to the lesson correctly or not. In the 5E learning model, the purpose of the evaluation stage is for both students and teachers to determine how much learning and understanding has taken place. Adams et al. (2008) have provided one diagnostic tool in assessing students' learning by using simulation as homework. The students are provided with a series of questions to understand how a laser works using simulations and then later asked to write an essay on why a population inversion is necessary to create a laser and why this requires atoms with three energy levels instead of two. Almost all students' papers are written thoroughly and correctly. Also, results from interviews, field notes, and problem-solving sessions verified the idea that computer simulations are used to evaluate students' learning. Durán et al. (2007) included simulations within a method that promotes students' understanding. Students were shown first a real-world scenario and theoretical explanations of the main concepts, then later were challenged to brainstorm ideas in foreseeing the development of the scenario. A simulation was then run to check whether students came up with the correct predictions or not, then the discussion followed. Ideas drawn during the discussion were then contrasted with the phenomena shown in the simulation stage.

The last emergent sub-theme under the teacher manipulated is elaborating. Simulations to further explain concepts, address misconceptions and provide generalizations and conclusions are all considered elaborating. Adams et al. (2008) set out to determine the pervasiveness of student difficulties in a specific topic in physics and evaluate the effectiveness of simulation in addressing the challenges. As a result, the integration of simulation and the accompanying lecture and homework were highly effective in helping students understand the topic and address the misconceptions. Adams et al. (2008) investigated the effects of radio simulation on students who have trouble seeing the relationship between frequency and wavelength in physical science classes and algebra-based physics classes. These learners are still confused about the relationship between these terms and have difficulty interpreting one wave representation. After exposure to sound simulations in lecture classes, students can comfortably explain the concepts well, relating the ideas to the sound simulation while describing the ideas even after four weeks of the follow-up interview.

Student-manipulated

Given the necessary resources, all respondents have frequently mentioned computer simulations as a form of laboratory activity for students, whether as a group or individually performed. Two of the respondents said they use simulations as a substitute for actual experiments due to lack of equipment or if the class has no laboratory components. The third respondent stated that simulation as a virtual laboratory is encouraged to eliminate risk and hazards such as performing chemical reactions. Multiple literature pieces support the use of simulations as a pre-laboratory or as primary laboratory activities. Sahin (2006) emphasized that computer simulations are potentially helpful for simulating impractical labs, expensive, impossible, or too dangerous to run. It allows students to observe a real-world experience and interact with it. Chang et al. (2008) compared students' learning outcomes who emerged in the computer-simulated lab and traditional laboratory practice. The papers of Limniou et al. (2007) and Winberg and Berg (2007) are some of the many studies that utilize simulations as pre-laboratory exercises or activities. Some of the researchers that thoroughly utilized simulation as the primary laboratory activity are Baltzis and Koukias (2009), Dalgarno et al. (2009), and White et al. (2010).

Impact of Computer Simulation Integration on the Learning Process

The themes on the impact of integrating computer simulations in teaching physics are subdivided into knowledge-based, skill-based, and value-based.

Knowledge-based

Knowledge-based impact refers to the perceived effect of simulations in the acquisition and construction of knowledge by learners. It focuses on how learning is affected by the integration of computer simulations. All respondents commonly stressed the importance of these simulations as a tool in promoting conceptual understanding. Accordingly, having the students use more of their senses, the students absorb concepts better. Additionally, students were given a chance to explore the ideas independently when used as a guided inquiry or laboratory activity. One of the respondents categorically stressed the importance of these simulations in catering to visual and experiential learning. In general, all respondents acknowledged that it reinforces students' acquisition of concepts. Several kinds of literature have investigated the effects of computer simulations in teaching science as a supplement or alternative to traditional. In physics, however, computer simulations promote better understanding, predicting, and explaining (Clark & Jorde, 2004; Limniou et al.,2007; Adams et al.,2009; Stern et al., 2008; Ploetzner et al., 2009); better conceptual understanding and learning outcomes (Bell & Trundle, 2008; Chang et al.,2008; Zacharia 2007) and better performance or achievement (Baltzis & Koukias, 2009; Bell & Trundle, 2008; Shieh et al., 2010).

Skill-based impact

This theme denotes the impact of computer simulations in promoting the acquisition and development of scientific processes and skills. Respondents have varied responses such as fostering critical thinking skills, curiosity, social skills, interpreting process, predicting, inferring, communicating, and problem-solving skills. Physics-related studies have validated these claims of the teacher-respondents. For example, Mitnick et al. (2009) claimed that simulations resulted in better graph interpreting skills. It was further validated by Ploetzner et al. (2009) in their intervention on dynamic visualizations with pedagogical measures vs. dynamic visualizations without pedagogical standards. Saab et al. (2007) also highlighted the importance of simulation in developing students' constructive communication skills. Research on the effects of computer simulations on developing and promoting scientific processes and skills to students is more diverse in other sciences like biology and chemistry.

Value-based

Developing and demonstrating scientific attitudes and values are the components under value-based. Based on the teachers' responses, students' attributes when simulations are used to teach physics aroused their curiosity, engagement, and enjoyment. As one respondent emphasized, students must enjoy the simulations because they learn better when having fun. It has been confirmed by Mitnik et al. (2009) when they contrasted the effect of robotic and computer simulations that increased motivation and more collaboration of students. The studies of Zhang et al. (2004), Veermans et al. (2006), Saab et al. (2007), and Wu and Huang (2007) all point to the value-based impact of simulations like better and meaningful, systematic, and reflective discovery learning, more self-regulation, more and practical discovery learning activities, and more emotional engagement.

Impact of Computer Simulation Integration on the Teaching Process

Three themes have emerged from the respondents' answers on the effect of integrating simulations on their teaching process. These are efficacy, convenience, and heterogeneity.

Efficacy

Three respondents mentioned time as one of the impacts of integrating computer simulations to the teaching process. One particular statement is, "Lesser time of preparation. For example, we need plenty of time to improvise materials and equipment to be used in their laboratory activity; however, with computer simulations as a laboratory activity, less time is devoted to preparation because we can download specific Phet simulations to be used. As a result, it is much easier and faster."

Convenience

All the respondents attributed convenience as the most logical impact to them. One respondent stated that simulations serve as his guide during the discussion since there are times that when students are confused, he needs to present the concepts from a different perspective. As he manipulates the simulations, he can quickly point out the essential concepts based on the learning competencies. Another respondent also emphasized the ease of using simulations as a laboratory activity since students can perform the activity even without laboratory equipment and materials. Lastly, the remaining respondent categorically stated that concepts that are not strictly relevant to the students' situation could also be easily pictured using simulations.

Heterogeneity

This theme can be stated as the diversity of what the teachers can do because of computer simulations. One of the respondents cited that using simulation is an innovation to be shared with other science teachers. It was upheld by the statement of the second respondent, saying that using it encourages the teacher to think of new strategies in teaching where technology is incorporated. Finally, the teachers can also teach the concepts in more advanced detail since the simulations provide multiple parameters and variables.

Challenges of Integrating Computer Simulations to Physics Teaching.

Based on the diverse answers of the physics teachers, resources and TPACK of teachers emerged as the themes of the challenges encountered in the utilization of computer simulations.

School-related

Most of the respondents pointed out that the main challenge in integrating computer simulations in their classes is the availability of ICT equipment in their schools. The first one is the low computer ratio to students that hinders teachers from designing and implementing learning strategies that focus on independent learning. All respondents have clearly stated that a computer simulation experiment is not feasible if there are not enough computer units. As a result, teachers either resort to grouping the students or giving the learning activities as homework. In most instances, instead of letting the students experience hands-on learning in manipulating the simulations, teachers rely upon demonstration strategy just for the students to experience what is all about the simulation. Thus, it limits the maximum potential of these simulations to impact students' conceptual understanding. The second school-related problem specified by the respondents is internet access. Two teachers from rural areas stated that this is a perennial problem because their schools rely mainly on broadband connection and mobile data as internet service providers. Unfortunately, these internet connections in remote schools are not as fast and reliable as in urban secondary schools. In turn, teachers explained that they download offline versions of these computer simulations themselves in areas with reliable access then save them into the computers utilized by students, which is a time-consuming process. These issues and problems with resources in physics instruction were previously classified by Orleans (2007) as school-related factors.

Teacher-related

This theme concerns mainly the teachers' knowledge and skills in integrating computer simulations in their classes. This theme can be referred to as teachers' technological, pedagogical, and content knowledge (TPACK) or the knowledge required by teachers for integrating technology, particularly computer simulations, into their teaching in any content area. Four of the six respondents have explained that they often demonstrate specific competencies using the computer simulations brought about by limitations of ICT resources. Another common strategy of integrating simulations is the laboratory method brought about by the lack of laboratory equipment and apparatus. Most of the teachers rely on integrating these simulations, which is either demonstration or laboratory method. However, it turned out that even with limited resources, other strategies and techniques were implemented by other respondents. The following teachers' statements disclose the challenges they encountered in utilizing computer simulations in their physics class.

> *In our current setting, there are not many difficulties encountered in integrating simulations in our classroom instruction. If there are, it is more of the technical part. Some simulations are not accessible for instructors. It needs to be purchased at a very reasonable price.*
>
> *I think it is better if school heads are trained in ICT integration to see the significance of these. For example, in one of the seminars for science teachers, I overheard some teachers discussing problems using simulations in their school. Accordingly, some school heads are not supportive of investing in ICT integration, for example, computer simulations, because they have not seen the effect of these on the teaching-learning process.*

Furthermore, one of the teachers explained that while he is adept at manipulating computer simulations, some advanced and higher physics concepts are unfamiliar since it is not his specialization. Also, some of the teachers stated that one of the reasons why they occasionally use simulations is because of the technical issues they encountered. While most simulations are readily available and considered freeware, certain minimum specifications must be required to function. When these are not present, installed, and updated in the computer system, these simulations will not run and often requires the user to satisfy these minimum specifications. As revealed, some teachers who lack the technological knowledge and skills spent more time resolving these issues, which often resulted in less time for the students to perform the target learning activity. In some instances, teachers avoided using these simulations because of the issues they have experienced.

The TPACK knowledge of teachers is crucial in determining the successful integration of these simulations. Sarabando et al. (2014) suggested that teachers should be provided with the necessary skills and knowledge to integrate these in their teaching activities to attain the full potential of computer simulations as practical educational innovations. Rutten et al. (2012) have earlier stressed that computer simulations can significantly impact science education when they interplay with the nature of the content, the student and teacher are considered. Determining the learning needs of students, the choice of a good simulation, and how it is being integrated into the classroom environment are factors to consider in achieving desired learning outcomes. Thus, teachers play the central role in "selecting appropriate resources, sequencing and structuring learning activities and guiding students' experimentation, generation of hypotheses and predictions, and critical reflection upon outcomes" (Sarabando et al., 2014, p.120).

CONCLUSION

Based on the results of this study, it is determined that physics teachers are generally aware of the potentials of computer simulations to bring significant changes in the way ICT or technology is being integrated into the learning environment. When properly integrated into the pedagogy, the impact on learners is not limited to acquiring a single domain of learning. It is instead exceptionally observed across the knowledge, skills, and attitudes. Also, the utilization of these simulations generates an encouraging effect on teachers' ability to manage the learning process that can help them become innovative and effective teachers. However, there is still a need to promote and strengthen teachers' technological, pedagogical, and content knowledge, as seen in the results of this study. These components of the TPACK framework are treated as interrelated mechanisms in teaching content, teaching effectively, and using technology appropriately. The rapid growth of technology integration in science instruction requires content and pedagogy to achieve an effective classroom learning environment. Therefore, teachers should continually rethink their teaching practices and discover new strategies to effectively integrate simulations into their teaching. However, these findings and conclusions may apply to a limited group of science teachers that may not reflect the majority of experiences among the physics teachers in the locality. Nevertheless, primary and secondary findings were presented in the study; thus, further investigations are encouraged.

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