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Technology Integration in Teaching Science in Relation to Technology Literacy Skills of Prospective Science Teachers: The Case of Online Distance Learning

Jannieryl Niedo Mata
San Agustin Elementary School, Madridejos, Cebu
Email address: jannieryl.niedo@deped.gov.ph

Abstract*—This literature review aims to explore technology use in the classroom for science teaching, specifically the technology literacy of prospective science teachers through distance education. ICT – simulations, multimedia – facilitate science learning by making it easy for students to understand. But they must be used with teachers who have great technology expertise, good attitudes and support from the institution. The roadblocks – low-quality resources, inadequate training, and inversion – stifle adoption. The research emphasizes professional development and teacher confidence as a way of creating an environment of technological learning for the future science teacher to prepare them to use ICT effectively*.

***Keywords*—** *Technology Literacy, Science Education, ICT Integration, Distance Learning*.

I. INTRODUCTION

A new era of globalization, acculturation, knowledge creation and mass acceptance of new behaviors have emerged due to emerging information and communication technologies. Furthermore, these options have influenced how people think, act, communicate, work, and live (UNESCO, 2005). It is becoming increasingly challenging to keep up with the massive increase in the volume and transmission of information. Consequently, to succeed in the knowledge era, people's skills and talents must grow, and people must learn to better critical access to information, apply what they already know, and repurpose their existing skills to create new knowledge by repurposing their current capabilities. There has been a consensus on subjects such as lifelong learning, innovation, and continual improvement due to the growing focus on the information society (Tinapay & Tirol, 2021).

People should be taught how to use information and communication technology from a young age to prepare them for the demands of a fast-paced working and thinking environment. Computers can be used to teach science in various ways, including simulations, data collecting, animation, and more. In science, educational software can be used to teach and observe complex topics and skills. Encarta educational software, for example, can be used to teach electric motors in Physics. Students can grasp the spinning of the coil in the magnetic field best when it is presented using this software. Aside from employing instructional tools, as previously mentioned, video is another option for learning. Concurring to inquire about discoveries, although science instructors were more likely at that point science instructors to utilize devices that would contribute to the development of 21st-century aptitudes, both were using conventional hands-on materials instead of computerized instruments and resources (Tinapay et al., 2021).

Donnelly, McGarr, and O'Reilly (2011) expressed that considering a few potential obstructions was fundamental to integrating CT-based assets into schools. In this ponder, a working system has been created to portray the level of ICT integration (a Virtual Chemistry Research facility, "VCL") into educating hone and the variables underpinning this integration. After pondering interviews, instructors expressed that ICT (Virtual Chemistry Research facility) usage given superior organization, time sparing, asset sharing between understudies and between instructor and student, definitive clarification, and innovation in classrooms. Also, instructors' conversations have approximately a few obstructions, such as willingness and instructor convictions (Rehmat and Bailey, 2014). Thus, this literature review looks at previous research on technology integration, starting with the benefits of ICT to science education, followed by teachers' beliefs about integrating technology in science teaching. The challenges and barriers to integrating technology are also explored.

II. METHODOLOGY

This study adapts a systematic literature review (SLR) approach. An SLR is an evidence-based method that collects, assesses and synthesizes all research literature on a topic, structured. This enabled the research to cover the literature on the use of ICT in the teaching of science and the technology-literacy of aspiring teachers in an ODL setting.

III. DISCUSSIONS

Benefits of ICT to science education

When used correctly, ICT can provide significant advantages to both students and teachers of physics. Physics is a quantitative science, and information and communication technology helps physics students make accurate and reliable measurements. The majority of educational institutions now have computers and other forms of ICT. Information can be presented in a variety of ways using computers, including

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graphics, photos, videos, and animations, among other things. Multimedia environments have the potential to induce significant learning, according to Mayer and Moreno's research. Dual-channel theory, cognitive load theory, and constructive learning theory are used to produce a multimedia learning theory developed by Mayer. Students must choose, arrange and integrate pertinent information into their past knowledge during the learning process (Tirol, 2022).

Collaborative models can be utilized during science lessons. These are simple to use and offer a lot of didactic potentials. They provide students with visual representations of processes that are difficult to view directly, such as photon and electron movement. The simulations encourage students to participate by providing dynamic feedback. The learner can experiment with various parameters to see how this intervention affects the outcome. When a teacher is planning a lesson, interactive models help save time. An interactive simulation makes it easier to conduct an actual experiment (Tirol, 2023).

Technology and other educational innovations must be integrated into physics education "1) to improve students' physics ability and2) to enhance students' unfavorable attitudes about physics. For example, in their paper, Rios and Madhavan (2010) identified four types of physics-related technologies, each with a brief description. Data collection and processing equipment, experimental or theoretical modeling, computer simulations that require graphics, information gathering, reporting, or presentation programs, as well as (a) research/reference/presentation programs that require graphics, were the categories. As a result, the following is an updated and expanded explanation and discussion of a wide range of technology that falls into each of these categories and that physics educators should use to help students understand physics topics better. There seems to be a selection of studies on how each is used.

Teachers' Belief in Technology-based Teaching and Learning

Learning concepts have changed dramatically with the advent of instructional technology in the late twentieth century. This is in line with the ability of skill to create a classroom atmosphere that is responsive, available, and inclusive. Secretaries of education, in particular, are increasingly giving a variety of facilities and training to help countries better utilize advanced knowledge in their instruction and education processes. A large amount of money has been set aside to provide teachers with the necessary facilities to boost the education industry.

A similar challenge is plaguing numerous countries: teachers are not making the most of what technology they have at their disposal, despite their efforts (Albirini, 2006). Multiple studies have demonstrated that incorporating technology into the teaching and learning process can help students attain higher levels of accomplishment (Nakayima, 2011, Jamieson-Proctor et al., 2013). Technology in the classroom is a topic that many researchers have tried to figure out what factors influence teachers' adoption of (Capan, 2012; Virkus, 2008; Zhang, 2013; Dudeney, 2010). Instructors, who are in charge of making changes to their teaching and learning processes, have shown that their beliefs were the most significant impediment to change. As a result of the digital-native phenomena in which the present generation was born and raised with technology, students have high expectations for technology integration in the classroom, according to Chien, Wu, and Hsu (2014). Technological integration in the school is becoming more and more critical to students as they evolve. It also indicated that personal qualities, characterized as self-perceptions, had a significant impact on Integrating Technology. This study found that both teachers and students enjoy using information technology in and out of the classroom, preferring to use it outside of the school.

Teachers' confidence, competence and attitude hinder the introduction of technology in schools and reduce the level of ICT penetration. The findings of a previous study suggest that in instruction to teach ICT skills in the school, teachers merely need to use a traditional orientated technique (Cox & Marshall, 2007). Teachers have a lot of confidence and skill to use ICT in class, even if the sorts of ICT used are not visible. As a result, they believe that information and communication technology (ICT) is a tool that can help students learn more effectively, especially when dealing with real-life problems. To help students create and construct knowledge, this factor has inspired the teaching technique to use ICT (Tinapay et al., 2023).

A balance of training and pedagogically focused strategies, according to the studies, could indicate the relationship between competency and confidence in ICT professional growth. The school administration might use this information to ensure that teachers have the resources to integrate technology into the classroom. Teachers' efficacy in urban schools, on the other hand, varies with their years of experience and age (Cuban, 2001). It reveals that when teachers' years of experience and age increase, their efficacy decreases, but the school administration influences the drop and efficacy beliefs. In this context, the management of the school is related to the social activities and the use of educational resources.

Schools that support the use of instructional resources allow teachers to share their reflections on teaching and learning with their colleagues and allow administrators and teachers to cooperate and communicate. According to this study, teachers' conviction in their efficacy is influenced by school administration and culture. If the school has a culture of change and teachers are frequently sent for training to improve their skills, the use of technology in education will be easier to develop (Tinapay & Tirol, 2021).

Challenges and Barriers to Using ICT in the Classroom

Although ICT benefits teaching and learning, various obstacles exist in many schools that prevent its exclusive use. The promise of information and communication technology (ICT) to aid teaching and learning is not without constraints. A severe risk of information overload may exist if teachers cannot filter material for relevance or develop an effective organizing principle in an educational setting due to the almost limitless opportunities for access to information (Grageda et al., 2022). Students and teachers may lack the abilities to

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access, analyze, and use data. Yet, several challenges serve as roadblocks to teachers using ICT in the classroom. A barrier, according to Schoepp, is any circumstance that makes development or achievement difficult.

When it comes to implementing ICT in the school, educators say there are two sorts of barriers: external and internal. There are two types of extrinsic hurdles: first-order outside walls that include factors like time and support; second-order outdoor barriers that involve attitudes, beliefs, actions, and opposition. There are two types of hurdles: intrinsic and extrinsic. Extrinsic barriers are tied to organizations rather than individuals and are known as inherent difficulties. According to others, the borders were separated into individual (teacher-level) and institutional (school-level) barriers. Becta divided the borders into individual (teacher-level) and institutional (school level). Some Barriers to teachers' attitudes and approaches to technology were split into micro and meso levels.

Another set of academics, on the other hand, defines obstacles as situations that are either material or non-material. Pilgrim identifies one of the material conditions as an insufficient quantity of computers or software copies. Teachers' limited ICT knowledge and abilities, as well as the difficulties of introducing technology into the classroom, are examples of non-material obstacles that need to be addressed. Computer limitations, a lack of free time for education, and a shortage of computer time for students in the classroom were the most significant barriers to high school teachers adopting Technology in the United States. A lack of computer access was more likely to be blamed by teachers at larger schools and city schools. In contrast, teachers in schools with a substantial minority population were more likely to blame outdated, unreliable computers for the problem (Tinapay & Tirol, 2021).

Support from the school's stakeholders

Stakeholder support for teachers' ICT integration in the classroom, which leads to successful ICT integration in schools, has been covered in a large amount of literature. A sociocultural approach was used in one study in Turkey, which indicated that instructors saw the administration as a significant obstacle preventing them from incorporating technology into their classrooms.

According to other studies, adequate administrative and ICT coordinator support will boost educators' commitment to integrating ICT. Goktas et al., for example, argued that providing continual support to instructors would instill confidence in their ability to integrate ICT into their classrooms. Goktas et al., for instance, argued that providing continual support to instructors would instill confidence in their ability to integrate ICT into their classrooms. Peer support in ICT integration among teachers has been highlighted in previous research. Teachers would be burdened or distracted by administrative tasks, according to Zah et al. That is why teachers should be given training programs and workshops to have prior knowledge in using ICT in their class. Thus, saying that the school should also provide an individual who is an expert when it comes to using ICT to assist and help the teachers (Tinapay et al., 2023).

Humanistic influence on technology integration

Using a humanistic approach, a person's values, beliefs, confidence, and feelings are represented in their values, beliefs, and emotions (Fedorenko, 2018). Educators enjoy communicating with and sharing their expertise with students since teaching is a humanistic endeavor (Azzaro, 2014). Educational institutions require teachers who can bridge the gap between human and technical cultures (Dominici, 2018). Some educators may find technology too impersonal to embrace because learning and education should be based on students rather than teachers. Educators' values, beliefs, and degree of confidence are all factors to consider while implementing new technology and pedagogies (Tinapay & Tirol, 2021).

A positive attitude toward technology was found to be a significant factor in deciding whether or not to employ it in the classroom. Positive attitudes significantly impact whether or not new technology integration is adopted (Tinapay et al., 2023). The transformation could be in the shape of a college or university, bringing about a change in education. Educators might be more willing to accept the difference if the transition was easy and beneficial. With any new initiative, even if the change was not favorable, it is possible that the announcement would cause unpleasant emotions and mistrust. There could be resistance, self-doubt, and uncertainty as a result of the transition (Reid,2017; Kilinc et al., 2017). The ability of educators to absorb an innovation, such as technology successfully, may be influenced by their previous experiences (Demirba and Klnç,2018; Reid, 2017). As a result, if the change's focus contradicts their current belief system, teachers are less likely to put it into practice and become resistant to it. Those who make changes that align with their underlying convictions are more likely to succeed (Demirba and Klnç, 2018).

Teachers are more inclined to use technology and feel more confident about the transformation process due to the alignment. When educators use technology in a superficial or non-existent manner, they build opposition to it. They become resentful when educational technology does not seem to be helping them with their traditional teaching methods (Demirba and Klnç, 2018). Educators may learn to use the newly adopted technology as a challenge (Cheung et al., 2018).

However, while the instructional technology is helpful, the resistance hinders them from expanding their possibilities for employing it. The efficacy of an educator can also be linked to a teacher’s resistance to technology. A person's ability to succeed in a task or activity that is unique to their surroundings is known as "self-efficacy" (Bandura, 1986; Alenezi, 2017). Computer self-efficacy is a term that refers to a person's ability to use technology and computers with confidence (CSE). The ability to achieve a goal and apply skills is called CSE (Alshammariet al., 2016). The importance of CSE has expanded since the advent of computer-based learning at all levels of education (Bhatiasevi and Naglis, 2016). In their daily and personal life, educators who have had little or no exposure to technology or who have received little or no support will be hesitant to use it (Kilinc et al., 2017).

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An instructor with a greater degree of CSE will be less frustrated and employ technology more frequently (Cheung et al., 2018). The value of technology is more likely to be believed by users if it is simple to use and makes activities easier to complete (Bhatiasevi and Naglis, 2016). As a result of a lower degree of CSE, there is a lack of motivation and perception of technology as brutal and pointless (Alshammari et al., 2016). Though a substantial contributor to change aversion, CSE is difficult to identify barriers is possible, however, to evaluate an educator's resistance to technology by combining CSE with their previous experiences as a teacher. Integrating technology may be more straightforward for educators who are more acquainted with traditional teaching methods if they have a colleague or mentor to guide them. The change agent would be a mentor or a colleague (Tinapay & Tirol, 2021). Change agents are people who can reassure you and help you through difficult times. It would necessitate not only a shift in an educator's pedagogy and technical skills but also a shift in their self-efficacy (Reid,2014). These mentors can assist the educator in boosting the use of technology by providing just-in-time assistance and simplifying the educator's transition (Tirol et al., 2022).

Technology Literacy Skills

A range of pedagogical, social, and environmental elements, among others, influence educational technology and its practical usage in the classroom (Ertmer, 2005). A significant correlation exists, for example, between computer access at home and academic success, both in general and in mathematics and science (BECTA, 2003;National Center for Educational Statistics, 2000. The quality of the learning process can be linked in this way to a good relationship (Jackson, Von Eye, Biocca, Barbatsis, Zhao, &Fitzgerald, 2006).

However, besides ICT access, several other factors, such as parental income and education, should be considered when addressing this favorable association. As an outcome of our technologically advanced, rapidly changing environment, teachers are expected to not only be able to integrate technology into traditional aspects of literacy (such as reading and writing) but also to engage students in increasingly important technological literacy (such as online reading and writing) (Karchmer, Mallette, KaraSoteriou, & Leu, 2005). The developing Net Generation requires basic facts and information and the capacity to efficiently negotiate, process, and synthesize large amounts of data to succeed in the future. Another attribute of the N-Generation, who prefer to be active consumers rather than passive recipients of information, is the transition from simple information transmission to an interactive learning process (Tapscott, 1988).

When it comes to ICTs, although they can help students become more active, effective technology integration is often complicated. This is especially true in the early stages when a lot of research and preparation is required, and there is a lot of confusion about how it will go (Niederhauser & Perkmen, 2010). In addition, the capabilities of developing technologies are continually and rapidly altering in terms of their development. Schools must keep up with the latest technological advancements in terms of hardware and software. In some countries, school administrators have even mandated the use of ICTs in the classroom to use them as teaching tools rather than as a way to improve technical skills (Vanderlinde & van Braak, 2010). In summary, researchers must produce up-to-date standards and metrics to explore learner skills, which may be used as indications for future policymaking because policies, pedagogies, technologies, and learner expectations are changing quickly.

IV. Conclusion

The adoption of technology for science teaching – especially for online distance education – has immense advantages for student learning and mastery of abstract ideas. Science lessons can benefit from the use of ICT (simulations and multimedia), but only with technological literacy among teachers, a good attitude, and the backing of school authorities. The barriers of resource shortage, lack of training, and resistance to transformation prevent widespread implementation. They need to overcome these barriers through professional development and build teacher confidence. In the long run, educating the next generation of science teachers with strong technological literacy will put them on a technology-savvy footing.

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