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Advantages of Using Innovative Technological Pedagogy to Teach Chemistry in Secondary Schools

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Science and technology have become the leading foundation of global development. Both subjects continue to improve the quality of life as new findings, inventions, and creations emerge from the basis of science. Chemistry, a physical science, provides a strong foundation in the advancement of science and technology. Chemistry, or the central science as it is sometimes called, bridges other natural sciences together. Although chemistry plays a vital role in the world of science and technology, students and teachers in secondary education alike have always found difficulty with this particular subject. As students in secondary education lose interest in studying chemistry, it is crucial that researchers create innovative technology to increase and enhance pedagogical approaches [1].

Teachers, students, and even chemists would agree that understanding the concepts of chemistry are challenging.According to the American Chemical Society (ACS), using traditional classroom methods have become problematic as technology progresses and students lose interest in the dated methods of teaching chemistry [1]. Many students enter into the chemistry classroom with a preconceived idea that the course will be extremely demanding and they will struggle to do well [2]. This growing problem, as well as the high demands of teachers to perform well on high stakes standards testing, has led to students failing to understand the main concepts of chemistry [3]. One major goal for chemistry teachers is to develop more current methods to teach secondary students the necessary concepts of chemistry.Researchers worldwide have been working to create technological advances for chemistry in the classroom. These new and improved technological advances have been created to ease the fear of the students and the possible misconceptions they may have about chemistry before even entering the classroom. The new technology in the classroom is also helping students to comprehend and retain more information as they complete the chemistry courses. Two such technological advancements are virtual laboratories and the utilization of tablets in the classroom. Technological Pedagogical Content Knowledge (TPACK) is also a technological advancement that has helped teachers' pedagogical approaches to teaching chemistry in secondary schools [4].These technological advances in the chemistry classrooms of secondary schools are beneficial to teachers, students, and the future of chemistry [1].

Virtual laboratories have emerged in secondary schools. These virtual laboratories have created a cheaper alternative while still allowing the student to participate in performing experiments. Websites such as ChemTeacher, Chemical Education Digital Library, and Virtual ChemLab are a few of the virtual laboratories that give students in secondary education an insight on experiments [5-7]. Lerberg agrees that virtual labs allow students to connect chemical experiments to situations in the real world [8]. Virtual labs also allow students to experience hundreds of different labs and do not limit the student to the very few physical labs they would experience otherwise. In addition, these virtual labs allow teachers more opportunities to expound on material and concepts they otherwise would not have access to. The virtual labs are not just a click through tutorial. Students must actively participate in making critical thinking decisions such as what laboratory tools and chemicals to use and why. The virtual labs also grab students' attention with the flawless graphics, color, and animated pictures. The amount of information that is gathered from visiting these websites is infinite. With the virtual laboratories, students gain access to much information that textbooks cannot produce [8]. The American Chemical Society states that all students should have access to physical laboratories [1]. While nothing can take the place of performing actual experiments in the laboratory, many issues have surfaced in the past few years. Costs of materials that are used in laboratories have prohibited some schools from being able to provide the necessary tools for students to complete experiments. Although ACS would prefer students have access to physical laboratories, it is understood that some experiments are much too dangerous to perform in secondary schools. It is also stated that technology should be used as an enhancement to experiments, not a replacement. The knowledge that can be gained from physically performing laboratories is irreplaceable but as mentioned, reactions such as thermic reactions can be best demonstrated through virtual laboratories for the safety of the students. Another benefit to virtual laboratories is that they are automated. Secondary school students are becoming more technologically advanced. The need for many pen to paper activities have ceased to exist. By using computers and computer based programs we can meet the demanding needs of the diverse learners in the classroom. Computers can also interact with many databases to collect an endless amount of data to make the experiment rich with information. Computers can also graph this data and create best fit lines that are clear and concise, which helps students to comprehend and explain the results. Virtual laboratories provide teachers with a valuable tool to help secondary students to excel in chemistry [1].

Secondary school aged students are hooked on technology. Rarely does one see an adolescent without an iPad, iPhone, or other smart device. As textbooks become a thing of the past, many schools are seeing an emergence of tablets in the public school systems [9]. Researchers work diligently to create learning devices that can be used on the tablets, which can enhance the learning that is currently taking place in the classroom. While virtual laboratories provide a great insight to laboratory experiments, students who use tablets are able to download thousands of scientific applications, many for free, that can be used while students are sitting in the classroom. According to Hesser, students can learn via game-based scenarios as well as simulations [10].

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Many simulations provide students with instant feedback, which helps them, recognize what concepts they may have missed or which they understood. The use of tablets also allows students to keep a notebook of their work and submit a weekly or monthly report of their scores. One such application is called CloudOn which allows students to attach graphs to their submitted work [11]. Another application, uPad, allows students to write on the tablet, just as if they were using pen and paper [12]. This is extremely helpful in situations involving chemistry as well as math where tablets have yet to add many symbols of the periodic table or chemical equations. Other benefits to using a tablet are that it saves paper, students can screenshot a slide and save it in their notebook to study, and being able to see figures in color can be a valuable study aid. The use of tablets also ensures that students receive the most up-to-date information. Software application creators can easily change information as it becomes available. Teachers use the applications to easily see which students need additional support in the course. They can also keep track of who is turning in assignments without the hassle of stacks of paper. Tablets give teachers more time to focus on their pedagogical approaches and planning instead of grading work that is simply able to be corrected by technology. In a world that is soon to be overrun by technology, teachers and students must familiarize themselves with the changes that are coming from this advancement [10].

The technological advances must coincide with the pedagogy. The relationship between teachers and students is already a very complex one in a chemistry course. Teachers must balance their own ideas and level of knowledge with that of the students' ideas, level of knowledge, and the ability to comprehend the lessons. As Seerypoints out, pedagogy must come before technology [13]. If the teacher lacks the ability to use the technology, then it is not useful to anyone. The virtual sites that help to explain a difficult concept of chemistry are much more useful than a site that looks good but complicates the student further. TPACK, a software application, has been created to help teachers connect their pedagogical approaches with technology advancements [4]. TPACK focuses on 6 areas of content, pedagogy, and technology which include 1) technological pedagogical knowledge, 2) technological knowledge, 3) technological content knowledge, 4) pedagogical knowledge, 5) content knowledge, and 6) pedagogical content knowledge [4]. As Yurdakul stated, every teacher and school system can use TPACK since there is no one person or school that is exactly alike [14]. TPACK allows teachers to utilize the technology that is being placed in their classroom with the necessary content that needs to be discussed to educate the students [4].

Comprehending the basic concepts of chemistry is important for students in secondary education. Chemistry provides a path for students to excel and create new waves of technology. Pharmaceutical companies, doctors, teachers, and every individual rely on chemistry to thrive. As stated in the article "Chemistry is Everywhere," the air you breathe, the water you drink, and the Earth you live on can all be associated with chemistry [15]. Chemistry affects humans not only in the classroom, but in daily life. Therefore, it truly is an essential science to understand. The advancement of technology is helping more students to be able to grasp the necessary concepts in a more understandable manner. These technological advances will also help to create more individuals who enjoy chemistry and study it further. Since technology and chemistry go hand in hand, it is important that more individuals take interest in these subjects so that the quality of life can continue to flourish. Chemistry becomes not only the central science, but the center of life. The work of researchers to find various ways to improve education of chemistry in secondary schools by way of technological advances has greatly helped teachers and students alike.

Technology has helped chemistry to become more understandable and relatable in secondary schools' classrooms. Teachers are able to relate chemistry to students in a manner that is informative, interesting, and understandable. Students' negative attitudes and preconceived ideas have subsided when it comes to taking chemistry classes with the help of these aids. Technological advances such as Chemical Education Digital Library, ChemTeacher, Virtual ChemLab and TPACK are only advancing more every day [4-7]. Pedagogical approaches are becoming easier for teachers with these new teaching aids. Chemistry can now be viewed as a course that can be innovative, original, and technologically advance; all of which are necessary to continue to progress in the world of technology.

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