Applying TPACK to Science Education

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# Introduction

 Technology is constantly changing and altering the way people live, learn and work. The integration of pedagogy and technology into specific content areas is essential to enhance learning on the intrinsic level. Technological Pedagogical Content Knowledge (TPACK) is a model that explains how this incorporation can occur. Science is a content area that is notorious for advances that drastically change how an experiment is performed. Science education is enhanced as a whole when the instructor uses their knowledge of technology and creates effective learning modules using the TPACK model.

# What is TPACK?

 In order to truly understand TPACK, one must look at the seven different knowledge areas and apply them to the curriculum structure. The knowledge areas include: Content Knowledge (CK), Pedagogical Knowledge (PK), Technology Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK) (Koehler & Mishra 2010).



Figure 1.
TPACK Technological Pedagogical Content Knowledge

<http://tpack.org/>

 CK refers to the firm grasp on the knowledge behind the content. This is the base of TPACK in which everything else is built upon. In the teaching of the sciences, one must have a strong college based understanding of the information. This includes the latest ideas, theories, studies and concepts (Mishra & Koehler, 2006).

 After a strong knowledge is acquired, one must understand how students learn. This is where PK is instituted. Students learn in many ways, and there are many theories that educators must know before they enter a classroom. The different learning theories vary from Vygotsky’s theory of scaffolding (Social Development Theory) to Piaget’s development theory of learning in stages, (Atherton, 2010). Instructors must know their students, their learning styles and what teaching methods would be appropriate to present different scientific techniques (Mishra & Koehler, 2006).

 TK is the knowledge of technology and keeping up with the many updates and alterations to specific technological devices within the content area (Mishra, P., & Koehler, M.J., 15). Science is an ever changing field and new methods of performing tests and experiments are always being developed. “So much of contemporary technology is based on the sciences, particularly such disciplines as physics, chemistry, biology, and other sciences that deal with the study, measurement, and understanding of natural phenomena” (Science & Technology, 2000). It is crucial for an instructor to stay aware of the newest trends and developments that it compares to learning new content within science.

 PCK, TCK and TPK are the pairing of two knowledge areas. PCK joins pedagogy and content knowledge, TCK combines technology and content knowledge and TPK pairs technology and pedagogy (Mishra & Koehler, 2006).

“The TPACK approach goes beyond seeing these three knowledge bases in isolation. On the other hand, it emphasizes the new kinds of knowledge that lie at the intersections between them” (Koehler & Mishra, 2010). The real challenge is when an instructor begins to combine knowledge concepts in order to enhance learning. However, in order to achieve an optimum learning environment, one must seamlessly blend pedagogy, technology and content knowledge within the curriculum. “Effective technology integration for pedagogy around specific subject matter requires developing sensitivity to the dynamic, [transactional] relationship between all three components” (Koehler & Mishra, 2010).

TPACK and Science Education

As our world becomes increasingly subject new to scientific and technological innovations, the educational community needs to better prepare the students entering those fields. Issues such as nuclear waste, stem cells, and global warming are all at the forefront of the news and each have a unique technological component (Trefil & Trefil, 2009). Given the rise of instructional technology, the integration of content, pedagogy and technology in science education is increasingly important.

Studies have already shown, even at the middle school level, that the integration of something as minor as a pedometer to replace traditional measuring methods increases overall satisfaction with and retention of material (Sun, Rye, & Selmer, 2010). At the high school level, concepts like pH and digestion are now being taught with pH meters that connect to student’s calculators, overcoming the limitations of traditional pH strips (Kim, 2008). Furthermore, investigation into Earth science is now being done with remote sensory imaging (Vierling, Frykolm, & Glasson, 2006).

These examples of how technology is used to teach science have a definite parallel to how technology is being used to give scientists better results, and the ability to attain them quicker. Something as basic to scientists as imaging a cell has become streamlined with the use of X-ray diffraction (Flannery, 2005). Perhaps the biggest trend in analytical science is the use of mass spectrometry to enhance, or replace, traditional methods such as chromatography columns (Sobel, Ballantine, Ryzhov, 2005). Mass spectrometry has even found its way into areas as diverse as fingerprinting and protein sequencing (Counterman, Thompson, & Clemmer, 2003).

Mass spectrometry has become an integral part of all chemistry coursework done at the collegiate level (Kooser, Jenkins, & Welch, 2003). Many chemists report having their first encounter with mass spectrometry in the 1980’s or 1990’s, even though production began in the 1940’s for a highly technical procedures. In a short forty years, it has become integral to biology, chemistry and the pharmaceutics industry. As the technology progressed it was coupled with the standards of analytical science, such as the gas chromatograph; which itself had replaced the practice of chromatography columns (Shaw, 2009).

With all these developments in scientific technology, and the subsequent introduction of the technology into the laboratory and classroom, one could question how this truly translates into scientific knowledge. The studies previously cited show that these technologies are a true gateway into highly valuable areas like the development and testing of new drugs and cellular imaging. The question proposed to research is how integrating technology, content and pedagogy translates into true scientific knowledge and understanding. Given all of this new information and technology, the hope is that science literacy is on an upswing. However, a report from the National Science Foundation states that it has remained nearly stagnant for the last twenty years (Klentschy, 2008).

This information may not be shocking, given the now famous 1983 report by the Reagan administration; A Nation at Risk: The Imperative for Educational Reform (Lawrence, 1994). These reports essentially sum up the ideas that we, as a country, are falling behind in scientific education and literacy. We might find ourselves wondering how this could be now that scientific education and innovation and technology present themselves in the science classroom daily. This study seeks to explore the question of how these advances in technology translate to scientific knowledge and achievement. As it is now, students must be tested in the sciences once in elementary, middle, and high school due to federal legislation. The National Assessment of Education Progress is given every four years in science and as a part of No Child Left Behind, science testing is voluntary (Rhoton, 2010).

Research Questions

When searching for a tool to measure scientific success at the collegiate level, this study is using the Chemistry Graduate Record Examine as a tool. This is an adequate measuring tool for a few reasons. Currently, there is no standard chemistry test in collegiate education. However, the Chemistry Graduate Record Examine is used to determine how prepared sceince students are to undertake graduate studies in the field. The test encompasses the four main branches of chemistry: analytical chemistry, inorganic chemistry, organic chemistry and physical chemistry. Within these sections there is a high importance placed on topics that now benefit from technological aids in chemical education; especially mass spectrometry.

This study will compare the recent achievement on these tests to those taken in the 1990’s. The years 1990-1999, and 2000-2009 were selected for one main reason. As stated many of the technological tools used in the lab today came out in their earliest form in the mid 1900’s, but did not find their way in the common lab until after the 1990’s. By the 2000’s they were not only common practice but also a part of science education. The student test scores of each respective decade can be used to study the effects of technology on scientific achievement.

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