Chapter 9
STEM Teaching and Learning via Technology-Enhanced Inquiry

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ABSTRACT

This chapter aims to address several limitations of Technological Pedagogical Content Knowledge (TPACK) – a theoretical model used in the application of technology when teaching STEM disciplines. To this end, a supplement to TPACK drawn from the Action on Objects (AO) framework (Connell, 2001) is suggested. To illustrate the value of the proposed enhancement of TPACK, an example integrating science, technology, and mathematics is provided. The Texas College and Career Readiness Standards are used to demonstrate the relationship between the proposed theoretical modification of the leading model and the current teaching practice involving such scientific activities as measuring, record keeping, analyzing, conjecturing and evaluating. Additional suggestions and applications of the TPACK/AO model are provided.

INTRODUCTION

STEM Education has undergone changes regarding the manner in which core foundational understandings of content are best developed (Breiner, Harkness, Johnson, & Koehler, 2012; National Research Council, 2003). These changes have contributed to a growing need for revision of existing pedagogy (Hulleman

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& Harackiewicz, 2009; Labov, Reid, & Yamamoto, 2010). The need for such pedagogical changes in many cases have been both enabled and exacerbated by the application of increasingly powerful educational technology in the K-16 schools (e.g., Abramovich & Cho, 2009; Bodzin, Fu, Bressler, & Vallera, 2015; Hall & Chamblee, 2013; Jang, 2012; Lyons & Tredwell, 2015; So & Ching, 2011; Valanides & Angeli, 2008; Winkel, 2013; Yu & Yu, 2002).

If we take a view of pedagogy as an intersection of student need, teacher ability, and content requirements, the addition of educational technology into the STEM classroom creates new problematics which need to be addressed. In particular, when the teacher is unsure how to apply technology, the content being taught can be diluted or misinterpreted. This is a natural consequence resulting from an increased focus on the development of procedural skills needed to use the technology itself, something that leads to decreased time available for the content. In these cases, students often develop either a broad superficial understanding of a few independent content areas or a small set of procedures only useful for a select set of problems.

Attempts to address such problems may lead to an adoption of a teacher replacement model which incorporates an integrated learning system (ILS) to bypass teachers completely and standardize content delivery. Such efforts to "teacher-proof" content lead to the creation of pre-programmed instructional modules which fall back on a behavioral view of the content (Williams, 1999; Martens, Daly Begeny, & VanDerHeyden, 2011) where each learning objective devolves to an isolated item to be memorized.

Once this viewpoint is adopted, notions of efficiency come into play, in particular, "faster is better" and become the instructional focus. Within this orientation the ILS is designed to take advantage of the computer's speed in enabling a student to "produce" the end product as quickly as possible using immediate feedback to simply posed memory recall items. This "faster is better" belief is then applied using the tremendous speed of the computer, making it possible for the student to know within milliseconds whether or not the memory prompt was addressed correctly. In fairness, it should be noted that such on-the-spot responses may be appropriate for learning in STEM content domains that are very restricted and require a high degree of memorization. For example, development of initial terminology could be well addressed by such methods.

However, outside of such special cases, the immediate feedback produced by implementing this model of instruction does not develop higher order thinking skills. Although the student knows whether or not the answer provided was right or wrong nearly instantaneously, the reason for this answer is not addressed. At a foundational level, the computer in this case does not provide sufficient time for the student to