Measuring Technology Integration in Science Classrooms

STYLINSKI Cathlyn (1), PARKER Caroline (2)

University of Maryland Center for Environmental Science, United States (1)
Education Development Center, United States (2)

Abstract

Today's science teachers are challenged with immersing their students in the practices of science inquiry, while also using technology as a learning and organizational tool. Researchers and practitioners need instruments to identify and describe applications of technology that support and even transform instruction. Classroom observation protocols provide critical tools for examining impacts on student learning. However, of 11 existing English-language technology-based protocols, most only acknowledge the presence of technology or simply describe it in broad terms. Just five of the 11 address the integration of technology with key pedagogical practices, and none of these consider alignment of technology implementation with specific attributes of science classrooms, such as the pursuit of authentic science questions. Using a published framework, we developed, piloted and validated an observation protocol that captures the quality of technology use to support science inquiry in secondary schools. We conducted four iterative rounds of testing in 26 high school science classrooms across the U.S. The resulting protocol focuses on the integration of technology into (1) science and engineering practices (from the U.S. Next Generation Science Standards); (2) student-centered teaching (with students accountable for their own learning), and (3) contextualization (grounded in local geographic contexts, focused on real problems and solutions, and connected to the work of science professionals). The protocol couples numeric codes with written descriptions of evidence, and then synthesizes these into a multi-dimensional measure of quality. Overall, our observation protocol fills a gap in understanding technology's role in supporting science inquiry in schools. It can serve as an instrument for researching applications of technology that enhance science instruction, and can also be used as an evaluative tool by coaches and teachers to reflect and improve technology integration in the context of science inquiry.

Keywords: *observation protocol, technology science inquiry;*

1. Introduction

Both ubiquitous and novel technology applications offer opportunities to support and extend student learning and application of science inquiry [1]. Researchers, evaluators and practitioners need instruments that help them distinguish applications of technology in science classrooms that support, enhance and potentially transform classroom instruction from those that are ineffective. One option are classroom observation protocols, which can examine impacts of pedagogical approaches, curricular resources and student learning [e.g., 2], and can be triangulated with other data types to substantiate findings [e.g., 3]. In this paper, we review existing protocols, identify a gap among these protocols for science instruction, and describe the new Technology Observation Protocol for Science classrooms (TOP-Science) that addresses this gap.

2. Existing classroom observation protocols

In a review of existing English-based classroom observation protocols, we uncovered 35 tools published since 2001 that document and describe a variety of classroom-level variables [4]. Eleven of these provide opportunities for observers to describe the quality of technology use in classrooms. All 11 capture the presence of technology, either through checklists or descriptions of technology type [e.g., 2]. Seven of the 11 protocols move beyond documenting technology presence to broadly describe its use [5]. However, they address technology as an add-on piece of instruction. Only five protocols specifically look at the integration of technology with key pedagogical practices such as individual instruction and technology standards [6]. But, none of these comprehensively capture the quality of technology use in the context of science instruction.

3. Theoretical framework

The TOP-Science tool addresses this gap by building directly on a published framework, which is based on a review of classroom artifacts and relevant literature [7]. Drawing from Cox and Graham [8], the framework categorizes technology by type: ubiquitous, instructional and STEM workplace. It considers integration of these types within three dimensions: science practices using the U.S. Next Generation Science Standards [9], student-centered teaching with students accountable for their own learning [e.g., 10], and relevance to student lives. For example, teachers can capitalize on technology capacity to support personalized learning and promote student ownership [11], or can ground lessons in local geographic context, focus on real problems, and connected to the work of science professionals [12].

4. Protocol design

We created an initial draft of the TOP-Science tool with indicators for each of the framework dimensions. We then refined it through four rounds of iterative testing. In total, 68 observations were made by eight different observers in 26 high school science classrooms across seven U.S. states. Our team of eight observers used reflection worksheets to discuss the protocol strengths and weaknesses, made necessary revisions, and re-test.

We addressed content validity by aligning the TOP-Science tool with our framework and relevant literature, and comparing it to similar protocols. We established face validity with an expert panel who provided feedback, which we used to refine the protocol drafts. We conducted inter-rater reliability during the final pilot testing with at least two team members simultaneously observing 41 class periods. From this, we calculated reliability using Krippendorf's alpha [13]. The codes for three dimensions had acceptable reliability estimates that varied from 0.51 to 0.78.

5. Key protocol elements

This process produced the final protocol, which consists of four parts: (1) pre-observation teacher questions to understand teachers' intention for technology integration in their class; (2) observation sheets to record codes and field notes in 10-minute intervals for each of the framework's dimensions (see Fig. 1); (3) post-observation teacher questions to gather the their reflection on the lesson; and (4) a summary sheet that produces a multi-dimensional measure of technology integration quality (see http://topscience.edc.org/index.php/resources/ to accessnthe protocol).

In initial drafts, we considered technology use separately from the three framework dimensions. However, piloting revealed the importance of framing observations around the integration of technology. Thus, we developed a coding system to classify and describe the degree of technology integration within the three dimensions of the framework (science practices, student-centered teaching and contextualization).

We sought to design a straightforward observation system for these dimensions that extended beyond simply recording technology presence but that also did not mire observers in complex details. Numeric coding offers a fast and efficient means to describe observations but our testing revealed difficulties in consistently distinguishing more than three codes. Written text provides a more comprehensive description of technology integration but detailed field notes proved onerous to complete in 10-minute intervals. We balanced these challenges by creating a system of three-level numeric codes coupled with brief written evidence of each one. Specifically, observers first code the "level" of each dimension, then code the "extent" of technology integration, and finally provide written evidence for both codes.

Our 10-minute interval data provides a streamlined and comprehensive view of technology integration for the entire class period but lacks a summative term of quality. Because the protocol produces quantitative and qualitative data, we developed a final worksheet that summarizes data for each dimension. Specifically, observers determine average and highest value for each code and write an synopsis of the overall evidence based on their field notes. Together, these dimensions provide an aspect of the quality of technology integration.

6. Conclusions

Classroom observation protocols can help identify technology applications that support and even transform science instruction. However, few existing protocols examine the integration of technology with key pedagogical practices, and none of these address the alignment of technology implementation with specific attributes of science classrooms. The TOP-Science tool described here fills this important gap by providing a robust multi-dimensional measure of technology integration with science practices, student-centered teaching and contextualization. It offers a comprehensive view with consideration of teachers' pre-class intentions and post-class reflections, and balances coding with written descriptions of evidence. It does have limitations. It suggests full integration of technology offers the highest quality, when this may not always be possible or even desirable. Further work is needed to determine technology use relative to its benefits and affordances. Additionally, the protocol does not incorporate students' perspective or their learning outcomes. Despite these limitations, the TOP-Science tool successfully frames the quality of technology integration from the perspective of the teacher and in the context of today's science classrooms. It can serve as an instrument for researching applications of technology that enhance science instruction, and can also be used as an evaluative tool by coaches and teachers to reflect and improve technology integration in the context of science inquiry.

7. Acknowledgements

The TOP-Science project is co-led by the two authors with Christina Bonney and with extensive support from Jackie DeLisi, Joe Wong, Cassie Doty and Neil Stylinski.

Fig 1. Protocol classroom coding sheet

Ten-Minute Interval Coding & Evidence			
Category (may check more than one)	**Level[a] (select only one)**	**Tech Integration (select only one)**	**Evidence for Category, Level, & Tech Integration Codes**
Science and Engineering Practices ☐ Asking questions & defining problems ☐ Developing & using models ☐ Planning & carrying out investigations ☐ Analyzing & interpreting data ☐ Using mathematics & computational thinking ☐ Constructing explanations & designing solutions ☐ Engaging in argument from evidence ☐ Obtaining, evaluating, & communicating information	☐ 0 ☐ 1 ☐ 2	☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ N/A	
Student Centered Teaching ☐ Autonomous ☐ Personalized ☐ Competency-based	☐ 0 ☐ 1 ☐ 2	☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ N/A	
Contextualized Teaching ☐ Youth Experience ☐ Science careers or work ☐ Local/geographic context	☐ 0 ☐ 1 ☐ 2	☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ N/A	

[a]LEVEL CODES: 0 = No evidence • 1 = Incidental • 2= Embedded
[b]TECH INTEGRATION CODES: 0 = No Tech • 1 = Minimally integrated • 2 = Partially integrated • 3 = Fully integrated • Not Applicable (if category code is N or None)

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