

Two Exploratory Case Studies of Teachers' Adaptive Expertise in teaching Bioinformatics in High School Science Classrooms

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Abstract: In this study, we use an adaptive expertise lens to examine two contrasting cases of how teachers implemented a data-intensive curriculum in environmental science classes. Analysis showed differing levels of teachers' adaptive expertise as well as challenges when working with data representations. We found that teachers' adaptive expertise depends on teachers' awareness of students' context and extensive knowledge of data literacy and suggest that teacher learning experiences should focus on developing these qualities in instruction.

Introduction

Emphasis has been placed by educational researchers on promoting data literacy in science education (NGSS Lead States, 2013). Initiatives have continued to integrate data literacy into science classrooms through curricula that are embedded in students' contexts, tied to real-world problem solving, and focused on creating artifacts related to community issues using collaborative tools (Kjelvik & Schultheis, 2019). Bioinformatics is an ideal topic for this integration because it is a growing field that incorporates science and big data and has real world needs in the STEM workforce (Tractenberg et al., 2019). However, teaching with bioinformatics content is a complex endeavor (Machluf & Yarden, 2013) and science teachers' content knowledge and skills acquired from professional development (PD) often do not transfer to their instruction and result in a weak increase in student learning (Fischer et al., 2018). Thus, research has suggested that teachers must consider the expertise that is required in instruction, becoming not only technically competent working with data, but also responsive to students' diverse contexts and situations (Almerich et al., 2016). Therefore, teachers' decisions about how to be adaptive in their teaching constitute important information for PD researchers to use to understand how to best support the implementation of bioinformatics. In this study, we use an adaptive expertise lens to explore contrasting cases of how teachers were able to implement bioinformatics curricula in their environmental science classes. This study was guided by the following questions: (1) How is a teacher's adaptive expertise enacted?; and (2) How do teachers use resources to enhance their adaptive expertise?

Conceptual framework

Compared to routine expertise which refers to accomplishing familiar procedural tasks efficiently and accurately, adaptive expertise goes beyond the routine and is defined as being able to use knowledge and skills more flexibly to solve problems in new tasks (Corno, 2008). A study by Authors (2015) used an adaptive expertise lens to evaluate how teachers implemented curricula anchored in agent-based computational tools. They defined adaptive expertise through three characteristics. The first characteristic is *flexibility*, involving teachers' ability to change implementation plans and practices according to emerging issues in the classroom. The second characteristic is *deeper level understanding*, which is the ability to demonstrate a deep understanding of content and pedagogical knowledge as they use that knowledge more effectively to keep students engaged and help them advance to next level of learning. The third characteristic is called *deliberate practices*, a process in which teachers reflect on their instruction to improve teaching performance by first analyzing problems and then trying new approaches.

Method

For this early-stage exploratory case study, we selected two environmental science teachers who taught in two different schools in the Northeastern United States. The first teacher was Clara, who had 5 years of teaching experience and taught 10-11th grade environmental science in a school that was comprised of 99% minority or non-White students, all of whom were eligible for a free or reduced-price lunch. Vera, who had 11 years of teaching experience and taught 11-12th grade environmental science in a school that was comprised of 62% minority students and where 98% of the students were eligible for a free or reduced-price lunch. On the state standardized test, students scored as 26% and 35% as proficient in science respectively. A three-week summer PD workshop was designed to help teachers teach problem-based learning (PBL) curricula that included bioinformatics research, data literacy, and mobile learning. We ran the PD for 75 hours in July 2019. During the PD, the teachers learned the bioinformatics content and introduced to student-centered and community-centered approaches. The curriculum required a focus on solving air pollution problems related to asthma in their local area. Teachers also collaborated to revise and pilot tested curricular content that combined using tools for data collection and analysis tailored specifically to their local student context.

We used a multiple case study method (Yin, 2017) to provide a rich description of our participants' adaptive expertise. The three data sources used were: post-implementation semi-structured interviews; classroom observation notes; and the instructional materials used in each lesson. The semi-structured interview was conducted to probe the teacher's specific practices, beliefs, and understanding of implementing the new curricula, as well as the teacher's experience of preparing the class and participating in the project. The observation notes included descriptions of teachers' instructional practices. Instructional materials included the lesson plans and worksheets. With this data source, we gathered detailed information about the design of and reflection on the classroom activities. Transcriptions of the data sources were analyzed through an iterative mining of the data sources by the authors to identify the instances that would highlight the theme of teachers' adaptive approaches.

Findings

Adaptive Expertise: Flexibility

Overall, Clara demonstrated substantive adaptive expertise. For the *flexibility* category, Clara showed an ability to introduce the bioinformatics projects to students in a way that tied in well with the students' context. For instance, when starting the lesson on asthma, air quality, and bioinformatics, Clara was able to anchor the conversation in current events by using news articles on an explosion at [Blinded city] oil refinery that occurred two months before the class. With this example, she prompted students to think of the complex variables that interact with air quality and their impact on health by asking questions such as "what do you think [the event] did to the air quality for people who lived in that area? How did that affect them? What type of people live in that area?" This example shows that Clara could motivate students with topics that resonated with many of them by using real-world examples that were relevant to students' daily lives. On the other hand, Vera demonstrated less prominent adaptive expertise in her classroom implementation. Regarding *flexibility*, the observation notes showed evidence that she incorporated culturally situated approaches to the project activities, however, there were challenges to her content instruction. For example, one observation showed that she introduced asthma and air quality effectively to students by sharing her personal stories related to asthma and healthcare experiences (09/05/19). Vera was also able to encourage students to answer questions without giving them direct answers. However, when it came to the bioinformatics content, the necessary depth of connections between bioinformatics and the factors contributing to asthma was not evident. The observation notes stated that "there was a lot of info presented and I'm not sure the students really absorbed from just reading definitions on the slide" (09/19/19). This example shows that Vera allowed students to draw upon their own experiences and have discussion about asthma, which captured their interests, but the connection with the bioinformatics was not explicit enough and less situated. More details of findings and further discussions will be available in the larger paper.

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