Designing an Educative Curriculum Embedded Within an Interactive Web-Based Platform to Facilitate Teacher Learning

Miray Tekkumru-Kisa, Florida State University, mtekkumrukisa@fsu.edu
Christian D. Schunn, University of Pittsburgh, schunn@pitt.edu

Abstract: Educative curricula are often considered as one potential vehicle to support changes in how students learn science in classrooms, especially for instruction currently not aligned with ambitious instructional reforms. Our work presents one such effort, focused on teachers as a community of learners. Using a design-based approach, we developed a web-based tool, *iPlan*, which provides online access to educative curriculum materials in an interactive learning platform. The purpose of this study is to examine design features of *iPlan* in terms of affordances and challenges. We examine an implementation in an integrated math-science curriculum unit. Through qualitative analysis of interviews with 13 high-school biology teachers across two cycles of design and testing, we identified the ways in which teachers used and learned from the *iPlan* tool; which features seem to work and why. The study provides implications for developing online learning environments for teachers.

Introduction

Science education has recently been the focus of ambitious instructional reforms in the United States. The Framework for K-12 Science Education (National Research Council, 2012) together with the Next Generation Science Standards (NGSS; NGSS Lead States, 2013) emphasize in-depth development of core explanatory ideas and engagement in scientific and engineering practices. This will mean substantial instructional changes for many teachers (National Academies of Sciences, 2015). Well-designed, reform-based curriculum materials in science can be used to anchor discussions about efforts to put these reforms into practice and as tools to guide initial attempts in the classrooms (Schneider et al., 2005). Particularly, educative curricula—curriculum materials designed to address teacher learning (Ball & Cohen, 1996; Davis & Krajcik, 2005)—can be leverage for large-scale instructional improvement. Moreover, given the scale of the need for the kind of complex learning called for in these ambitious reforms, another promising area for supporting teachers' learning is online environments (Moon et al., 2014; National Academy of Sciences, 2015).

This paper presents an effort that was conducted for instructional improvement in biology classrooms by considering teachers as key players for successful implementation of reform-based curriculum that aims to address goals for student learning as envisioned in the NGSS. As part of this effort, educative curriculum materials that integrate biology and mathematics ideas within an engineering problem context were developed. The curriculum targeted key goals for students' learning as defined in the NGSS, and was educative for teachers. They were situated in an online platform, *iPlan,* that creates a web-based community of learners among teachers implementing the reform-based curriculum materials. Our goal in this study is to uncover design features of *iPlan* in terms of affordances and challenges during the implementation of these curriculum materials. Specifically, we are interested in identifying specific design features of iPlan that were (or were not) taken up by teachers and the reasons for why. Consistently, this study aims to answer: (1) How did teachers use educative curriculum materials embedded in the designed online learning environment? (2) How did teachers use collaborative aspects of the online environment in which curriculum materials were embedded?

Theoretical framework

Among all different instruments for conveying reforms on a large scale, curriculum has the most direct effect on what teachers do in their classrooms, making curriculum a frequently used tool for reformers and policymakers to influence practice (Brown & Edelson, 2003). Curriculum is often transformed and goes on to influence students' learning *through* teachers (Stein, Remillard & Smith, 2007). Therefore, curriculum materials should be developed by placing teachers' learning at the center of these development efforts (Ball & Cohen, 1996).

There has been growing knowledge base about the design and use of educative curriculum materials. Davis and Krajcik (2005) proposed a set of design heuristics for educative curriculum materials that facilitated discussion about how curriculum materials support teachers' learning. Designing curriculum materials that are written to speak to the teachers about the tasks and the ideas underlying them has also been emphasized (Remillard, 2000) because it is important to engage teachers in the ideas underlying curriculum designers' decisions and suggestions. One consideration in the design of educative curriculum materials is how and what

teachers read, and where they focus (e.g., Beyer et al., 2009). These studies suggest that more needs to be done to understand what teachers focus on in the curriculum materials.

Educative curriculum materials could be more effective if they are used in conjunction with other forms of support for teachers (Davis & Krajcik, 2005). For example, in a study of three beginning teachers Forbes and Davis (2007) suggested the formation of materials-based teacher communities especially for beginning teachers who have little or no expertise in using particular curriculum materials. Davis and colleagues (2004) discuss design principles of one such design for new elementary science teachers.

Given the potential of the online learning environments for creating rich opportunities for teachers' learning that are scalable and accessible to large numbers of teachers (National Academies of Sciences, 2015), we brought together educative curriculum materials and online learning environments in our design to facilitate science teachers' learning. By doing so, this study stands out contributing to the limited knowledge base given the general focus on teachers as isolated learners in prior research on educative curriculum materials. In general, little research has examined online learning environments for teachers, especially science teachers (National Academies of Sciences, 2015).

Methods

Background and context

The study was situated within a project that focused on the design of scalable STEM units aimed to teach rigorous mathematics tied to big ideas in biology in high school science classrooms. We focused on the implementation of one of these units in Fall 2013 and Spring 2014. The curriculum that we focused on was a four-week genetics unit situated within a large design challenge for students to help an imaginary local zoo to develop a plan to breed rare geckos. The tasks in the unit were developed to help students to explore how genetic information is inherited and expressed. NGSS-based emphases on greater depth, connections to mathematics, and engagement in scientific practices were incorporated into the design of this four-week unit. The unit differs from traditional curriculum in inheritance in important ways, including its impact on students' learning gains (Schuchardt & Schunn, 2016).

The design of the iPlan tool was grounded in design-based research (The Design-Based Research Collective, 2003). In Fall 2013, 3 high-school biology teachers voluntarily participated in the study. They used the iPlan tool during their implementation of the curriculum described above. Based on the feedback that they provided, iPlan was revised and was used again in Spring 2014 by another 10 teachers during their implementation of the same curriculum. We focused on a broad range of science classrooms with students that differ in their achievement levels and socio-economic status.

iPlan: Educative and interactive learning platform for teachers

iPlan tool is both a learning environment for teachers designed to support interactions among the teachers as well as a resource that provides access to educative curriculum materials. *iPlan* was designed to create a web-based community of users, thereby giving implementing teachers access to peer resources but also by locating expertise and knowledge-building in the participating teachers. The web community extends across space (geographical boundaries) and time (teachers can access discussions and implementation notes from others even if they are not implementing at exactly the same time).

Educative curriculum materials embedded in iPlan were designed to support teachers' learning as they enact our reform-oriented curriculum materials. Representative set of the curriculum materials were analyzed for educative aspects using the criteria for educative quality by Beyer, Delgado, Davis, and Krajcik (2009). These analyses revealed that curriculum materials address all three domains of knowledge in Beyer et al.'s criteria: PCK for science topics, PCK for scientific inquiry, and teacher's subject matter knowledge (Schuchardt et al., 2017). These analyses provided justification for the claims about the educative nature of the materials.

Table 1 provides features of iPlan designed to structure and support learning interactions among teachers as well as features of educative curriculum materials and structures built in iPlan to make these features visible for the teachers (also see Figure 1). The first three features focused on facilitating teachers' learning through their implementation of the curriculum materials and also supporting them in making adaptations that were consistent with the intended learning goals. The latter two features focused on supporting teachers more broadly in productive adaptations (i.e., considering broader pragmatic and local context issues) and also leveraging distributed expertise to support curricular innovations.

Table 1: iPlan Design Features and Rationales

Design Rationales	Structures and Functionalities Embedded in iPlan
Conceptually connected arc of tasks	Each task in the curriculum has a macro and micro view. The macro view clarifies the connections between tasks through two specific sections: *"Why this task now?"* situates the task within the larger unit; *"Moving on from here"* how it conceptually relates to the next tasks.
Modeling a vision for quality science teaching as emphasized in the NGSS	Micro view of each task makes clear the relevant NGSS practices and concepts involved completing the task. For example, *"target"* boxes indicate the core ideas that students should develop in the task; *"important"* boxes indicate why the teacher or students are suggested to do certain things during the implementation of the task.
Transparency of the designers' intent	iPlan has tools and structures to bring teachers' attention to "why" regarding the purposes and timing of recommended task components.
Locating expertise and knowledge-building in the participating teachers with an encouragement to share	iPlan provides space for teachers to take *notes* about the lesson implementation (e.g., lesson planning notes, reflection, modifications, reminders, etc.) and to share these notes with others.
Supporting learning interactions for knowledge-building	iPlan allows dialogue with other teachers and developers within *discussion* sections.

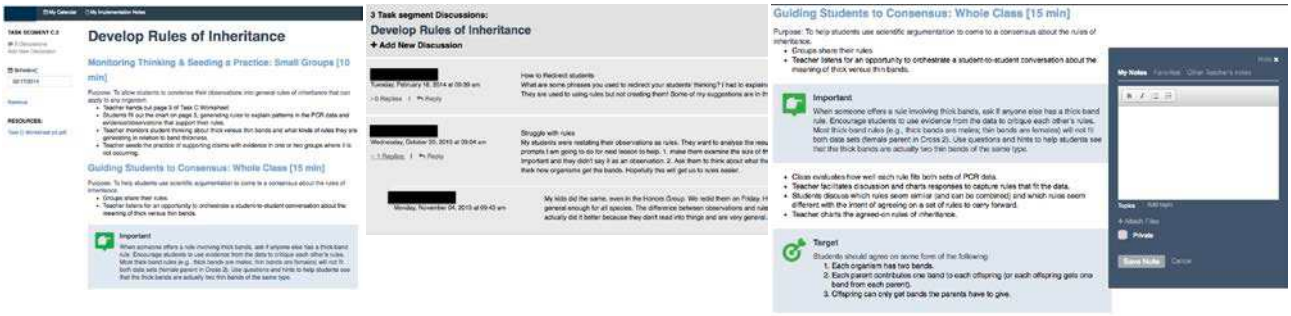

Figure 1. iPlan: Micro view, discussion space, implementation notes (from left to right).

Data analysis and preliminary findings

Teachers were interviewed just after their implementation of the curriculum. Questions targeted the ways in which iPlan supported teachers' implementation of the curriculum. For example, one of the questions was: *Were there particular sections of the iPlan tool that helped you to understand not only what we wanted you to do but also the reason for why we recommended you to do certain things?* We analyzed the interviews to find patterns in the aspects of the educative curriculum features that were (or not) found to be helpful by the teachers, the ways in which they used collaborative aspects of the curriculum materials, and why. Therefore, in our analysis our purpose was not only to identify what works but also why.

The analysis from the first round of data collection informed the revisions in the iPlan tool, which were quickly implemented before the second round of implementation/data collection with the second set of biology teachers (a given teacher covers this topic only once a year). In the first round, teachers were satisfied with having access to the curriculum materials online because they liked having everything organized in one place and easy to access from everywhere. They did not find the interactive features as useful. Some of their challenges informed the redesign (e.g., difficult to find earlier posts; not located in a visible space on the page). However, some of the reasons for not using these features were related to their issues of their current constraints (e.g., finding the time to write implementation notes).

The second-round interviews have already revealed that most of the teachers found the detailed guidance with designer intent information to be helpful. While some teachers found it helpful to read implementation notes posted by other teachers in the online platform, some stated that they did not find other teachers' implementation notes as useful since other teachers' classroom context seemed to be different than their own classroom context and student composition. Some of the teachers also expressed hesitation about posting in an online platform. These (preliminary) analyses have begun to reveal that teachers did not see the benefit or necessity of collaborating with other teachers virtually. Future analysis will examine the patterns for the reasons for why teachers did not choose to use interactive features of iPlan as intended by the designers.

Discussion

Given the recent ambitious instructional reforms and the scale of the need to successfully implement these reforms, designs for teacher learning that can reach out to more teachers in meaningful ways have gained more importance. Curriculum is often seen as a tool to influence practice on a large scale. Similarly, there has been a growing attention to online learning environments. In this study, we combined these features for teachers' learning within a new tool, iPlan. This study will reveal key and effective design features of on an online platform that supports enactment of NGSS-aligned curriculum materials.

Evidence base on the online programs designed to support teacher learning is not very robust (National Academy of Sciences, 2015). Moon and colleagues stated (2014), "as a field, we know little about how these web-enabled and social media capacities interact with teacher learning ... By connecting particular design elements to the theoretical basis for the design and to a set of research questions about that design, the important work of theory building for online PD, indeed PD more generally, can proceed." (p. 175) Addressing this call, this study has the potential to contribute the knowledge base on teachers' learning in online environments.

References

Ball, D. L., & Cohen, D. K. (1996). Reform by the book: What is or might be the role of curriculum materials in teacher learning and instructional reform? *Educational Researcher*, *25*(9), 6–14.

Beyer, C. J., Delgado, C., Davis, E. A., & Krajcik, J. (2009). Investigating teacher learning supports in high school biology curricular programs to inform the design of educative curriculum materials. *Journal of Research in Science Teaching*, *46*(9), 977–998.

Brown, M., & Edelson, D. (2003). *Teaching as design: Can we better understand the ways in which teachers use materials so we can better design materials to support their changes in practice.* (Design Brief). Evanston, IL: Center for Learning Technologies in Urban Schools.

Davis, E. A., & Krajcik, J. S. (2005). Designing educative curriculum materials to promote teacher learning. *Educational Researcher*, *34*(3), 3.

Forbes, C. T., & Davis, E. A. (2007). *Beginning elementary teachers' learning through the use of science curriculum materials: A longitudinal study.* In Annual Meeting of the National Association of Research in Science Teaching, New Orleans, LA.

Moon, J., Passmore, C., Reiser, B. J., & Michaels, S. (2014). Beyond comparisons of online versus face-to-face PD: Commentary in response to Fishman et al.,"Comparing the impact of online and face-to-face professional development in the context of curriculum implementation". *Journal of Teacher Education*, *65*(2), 172-176.

National Academies of Sciences, Engineering, and Medicine. (2015). *Science teachers learning: Enhancing opportunities, creating supportive contexts.* Committee on Strengthening Science Education through a Teacher Learning Continuum. Board on Science Education and Teacher Advisory Council, Division of Behavioral and Social Science and Education. Washington, DC: The National Academies Press.

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press.

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

Remillard, J. T. (2000). Can curriculum materials support teachers' learning? Two fourth-grade teachers' use of a new mathematics text. *The Elementary School Journal*, *100*(4), 331–350.

Schneider, R. M., Krajcik, J., & Blumenfeld, P. (2005). Enacting reform-based science materials: The range of teacher enactments in reform classrooms. *Journal of Research in Science Teaching*, *42*(3), 283-312.

Schuchardt, A. M., & Schunn, C. D. (2016). Modeling scientific processes with mathematics equations enhances student qualitative conceptual understanding and quantitative problem solving. *Science Education*, *100*(2), 290-320.

Schuchardt, A. M., Tekkumru-Kisa, M., Schunn, C. D., Stein, M. K., & Reynolds, B. (2017). How much professional development is needed with educative curriculum materials? It depends upon the intended student learning outcomes. *Science Education, 101*(6), 1015-1033.

Stein, M. K., Remillard, J., & Smith, M. S. (2007). *How curriculum influences student learning. Second Handbook of Research on Mathematics Teaching and Learning*, *1*, 319–369.

The Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher*, 5-8.