DynaLogue: Teacher Candidates Collaborating to Learn and Teach Proportional Reasoning

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Abstract: DynaLab is an interactive, Web-based resource for teacher educators to use with beginning teachers, helping them learn to teach mathematical reasoning. This demonstration focuses on one aspect of this hands-on curriculum, DynaLogue. Participants will collaborate to compose simulated dialogues between a hypothetical student and teacher, including a whiteboard to draw and write visual representations. They will discuss and share their ideas for how to understand student thinking around a proportional reasoning problem, thus building a repertoire of explanations and broadening their knowledge of how to teach complex mathematical ideas.

Purpose

DynaLab is an interactive, Web-based curriculum for teacher learning. Teacher candidates use this hands-on curriculum when taking courses needed to complete their training as teachers. (Hereafter, we use the term “candidates” for university students who are preparing to be certified as a K-12 teacher). The purpose of DynaLab is to help candidates learn more about how to develop students’ mathematical reasoning, and particularly, their proportional reasoning. In service of this purpose, the DynaLab exploits capabilities that are unique to the digital medium.

Instead of the traditional chapter structure of a textbook, the DynaLab is organized in a five by three matrix (see Figure 1) covering three proportional reasoning domains (ratio, geometric similarity, and linear functions), and offering three opportunities for engaging with each domain (interactive lessons with dynamic representations, video cases of students reasoning through problems, and context-rich problems to try themselves). This feature enables university instructors to customize the use of DynaLab.

Within each category, DynaLab includes dynamic learning tools to engage candidates in collaborative learning. One tool focuses on candidates’ learning of mathematics content. An individual candidate often has difficulty thinking of more than one way to solve a mathematics problem. However, a classroom of candidates often comes up with many strategies. The multiple modes of responses and “shared work” tool allows each candidate to use multiple representations to share their solutions: text, drawings, uploaded photos, recorded audio, and their demonstrations with interactive tools. These varying solutions can then be compared by the instructor in a shared workspace, which can lead to very good discussions among future teachers – how can teachers avoid the misconception that there is only “one right way” to solve a math problem and instead make sense of varying strategies?

Another tool, called DynaLogue, enables candidates to write simple dialogues in which they envision how a teacher and a student would interact so that the student’s mathematics reasoning becomes stronger (see Figure 2). The dialogues are synchronized with a whiteboard between the virtual participants, because mathematical reasoning often involves drawing and gestures linked with talk. Collaboratively writing DynaLogues is a powerful activity in which candidates can share their mathematical thinking, practice pedagogical ideas, and engage in constructive criticism.

Overall, the tools within DynaLab are designed to help candidates make judgments about students’ proportional reasoning and how to work with students to improve this reasoning. This requires building teacher candidates’ pedagogical content knowledge (Shulman, 1987) in proportional reasoning, increasing their confidence about how to teach these concepts, growing their appreciation for mathematical reasoning, leading them to use precise language when explaining concepts to students, and helping them to build on what students do.

Theoretical Frame

The DynaLab project helps teacher candidates make judgments about student’s ideas of proportional reasoning and how to work with students to clarify and correct them. The DynaLogue tool was designed under the two theoretical frameworks of Universal Design for Learning (UDL; Rose & Meyer, 2006) and Technological Pedagogical and Content Knowledge (TPACK; Mishra & Koehler, 2006). UDL is a set of principles that consider alternative ways for students to engage with curriculum, to learn through multiple representations, and to demonstrate what they know. DynaLab explicitly teaches the principles of UDL and also incorporates them into the design. For example, DynaLab uses multi-modal response spaces where candidates can type, use digital interactive manipulatives, draw, record, or upload a response. One such manipulative is a ratio bar visualizer. Candidates can represent a ratio in red parts to blue parts and then split the display to see if another ratio is equivalent.

Shulman (1987) defined pedagogical content knowledge as the professional understanding of teaching, or "how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (p. 8). TPACK is an extension of Shulman's (1987) conceptualization of pedagogical content knowledge, combining technological advances with knowledge required to teach specific content (see Mishra & Koehler, 2006). Candidates build a deep understanding of how to teach proportional reasoning by incorporating technology into building their own knowledge. They create digital representations and model pedagogy by creating DynaLogues to teach challenging content to a hypothetical student who harbors deep misconceptions.

Contribution

A globally important transition from print to electronic textbooks is occurring. This demonstration contributes by showing one way to re-imagine the role of the textbook in a particular context – the teacher education context. We will demonstrate a resource that started with the concept of an "electronic textbook" for teacher education courses but became an interactive environment where teachers collaborate to increase their math knowledge, to develop their strategies for working with students, and to become familiar with constructivist technology for learning mathematics.

Further, this demonstration closely aligns with the theme of the conference, learning across space, time, and scale. DynaLab and its many components, including DynaLogue, create opportunities through innovative technology to spark dialogical learning across three levels: (a) teacher educators, (b) teacher candidates, and (c) their students.

Empirical Support

DynaLab development involved collaboration among researchers at SRI International, UDL designers at CAST, special education teacher educators at San Francisco State University, mathematical teacher educators at San Diego State University, and project evaluators at Inverness. They used a design research approach to collaborate and develop progressively more interactive, collaborative iterations of this resource.

Design Research

Schoenfeld (2006) presented several definitions for design research. He acknowledged that design experiments manipulate multiple dependent variables "in the messy situations that characterize real life learning" with flexible design revisions (p. 200). During this project, data collection has been ongoing during the three years of developing DynaLabs. For example, at San Francisco State University, researchers have been designing lessons using DynaLabs during a student teaching seminar offered every semester. They presented DynaLab versions to one or two classes each semester and collected data from surveys, assessments of pedagogical content knowledge, video observations, and lesson plans written by teachers after DynaLab lessons. At the end of its development, data will be reevaluated systematically in a retrospective analysis and serve to build a set of claims into a coherent theory. Through the design process, DynaLab was changed from a text-heavy, linear website to an interactive, content-rich resource that includes collaborative discussions of different ways of thinking about proportional reasoning.

Findings

Findings from two pilots at San Francisco State University and San Diego State University will be discussed next.

Study 1

DynaLabs was presented to 17 special education teacher candidates during two, three-hour lessons at San Francisco State University. Participants in these lessons significantly improved their scores on a measure of pedagogical content knowledge, $t(16) = 2.72$, $p < .05$, with a moderate effect size (Cohen's $d = .44$). However, overall scores at pretest were 10.65 ($SD = 6.21$) or 34% correct and posttest ($M = 13.12$, $SD = 4.95$), or 42%.

Surveys indicated that the class activities were engaging (particularly creating teaching scripts, small group discussions, and problem solving). Candidates reported that they learned *some* or *a lot* about ratio (65%), UDL (55%), using technology for teaching (55%), student thinking (50%), and their own understanding (55%). Class observations suggested that videos of student thinking were particularly motivating and anchoring. By the final class, candidates were observed to engage in extended discussions about mathematical reasoning. These analyses revealed that

- DynaLab's usefulness in preservice education relies on the ease of expressing mathematical thinking and reflections in DynaLab. DynaLab uses short videos and tutorial scripts to *dramatize the practices of mathematical thinking* in ways that are directly relevant to how middle school teachers interact with middle school students and provides dynamic representations to exemplify how technology can support deeper mathematical thinking.
- Although these dramatizations can be somewhat idealized, it is critical that preservice candidates can *suspend belief* and treat the expression of mathematical thinking in DynaLab as exactly what they might with real students because this both generates a high level of engagement and creates the potential for usable mathematical knowledge for teaching.

Study 2

At San Diego State University, various tools within the DynaLabs including the DynaLogue activity were enacted with two sets of preservice teacher candidates who wanted to specialize in middle school mathematics. Analyses of the resulting DynaLogue videos focused on documenting the degree to which this could be used as a tool to reveal prospective teachers' understandings of the (then new) Common Core State Standards and the eight associated Mathematical Practices. These analyses revealed, among other findings, that

- Pre-service teachers were most comfortable identifying and creating scenarios that demonstrate Math practice 1: (Make sense of problems). They were less comfortable with practices 4&5 (Modeling and Tool use). This indicates a critical deficit that we are planning to address in the next iteration of DynaLab tools.
- Use of DynaLogues made Preservice teachers' beliefs about teaching more explicit objects of study. As the students engaged in a *create-share-refine* cycle, they become more comfortable observing others' videos and offering supportive feedback. In this way, they became better skilled at identifying and enacting the various mathematical practices. Reflections on the activity revealed that these teacher candidates felt more prepared to support and predict their future students' discoveries, engage their future students in productive mathematical ways of thinking, and see teaching as an ongoing, multi-faceted process *open to peer review* rather than a private series of unrelated "single shot" lessons that are presented without connections.

Structure of Demonstration

In this demonstration, we will invite attendees to take the role of a candidate who is attending a university course in order to learn how to become a better mathematics teacher.

Simulated Teacher Education Experience

Attendees will experience a simulation of the university courses we have conduct with DynaLab, and will participate using their own laptop. First, they will work in teams to express creative strategies to solving a ratio problem and will be encouraged to describe their solution with multiple representations. They will post these responses to a shared workspace that anonymously showcases each team's contribution. These solutions will spark a discussion with all participants imagining and describing the thinking behind each response. This discussion emphasizes multiple solution pathways and the importance of understanding proportional reasoning conceptually and not relying on a memorized algorithm. After this discussion, participants will watch a video describing levels in proportional reasoning understanding, (a) illogical, (b) additive, (c) transitional, (d) ratio (Khoury, 2002). Then, attendees will watch a short video of a student incorrectly solving this same problem and discuss the student's thinking and stage of understanding proportional reasoning. They will write a script that addresses that student's misconceptions using DynaLogue. Participants will watch each other's DynaLogues and discuss the effectiveness of the hypothetical teacher's approach to working with the student in the video. At the end of these experiences, we will have a general conversation about the potential implications of DynaLab and similar resources to transform teacher training.

Participant Outcomes and Implications

By actively participating in a dynamic learning environment, participants are expected to more deeply understand mathematical content and students' thinking. Discussions act as a model for how to organize lessons around mathematical practice standards found in the Common Core State Standards in Mathematics (2010). It is our hope that participants will begin to value understanding and discussion over just helping students arrive at the correct answer.

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Appendix

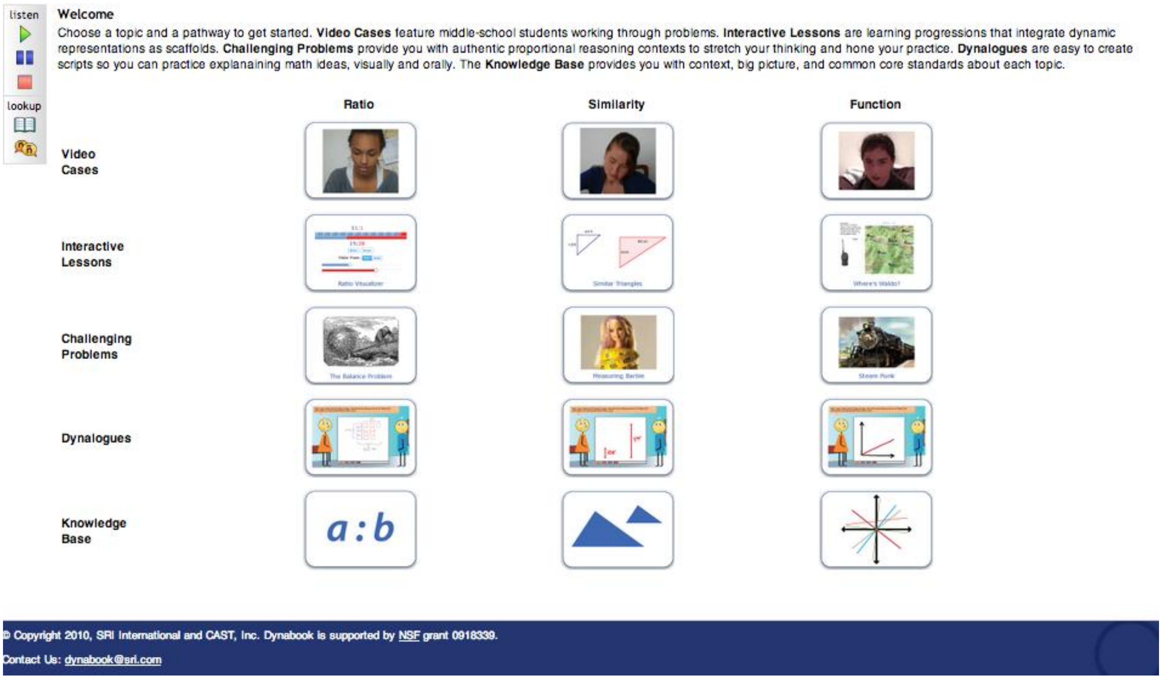

Figure 1. A screenshot of the five by three matrix on the DynaLab home page.

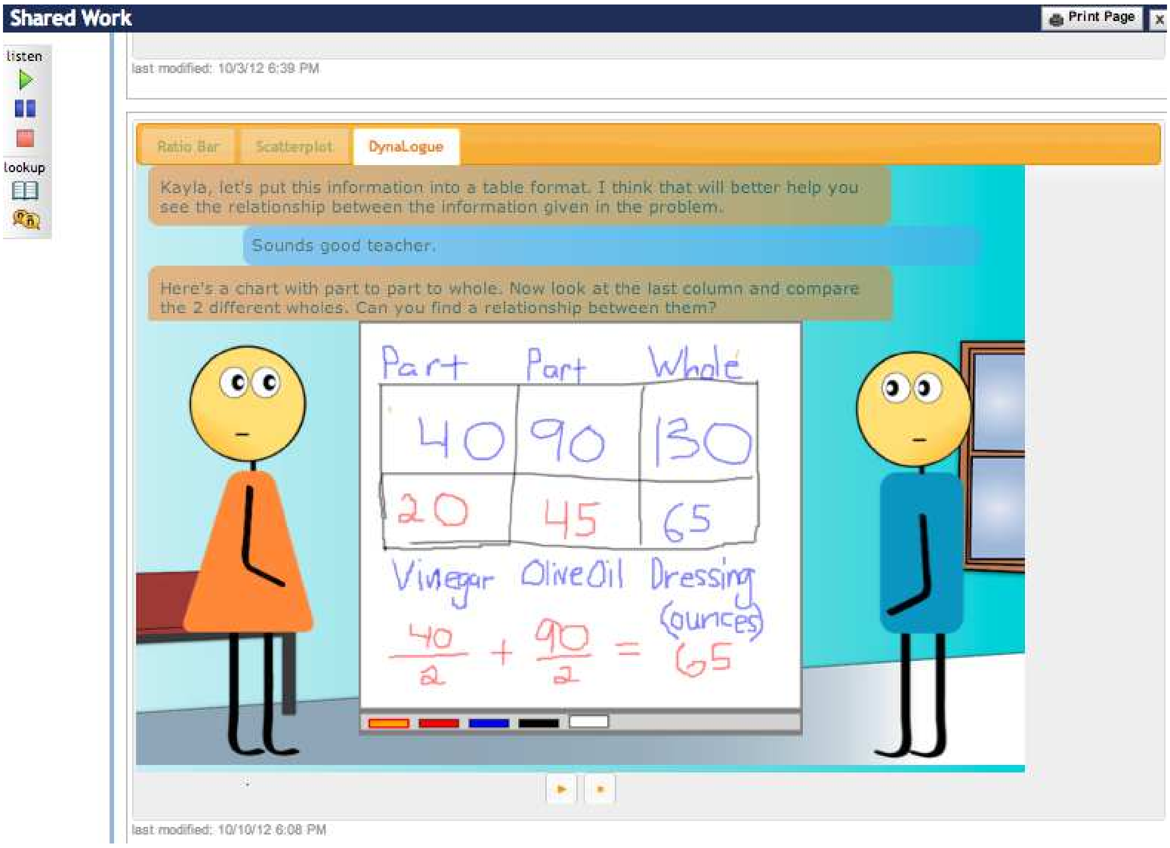

Figure 2. Screenshot of a sample DynaLogue.