Designing for Effective Collaborative Learning in High-Needs Rural Classrooms

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Abstract: Orchestrating collaborative meaning making in classrooms can present a significant challenge to teachers, in particular, for teachers in under-resourced middle schools in rural areas. This paper reports on issues that arose during a prototype implementation of a biology curriculum for middle school students, which resulted the design of collaborative scripts supported by technology that aid teachers in advancing student thinking.

Keywords: collaboration, technology, classroom orchestration, macro- & micro-scripting

Introduction

The context of our research is Biosphere, a federally funded Design-Based Research (DBR) project that is a collaborative effort between the University of Wisconsin at Madison and the University of North Carolina at Chapel Hill. We are developing an inquiry biology curriculum that focuses on local sustainability issues and is suitable for under-resourced middle schools in rural areas within the United States. Our work is grounded in foundational research on collaborative meaning making, which has shown that technology-mediated building and sharing of collaborative knowledge advances both group and individual development (Scardamalia & Bereiter, 2014). However, productive technology-infused collaborative learning environments cannot happen without proper design and support (Kaendler, et al., 2014; King, 1997).

Orchestrating collaborative meaning making in classrooms can present a significant challenge for even the most experienced teachers. Orchestration of collaborative learning in classrooms has been conceptualized in terms of macro-scripts and micro-scripts (Kaendler et al., 2014; King, 1997). *Macro-scripts* are specific activity plans for teachers and students, designed in accordance with research and theory, which help ensure productive collaborative interactions (Kaendler et al., 2014). *Micro-scripts*, in contrast, are small repeatable routines that represent possible just-in-time principled pedagogical interventions that a teacher can use in situations where students need additional guidance for collaborative learning. Kaendler et al. (2014) examined the nature of effective macro- and micro-scripting in classroom settings and conceptualized the teacher competencies necessary for effective collaborative learning as including these scripting skills.

The Kaendler et al. model, while providing useful inspiration for our work, assumes developing high levels of teacher competence and significant planning and reflection time for implementation. These requirements are not easily met at our research site, a rural, under-resourced middle school. As is typical in many under-resourced schools, our site school has rates of teacher turnover and levels of uncertified or under certified teaching staff. Therefore, our challenge is to shift the major scripting demands put forth in the work of Kaendler et al. (2014) away from teachers and onto the curriculum itself, thus reducing the teachers' "orchestration load" (Dillenbourg, 2013). The design solutions we are exploring necessarily rely on technologies that are accessible, affordable, and usable to help even underprepared teachers orchestrate technology-mediated collaborative learning and teaching in high-needs rural schools. This is a substantial challenge and the theoretical contributions of our work pertain to adapting previous work on scripting and orchestration of collaborative learning for high-needs contexts.

Theoretical framework

Collaborative script theory provides a useful framework for the evaluation and design of collaborative learning environments (Fischer et al., 2013; Kaendler et al., 2014). Fischer and colleagues propose seven principles of their script theory. For example, the sixth principle based in Vygotsky's (1978) zone of proximal development states that external scripts can allow learners to engage in collaborative learning at a level beyond what they are able to successfully accomplish on their own in the beginning of a collaborative process. External collaborative scripts are gradually faded to foster development of student internal collaborative scripts (Fischer et al., 2013).

Knowledge Building as conceptualized by Scardamalia & Bereiter (2014) provides additional theoretical inspiration for conceptualizing our technology-based design solutions in which small group knowledge is disseminated among the class using a platform conducive of open sharing of content information. This theory disseminated among the class using a platform conducive of open sharing of content information. This theory argues that technology-mediated building and sharing of collaborative knowledge advances both group and individual development (Scardamalia & Bereiter, 2014).

Methods

Our over-arching method was *Design Based Research* (DBR), an iterative process that incorporates cycles of data collection, analysis and reflection to inform design of educational innovations and develop theory (McKenney & Reeves, 2012; Easterday et al., 2014). The Easterday et al. model has six iterative phases: Focus, Understand, Define, Conceive, Build, and Test. The research reported here is based on data obtained from implementing a prototype of Unit 1 in the Biosphere curriculum, which will have three units. In Unit 1 students design a composting bioreactor to anchor science inquiry. Although we followed all the six stages of DBR within this prototype study, this study was our first experience with the school and population and thus represented the early Focus through Conceive phases in relation to the larger, multi-year DBR project. This prototype study informed design of the version of Unit 1 now being implemented in classrooms. The study also served as a baseline since the curriculum at this stage provided minimal scripting and orchestration, allowing us to judge baseline capabilities of teachers and students.

Data were collected during Biosphere Institute (BI), an 8-day after school program with two follow-up summer sessions. The participating school was a STEM middle school in a rural and economically disadvantaged county in the Southeast staffed largely by teachers with alternative training such as Teach for America. The school purports to focus on project-based learning and the principal believed that teachers and students were experienced with collaborative learning. Student volunteers were solicited through letters sent to parents by the principal. Eighteen students agreed to participate. Participants were racially diverse and included students from grades 6-8.

The BI took place mostly in a large science classroom. During seatwork students were grouped by grade level (6-8) around rectangular tables, although projects took them into other parts of the school grounds. Each day students engaged in a collaborative task with their small groups, but recorded reflections and results on personal iPads that contained curriculum materials, which prompted students to answer specific questions about their inquiries. Examples of small group inquiry activities in Unit 1 of the Biosphere curriculum include collecting evidence about the school environment, conducting inquiries into how much trash the school creates, designing a composting bioreactor, and creating a composting plan for the school. The learning goals include development of complex biology knowledge related to energy cycles.

The primary analytic method was video recording and analysis following guidelines for video research in the learning sciences (Derry et al., 2010). Each student group was video recorded with a researcher taking field notes. A camera in the corner of the room recorded whole class activities and the instructor.

Data from the 6th and 8th grade groups were analyzed to afford contrasting cases of how the curriculum worked at two different developmental levels. Two researchers repeatedly reviewed the 6th and 8th grade videos. From these viewings researchers compiled 90 minutes of clip samples that ranged from 10-15 minutes in length and enabled study of group behaviors during collaborative tasks. These selections were transcribed and examined in depth through a process that involved repeated interaction analysis of discourse (IA; Jordan and Henderson, 1995) by the authors. Recordings of the IA sessions and session notes were analyzed in accordance with conversation analysis conventions with no coding applied.

Summary of main findings

Video analyses of the prototype implementation uncovered numerous problems we could address with improved macro- and micro-scripting. The issues students experienced in small group learning included:

- Frequent off-task behavior and argument digressions.
- Failure to transfer individual ideas expressed on iPads to group collaborative thinking.
- Focus on individual technology that hindered group collaboration.
- Extensive overlapping talk and significant difficulty sharing and exchanging ideas in ways that included all voices.
- Focus on task completion at the expense of deep thinking.
- Failure to utilize argumentation scripts for target content, despite evidence of internal argumentation scripts.

Concurrently, we observed that teachers experienced the following in orchestrating and facilitating student groups:

- Missed opportunities for supporting and interrogating student thinking.

- Inability to scaffold student argumentation with science content.
- Failure to recognize all students' contributions.
- Focus on affective engagement rather than student thinking.
- Sub-optimal orchestration of classroom technology infrastructure.

Design of macro- and micro-scripting support

Based on the prototype study the design solution addressing these issues has four components: Macro-script for students, macro-scripts for teachers, micro-scripts for teachers, and technology support for collaborative orchestration.

Student macro-script

To assist students with group collaboration a Think, Collaborate, Share (TCS) script was designed into the curriculum materials and teacher guides to provide students with individual thinking time, time to share their ideas with their small group, and then an opportunity to discuss with the whole class. Additionally, collaborative roles such as *Scribe, Speaker,* and *Task Minder* were incorporated into curriculum and teacher materials.

Teacher macro-script

Teachers will be trained and curriculum materials will be structured to support the 3R orchestration cycle, a macro-script based on Fong et al.'s (2015) observations of experienced teachers orchestrating collaborative learning. The 3R orchestration cycle consists of teachers regularly calling a whole-class plenary session to Reflect (pause group work to study and evaluate what is going on), Refocus (redirecting work if necessary), and finally Release (return students to working collaboratively in groups). Teachers will enact the cycle multiple times during collaborative group work, using the technology system described below, to help them gain insight into and ability to interrogate and push student thinking.

Technology support for collaborative orchestration

The 3R cycle will be facilitated by technology through the use of Linoboard, a free collaborative tool where teachers can create space for students to share ideas. The Linoboard interface will be on the small group iPads as well as projected onto a screen that will facilitate whole class discussion. After students collaborate in their small group, the Scribe in each group will be responsible for constructing the group's note on the Linoboard platform. Once submitted, the note is shared with the whole class thus offering a space for knowledge distribution on the class level. Students can view all submissions via their iPad or the projection on the larger class screen. The teacher can use this technology feature to highlight group ideas and have the Sharer respond and Reflect upon the work that has been completed. The Linoboard interface provides teachers a platform to Refocus student thinking before Releasing them to edit and refine their thinking. Once released students will use the Linoboard feature that allows them edit their previously made note to incorporate new ideas from the Reflect phase of the 3R cycle. The collaborative space also serves as a platform for teachers to view all group work and indicates which groups need micro-scripting for further refinement of ideas.

Teacher micro-scripts

Teachers will be trained when and how to use several micro-scripts designed to address specific student issues observed in our study. Curricular materials designed for the teacher will provide suggestions and reminders for when they should be used. An example of one micro-script is re-voicing (Alozie, Moje, & Krajcik, 2010), which can be implemented during the Reflect phase of the 3R cycle. Re-voicing is a technique for facilitating collaboration by reflecting back and restating the contributions of students in order to clarify and draw attention to specific ideas. The teacher can use re-voicing to highlight student contributions and to aid in Refocusing the class or individual groups. Other micro-scripts will require teachers to be vigilant for certain thinking issues, such as evidence of common misconceptions related to understanding ecosystems and energy cycles or for evidence of argument digressions. Materials and training will supply micro-scripts for particular problems that are expected to occur.

Concluding comments and next steps

The problem we address is how to orchestrate effective collaborative science learning in under-resourced rural schools characterized by high-needs students, high teacher turnover, and a high percentage of under-prepared teachers. We make use of theories and research on collaborative learning from The Learning Sciences to create educative curriculum materials designed to support orchestration of effective collaborative learning through the coordinated use of macro-scripts for students, macro-scripts and micro-scripts for teachers, and supportive collaborative technologies for students and teachers. Our design challenge is to discover ways to embed these within student and teacher curricular materials so that, as a coordinated system, they will function effectively as scaffolding that might be faded over time, building on and enhancing both the collaborative scripts of students, and the orchestration capabilities of teachers. An added dimension of our challenge is our choice to rely on technologies, that are accessible, affordable and usable. An example is the sharing platform, Linoboard, which is free, web-based, and allows many different devices to use it simultaneously to create a seamless, collaborative, knowledge building-learning environment. Important research questions for our work include understanding the extent to which effective collaborative knowledge building can be supported and acquired through curricular design inspired by research and theories from The Learning Sciences but that does not depend on long-term development of skilled teachers. We also seek to understand how these theories must be modified in service to this population. Our next curricular implementation that includes design changes described in this contribution will help shed light on these questions as we examine the evidence on whether our designs have the intended impacts on students' and teachers' collaborative knowledge building processes.

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