The 15th International Congress on Mathematical Education
Sydney, 7-14 July, 2024

EXPANSIVE FRAMING OF MATHEMATICS AND COMPUTER SCIENCE: SUPPORTING EDUCATORS IN CROSS-CURRICULAR TEACHING

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Expansive Framing (EF) is a theory to explain transfer of learning and an instructional technique to facilitate transfer. We employed EF as an approach to create a series of integrated mathematics-computer science (CS) lesson plans and studied their implementation by teachers in two fifth-grade classrooms and a paraprofessional in one Computer Lab classroom. We used deductive theoretical qualitative analysis of transcripts of classroom implementations to investigate how educators used EF in their lessons. Findings suggested that educators most effectively engaged in EF principles when they were present in curricular materials. We recommend that mathematics-CS integrated curricular materials include framing language and other supports that make unambiguous, explicit connections across learning contexts to support educators in helping students engage in productive transfer between mathematics and computer science.

INTRODUCTION

The theory of Expansive Framing (EF) characterizes learning as a series of interrelated, overlapping ideas and provides a way to conceptualize transfer between contexts (Engle et al., 2012). When content is framed expansively – across contexts, spaces, and times – learners may be better able to make broad connections to other ideas and ultimately transfer that content across disciplines or outside of the classroom, which are important pedagogical goals (Engle, 2006). We used EF as a design approach to develop several mathematics-computer science (CS) integrated lessons for upper elementary students. The aim of this approach was to support educators' enactment of this integrated curriculum to help foster students' connections across mathematics and CS (Beck et al., 2024).

This paper explores how two fifth-grade teachers and one computer lab paraprofessional enacted the expansively-framed mathematics-CS curriculum. We are interested in investigating to what extent expansively framed content and context in the lessons are carried over into instruction. Our inquiry was guided by two questions: In what ways is EF evident in the educators' implementation of lessons? What does this EF integration model look like in practice?

Our research highlights Theme 3 of this Topic Study Group, namely the relationships among curriculum development, teachers, and teaching. We believe that the inclusion of a paraprofessional educator and teachers on a *Design Team* (see Methods) and the focus on *framing* as a model of integrated curriculum provide unique contributions to the mathematics curriculum discussion.

LITERATURE REVIEW

Transfer is an individual's ability to abstract content learned in one context and apply it to another. Transfer has been extensively studied for over a century (Barnett & Ceci, 2002), yet much debate remains around how to define, facilitate, and measure transfer (Roberts et al., 2007). EF (Engle et al., 2006, 2011, 2012) reconceptualizes transfer by focusing on how content is framed across contexts. As an instructional approach, EF encourages educators to help students draw upon their existing knowledge and make explicit connections between the present learning environment and other times, places, groups of people, and topics (Lam et al., 2014). The theory also frames students as owners and authors of their own knowledge, placing the onus on the learner to create and own their ideas and to adapt existing knowledge to a new context more readily (Engle et al., 2012). Framing broadly across contexts can help students create intercontextuality, which is when multiple contextual frameworks become linked (Engle, 2006). Research suggests that creating intercontextuality through EF is effective in facilitating transfer across contexts (Engle et al., 2011). In the present study, we employed EF as an approach to design integrated, cross-contextual mathematics-CS lessons.

METHODS

This study used deductive theoretical analysis (Percy et al., 2015) of qualitative data to answer the research questions. The data in this study are part of a larger project aimed at supporting teachers and paraprofessional educators in rural schools in the United States to provide effective and equitable computer science (CS) education to all elementary students in the district (Shehzad et al., 2023).

Design Team and Materials

A Design Team comprised of fifth-grade teachers, paraprofessional educators who teach CS in the computer labs, district specialists, and university researchers, created the integrated, cross-contextual mathematics-CS lessons for the research study. The lesson materials are designed for two different classrooms spaces: the mathematics classroom, led by elementary teachers, and a Computer Lab classroom, led by a Computer Lab paraprofessional educator.

The Design Team worked to identify topics that either had inherent cross-contextual features (e.g., conditionals in math and CS) or that students typically struggled with (e.g., multiplication of fractions), and created three units linking computer coding ideas such as repeats and conditionals with mathematics concepts such as exponents, fractions, and geometry. Using EF as a guide in writing lesson plans, we wrote clear connections across contexts in teacher statements, created computer coding visualizations to be used during mathematics lessons, and used mathematics content as the basis of Computer Lab lessons on coding. For example, we used the CS concept of conditionals in the mathematics classroom when students were tasked with classifying quadrilaterals using if, then, else statements.

Participants

The participants in this study are two fifth-grade teachers and one Computer Lab paraprofessional educator in the same school in a rural area of the western United States.

Data Sources and Analysis

The data sources for this study include transcripts of educators' implementation of two units of study: exponents/repeats and geometry/conditionals. We recorded the educators' implementation of the exponents/repeats unit (4 math lessons, 1 computer lab lesson) and geometry/conditionals unit (5 math lessons, 1 computer lab lesson). In total, 7 hours of audio were transcribed for analysis. We enacted a multi-stage deductive theoretical analysis (Percy et al., 2015) and used MAXQDA 2020 (VERBI

Software, 2021) to organize the coding of the transcripts. First, we coded the transcripts using a researcher-developed a priori code book based on Lam et al.'s (2014) codes of time, place, role, participant, and topics. We coded transcripts line-by-line and aligned specific text segments with the code's definitions. We then conducted additional rounds of coding and collapsed initial codes until broader themes emerged.

RESULTS

In this paper we provide examples of three emergent themes, all of which led us to conclude that the use of framing in curriculum materials is a promising model for curriculum integration that supports teachers' connections across content and contexts in their instruction.

Purposeful framing of content in curricula was used in instruction

Expansive framing of content was intentionally incorporated in the lesson plans. The Computer Lab lessons included mathematics topics as a basis for coding and the mathematics lessons referenced computer coding concepts throughout. Lesson supports such as coding visualizations in the mathematics classroom and a math terms glossary in the computer lab helped facilitate framing of topics across contexts. Our analysis of the lessons found that educators' references to other content areas were primarily rooted in the lesson plans. For example, framing of content occurred frequently in the introduction and conclusion to lessons in statements such as, "You were able to visualize a shape using the ordered pairs as vertices. You will use what you know about ordered pairs and the attributes of shapes to create a quiz in the computer lab using Scratch programming." Educators used these statements from the materials to frame across content areas.

Spontaneous contextual connections happened but often remained school-based

Beyond the lesson plans, educators made expansive connections to each other (e.g., teachers to Computer Lab paraprofessional), who were also using the integrated curriculum. However, learning experiences were primarily framed as happening within a bounded place and time. While teachers occasionally referred to another location (such as the computer lab or math class), locations outside of the school context were rarely mentioned. Teachers often made connections to the recent past while activating background knowledge (for example, "Remember clear back to [when] we talked about that multiplication is a way to more effectively write repeated addition?") yet there were no connections made to the future (for example, noting ways the content would reappear in future settings inside and outside of school).

Promoting student authorship goes beyond lesson plans

The mathematics classroom lessons planned for discussion among students using routines such as think-pair-share, while the computer lab lessons did not have the same kinds of authorship activities. Hence, the classroom teachers frequently framed students as authors of their own knowledge, while the activities in the computer lab were much more individually completed. The teachers often cast students as the experts and credited them for their knowledge. For example, a teacher presented a problem and remarked on a student's unique solution: "I have looked at this [problem] many times and that is the first time I'm seeing what you're saying." Here the teacher credited her student as the knowledge creator, rather than framing herself as the owner of the knowledge. Engle et al. (2012)

asserted that this is a vital component of EF because it encourages students to apply background knowledge more effectively and holds students accountable for knowing and expanding the content.

DISCUSSION AND RECOMMENDATIONS

Our analysis provides evidence that teachers were able to effectively use lesson plans and supports to frame across content areas, suggesting that teachers and paraprofessionals understand how to design and adapt their lessons to include EF. While educators also made contextual connections beyond the lesson plans, these connections were primarily school based. Teachers also framed students as authors and owners of their learning. These findings support the potential of EF as a promising approach to integrated curricula. We recommend that mathematics-CS curricular materials include teacher supports such as EF language to illustrate broad framing and classroom tools like digital visualizations that overlap content areas. These purposeful supports will help students engage in productive transfer between contexts. This research continues to evolve, and an expanded paper is forthcoming, which will discuss potential scalability and sustainability.

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