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Factors That Impact the Implementation of a Game Based Curriculum and Adaptations Teachers Design to Address Them

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Abstract: Teachers play critical roles in both co-design processes and intervention studies, yet both approaches have distinct theoretical underpinnings that impact how teachers interact and what they contribute. In this paper, we analyze the co-design and implementation of an intervention called *Fraction Ball (FB)*, a game-based curriculum that teaches fractions and decimals to elementary students. We present preliminary analysis of the contributions from teachers who participated in the co-design or intervention study. We argue participating in different aspects of the project will illuminate different factors that might affect the implementation, and lead to different adaptations to address these factors. Teachers identified nine factors as influential in the implementation of *FB* across four levels, including school, teacher, students, and intervention levels. The findings demonstrate that teachers contribute differently based on their role in the project and has implications for how we co-design interventions and frame teachers' roles in the future.

Introduction

Teachers play critical roles in both co-design and intervention studies such as Randomized-Control Trials (RCT). In co-design, teachers and researchers engage in a collaborative process to develop curriculum that fit into the learning context and address their unique needs (Penuel et al., 2007). Such curricula can then be used as classroom intervention materials. In RCTs, teachers are positioned as participants that enact interventions designed by researchers and their collaborators. Co-design and RCT processes have different theoretical assumptions, affecting how they are typically developed and studied and teachers' roles within them. In our paper, we present a study that examined teachers' contributions in the co-design process and intervention study of *Fraction Ball (FB),* a game-based curriculum that teaches fractions and decimals to elementary schoolers (Bustamante, 2022). We co-designed the *FB* intervention with two schools and implemented an RCT with four different schools, all in the same school district. We describe the factors that teachers identified as important for the success of *FB* and discuss what they did or suggested to address them (i.e., adaptations).

Perspectives and theoretical framework

Traditional RCT studies prioritize fidelity, reflecting how researchers want participants to implement their interventions as designed with minimal deviation (Carroll et al., 2007). Yet, there is a growing movement to examine the adaptations that inevitably emerge when interventions are implemented (Durlak & DuPre, 2008). There is a long history of education research that observes that teachers, almost always, make modifications to new interventions in their classroom (Lipsky, 2010). Such adaptations have been shown to improve learning outcomes, as teachers typically make adaptations based on their experiences and knowledge of their students and learning environments (Durlak, 2010). Durlak and DuPre (2008) highlight the factors that often affect interventions including community factors, personnel characteristics, and innovation characteristics. These topics are often the focus of the co-design, wherein researchers begin by understanding the community context, the teachers' needs and the learning context to create innovative learning materials.

Scholars who study interventions argue that community participation in designing innovations can improve outcomes and inform fidelity and adaptations (Durlak & DuPre, 2008). Theoretically, co-design processes argue for the process of mutual adaptation from the beginning. Mutual adaptation is the process of researchers and stakeholders dynamically altering the intervention to improve and strengthen the innovation (Lotan et al., 1986). Co-design foregrounds mutual adaptations by asking teachers to engage in design with researchers while explicitly addressing their unique learning goals and context (Fishman et al., 2013; Penuel et al., 2014), whereas intervention studies prioritize mutual adaptation less often. Whether interacting in the co-

design process or intervention studies, teachers have different pedagogical preferences, organizational politics to navigate, along with classroom needs, values, and norms that affect how they design and implement curriculum.

In this paper, we present a preliminary analysis of the different contributions toward the *FB* intervention from teachers who participated in the co-design or the RCT. We argue that implementing an intervention compared to imagining what implementation might be like includes different assumptions and processes, therefore, leads to different factors that affect the implementation, and in turn, different adaptations to address them. We ask the questions, *what factors do teachers identify that might influence the implementation of FB* and *what adaptations do teachers create to address these factors?*

Methods

FB is a learning activity that utilizes a basketball court painted into equal segments to reinforce fraction and decimal learning (see Figure 1). The spatial layout of the court is designed to reinforce fraction magnitude understanding, and students' shots are translated into fraction and decimal points and tallied on a number line. Students work in groups to play a series of games shown to improve students' rational number understanding. This study was completed as part of a multi-year research-practice partnership with a public school district in a low-income, predominantly Latine community in Southern California. We worked with six elementary schools: two schools in the co-design ($N = 20$ teachers) and four different schools in the RCT ($N = 16$ teachers).

Figure 1

Left: FB court. Middle: Students keeping teams' score on the number line. Right: Students working on a collaborative classroom lesson.

We collected video data, observation notes, and artifacts during co-design sessions where the focus was to create classroom lessons for *FB*. We held five 90-minute co-design sessions, repeating the first twice and the second three times. In the first session, we play-tested an existing game and lesson and generated new lesson ideas. The second session consisted of a gallery walk of the lessons that teachers created, with small group work to iterate and develop a cohesive lesson.

We conducted an RCT with four schools and 16 teachers using the co-designed curricula as the intervention. Eight teachers taught *FB* and eight taught their class business-as-usual. Teachers were supplied with an activity guide, lesson scripts, slide decks, worksheets, and materials needed to facilitate the intervention that were developed through our co-design process. After the intervention, we recorded hour-long focus groups with the eight teachers who implemented *FB*. Control teachers were not interviewed.

To analyze the co-design and intervention data, we first conducted affinity diagramming (Hanington & Martin, 2012). We examined all data and pulled ideas and feedback into design ideas and inductively clustered data into themes. We analyzed 305 data points from the co-design sessions and 345 from the implementation. To achieve reliability, two researchers analyzed the co-design data, and three researchers analyzed the implementation data, negotiating themes and reviewing the data until consensus was reached. We then leveraged those themes to identify factors that impacted *FB*. Through an iterative process of clustering, three researchers synthesized findings into nine preliminary factors within four levels.

Findings

We identified nine factors, across four levels including school, teacher, students, and intervention levels (see table 1 for definitions and examples of adaptations that emerged). At the intervention level, teachers highlighted three factors – management and facilitation in the classroom and on the court and the sequence of the lessons. Teachers differentiated the classroom and court because the routines and materials are different working within the

boundaries of their classrooms compared to outside on the court. Student level factors included their prior knowledge around the math concepts and basketball, sense of belonging and representation, and inclusion. While much of the focus of the co-design and implementation was on the intervention and how it might support student learning, teachers described factors regarding their needs and the school logistics. At the teacher level, two factors emerged – community and support, and preparedness. Teachers emphasized that a teacher community was critical so they could collaborate and learn from each other and highlighted the need for materials to help them learn the games and implement *FB* with ease. Lastly, teachers called attention to the school factors, or contextual details at the schools that might affect *FB.* These factors varied from school to school but included booking courts, handling noise on the court, and managing schedules. In table 1 we describe examples of how teachers suggested or implemented adaptations to address these design factors. First, we note that not all factors had adaptations. For instance, making *FB* inclusive for all students, especially those with different learning abilities was a high priority for our co-design teachers, compared to our intervention teachers where it was not a focus. Similarly, students' sense of belonging was not a focus of our co-design sessions, however several teachers who implemented the intervention made it a priority in their classrooms.

Table 1
Factors teachers identified that might influence FB, and their adaptations to address them.

Level	***Factor***	**Definition:** Definition of factors	**Adaptations:** What teachers did or suggested to address these factors
Intervention	*Classroom management and facilitation*	The routines and materials needed for teachers to ensure the instruction is delivered in the classroom.	Co-design: Create scripts that are detailed but not overwhelming for classroom lessons. Intervention: Teacher consolidated a worksheet into one page to consolidate activity.
	Court management and facilitation	The routines and materials needed for teachers to ensure the instruction is delivered on the court.	Co-design: Adding a tracking sheet on the court so more students can document shots. Intervention: Teacher created a roles chart, so students know where to go.
	Sequencing	How concepts and aspects of *FB* are ordered.	Co-design: Front loading instructions about the game before moving to the outdoor court. Intervention: Finish intervention with games that are particularly fun.
Student	*Prior knowledge*	How students' background knowledge on math or basketball affects *FB*.	Co-design: Simpler activities for students who have less fraction knowledge. Intervention: Teacher connected past lessons with current lesson to build connections
	Student belonging and representation	Helping students see themselves in the curriculum and game play.	Co-design: N/A Intervention: Teacher built a bulletin board so kids could see themselves playing the game.
	Student inclusion	Sensitivity to students of all physical and learning abilities.	Co-design: Refashioning *FB* into Cornhole increases accessibility. Intervention: N/A
Teacher	*Teacher community & support*	Creating a community for teachers to support each other through *FB* implementation.	Co-design: PE teachers and math teachers need should be in close communication to make sure learning goals are aligned. *Intervention*: Call for conversations between teachers about their experiences with *FB*.
	Teacher preparedness	Training and readiness so that teachers are prepared and ready to deliver instruction	*Co-design*: Wanting digital worksheets so that there is no paper preparation. *Intervention*: Video of students playing FB to teach teachers.

School	*Logistics*	Fixed contextual details at the school level that affect the implementation of *FB*.	*Co-design*: Book courts in advance when space is limited, using megaphones to counter noise. *Intervention*: Rescheduling *FB* when it conflicts with a school-wide event.

Discussion and conclusion

Our study identified factors that affected the *FB* intervention from both co-design and RCT teachers' perspectives, and adaptations they suggested or implemented to address them. The high-level factors that emerged mirror findings from Durlak and DuPre (2008) regarding aspects that affect interventions (e.g., community, personnel, and intervention factors). The factors highlight elements that emerged for teachers, including potential tensions, areas for improvement, and sometimes fixed constraints at different levels. The adaptations that teachers made or suggested illuminate possible solutions to those factors, and ideas that make our intervention more usable and flexible in the classroom (Lortan et al., 1986). However, we also acknowledge that not all factors have adaptations to address them. Due to the theoretically different approaches to co-design and RCT studies (Durlak & DuPre, 2008), some teachers in the intervention felt constrained by the materials and that they could not make adaptations to the materials so as not to alter the research findings. As opposed to the co-design teachers, who were encouraged to make changes from the start. Additionally, because this is an innovative, game-based intervention that was new to teachers, coming up with adaptations can be challenging. Identifying the differences between teachers participating in the co-design or RCT informs how we might co-design interventions in the future, how we might frame teachers' roles differently to support adaptation and highlights the differences in contributions teachers make at different stages in the project. Our future work will apply this code book to the entirety of the dataset to explore the frequency of these factors, all adaptations that emerged to address them, and the differences between teachers' who engaged in the co-design and intervention.

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