

# Participatory Design of Game-Based Math Learning Platform: Teacher-Researcher Negotiation and Collaboration

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**Abstract:** Teachers' involvement legitimizes learning artifacts design, development, and implementation. We present a case study on the teacher-researcher participatory design of a game-based math learning platform. A thematic analysis with the empirical data from two teacher workshops indicated (1) problem spaces that frame participatory design; and (2) tool that supports sustainable participatory design of game tasks. We discussed suggestions for teacher-researcher participatory designs for DGBL.

## Introduction and theoretical background

The educational affordances of digital game-based learning environments (DGBL) had drawn much attention of educational researchers and practitioners. However, it is still a challenge to implement game-based learning in the classrooms. The design and implementation of game-based learning technologies cannot be successful without the involvement of teachers (Matuk et al., 2016). Research-practice partnerships, more specifically, teachers' participatory co-design with researchers should be emphasized in the process (Coburn & Penuel, 2016; Matuk et al., 2016). Teachers' participatory co-design for game-based learning is a bidirectional and reciprocal participation between researchers and practitioners. The aim is to design a more practicable learning environments and increase the scalability and sustainability of implementation (Coburn & Penuel, 2016). Participatory design engages multiple stakeholders in envisioning and prototyping of learning environments in creative design activities beyond decision-making; through positioning and situating stakeholders' rationale and input, the design can be enhanced (Bjögvinsson et al., 2012; Muller & Kuhn, 1993). In participatory design, teachers and researchers could bring different point of views. These exchanges of view, negotiation, and collaboration should be rooted in and focused on designing learning technologies to solve an educational problem with mutual agreement. Bjögvinsson et al. (2012) put it as *designing, staging, and infrastructuring* (p. 103). Both teachers and researchers gain legitimate participation, working on artifacts, and brainstorming about how to make the design artifacts more scalable and sustainable for use in the classrooms.

An increasing focus have been given to understanding participatory design research and partnerships between communities of researchers and practitioners (Coburn & Penuel, 2016; Matuk et al., 2016). However, there is still a gap in the literature regarding the landscape of the participatory design and "what happens" in the process despite an extensive advocacy. Thus, the following research question remains underexplored: *how do teachers and researchers negotiate and collaborate in the participatory design of a game-based math learning platform?*

## Method

We collected data from the teacher workshops conducted in the southeastern US for the purpose of designing an architectural game-based math learning platform called *E-Rebuild* (Ke et al., 2019) as well as exploring game-based pedagogies with teachers. We used two artifacts of *E-Rebuild*: the learning game *per se* and the level editor (for customizable level design with the teachers). The game was intended for middle school students. We invited 10 teachers from two schools to participate in both teacher workshops and the participatory design process (Muller & Kuhn, 1993; Bjögvinsson et al., 2012). The first workshop was conducted with 3 teachers from a suburban charter school. The second workshop was held for seven teachers from a suburban public school in a fourteen-week design-based cycle. Each workshop was conducted for about eight hours. To study design-based teacher-researcher collaborations, we adopted a case study approach (Yin, 2009) for an in-depth and in situ investigation of the negotiations and collaborations between teachers and researchers. We collected data from participatory observations, screen recorded videos, semi-structured interviews, and design artifacts analysis. In the first round of data analysis, we reviewed the videos and dataset with open-coding technique to identify informative codes. Next, we engaged in the second wave of data analysis with axial coding and selective coding; we used a constant comparative method for emerging themes identification. Multiple data sources as well as reflexive journals and memos during two cycles of data analysis established trustworthiness.

## Results

### Problem spaces that frame participatory design

In participatory design, a mutual understanding of the *problem space* that both teachers and researchers are working on is critical. The knowledge sharing started from the recognition of the problem spaces. Researchers and teachers were observed engaging in stages of building shared understanding and orienting the *problem space* for participatory design before proceeding to the knowledge sharing stages. Teachers from two schools first acknowledged the challenges they are facing in math education: *lacking real world examples*. This shared understanding of problem was identified between the teachers and researchers. Both agreed that DGBL could be infused to resolve this problem. Specifically, the game environments and features designed could create *connections* between content learning and disciplinary practices: “*If you are going to school and teaching kids numbers, the concept of numbers, they have a purpose. You don't just go to school and put down on a paper and tell them you have to do it*” (Teacher G).

After the problem spaces have been mutually agreed, teachers were engaged in gameplay to visualize and concretize the artifacts to be co-designed. During the process, teachers contributed ideas for the game refinement by considering how the students would perceive what they are experiencing in the problem spaces. For example, one teacher commented, “*The ratio and proportion ones, they are...our kids probably can do that. But then...some bizarre ones they have to figure out. Like this one (while pointing the mouse to a Challenge of Ancient Mesopotamia in the game environment)*” (Teacher F). This perspective-taking stance is a common strategy teachers used during design collaborations. Furthermore, teachers and researchers were counterbalancing and reconciling the philosophy of teaching and learning with DGBL. Teachers brought up the reality of limited time in the classroom that makes it harder for the students to practice math thinking in the constructivism DGBL. They envisioned how DGBL could possibly complement their math instruction by saying, “*It should be used more for an enrichment thing, it gives more hands-on, yeah, I can see that*” (Teacher H).

### Tool that supports sustainable participatory design of game tasks

When using the level editor, teachers asked the possibilities of creating a community for teachers to share customizable design artifacts and improve practice, “*If there is a teacher, say, in Lea county (pseudonym), she made a...a question, on the same concept or levels that I am using, is there a thing that I am able to see, so that I won't have to recreate*” (Teacher I)? Moreover, teachers proposed to involve students in using the level editor as a learning-by-making tool, “*If the students use the level editor to build their own game, they will better understand the concept, and they will see why the problem looks like that, and they will tell the story based on that*” (Teacher H). These ideas suggested that the level editor supported sustainable participatory design for more game levels.

## Conclusion and implications

The study findings portrayed teacher-researcher participatory design. They underscored the phenomena of teachers' perspective-taking as students in providing insights for participatory design in problem spaces. They also indicated the role of a participatory design tool in enacting or supporting a community for teachers' collaborative and participatory design of game-based learning tasks or artifacts. We argue that participatory design of teachers with researchers should emphasize teachers' voices to transform the process of design and implementation of DGBL, and the participatory design process should be sustainable to ground DGBL in practice.

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