Design Practice and Learning: (Re)Designing a Tabletop Game in a STEM Classroom

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Abstract: The study discussed in this paper identified a range of activities and exercises through which learners modified *Triominos*, a mathematics-oriented tabletop game, and developed their ideas and skills. We gathered data through weekly observations of two groups of 20 to 25 learners (grades 3 and 4) in a western Canada school. We found that any changes made by learners not only influenced mechanics, aesthetics, and dynamics of their games but also helped them discuss, criticize, test, and refine their games and mathematics-oriented ideas.

Theoretical framework

The basic game components of mechanics, dynamics, and aesthetics proposed by Hunicke, LeBlanc and Zubek (2004) have been useful in framing how we understand, design and use games in various disciplines, including educational research. They suggested that game mechanics specifies rules and laws of physics in the game (e.g. gravity) while dynamics portrays how the rules work in action through player interactions. Aesthetics is concerned with how the looks and feels of the game influence the sensual and emotional perceptions of the player. While aesthetic attributes such as shape, texture, and color in a tabletop game are related to the sensory experience of the player (visual and tactile), designers often use them to support rules as part of mechanics. The material and texture of a tabletop game influence the experience of the player. On the other hand, these attributes of the game emerge from the interaction of the player with the game when the player touches the game pieces or controller in play and therefore, they are a piece of dynamics as well.

(Re)designing a game in a STEM classroom can provide learners with opportunities for decision-making, exploring new ideas, developing them, and creating a working system (Schell, 2019; Baradaran Rahimi & Kim, 2019). The activities involved in game (re)design can support learners in developing skills of decision making, design thinking, and systems thinking. Moreover, playtesting a game can be critical both in designing and modifying a game to see how design decisions and changes can sway the player's experience. In the context of a STEM classroom and with the help of teachers, learners can explore new possibilities for player's experience by introducing changes to mechanics, dynamics, and aesthetics for the game.

Research design

The study was conducted in inner-city elementary school STEM classrooms in western Canada. The learners and their teacher decided to change several aspects of *Triominos* in terms of aesthetics (e.g., shape and size of the tiles as well as the symbols that appear on each tile), mechanics (e.g., new rules, scoring system, and score-keeping mechanism), and dynamics (i.e., the interactions of the players while playing the game). The process took six weeks for three and four graders and learners made several paper-crafted games (two or three 45-minutes sessions per week). The process started with an introduction to *Triominos'* rules followed by a discussion of strategy versus luck in this game. Learners worked on their individual ideas for making a new game out of *Triominos.* The teacher then teamed up students based on the similarity of their individual ideas in groups of two to four students. As teams, they negotiated the shape and look of the tile within their groups. Learners made a rough version of their board-game with tiles and rules. The teacher supported learners to determine if their tiles are created identical in terms of shape and size, if the symbols, letters, or numbers are organized consistently, and if their scoring systems work properly. Learners iteratively play-tested and adjusted their games.

Our data collection combined intrusive and obtrusive approaches. For obtrusive data collection, one researcher was a silent observer taking detailed notes on all the students within their groups while video-recording the progress of the learners. The teacher carried a GoPro to record her interactions with team members. For intrusive data collection, one or two other researcher(s) made conversations with learners while video-recording the progress of learners. Data collection was followed by a semi-structured interview with the teacher and learners at the end of the sixth week. Data analysis included transcribing the interviews and logging observational videos. The textual materials, including the video logs, transcriptions, and observation notes were initially analyzed through margin coding (Bertrand et al., 1992). Sessions of discussions helped us to reach an agreement on codes.

Findings and discussions

Learners changed the mechanics of *Triominos* by implementing new rules, scoring systems, and score-keeping mechanisms. These changes included simple mathematical functions (e.g., addition, subtraction, etc.). They also changed the aesthetics of *Triominos* by altering the geometry, shape, and size of the tiles as well as the symbols that appear on each tile. Dynamics was also changed through playtesting. For example, playtesting showed that the number of tiles a player gets to begin the game must reduce for the game to run longer. Mathematics conversations around shapes (e.g. the number of the edges that hexagon has) and matching systems (e.g. getting bonus points vs. minus points), discussions, and reflections to geometrical concepts (e.g. making a larger shape with a different geometry like hexagon from triangular tiles) were the primary sources of binding the aesthetics, dynamics, and mechanics in learners' designed games.

Systems thinking, critical thinking, and design thinking were practiced by learners in different ways. For instance, learners created tiles for *Squareominoes* by folding papers, using corners to draw the edges of tiles, and tracing tiles. Design thinking here led to an effective strategy for dealing with the complex task of making identical tiles. The strategy was unique in a sense that not only facilitated the process of making but also added value to their work by less paper consumption often emphasized in the classroom. Some teams such as *Type-ominos* were inspired from existing characteristics of other games like *Pokémon*. They started making tiles with one power-type and step by step added to the types to lay out their tiles. Learners focused their work on geometrical shapes and use of templates, and rulers for making tiles. The selection of a proper template in terms of shape and size is tied to the playability of the game: they brainstormed to make a different or bigger shape (i.e., a bigger triangle or a hexagon) to earn higher scores. Development of the skills in terms of using rulers and simple mathematical concepts that they used in (re)designing the game were part of the learning outcomes.

The process of exploring, developing, and creating their games was important for learners to understand how the system becomes playable by others. To exemplify, for *Squareominoes*, in the initial phase of exploration, learners within team explored different possibilities for creating their tiles. They chose the same shape of the tile (i.e. square) but had different ideas about what should go on the tiles (i.e. shapes vs. numbers). This was followed by an ongoing discussion between the learners in the developing phase to figure out what should go on the tiles. In this phase teacher provided various suggestions such as combining shapes and numbers. Discussions in the developing phase helped students make their decision to include circle, square, star, and triangle in the game and assign numerical values to each shape (i.e., the number of sides for each shape) for scoring points (i.e., mechanics). Creating phase for this game involved folding and tracing strategy to make tiles. When playtesting the game with learners to see the behavior of the mechanics in play (dynamics), all the pieces were identical and the rules for the game were elaborated enough (mechanics) to be enjoyable for players (aesthetics). This study demonstrates how (re)designing games may improve systems thinking (Baradaran Rahimi & Kim, 2019), critical thinking (Brown & Katz, 2002), and design thinking (Lawson, 2005) of elementary learners. We suggest that carefully chosen tabletop games could be powerful materials for the learners to engage in (re)design activities for disciplinary and creative learning process.

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