“If You Add Too Much Science, It Gets Boring.” Exploring Students’ Conceptual Change Through Their Game Design Iterations

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Abstract: Game design offers many opportunities for facilitating and understanding learning. We facilitated a 5-day game design workshop for eleven grade 7 students to design educational board games about virology. Through analyses of field notes, audio recording, and design artifacts, we illustrate conceptual change of virology through two student teams’ game design iterations. Findings show how the design process facilitates conceptual change, and how games can be used as assessments of student thinking.

Background and objectives

Games are dynamic systems, and models of their designer’s understanding of that system. When students design games to teach domain content, their games become sites for assessing their understanding (Ackerman, 2001). However, some argue that the educational value of design is in the process, and not in the product (Dancz et al., 2017). Indeed, student designers can learn content even when their designs are not effective at teaching it to their peers (Harel & Papert, 1990). Game design engages valuable skills of inquiry, problem-solving, reflection, explanation, critique, refinement, and collaborative knowledge construction. In particular, designing games for learning requires integrating knowledge of games, of relevant domain content, and of how people learn (Khaled & Vasalou, 2014). We argue that the iterative process of game design embeds opportunities for designers to test and get feedback on their current understanding, and to identify and correct misconceptions. Doing so can ultimately lead to better game designs as well as to better learning outcomes for designers and their players.

Based on two student teams creating games to teach players about the measles virus, we ask: (1) How do students approach the challenge of designing games for learning? and (2) What do students’ game design iterations reveal about their science understanding? Findings from this study have implications for using game design as an activity to support and assess science learning.

Methods and data analysis

We created a 5-day long elective game design workshop for eleven grade 7 students from a diverse public school in the eastern United States. The workshop occurred during the final week of the academic year, and was part of an effort to explore the opportunities of transmedia game design for shaping students’ scientific and design dispositions. Five graduate student facilitators and two accompanying teachers guided three student teams in designing games to teach players about measles, based on the comic book *Carnival of Contagion* (Hall, West & Diamond, 2017, worldofviruses.unl.edu/carnival-of-contagion). This comic tells of a dream shared by a group of unvaccinated youth as fall ill with measles. We asked students to create games to teach players the science covered in the comic, including the transmission and symptoms of measles and the importance of herd immunity. Here, we focus on contrasting episodes from two of the three student groups—*The Musketeers* (3 boys), and *The Weirdos* (4 girls)—to illustrate the ways that game designs can be evidence of learning.

We collected field notes, research reflections, and audio recordings of all activities, including within-team and student-facilitator discussions; students’ final game design artifacts; and documentation of their iterations. We then conducted a thematic analysis of the data (Vaismoradi, Turunen, Bondas, 2013), and met regularly to discuss, define, and refine emergent themes.

Findings

Students’ understanding of vaccines and of viral transmission was reflected in their design iterations. Creating the alignment between player actions (e.g., jumping, collecting objects) with learning actions (e.g., solving problems), which characterizes effective games for learning (Plass et al., 2011), was a chance to grapple with science concepts. In general, students easily identified misalignments within existing games. As one male student noted about a poorly designed digital mathematics game, “you just shoot things… adding (numbers) doesn’t have anything to do with shooting (those things).” Comparing this to a better designed math game, he noted that the player’s action “actually has something to do with (…) actually solving (math problems).”

However, students struggled to varying extents to embody this alignment in their own games. For example, when encouraged to incorporate more science into their path-based board game, The Weirdos added "fun fact cards" about measles, from which players selected on landing on marked squares. While the team learned content by making the cards, these were purely informational, and did to advance gameplay. Their cards represented an *extrinsic* integration (Kafai et al., 1998), wherein learning goals were not a component of the mechanics, but exist alongside them. Their superficial treatment of the science through this simple game design decision may have been a missed opportunity for the Weirdos to engage more deeply with the science.

In contrast, the Musketeers began with a misconception about vaccines that ultimately changed through their attempts to align learning with player actions. Initially, they proposed a game concept in which players "vaccinate the sick" to "cure" them or to "remove symptoms," an idea that reflects their misunderstanding that vaccines are curative rather than preventive. By their third iteration, this misconception had transformed. Adam (pseudonym) of the Musketeers described a game concept in which players "get chances to get different vaccines to prevent different diseases….some prevent one, some prevent three or four." However, the team struggled to integrate the preventive (vs. curative) nature of vaccines into an engaging game mechanic that would have the desired impact on players (damage to health) without the players' characters dying and causing the game to end prematurely. Through playtesting with facilitators, the Musketeers eventually formulated a solution in which each player controlled a party of characters who would not become infected all at once.

The Musketeers' solution and approach to incorporating the making and use of vaccines into their game mechanics reflects an intrinsic level of integration (Kafai et al., 1998), and their nuanced understanding of the alignment between player and learner actions. Their decision also showed the team's ability to incorporate accurate science into engaging game mechanics without needing to sacrifice one for the other, and effectively balancing fun and education in their design. As Adam noted, "The whole point is, we just want our gameboard to be fun, but like science. (…) If you add too much science, it gets boring."

Conclusions and implications

Designing games for learning requires integrating various skills and knowledge that students have yet to master. Our findings suggest that the process of designing such games offers a unique context for observing how students think about science concepts, and about a design practice. However, students' games may not reflect the extent of their understanding. Thus, continued research might expand on our sample size and seek ways to distinguish students' science understanding from their game design abilities, and the impact of designing games on science understanding. Future research might identify individual, social and contextual influences on the interactions between science understanding and design decisions.

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