CENTER FOR INNOVATION, DESIGN, AND DIGITAL LEARNING

CIDDL Research and Practice Brief 13: Leveraging Game-Based Learning–Lessons from Dream2B

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Topic: Leveraging Game-Based Learning Environments

The problem highlighted in this brief

Understanding how students are thinking in real time is essential for teaching. Teachers have many assessment tools at their disposal; yet, most tools don't meet this need to assess students in real time. Furthermore, elementary math instruction is often taught through memorization and practice drills, resulting in students disengaging from mathematics at an early age (White & McCoy, 2019). Games that emphasize problem solving and conceptual thinking can support instruction through increased student access and engagement. Also, a well-designed game can strengthen instruction through timely and relevant assessment data.

Why does this matter to teacher preparation?

Teachers need training on a wide variety of ways to know our students using different tools. Preservice teachers often enter the field with preconceived notions of teaching based on their own experiences (Liljedahl et al., 2019). As a result, some preservice teachers may have a narrow view of options for assessment practices. To address this challenge, CIDDL recently hosted a webinar where Drs. Jessica Hunt and Michelle Taub discussed how teacher observation of gameplay and gameplay analytics could support their understanding of student thinking and lead to instruction that takes into account students' diverse ways of thinking.

Guest Experts: Drs. Jessica Hunt and Michelle Taub

Dr. Jessica Hunt is an Associate Professor in Teacher Education and Learning Sciences at North Carolina State University. Dr. Hunt's research sits at the intersection of mathematics education and special

education, drawing from both fields to understand and enhance how students with learning disabilities (LD) build mathematical proficiency. She achieves this larger goal by designing and testing asset-based learning environments and interventions. Most recently, this has included the game-enhanced supplemental fraction curriculum, Dream2B.

Dr. Michelle Taub is an Assistant Professor in Learning Sciences and Educational Research at the University of Central Florida. Dr. Taub's research uses advanced learning technologies, theories of self-regulation, and multimodal data to better understand individual learning processes across a wide range of educational contexts. Specifically, she uses data channels, such as facial expressions, log files, and eye tracking, to examine how learning processes unfold across a learning task, and how those processes impact overall learning and performance.

What Will You Learn from This Brief?

The brief begins with a background on game-based learning and the principles of Universal Design for Learning (UDL). This is followed by information about the game-based learning context of interest in the webinar, Dream2B. Then, we present key insights from the webinar with Drs. Hunt and Taub, starting with how the Dream2B game and curriculum were developed and the priorities in training teachers to implement it. Recommendations for how game-based learning environments can improve instruction and assessment and considerations for teacher educators are included.

Research and Practice Context

Game-Based Learning

Digital game-based mathematics curricula have been shown to improve students' motivation, engagement, and learning outcomes (Alafari et al., 2012; Siew, 2018). Game-based mathematics interventions can also be a tool for students with LD to learn and express their STEM knowledge. Researchers have found that games have the potential to help all students access STEM content, increase their collaborative problem-solving, promote self-regulation, and explore mathematics in a way that may have previously been impossible for students with LD (Ke & Abras, 2013; Marino et al., 2013; Marino et al., 2014). Another advantage to game-based learning is the ability for students to receive immediate feedback, which can help improve their mastery of content (Lin et al., 2013).

Dream2B

Dream 2B is a universally designed narrative-based mathematics game and curriculum where students play the role of "Bunny," helping various STEM/ICT career specialists complete tasks by demonstrating their conceptual understanding of fractions. The game-based curriculum features five existing worlds that correspond to different STEM/ICT careers: wind technician, solar engineer, fire inspector, photogrammetrist, and programmer. World six integrates tasks from all careers. The universally designed components of Dream 2B are guided by the instructional framework of UDL.

The UDL Framework

UDL is a design and implementation framework for instructional materials to meet the needs of neurodiverse individuals (CAST, 2020; Vasquez & Marino, 2020). The framework is organized around three principles: (1) multiple means of engagement (i.e., considering how to engage students in multiple ways), (2) multiple means of representation (i.e., providing content in multiple formats), and (3)

multiple means of action and expression (i.e., providing opportunities for students to demonstrate their understanding in multiple ways). Interventions that adhere to the UDL framework must include a flexible, purposeful design to engage the maximum number of learners (King-Sears, 2020).

The design of Dream2B combines the three UDL principles across four core UDL implementation elements: (1) clear goals (i.e., alignment of the fraction concepts in the game to curriculum standards); (2) intentional planning for learner variability (i.e., an interactive learning environment where students can customize their game based on their preferences); (3) flexible methods and materials (i.e., students have a variety of choices so that they can employ their own individual strategies and ways of reasoning); and (4) timely progress monitoring (i.e., real-time reports on player performance can be accessed by teachers).

What follows are key insights shared by Drs. Hunt and Taub on how game-based learning environments can support assessment and instruction, through the lens of Dream2B. Their discussion with Dr. Matthew Marino, a co-Principal Investigator at CIDDL and Associate Professor from UCF, was guided by five questions about how teachers can incorporate a game like Dream2B into their assessment and instruction. Moreover, the panelists made several recommendations for how teacher educators can prepare future teachers to harness the potential of such games.

Key Insights

Q1: *How was the Dream2B game-based curriculum developed?*

> Dr. Hunt: “I wanted to [...] build a technology tool based on that same trajectory that did things like provide opportunities to both

> create and quantity fractions in game-based challenges, but also increase engagement and provide real-time strategy-specific cognitive feedback. [...] that turned into Dream2B."

The sequence of tasks in the Dream2B game follows a fraction learning trajectory that Dr. Hunt developed and confirmed through work with students with LD, as part of an earlier NSF-funded CAREER award. The intervention developed through this project was found to increase fraction concepts and overall fraction knowledge for 4th and 5th grade students with mathematics difficulty and LD (Hunt et al., 2020). The research team collaborated with game developers to bring the trajectory to life as a video game that incorporates UDL features and promotes STEM/ICT careers.

Q2: *How does Dream2B integrate learning and assessment?*

> Dr. Taub: "While we were developing this game, we wanted to make sure that researchers and teachers would be able to investigate learning in two different ways. We have the learning *process* and learning *product*."

The *product* refers to student performance (e.g., how many levels they've completed, how successful they are with the tasks). However, the data connected to the student's *process* (e.g., what students do in gameplay, strategies they use) arguably holds the most valuable information. Dr. Taub notes that Dream2B was designed to "foster the learning process" so that students don't just figure out how to beat the level in the game, but rather learn the mathematical concepts.

Q3: *How are you supporting teachers during the Dream2B pilot project?*

> Dr. Hunt: “Teachers are our partners in this work [...] now that we are asking them to implement from start to finish there are two main elements I wanted to mention. The first is how they anticipate possible student thinking or strategies in the game. [...] The second is how to implement the after-gameplay task.”

The teachers currently implementing Dream2B participated in professional development (PD) to prepare to enact the curriculum and support students in gameplay. One major goal of the PD was to support teacher anticipation of strategies students might employ in their gameplay so that teachers would be (a) prepared to ask strategic questions and (b) supported in making real-time informal assessments of student understanding. In the PD, this was achieved through video analysis. Teachers watched short videos of gameplay in each Dream2B world; then they discussed what they noticed and what the actions indicated about the student’s concept of fractions.

The other major goal of the PD was to prepare teachers to implement the two types of after-gameplay tasks in the curriculum: number strings and worked examples. In the PD, teachers experienced worked examples and number strings as students first; then, they stepped out and reflected on that experience. From there, they unpacked the structure of and intention behind each practice.

Q4: What is important for future teachers to know about game-based assessment data?

> Dr. Taub: “What we capture from learning analytics can demonstrate how students are using cognitive processes and their levels of conceptual understanding of fractions.”

Many games include a dashboard where teachers can access up-to-date information about students' progress. A well-designed teacher dashboard can show teachers a wealth of process-oriented data for highly nuanced formative assessment: where students click, what tools they use and in what order, how much time they think before taking action, what they do when their first strategy doesn't work, what game features they use most, and what they do when they see they've made an error. How students use tools can demonstrate their knowledge acquisition, levels of attention, metacognition, and conceptual understanding. It's important for future teachers to understand how this data contributes to meeting the students' to a level beyond what traditional correct/incorrect conceptions of assessment may offer.

Q5: *What recommendations would you make to teacher educators trying to support preservice teachers' (PSTs) use of games in the classroom?*

> Dr. Hunt: "If we want PSTs to value the use of games in classrooms, then we want to connect the use of games to the overall goals or our teacher preparation program."

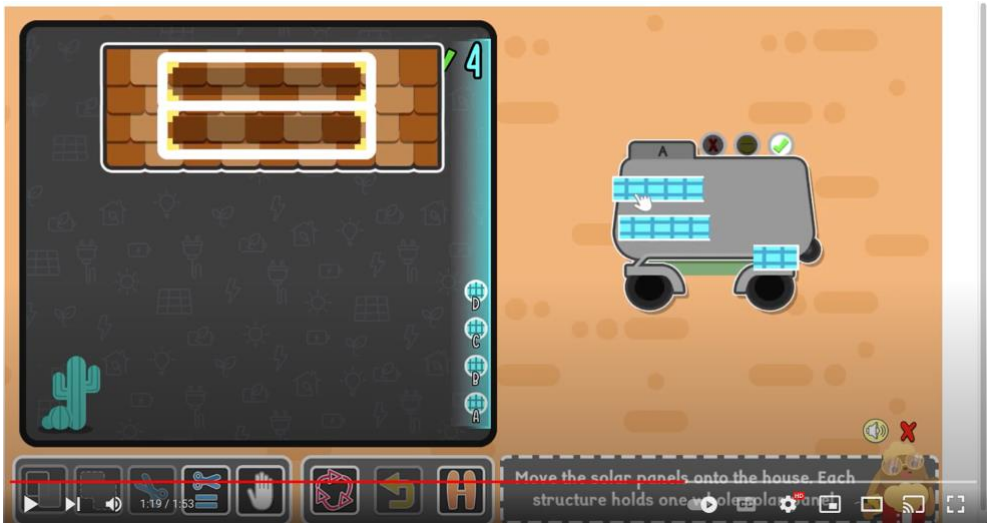
Dr. Hunt emphasizes the need for teacher educators to employ consistent messaging around how games and technology can support teaching *across* all areas of a program (e.g., teaching and learning, equity and diversity, assessment). On top of that, teacher educators need to provide PSTs with resources they can use to implement game-based learning in their classroom. These resources can include alignment with standards and integration with existing curricula. Teachers also need frameworks that help them have

conversations with colleagues and administrators about how games can support access and advancement.

Tying it all together: What does game-based assessment look like in action?

> Dr. Hunt: “Games don’t replace the work of teaching. They give us a tool and a resource to make our teaching better.”

The Dream2B game and curriculum are designed to help teachers make the most of the opportunities for assessment showcased in the webinar. The video below is a sample of one student’s gameplay in Dream2B; the task requires the student to equally share five solar panels among four vehicles for home delivery. The learning *product* was whether or not the student equally distributed the solar panels (they did) and whether or not the student accurately identified how much of one whole solar panel each home would receive (they didn’t). The learning *process* yielded far more information for the teacher to act upon with this student and others. Watch the two-minute video and keep reading to learn more.



A teacher observing in the moment or looking back at gameplay analytics could learn a lot about this student's thinking during these two minutes. For example, the student realized (a) they needed to distribute all the panels, and (b) every vehicle needed an equal share. In addition, the student relied on halving and seemed to employ a trial-and-error strategy. A logical next step would be for the teacher to talk to the student about *how* they decided to cut up the solar panels. The teacher might find that this student and others need support planning how items need to be cut based on the number of sharers. They could also make note of the student's difficulty in naming the units for each home's share of solar panels and work toward this goal in the after-gameplay tasks.

Resources

In the webinar, Drs. Hunt and Taub invited viewers to try the Dream2B game for themselves - either by playing the game or trying to use it with students.

- https://modelmemath.org
  This website gives information about Dream2B and is the place to go if you're interested in trying the game for yourself.
- Email jhunt5@ncsu.edu if you are a teacher who would like to implement Dream2B with students.

Link to Video

This Research and Practice Brief can be viewed on video online at https://tinyurl.com/RBP13Video

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