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Enhancing Engagement and Fraction Concept Knowledge With a Universally Designed Game Based Curriculum

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Teaching and learning fraction concepts continues to be increasingly challenging, especially for elementary and middle school mathematics teachers and students in intervention settings. It is critical for educators to implement instruction that proactively considers engagement, access, and conceptual growth for all students. Dream 2B, a web-based universally designed fraction game, has the potential to significantly impact engagement and conceptual understanding of fractions. In addition, it introduces students to Science, Technology, Engineering and Mathematics (STEM) and Information Communication Technology (ICT) careers. This manuscript provides guidance for utilizing Dream 2B as supplemental mathematics instruction. Components of Universal Design for Learning, as well as gameplay Concept/Skill connections, are provided. Guidance for expanding Dream2B into virtual learning environments is also discussed.

Keywords: **Fractions, Universal Design for Learning, Access, Engagement, Instruction**

Introduction

Promoting diversity in the workforce is paramount for U.S. innovation in Science, Technology, Engineering, and Mathematics (STEM) and Information and Communications Technology (ICT) fields. Individuals with disabilities are underutilized members of the STEM and ICT workforce (National Science Foundation's National Center for Science and Engineering Statistics, 2019), even though these individuals exhibit unique traits and skills that are particularly beneficial in these careers (Dreaver et al., 2020). For example, Scott et al. (2019) noted individuals with high incidence disabilities, such as autism or learning disabilities (LD), often exhibit: 1) sustained attention to detail, 2) systematic procedural knowledge and skills, and 3) the ability to conceptualize outcomes and solutions to complex problems. The un-

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derutilization leads to an inverse relationship between worker supply and workforce demand and perpetuates disparities, especially for underrepresented groups.

Students with LD, in particular, are the largest subgroup of individuals with disabilities served in K-12 schools (U.S. Department of Education, 2021). In the vast majority of US schools, students with LD receive specific interventions to remediate areas of difficulty, such as fractions and rational numbers, within a three-tier model of support. In tier two, students receive targeted, explicit instruction in small groups for 30 minutes a day, three times per week. This group exhibits reduced engagement and attendance in mathematics and science courses when compared to their peers in tier 1, often due to boredom (Sparks, 2015). As a result, students with LD often fail to consider careers in STEM and ICT (DeWitt, 2020).

The issue of reduced engagement may also be one of access. Students with LD often require access to different tools to learn or express their STEM knowledge (Marino et al., 2013). They also benefit from problems that allow for novel solutions because of the unexpected prior knowledge they bring to the classroom (Hunt et al., 2019; Hunt & Empson, 2015). Both instructional design elements position students' knowledge as important and valuable. Unfortunately, many Tier 2 environments afford students with LD one-size-fits-all instruction with little opportunity to engage in and express their unique reasoning.

Game-based mathematics interventions may be a powerful way to improve students' engagement and learning outcomes (Gao et al., 2020; Hussein et al., 2019; Tokac et al., 2019), especially in difficult to teach content areas such as fractions (Alafari et al., 2012). Summaries of gaming research have identified the potential of games to enhance STEM content accessibility, increase problem-solving, promote self-regulation, and allow students to explore mathematics in ways that were previously inconceivable for students with disabilities (Ke & Abras, 2013). This article presents a novel, innovative, game-based curriculum called Model ME. The game embedded within the curriculum is called Dream2B. Developed using the Universal Design for Learning (UDL) framework, Dream2B maximizes accessibility and engagement by providing fraction conceptual understanding challenges rooted in authentic STEM careers. Tutorials, action adaptive prompting, and authentic formative and summative assessments are included within the user interface. Dream2B's game based problem solving and the after game play tasks within the ModelME curriculum strategically link to National Council of Teachers of Mathematics (NCTM) standards. Below, we unpack the program's core components. Next, we explain how to use the Dream2B game and ModelME curriculum in inclusive settings as supplemental instruction. We provide sample lesson structures along with exemplar pedagogy to bolster student learning. Finally, we discuss how the program can be extended to other instructional settings, such as online learning.

Dream 2B Core Components

Dream2B is a narrative-based mathematics video game where students play the role of "Bunny" who helps various STEM/ICT career specialists complete tasks by demonstrating their conceptual understanding of fractions. The game narrative describes how Bunny attends career day at school and is introduced to five different careers in STEM and ICT fields. Bunny returns home, goes to sleep, and begins to dream about the different careers discussed that day. In the dream, Bunny is introduced to different career specialists who are each encountering an issue at work and are seeking Bunny's help to fix it. Therefore, Bunny's role in the dream (or game) is to solve these challenges. Each challenge requires Bunny to engage in problem tasks (see below) that can be completed by solving fraction problems.

There are six worlds in the game, with the first five worlds corresponding to the different STEM/ICT careers: wind technician, solar engineer, fire inspector, photogrammetrist, and programmer. These five careers were chosen based on projected career increases over the next 10 years by the U.S. Bureau of Labor Statistics. Each of the first five worlds corresponds to a specific career; world six is a combination of tasks from all careers. The use of game narratives has yielded mixed findings about their effectiveness on learning outcomes (e.g., Clark et al., 2016), however introducing a narrative has also been found to positively impact learning and motivational outcomes (Plass et al., 2015; Wouters et al., 2013). Therefore, we believe that providing a base narrative in Dream2B will positively impact learning aligned with the mathematics curriculum we included (see below) and interest in STEM/ICT careers.

We take an innovative approach to tiered instructional design by integrating the following core components into Dream2B and the overall ModelME program:: (a) Game Tasks along a Fraction Learning Trajectory, (b) Universal Design for Learning, (c) Action Adaptive Self-Regulation Prompts, and (d) After Game Concept/Skill Connections. Below, we describe each core component.

Fraction Learning Trajectory

The Dream2B game challenges and tools are based on a documented learning trajectory of fractions for students with LD (Hunt et al, 2020). Learning trajectories are not the same as a task analysis, the amassing of skills, or longitudinal cognitive patterns, such as processing or working memory. Instead, learning trajectories consist of a learning goal, developmental stages of thinking, and activities (i.e., problem tasks, representations) designed to explicitly promote each stage of thinking (Clements et al., 2020). The stages of thinking are grounded in students' conceptual development toward the goal, with each stage growing more sophisticated than its predecessor.

Hunt's program documented developmental stages of fractional reasoning within and among an inclusive group of students in authentic school settings that aligned with research in math education (see Table 1). Students' engagement in the progression of trajectory stages yields a concept of fractions as coordinated units of measure. Students build the concept by engaging in the actions of partitioning, iterating, and splitting as they solve fraction problems. We describe each action below.

Partitioning is the act of dividing a unit into equal-sized parts (e.g., cut a unit whole into three parts to make three thirds). As students become more fluid with partitioning, they can mentally extract a created fractional unit from the whole and understand it in relation to the whole without destroying it. They learn to *iterate*, or repeat, the fractional unit to make larger units (e.g., use 1/5 to make 3/5). In the initial stages of the learning trajectory, students make sense of larger fractional units within the bounds of the whole.

Table 1. ***Fraction learning trajectory into Dream2B game worlds (see Hunt et al., 2020)***

Game World	Concept	Gameplay Concept	After Game Concept/Skill Connections	NCTM Standards
1	Unit Fractions	Break a single wind gust into parts, test the length of one part against the whole.	Compare Unit fractions	Number and operations, 3rd - 5th grade: *-Develop understanding of fractions as parts of unit wholes, as parts of a collection, as locations* *on number lines, and as divisions of whole numbers.* *-Use models, benchmarks, and equivalent forms to judge the size of fractions.*
2	Proper Fractions	Break solar panels into equal parts; combine parts into a complete structure.	Equivalent Fractions	Number and operations, 3rd – 5th grade: *-Use models, benchmarks, and equivalent forms to judge the size of fractions.* *-Recognize equivalent representations for the same number and generate them by decomposing and composing numbers.*
3	Improper Fractions	Configure the amount of fuel across multiple tanks to meet fire code.	Unit Fraction times a Whole Number Compare Non-Unit Fractions	Number and operations. 3rd - 5th grade: *-Use models, benchmarks, and equivalent forms to judge the size of fractions.* *-Recognize equivalent representations for the same number and generate them by decomposing and composing numbers.*

Table 1. ***Fraction learning trajectory into Dream2B game worlds (see Hunt et al., 2020) (continued)***

Game World	**Concept**	**Gameplay Concept**	**After Game Concept/Skill Connections**	**NCTM Standards**
4	Reversible Fractions	Measure/interpret surveyed region to produce a mapping	Price adjustments Percentages	
5	Recursive Fractions	Alter code blocks by creating parts of parts.	Divide unit fraction by whole number Multiple unit fraction by unit and non-unit fraction	
6	Distributive Fractions	Distribute materials across sites, relate quantity created to contextualized referent.	Fractions to model and solve division problems	

Over time, students combine partitioning and iterating into a single structure called *splitting*. Splitting involves anticipating the results of partitioning a unit at the same time as iterating a related unit (Hackenberg, 2007). When students can split, they can understand larger fractional units outside of the bounds of a whole, and more advanced multiplicative notions of fractions (i.e., 7/5 as a unit comprised of seven 1/5 , each of which is related to a unit of one comprised of 5/5). Instructional activities that support the actions that create fractions as coordinated, numeric quantities will promote conceptual advances. Dream2B sequences tasks and representations to provide opportunities for students to access, build, and internalize partitioning and iterating to improve their fraction understanding within authentic STEM careers as shown in Table 1.

Universal Design for Learning

Universal Design for Learning (UDL) is a proactive design framework for meeting the needs of neurodiverse individuals (CAST, 2020; Vasquez & Marino, 2020). The framework is organized around nine guidelines and 31 checkpoints, organized vertically to provide: (1) multiple means of engagement, (2) multiple means of representation, and (3) multiple means of action and expression. Version 2.0 of the framework (see Figure 1) added horizontal alignment to identify how students could access, build, and internalize learning materials as they strive toward the goal of becoming expert learners who are purposeful, motivated, resourceful, knowledgeable, strategic, and goal directed (CAST, 2020). King-Sears (2020) pointed out UDL-based interventions must include a flexible, purposeful design in order to engage a maximum number of learners. Marino and Basham (2013) reported that the proactive identification of barriers across physical, social/emotional, cultural, and cognitive aspects of the lesson are critical during STEM lessons.

The implementation of UDL within Dream2B (and the larger ModelME program) focuses on integrating the three principles above across four instructional domains: 1) clear goals, 2) intentional planning for learner variability, 3) flexible methods and materials, and 4) timely progress monitoring. *Clear goals* are illustrated above in Table 1 as well as the alignment of the fraction concepts and skills with curriculum standards. The overall sequence supports the cognitive actions necessary to promote access to and advancement toward the learning goal, "Fractions are quantities with magnitudes determined by the multiplicative coordination of the numerator and denominator."

We also designed the Dream2B interface *intentionally for variability* so that players can access each challenge in multiple ways. For example, an interactive learning environment motivates players by allowing them to customize the game based on their preferences. The player has a choice of *flexible methods, materials, and analytical tools* that they can use to employ individual strategies and ways of reasoning. Sandbox play supports players to create fractional quantities by partitioning, repeating, distributing, and coordinating units without high stakes repercussions. Teachers receive real-time reports on player performance to support *progress monitoring*. Figure 2 illustrates the game's UDL innovative design features.

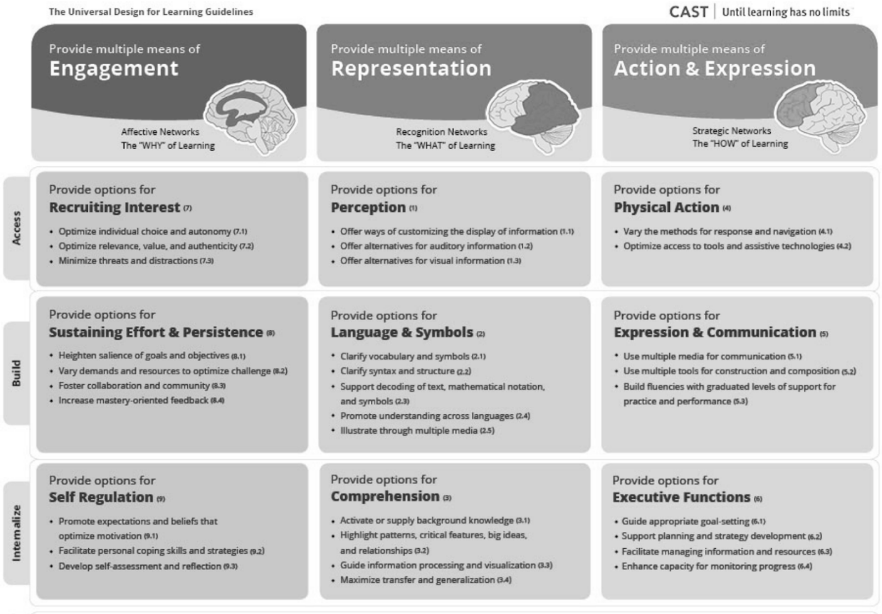


Figure 1. **UDL planning considerations (CAST, 2018)**

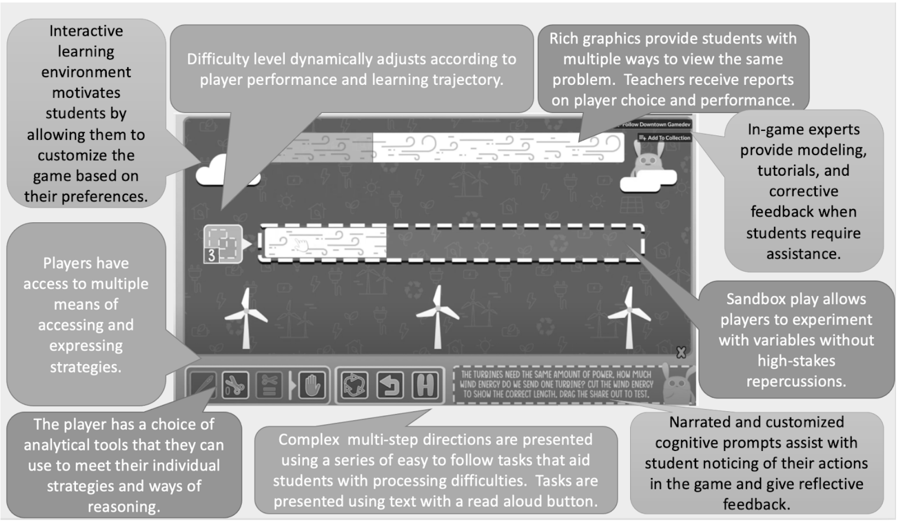


Figure 2. **UDL design techniques**

Action Adaptive Prompting

A growing line of research on student-centered math interventions reveals further design elements promoting robust STEM abilities. The most prominent - promoting noticing and reflection upon students' thinking while solving problems - are underutilized in instruction for students with LD. Research suggests students with disabilities rely upon suboptimal strategies (i.e., guess and check) as they solve problems (Taub & Azevedo, 2018; Taub et al., 2018). We contend that the use of such strategies is due to the limited opportunities students have to learn how to self-regulate within their own problem-solving actions. While students often require development of self-regulation, this need is not commonly addressed because instruction is not planned to be responsive to students' thinking. Students who are self-regulated learners play an active role in their learning by planning how they will achieve learning goals, monitoring their emerging understanding of topics, and reflecting on their performance and making adaptations to their set goals, as necessary (Winne, 2018). However, without the appropriate support, students often face difficulties self-regulating their learning (Winne & Azevedo, 2014). Thus, students' reliance on ineffective regulatory processes and communication of reasoning often continues because self-regulation is left unsupported in the midst of learning.

The first step in addressing these issues is ensuring students have the opportunity to utilize and regulate their own problem-solving strategies while developing rich concepts for fractions. Dream2B provides students this opportunity through the use of problem-solving challenges and Action Adaptive prompting. Action Adaptive prompts are narrated, real-time responses from a game agent to students as they engage in gameplay actions. The agent provides feedback to help the player notice and reflect upon the results of their game-based actions, which often feeds back into their goal setting within and across challenges. The prompts were designed as a part of Hunt et al.'s (2020) learning trajectory, which maps common strategies students with disabilities used to solve fraction tasks for each conceptual stage (see Table 1). Figure 3 illustrates a sample prompt in the midst of hypothetical gameplay.

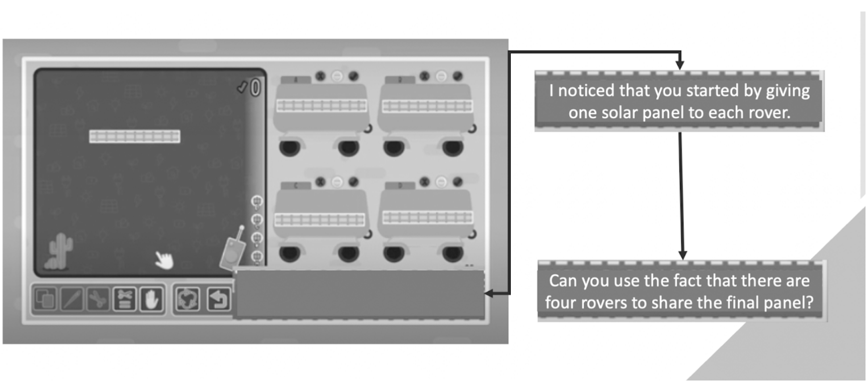


Figure 3. **Action adaptive prompts**

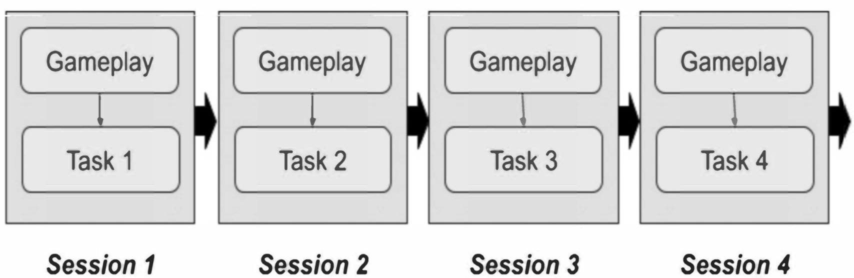
After Game Concept/Skill Connections

The curriculum on which the ModelME curriculum and Dream2B game is based (Hunt et al., 2020) used a think-pair-share structure so students could think about a solution, rehearse thinking in pairs, and discuss their reasoning in a larger group. In this program, we extended the curriculum to integrate students' gameplay with opportunities for students to engage in mathematical reflection, explanation, and justification through game replays, worked examples, number strings, and language routines (see Figure 4).

World 1 snapshot:

Conceptual Goal (game; task 1,2): Inverse order relation; Unit fractions

Associated Skills (task 3, 4): Compare same denominator fractions



Session	Task Focus	Presentation	Discourse Structure
1	Anticipate Inverse Order Relation/Coordinate Unit Fractions	Game Replay	Gather and Show Student Discourse
2	Anticipate Inverse Order Relation/Coordinate Unit Fractions	Worked Example	Explain/Revise/ Finalize
3	Apply Unit Fractions/ Comparison	Number String	Gather and Show Student Discourse
4	Apply Unit Fractions/ Comparison	Number String	Gather and Show Student Discourse

Figure 4. **World one snapshot**

Game replays directly connect to a problem students encountered during gameplay in a particular world. They give students opportunities to re-create their gameplay, notice their strategy, and reflect upon the resulting quantity they created. Noticing and reflecting upon problem solving is proven to aid in students' metacognition. In the ModelME curriculum, game replays represent critical points along the along the trajectory. Tiered number choices allow for differentiation.

Worked examples engage students in explaining and justifying a problem that has already been solved. They help students to focus on the concept or meaning of a procedure by presenting problems solved correctly, in part, or incorrectly. Worked examples are proven to be beneficial to students' conceptual development when interweaved with problem solving, especially for students who experience difficulties learning mathematics (McGinn et al., 2015). In the ModelME curriculum, the worked examples relate to a concept students are working toward within gameplay or a related skill that connects to a concept built up in gameplay.

Number Strings engage students in mentally solving a "string" of related equations. The repetitiveness encourages students to notice a particular mathematical concept or make use of a particular strategy. When paired with conversation about how students solved a problem, specifically discussions that highlight efficient strategies and how the strategies work, number strings can support abstraction of mathematical concepts (McGinn et al., 2015). In the ModelME curriculum, the number strings relate to a skill that connects to a concept built up in gameplay. Tiered number choices allow for differentiation.

Each game replay, worked example, or number string is paired with a mathematical *language routine* (Zwiers et al., 2017), which is a structured format for amplifying, assessing, and developing students' language related to a given concept. The routines emphasize the use of language that is meaningful and purposeful - as opposed to inauthentic or answer-based - and fits the mathematical work and goal of each world. They provide productive opportunities for students to revise and refine not only the way they organize and communicate their own ideas, but also to ask questions to clarify their understanding of others' ideas. Together, the after-game concept/skill connections can promote students' understanding of concepts, skills, and reasoning through explanation and justification (see Figure 5).

"The wind is flowing to three turbines. Here is the result of Bunny's estimate for one share of the wind repeated three times. Bunny decided to make the next estimate shorter, which doesn't work. Here is the result of Bunny's plan."

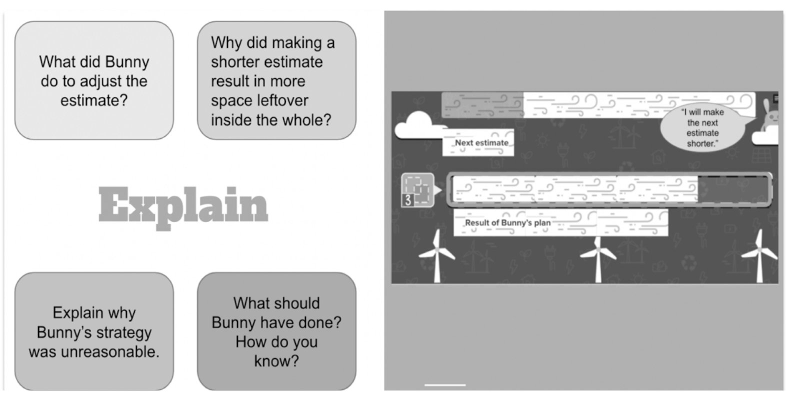


***Figure 5.* Worked example and student explanation questions**

How to Use Dream2B and the ModelME Curriculum as a Tier 2 Intervention

Each of the 36 ModelME curriculum lessons that align with Dream2B gameplay comes with a lesson plan, teacher resources, and student resources. An overview of the lesson plan guide is given in Figure 6. Each lesson consists of two parts: (1) *Gameplay* and (2) *After Game Concept/Skill Connections.* Teachers will need about 35 minutes of instructional time for each lesson; we recommend that lessons be delivered three to four days per week in small instructional environments with four to six students. Below, we will illustrate how the program is used as a Tier 2 intervention by walking through a sample lesson.

TASK ONE WHOLE CLASS

Content Standards:
National Council of Teachers of Mathematics
Number and operations, 3rd- 5th grade:
- Use models, benchmarks, and equivalent forms to judge the size of fractions.

Algebra, 3rd- 5th grade:
- Describe, extend, and make generalizations about geometric and numeric patterns.

Geometry, *3rd- 5th grade:*
- Investigate, describe, and reason about the results of subdividing, combining, and transforming shapes.

North Carolina
NC.1.MD.2: Measure lengths with [standard] and non-standard units.
NC.1.G.3: Partition circles and rectangles into two and four equal shares. Explain that decomposing into more equal shares creates smaller shares.
NC.3.NF.1: Interpret unit fractions with denominators of 2, 3, 4, 6, and 8 as quantities formed when a whole is partitioned into equal parts. Explain that a unit fraction is one of those parts.

Standards for Mathematical Practice:
Make sense of problems and persevere in solving them (SMP 1)
Construct viable arguments and critique the reasoning of others (SMP 3)

Materials:
Dream 2B game
Google slides
Whiteboards or student handout
Markers or pencils

Universal Design for Learning Design Principles:
Multiple Means of Engagement
Multiple Means of Representation
Multiple Means of Expression

Learning Goal: Anticipate the inverse order relation among unit fractions

Lesson overview:

Component	Student Actions	Teacher Actions	Time
Gameplay	Watch a video intro of game Play Dream 2B World One	Unpack context of game Observe and support student game play	15
Task ONE	Notice and reflect upon a game play strategy.	Facilitate explanation and discussion of a game replay task	20

Figure 6. *Lesson plan overview*

Gameplay

Gameplay includes the introduction to the lesson and gameplay and generally lasts anywhere from 10 to 15 minutes. Its purpose is to bring forward students' prior knowledge, unpack the context of the world in terms of the STEM or ICT career utilized, and immerse students in problem solving via gameplay.

Teacher Resources and Lesson Plan

Each lesson plan is supported by a slide deck to support teachers to use the ModelME curriculum and Dream2B game. The slide deck includes a story, picture, or video to launch the lesson. For example, the first lesson in World 1 includes the short video shown in Figure 7, which launches the dream sequence Bunny has after having a visitor in class during a mock career fair. When used online, the videos included in the slide decks allow for real-time captioning of speech, allowing people who may not be able to access audio content to have an alternative option for processing the instruction.

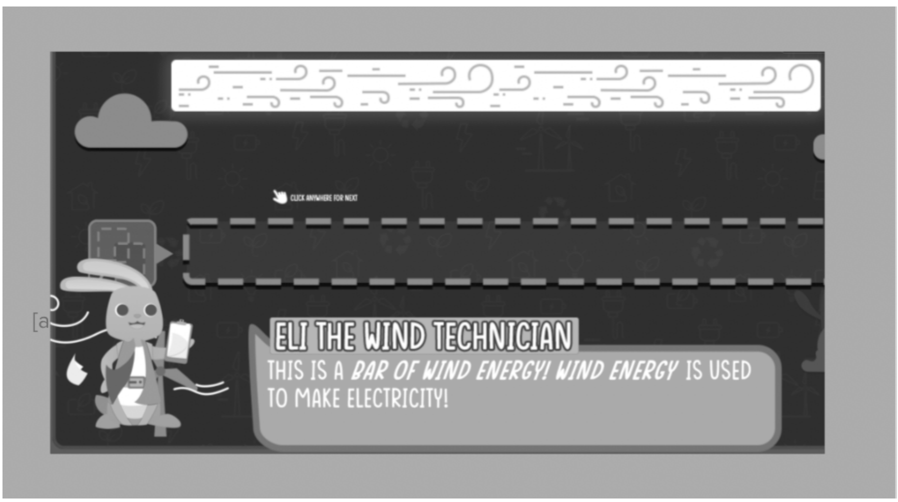


Figure 7. **Slide from World 1 deck**

After playing the one-minute video clip, the teacher asks students to talk about similar experiences they have had with visitors in class who discuss their careers. Then, they hold a brief, open discussion about equal sharing within the dream scenario, talking about the context of sharing equally and the idea of sending equal shares of wind to power a set of wind turbines. Bunny is dreaming, so the playful scenario makes sense.

Student resources. Next, students are immersed in gameplay in Dream2B. As students play, teachers circulate and observe student strategies and discussion, taking note of common or important strategies, words, and phrases (e.g., How are students adjusting the size of the estimates for 1/n shares? Do students anticipate the nature of adjustment within a share?). Teachers consult a guide (see Table 2) to notice different gameplay strategies and respond with helpful feedback that further helps students' regulation of thinking. After ten minutes, teachers ask students to log off of the game and gather in a small group.

Table 2. ***Teacher guide to observe gameplay***

Student Actions (if…)	Teacher Actions (then....)
When the estimate is too [short, long], students make the next estimate [even shorter, even longer].	ASK: What happened with your last estimate? How will making the next estimate even [shorter/longer] help?
When an estimate is too short, a student adds/subtracts all of the extra length not covered by *n* iterations of their estimate to make their next estimate.	ASK: Why did adding/subtracting all of the extra make it too long/short? How much longer or shorter should you make your next guess? Why?
When an estimate is too short, a student adds/subtract close to $\frac{1}{n}$ of the extra length not covered by 3 iterations of their estimate to make their next estimate. (May say "a little bit")	ASK: Why did adding/subtracting $\frac{1}{n}$ of the extra work?

After Game Concept/Skill Connections

After Game Concept/Skill Connections help students engage in explanation and justification about game concepts and related skills. They are composed of the worked examples, problem strings, and language routines described earlier.

Teacher Resources and Lesson Plan

Gathered with a small group of students, teachers return to the slide deck and display a worked example. In the first lesson in World One, the worked example addressed the nature of adjusting an estimate of a share (1/n). Students are asked to write a response to respond to Bunny's plan to make an already "too short" estimate shorter ("incorrect strategy"; see Figure 8).

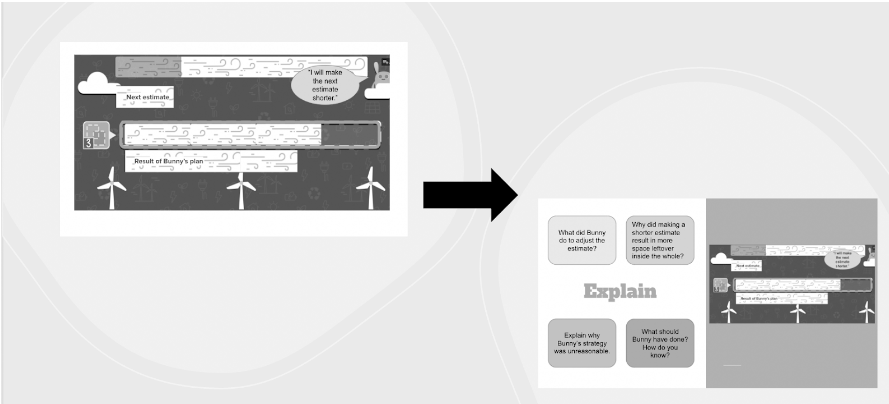


Figure 8. **Original worked example prompts followed by self-explanation questions for students**

Teachers say to students, "The wind is flowing to three turbines. Here is the result of Bunny's estimate for one share of the wind repeated three times. Bunny decided to make the next estimate shorter, which doesn't work. Here is the result of Bunny's plan. I want you to explain to yourself why making the next estimate shorter doesn't work. Here are some questions to help you. Use at least one 'what' question and one 'why' question to write your explanation."

Student resources. Students are given a choice of materials, such as graphic organizers or blank whiteboards, to use to construct their explanations. After students have written a draft of the explanation, they are next prompted by the teacher to revise their argument by explaining what they know will happen if Bunny makes the next estimate shorter and how they know that is true, adding pictures, numbers, and words into their explanation. Next, students share their argument with a friend and get feedback. Thought bubbles with sentence frames are used to support students to express their reasoning in conversation. Teachers position students in ways that promote participation, such as sliding individual papers from multiple students together when needed or acknowledging students who look like they have something to say (e.g., "_____, you have an idea. What is it?").

The final part of the structure gives students a space to do a final revision of their work, finalizing anything that was unclear to their partner or adding more evidence for justification. The teacher explains that additional evidence can be a non-example or another picture that supports the main points of their explanation. Students then engage in a small group discussion where a student is randomly selected to display their argument to a second student who plays the role of a "skeptic." After the first student shares their argument, the second student is invited to critique the overall argument and why it is viable. Both roles are supported by thought bubbles to help them discuss their argument and ask critical questions (see Figure 9). During this time, the teacher clarifies the precision of any student words or phrases in relation to the nature of adjustment (e.g., "too long" or "too short" as opposed to "too big" or "too small") and explicates which words and/or visuals accurately communicated the nature of adjusting estimates to the whole, with the goal of addressing why Bunny needed to make the share longer.

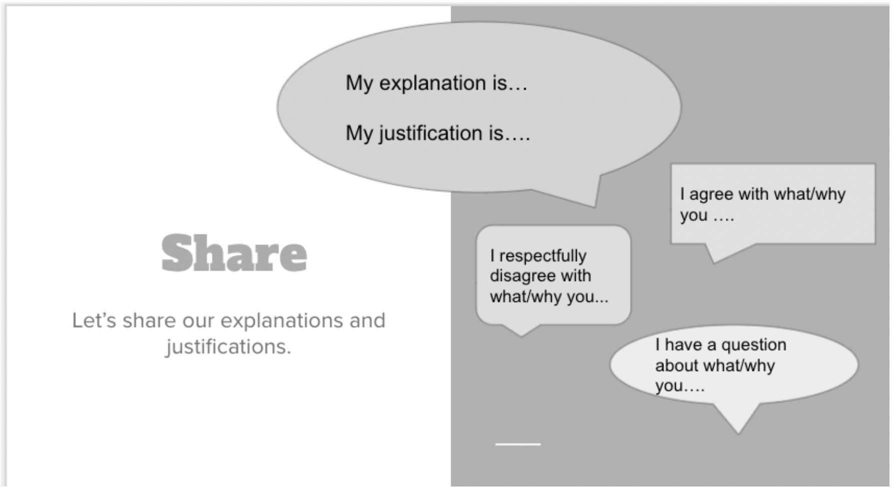


Figure 9. **Thought bubbles and sentence frames**

Using Dream2B and the ModelME Curriculum in Virtual Learning

Prior to the COVID-19 pandemic, student learning was supported mainly by in person teaching. However, due to the need to reach learners virtually, we now think differently and have adapted to the "new normal." The adaptation has afforded rich opportunities for us to consider what it means to create equitable, virtual learning spaces, especially for interventions. When thinking back over the information presented in this article, one might consider which aspects of Dream2B and the ModelME curriculum work well in virtual instruction? We would argue that all of them do, and our aim in this closing section is to illustrate how.

Gameplay

Dream2B is a web-based platform, so students can connect to the game from their homes given reliable internet access. Additionally, because the slide decks are also web-based, they are accessible to teachers and students in a synchronous or asynchronous learning space. Finally, teachers can download the slides for offline use in Microsoft PowerPoint to project on a screen or interactive whiteboard, or even print the slides and place them under a document camera for the opportunity to easily mark them up during discussions with students.

Incorporating the slide decks for the overall ModelME curriculum before and during gameplay in the virtual learning setting requires some adjustments. For example, to use the slide deck to launch Bunny's dream sequence, teachers can use the same questions that we listed for face-to-face instruction, yet they can support student engagement through the use of a Google Jamboard or a Padlet (Figure 10). Padlets, in particular, allow students multiple ways to engage with the question and express their knowledge (e.g., typing text, uploading an audio or video recording, uploading a photo of their work). Both of these tools can be utilized to support student dialogue and engagement with questions throughout Gameplay or After Game Concept/Skill Connections.

Another way for teachers and students to engage with each other during Gameplay is by using screen sharing capabilities on their device. Students can use a secure screencast application, such as Screencast-O-Matic, to record and potentially narrate the choices they are making as they complete tasks within the game. Once they send the recording to teachers or upload it to a learning management system, teachers and even peers could provide feedback and encouragement. A real-time alternative to screen casting is for students to screen share their Gameplay with teachers while meeting in a video conferencing app. Teachers can also use the screen share feature to provide additional guidance on Gameplay.

Figure 10. **Padlet**

**Names have been blocked to protect student identities.*

After Game Concept/Skill Connections

Finding a way for students to create, share, and revise their explanations and justifications (and receive feedback from other students!) online can be daunting. We recommend keeping the structure and flow of activities during After Game Concept/Skill Connections the same. Yet, in virtual settings, we also recommend taking the time to use and practice accessible tools and mechanisms to help them to create, share, receive feedback on, and revise their thinking.

Teachers can revisit Google Jamboard to support students as they construct their explanations. On one or more Jamboard slides, students can use plain text, sticky notes, and shapes to explain their thought processes. Screenshots of Gameplay could also be uploaded as images within a Jamboard to help illustrate a student's point. In addition, the drawing tool allows them to use a mouse, trackpad, or touchscreen to create visual representations of their mathematical thinking. There is also the opportunity to receive feedback from teachers or other students by sharing Jamboard links and creating a protocol for responses (e.g., teachers give feedback on yellow sticky notes and other students chime in with green sticky notes). Students can begin with a blank jamboard, or teachers might consider providing a pre-made template complete with a clearly stated task and sentence stems to support extended explanations.

To support students to share their argument with a friend and get feedback, the use of breakout rooms is effective for supporting in the moment student-to-student conversation. However, there must be intentionality with how breakout rooms are introduced and the expectations around them. During the first few experiences in breakout rooms, teachers will want to allow students to feel comfortable and engage with the other person. If possible, the teacher may want to consider pairing the students with someone you know they will talk to (a friend). Initially, practice the use of breakout rooms and build student comfort with the platform (i.e. practice sharing the screen or using an annotation tool), or use a "low risk" question that students can discuss, such as "Would you rather use a kangaroo or hippopotamus as a mode of transportation?" As learners' comfort level increases, you can return to final revision of work and transition into small group discussion.

As with in-person small group discussion, introducing students to a protocol equips them with clear expectations about roles and a path forward for structuring their conversations. There are many discussion protocols to choose from, depending on the purpose, but it can be as simple as one student sharing their work and explaining their process, followed by the other student explaining it back to them, providing a critique, and/or sharing why it makes sense. This would be repeated for the second student in the pair. For groups larger than three, protocols that define students' roles clearly can offer further guidance.

Final Thoughts

Ensuring high levels of engagement for students with LD continues to be a challenge educators face in the classroom, especially for difficult content, such as fractions. Implementing game-based learning has proven to be an effective means for student learning. The use of a UDL approach for game design and classroom instruction is a promising approach for fostering student motivation and engagement because they afford students multiple means to access material and demonstrate their conceptual understanding in an enjoyable way.

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