# SciGames: Guided Play Games to Enhance Science Engagement and Learning

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**Abstract**

In this paper we present a set of design principles for the creation and implementation of guided play games (GPGs) to support science learning and, and report on an experimental pilot study in which we tested the effectiveness of two playground-based GPGs we developed through our SciGames initiative. Specifically, we investigated whether GPGs could positively influence behavioral, emotional, and cognitive engagement, and at the same time support science content learning. We compared the outcomes for students who played the GPGs with those of students who engaged in free play with the same playground equipment but without any guides to their play. Results showed that GPG students persisted longer, engaged in significantly more scientific talk, and demonstrated greater knowledge gains compared to free play students. We discuss implications of the design principles and this study for future research and instructional design that leverages play and technology to support students' engagement and learning in science domains.

**Introduction to Guided Play Games**

Several characteristics of children's play are sought-after ideals in learning environments. Players are self-motivated to attend, persist, and discover. They evidence curiosity and creativity and express joy. While play has the potential to support many qualities that one would hope to find in any learning environment, researchers have found that differences in how play is structured influence the extent to which curricular content learning can be supported during such play.

Broadly speaking, play can be classified into two categories: free play and guided play (Fisher et al., 2009; Hirsh-Pasek, Michnick, Berk, & Singer, 2009), both child-centered, meaning that the children decide autonomously how to conduct their play. A free play environment, while somewhat difficult to define, is "fun, voluntary, flexible, involve[s] active engagement, has no extrinsic goals, involves active engagement of the child, and often contain[s] an element of make-believe" (Pellegrini, 2009). In guided play, adults set up the environment, enriching it with play objects specifically intended to provide experiences related to curricular content learning opportunities. Adults might further guide play by collaboratively exploring the materials with children, using the materials in ways that might not occur to children, remarking on what children discover, and asking the children open-ended questions (Fisher et al., 2009; Resnick, 1998; Fein & Rivkin, 1986). Studies have begun to show that children are more likely to learn curricular content in a guided play environment than in a free play environment and also that play appropriately guided can be a powerful learning tool (Fisher et al., 2009; Miller & Almon, 2009; Resnick, 2007; Youell, 2008).

A third possible guide to play beyond the nature of the play materials themselves and the role of an adult co-player might further support learning, namely, the rules of a game. Piaget

(1962) suggests that rules-based games naturally become part of children's play around the age of 7 to 11 years. This idea that a game and its rules can support content learning during play finds further support in the literature on games. Gee (2003) points out that good games have the potential of helping learners understand the embedded content within the game. Habgood and Ainsworth (2011) describe this as intrinsic integration. With careful design, the target content could be worked into the rules of a game such that the game player can progress in the game only by learning the content. In the case of this study, we were particularly interested in students learning science content. Games have been previously shown to support students learning science content (Barnett, Squire, Higginbotham, & Grant, 2004; Jenkins, Squire, & Tan, 2004).

To the extent to which repeated cycles of gameplay could mirror the scientific inquiry process as students play and replay in an effort to win, a game with rules could even further support science content learning. The rules of the game could be designed to support students' asking questions, developing and carrying out investigations, gathering evidence, and proposing explanations based on evidence, i.e., engaging in inquiry (Sandoval & Reiser, 2004; Singer, Marx, Krajcik, & Chambers, 2000) as they strove to win the game. Such inquiry-based practices have been shown to help students improve their understanding of scientific concepts (Kanter, 2010; Krajcik, McNeill, & Reiser, 2008; Marx, Blumenfeld, Krajcik, Fishman, Soloway, et al., 2004; Rivet & Krajcik, 2004; Schneider, 2002). Thus, designing the rules of the game to support engaging in science inquiry-based practices should further support the science content learning toward which the play is guided.

We are also particularly interested in guided play games (GPGs) due to the potential they would seem to have to positively impact the affective dimensions of students' learning, namely engagement, a set of interrelated factors having to do with an individual's behavior, emotion, and cognition in a learning setting. Behavioral engagement can include effort, persistence, attention, and asking questions. Emotional engagement has to do with affective reactions to learning, including interest, boredom, happiness, sadness, and anxiety. Cognitive engagement has been defined as the "student's psychological investment in and effort directed toward learning, understanding, mastering the knowledge, skills or crafts that the academic work is intended to promote" (Fredericks, Blumenfeld, & Paris, 2004). Studies have shown that improving each of these three dimensions of engagement can reduce students' tendency to drop out of school (Fredericks et al., 2004; National Research Council, 2003). Newmann et al. (1992) suggest that engagement can be enhanced by making tasks more authentic, providing more opportunities for students to "own" the tasks and collaborate, and providing more opportunities for fun. This sounds like exactly the kind of playful experience a GPG is designed to provide, and perhaps to a greater degree than traditional classroom instruction can offer.

We were interested to see if playing a GPG could boost engagement while at the same time improving student learning, reasonably expecting that these two outcomes would strongly mutually reinforce one another. This was our first hypothesis. We also aimed to test a second hypothesis: that GPGs would have an improved impact on engagement and content learning over that found when students engaged in comparable free play.

## Designing Guided Play Games

To test our hypotheses, we designed two different GPGs for students to play on the playground. Both GPGs were aimed at helping students understand middle-grades standards-based physical science content. (We chose to work with middle-grades students since that is the age group where the bulk of attrition away from school science occurs; the ability to positively impact engagement and science content learning for this age student might help work against this trend.) The first GPG was a scooter cart game focused on science content learning related to force and motion: the difference between velocity and acceleration, and the relationship between force, mass, and acceleration. The second was a playground slide game focused on science content learning related to energy: how energy can be interconverted from one form to another, specifically potential energy to kinetic and thermal energy, and what factors determine these energy amounts.

The design team was multidisciplinary and included two learning scientists, five teachers, three learning technologists, and one evaluator. After 12 weeks of initial content selection and setting of learning goals, the GPGs underwent three iterative design cycles over a period of eight months. As we continued to work on designing the games, we found we were able to formalize our above-presented ideas about GPGs as a set of specific design principles to which we subsequently adhered in completing both GPGs. These design principles are as follows:

- *Fun Factor*: Making the game fun to play was one of the most important design principles for the game design. Research on play suggests that while having fun, learners experience prolonged engagement (Piaget, 1962).
- *Control:* We wanted to ensure that the GPG design allowed students to be responsible for the decision-making regarding their own explorations. We wanted the design to enable students to take ownership, meaning that after students understood the rules of the game, they would require an absolute minimum amount of external facilitation or guidance.
- *Knowledge in Action:* This design principle was rooted in the concept of intrinsic integration. To succeed at the game, students would have to employ an acquired understanding of scientific content.

- *Inquiry-Based Gameplay:* The rules of the games were designed to encourage repeated cycles of gameplay that promoted prediction, exploration, and reflection, mirroring the scientific inquiry cycle.
- *Playful Data:* To support inquiry-based gameplay, we needed the students to collect data of some sort during the GPG on which to reflect. Since data would need to be part of the game, we needed a way to present these data in a way that was intuitively easy to understand. We also wanted the data to reflect the playful nature of the game and be less school-like, that is, to not look like tables, graphs, or charts.
- *Personalization:* We needed the experience to be personalized. This would reinforce the fun factor and also reinforce the control design principle by making students feel at the center of their own experience.
- *Reflection:* Besides the reflection that is already part of the inquiry-based gameplay, we focused on additional scaffolds that were necessary to help students see patterns in the data that they and others generated during gameplay in order to use those patterns to improve their performance.
- *Collaboration:* Not only did we want students to enjoy playing the games with others, but we also wanted them to interact and collaborate as they tried to figure out what was required to succeed. Our design supported students playing in teams and sharing hints or cheats.

**Scooter Cart Guided Play Game**

In the scooter cart GPG, a pair of students, one driver and one rider, had to match their motion to a target motion and the better their match, the higher their score. The driver pushed the rider on a low-to-the-ground scooter cart down a straight track approximately 50 feet in length. The students first interacted with a facilitator who explained how to play the game, helped them navigate the rules of the game, and helped them with the reflection process during the first few cycles of gameplay. The facilitator began by showing the students a video of three different types of motion — constant velocity, low acceleration, and high acceleration — and asked them to replicate any one of these. Winning required creating a motion that matched the ideal for that type. We chose these three kinds of motion to guide students toward understanding the difference between velocity and acceleration. Also, by pushing their rider on the cart, students would learn about the relationship among the amount of force required to push the cart, the amount of mass sitting on the cart (the rider), and acceleration (the increase in the cart's rate of speed along the straight track).

As the students pushed the cart we tracked the cart's motion in real time using custom software. A webcam connected to a computer mounted approximately 50 feet away from the track used a computer-vision algorithm to track the motion of the cart against any stationary background.

To start playing, a student waved a flag to signal the type of motion they wanted to re-create, and then selected a friend for the rider. The students would make their run and return to the start of the track, where they saw an instant video replay of themselves, with automated overlays using a vertical line to indicate the cart's location at regular time intervals and a green bar showing the force with which the driver was pushing the cart. The facilitator helped the students interpret the data during the first few runs by looking carefully at how their vertical lines matched up against those for the ideal motion. As the students became proficient at the game, the role of the facilitator was purposely tapered off, helping students only when they asked for advice.

The design of the scooter cart GPG was grounded in the design principles as follows. The design supported the *fun factor* by letting students push a cart fast with a friend on it. The students also had fun watching the instant replay of themselves. The GPG gave students *control* over their gameplay and encouraged them to fail and learn from their failure. Students had control over the kind of motion they wanted to re-create, the selection of the passenger and driver, and when to start the run. The GPG focused on *knowledge in action* by making the target physics learning an integral part of the game: the more students learned about the difference between velocity and acceleration and the relationship among force, mass, and acceleration, the better they could match their motion to the ideal and win. For example, if the rider was very lightweight, the driver would know that less force was required to push the cart to achieve a high acceleration.

To help students acquire the knowledge needed to perform better at the GPG, the rules supported *inquiry-based gameplay* — even though students probably weren't aware of this. The game's design, and the facilitator, encouraged students to make a prediction, do a run, analyze the resultant data for why that run scored a particular way, and draw inferences about what to change to improve the next run. Inquiry was supported by the *playful data* generated during the runs. The data were also *personalized* for every student, with the screen split horizontally to show video on the bottom half of the students themselves pushing/riding the cart down the track with an overlay of the vertical motion lines and showing the ideal motion on the top half. Showing these two motions side by side supported *reflection*. Students were easily able to compare their own motion lines and force bar with those of the ideal motion. Reflection was further supported by including a human facilitator as part of the GPG. The facilitator initially encouraged students to observe their data and make comparisons, and to talk about their perceptions of their success matching the target motion after each run and what to change to score better on the next run. Finally, the GPG supported *collaboration* with the students engaging in gameplay and reflection as pairs; the design also supported the reflection being conducted classwide where all students would dialogue to determine what types of strategies would lead to better outcomes.

**Slide Guided Play Game**

In the slide GPG, students chose different mats to transform energy as they slid. The goal was to slide in such a way as to end up with the right types and amounts of energy at the bottom of the slide to pass to a computer-based avatar riding in a hot air balloon in order to get the hot air balloon to hit a target. In this GPG, the students first weighed themselves, and based on the student's mass, a personalized and achievable target was set for his hot air balloon. Students then choose a mat and descended the slide. The amount of kinetic energy the student had at the bottom of the slide would spin the hot air balloon's propeller and push it horizontally toward the target, while the amount of thermal energy due to friction would raise the hot air balloon vertically toward the target. When students were not initially successful in hitting the target, they would try again, working to change their final energy amounts by choosing a different mat, giving themselves an initial push, etc.

The technology supporting this GPG included custom-made light sensors on one side of the slide and high-powered flashlights pointing directly at the light sensors from the other side of the slide. Two light-sensor/flashlight pairs placed at the top of the slide could calculate a student's velocity by how quickly she passed the first and then the second sensor. Another pair placed at the bottom of the slide similarly calculated a student's final velocity. These data, together with the previously recorded mass and the height of the slide, would be combined to calculate potential energy of the student at the top of the slide, kinetic energy of the student at the top and bottom of the slide, and thermal energy due to friction at the bottom of the slide. It was with these energy values that the students played the GPG.

The design was grounded in the GPG design principles as follows. The design supported playfulness and a certain *fun factor* inherent in letting students slide down a playground slide, including sliding down on mats made of different materials. The design encouraged the students to take *control* of the game by having them choose the type of mat they used to go down the slide and anything else they wanted to change about how to slide. The students also had control over the GPG insofar as the computer would start recording automatically whenever they decided to slide. The GPG focused on *knowledge in action* in that the game required students to use their knowledge of total energy being conserved, how energy is interconverted among forms, and the factors that determine the various energy amounts, to end up with the right amounts of the right kinds of energy to get their hot air balloon to hit the target. The better they understood energy, the more reliably they could hit the target, no matter where it was positioned.

To help students acquire this knowledge, we again designed for *inquiry-based gameplay*. The game's design, as well as the facilitator, encouraged students to think about what they needed to do to hit the target, do a run, analyze the resultant data for why they missed the target in a certain way, and draw inferences about what to change to get closer to hitting the target. Once again, students might not even realize they were engaged in inquiry, but they were. The students were working with a *playful data* representation of their energy amounts that was fairly nontraditional, i.e, the movement of a hot air balloon. These data were *personalized* in that the students weighed themselves before each run and thus the target was set based on the unique potential energy of each student. This GPG also supported *reflection* by showing a looped replay of a student's run, which, along with the facilitator's questions, encouraged her to consider how to improve her performance by thinking about why she missed the target and what to change to perform better on the next run. Finally, the GPG was designed to help students *collaborate* to improve their performance. Students would wait at the bottom of the slide and view the large monitor with the next slider to discuss what happened and what to do differently. Similarly, while students were lined up they were all able to see where the next student's target was set, and this supported their talking with one another about what to do to succeed, making suggestions about, for example, what mat to choose to better their performance.

## Methods

### Participants

To gain some preliminary insight into this study's two hypotheses, we recruited 43 eighth-grade students from a New York City middle school with a student population that was 62 percent Hispanic or Latino, 34 percent Black or African American, 3 percent White, 1 percent Asian, and 1 percent American Indian or Alaska Native; 90 percent of students were eligible for free or reduced-price lunch. We split the students randomly into scooter cart or slide groups, then split each group to play the GPG or engage in free play using that same piece of playground equipment. The numbers and demographics of the students participating in the study are presented in Tables 1a and 1b.

Table 1a. Scooter cart study participants

| **Group** | **N** | **Male** | **Female** |
|---|---|---|---|
| | | | |

| | | | |
|---|---|---|---|
| Guided play game | 15 | 8 | 7 |
| Free play | 7 | 3 | 4 |

Table 1b. Slide study participants

| Group | N | Male | Female |
|---|---|---|---|
| Guided play game | 12 | 6 | 6 |
| Free play | 9 | 3 | 6 |

**Experimental Conditions**

Both GPG groups played the games as described above. Both GPG groups reviewed their runs on the video monitor and then, initially with the help of the facilitator but later without, interpreted the data and decided what do next. In both GPGs, the students were allotted a maximum time of 30 minutes to play.

For both free play groups, gameplay was necessarily different than that for students playing the GPGs. None of the guides to play were employed. The scooter cart and slide and mats were available but all sensors and monitors were turned off. The facilitator was present but his role was strictly that of crowd control. The students could play with the playground equipment however they wished. The scooter free play students notably had multiple students driving and multiple students riding on the cart, and they often did not push the cart along the straight line. Like the GPG students, the free play students were given a maximum of 30 minutes to play.

**Constructs: Engagement and Science Content Learning**

We deployed multiple constructs and data-collection and analysis techniques to explore our two hypotheses and determine (1) the extent to which the scooter cart and slide GPGs impacted the students' engagement and science content learning, and (2) how these observed student outcomes compared to those observed with free play with the same scooter cart and slide.

The first set of constructs is related to engagement, including behavioral, emotional, and cognitive. Engagement is often measured with self-report surveys (Fredericks et al., 2004). To enhance the validity of measurement and to minimize disruption of gameplay, we sought to measure engagement directly through the observation of student behaviors and expressions, physical and verbal.

**Attentiveness.** Attentiveness is one way we measured behavioral engagement. Video coding was based on observational scales used for measuring playful behavior (Barnett, 1991; Marks, 2000). We developed and used a rubric to code video for the amount of time students were "completely attentive," "partially attentive," or "not attentive at all" while playing. The instances that a student was "completely attentive," "partially attentive," or "not attentive at all" were timed and divided by the average total time the students in that group played to arrive at percentages. Group average attentiveness was calculated by averaging all the individual percentages for the students in a particular group.

**Persistence.** Persistence is another way we measured behavioral engagement that we considered separately from attentiveness. We wanted to observe how many times students played and for how long. Watching the video, we coded persistence as the number of times a student completed full rounds of gameplay, whether this was the gameplay that was supported by the GPGs or the games students made up for themselves in the free play conditions. In both GPG and free play groups, group average persistence was determined by averaging the individual persistence tallies for the students.

**Fun.** In order to get a complete picture of student engagement while playing, we needed to examine some aspects of emotional engagement and thus we looked at whether the students were having fun. Fun was measured in three ways. First, we observed whether or not the students were having fun during play by reviewing the videos for relevant observable behaviors or utterances, e.g. instances where students smiled or laughed, made joyful noises, or vocalized enjoying themselves, or in contrast, appeared to be or stated being bored. We supplemented this in a post-interview by asking students directly whether or not they had fun during the GPG or free play experiences, as well as how much fun they had as compared to their favorite game. Group average fun was determined by averaging individual student's fun tallies.

We supplemented these direct observations of students' fun by asking two more traditional student self-report items during the post-interview. Students were asked to rate "How much fun was the game/experience?" on a 1 to 5 scale (1 = boring, 2 = average, 3 = good, 4 = very good, and 5 = excellent). We also asked them to rate how the game/experience compared to their favorite game on a 1 to 5 scale (1 = completely boring, 2 = just okay, 3 = almost as much fun, 4 = as much fun, and 5 = more fun than their favorite game). We recorded the individual scores for students and determined group average scores.

**Scientific Talk.** Scientific talk was considered to be an expression of cognitive engagement. Scientific talk was coded from video and was observed when students supported their arguments with evidence drawn from their GPG or free play experiences (Mortimer &

Scott, 2003). Instances of scientific talk were tallied per individual student and group averages for scientific talk were determined. Scientific talk also gives us some insight into the extent to which scientific inquiry-type processes were engendered as had been designed into the GPG rules to help promote science content learning.

**Science Content Learning.** Besides the impact on students' behavioral, emotional, and cognitive engagement, we also needed to measure whether students progressed in their physics content learning by virtue of their GPG or free play experience**.** It is easy to imagine guided play that would be fun enough to boost engagement but at the expense of any science learning, or that the game experience might lead students to improve their science learning but with such a heavy hand that their engagement would slump. To measure impact on content learning we used pre- and post-tests. To maintain the playful nature of the GPG or free play experiences, pre-tests were given at least a week in advance to the students doing the playground activity. The post-test was given the next day. Students who engaged in the scooter cart GPG or free play experiences took a force-and-motion test, and students who engaged in the slide GPG or free play experiences took an energy test. Where possible, questions for both tests were adapted from the Physics Force Concept Inventory (Hestenes, Wells, & Swackhamer, 1992) to be appropriate for these younger students or were identified from standardized test item banks.

## Results and Conclusions

This study investigated whether GPGs could positively influence behavioral, emotional, and cognitive engagement, and at the same time support science content learning. We compared the outcomes for students who played the GPGs with those of students who engaged in free play with the same playground equipment but without any guides to their play.

For both the scooter cart and the slide GPGs, our results indicated a positive impact on behavioral engagement (attentiveness, persistence), emotional engagement (fun), cognitive engagement (scientific talk), and physics science content learning. The GPGs created impressively high levels of student attention and kept them high throughout the game ("completely attentive" 99% of the time for the scooter cart GPG and 97% for the slide GPG).

The free play students were also attentive ("completely attentive" 80% of the time for scooter cart free play and 100% for slide free play), but they played for a shorter time (on average, 15 minutes for scooter cart free play compared to 30 minutes for the scooter cart GPG; on average, 17 minutes for slide free play compared to 30 minutes for the slide GPG). Students were also significantly less persistent in repeating runs during free play as compared to the GPGs (on average, 3 complete runs for the scooter cart free play compared to 7 for scooter cart GPG; on average, 2 complete runs for the slide free play compared to 4 for slide GPG). This finding was influenced by the fact that the GPG rules supported *all* students having a chance to play the game, whereas in free play, some students did not play at all, perhaps because they felt excluded. So, in the end, our guiding the play did not seem to decrease students' playful participation at all and in some ways increased it.

We might attribute the higher levels of attentiveness and persistence for the GPGs compared to free play to the GPGs being more fun, i.e., emotionally engaging. Certainly, the GPGs were created around the design principles of fun factor, control, personalization, and collaboration in an attempt to promote both behavioral and emotional engagement. However, the findings related to fun are not entirely consistent. While both GPG and free play groups self-reported having statistically the same amounts of fun (on average the students self-reported the experience being between "very good" and "excellent" and between "as much fun" as and "more fun" to play as their favorite game for both the scooter cart and slide GPGs, and for both scooter cart and slide free play groups), we actually documented more observed instances of fun with free play than with the GPG students (on average, 13 instances of fun for scooter cart free play compared to 7 instances for the scooter cart GPG; on average, 15 instances of fun for slide free play compared to 7 for the slide GPG). The finding that free play might indeed promote more emotional engagement seems reasonable, but as you will see, it also results in less behavioral and cognitive engagement and less learning. That said, it is also hard to know if we should rely on either the self-report or direct observation of emotional engagement as more valid. It is interesting that both the GPG and free play students self-reported an equivalent amount of fun.

To document cognitive engagement, we looked at scientific talk. We observed that the GPG students used scientific talk significantly more often (on average, 21 instances of scientific talk for the scooter cart GPG; on average, 16 instances of scientific talk for the slide GPG) than the free play students (who in fact never used scientific talk during their play at all). This finding indicates the extent to which the inquiry-based gameplay and playful data design principles worked. This finding is particularly interesting because it highlights the extent to which the cognitive engagement engendered by playing GPGs did not come at the expense of behavioral and emotional engagement, which were found at levels similar to or even greater than those found during free play. In this regard, GPGs can be seen to strike an exciting balance, and should the cognitive engagement ultimately support the learning of science content, which we will discuss next, this guided play model might have the potential to keep students both engaged and achieving in science in a virtuous cycle.

Students playing both GPGs improved a significant amount on their content learning tests from pre to post (students improved on the force-and-motion test a statistically significant 1.4

standard deviations after playing the scooter cart GPG; students improved on the energy test a statistically significant 1.2 standard deviations after playing the slide GPG), whereas the free play students did not (there was no statistically significant change pre to post on either test with either type of free play). These findings are consistent with the literature discussed above suggesting that free play does not support content learning as well as guided play. These findings are also consistent with the literature on how games can support science content learning. In sum, we did find evidence of the potential of guided play games to improve students' engagement and achievement at the same time.

**SciGames** It is important to note that after playing the GPGs, students achieved only 60 percent and 53 percent of the total points possible on the force-and-motion and energy post tests, respectively. There is room for further improvement in science content learning beyond what the GPGs were able to support. However, if we add more guides for learning to the game, we might risk reducing the positive impact on engagement by effectively tipping the experience from one of student-directed guided play to one that would feel to the student more like guided inquiry, directed by some external authority.

Is there another way we might further improve science content learning while keeping the experience feeling playful to students and thus keeping engagement just as high? It is in this direction that we are extending our work on GPGs with our new SciGames project, work that is being generously supported by the U.S. Department of Education (Investing in Innovation program) and the National Science Foundation (Transforming STEM Learning program), with additional funding from the John D. and Catherine T. MacArthur Foundation, the Motorola Solutions Foundation, and the Bank of New York Mellon Foundation.

SciGames begins using the same GPGs described above, played in the informal playground setting, but with all participating students wearing radio-frequency ID bracelets. We use these bracelets to log students' quantitative data generated playing the GPGs automatically and invisibly while they play. The SciGames system uploads these student-specific data onto a virtual playground application that digitally extends the physical playground into the students' science classroom. In this new virtual space, students will be able to replay their own runs from the GPGs and those of their friends, as well as conduct new rounds of gameplay, including runs that are not possible in the real world, such as runs without friction. Most important, the digital application provides specialized tools that support students (with teacher guidance) inquiring deeply into this class-generated quantitative data to look for the patterns that help win the GPGs; due to the Knowledge in Action design principle that guided the design of the GPGs from the start, winning depends on mastering the underlying scientific principles we wanted students to learn.

We have now determined that GPGs can positively affect student behavioral, emotional, and cognitive engagement in learning. We are excited to see if the SciGames approach can extend the GPG idea in a way that further improves students' science content learning while retaining, if not enhancing, its positive impact on engagement.

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