How Classroom Gameplay Changes Teachers: Perceptions and Takeaways on the Use of Computer Games After a Classroom Intervention

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Abstract: While teachers are consistently asked to investigate new forms of technology, the use of computer-based games provides additional, unique issues. This research describes the changes in 12 elementary teachers' perceptions of games in the classroom after participating in an early algebra game-based intervention. Teachers implemented two computer-based games and one interactive tool as part of their daily mathematics lesson. They were also asked to guide their students through specific supplemental activities for out-of-game learning, which directly related to the content in the games. Surveys, classroom observations, self-reflection logs, and interviews documented teacher-student interaction during *Math Snacks* games. Findings reflect how the intervention changed teachers' views of games; their orientation to using inquiry in the classroom; their facilitation of technology; and their perception of including students with different abilities in gameplay. Participating teachers saw games as a tool to let students explore and introduce a topic with minimal initial guidance. Some teachers also noted the value of computer-based games in supporting low-performing students' integration and participation with the rest of the class. Teachers reported that students' collaboration and discussion skills were the primary competencies noticed while students were playing. Most of the teachers noted that their role as facilitators is essential n in the students' learning.

Keywords: game-based learning, teaching practices, educational games, mathematics education, learning pedagogies

Introduction

Studies on integrating educational games into the classroom are extensive regarding video games' positive or negative impact as learning tools [1-6]. Research depicts the use of computer games in the classroom as significantly impacting students' cognitive skills for topics such as mathematics and science [7-8]. The suite of games and animations in this research, called *Math Snacks*, were designed to encourage student learning of mathematics content. Research on the impacts of *Math Snacks* games reveals significant pre-post test gains in increasing student understanding of middle school mathematics concepts [9]. Despite the research conducted in the field of educational games, few studies investigate the role of teachers during the game implementation, which is surprising given the purpose of the teachers as true change agents in schools [10].

Researchers consistently suggest that teachers play an important role in facilitating learning with video games, particularly in how teachers guide the use of video games and debrief with students. Yet, teachers are often afraid to integrate the games into lessons even when they intuitively know the importance of their involvement when using video games [11]. Some teachers are uncomfortable moving beyond the simple practice of allowing students to play independently without guidance or lessons or integrating what students learn in games into the classroom [12-13]. Research on the use of commercial off-the-shelf titles documents many challenges teachers face, such as their reluctance to engage with games due to their lack of knowledge of best practices for integrating games within the classroom [14, 12, 15]. However, teachers' role as facilitators of game-based learning can be significant in the success of classroom-based gameplay.

The importance of the role of teachers as facilitators reflects their responsibility to enhance student learning with games and complementary activities, such as post-gameplay exercises, conversations to engage students, and scaffolding the use of educational tools and processes. De Freitas and Jarvis [16] emphasized the importance of the teacher's support in gameplay contexts and indicated the importance of embedding the games into learning contexts using support materials and debriefing or reflection activities to enforce learning outcomes; other activities like discussions and reflections about the learning and playing activities can also enforce students' learning with games. To facilitate these interactions, teachers need to know what students did in the game, what topics were addressed, and how these concepts were presented through the game and complementary activities [8, 10]. It would follow that giving teachers an opportunity to better understand gameplay is an important part of classroom success.

Research reflects the need to study teachers' experience integrating education games in their classrooms. Important insights would aid in improving teacher training, enhancing in-classroom supporting strategies that accompany the game, and enriching role practices for teachers who want to use computer games in their classrooms [8, 10, 16, 17]. These teaching strategies could support pre-service and current teachers in having a successful game integration as part of their lessons, as research has found that teachers' acceptance and familiarity with games positively impact their role as facilitators [18-20]. In fact, games are usually introduced by the actions of an enthusiastic teacher who is familiar with a particular game and can see the game's potential for a specific subject [21]. If teachers consider digital games tools that can provide learning opportunities to students, teachers will also perceive digital games as useful to enhance job performance [20].

Previous games research presents specific ways in which integrating computer games with different pedagogical practices illustrated important insights, challenges, and changes in teaching practices [22-25]. Even when each study differs in methodology, findings among them relate to pedagogical approaches and challenges collected from self-reported measures indicating a present or future intention.

- The role of the teacher in structuring and framing the learner's activity remains crucial if learning outcomes are to be achieved [22].
- The teacher wishing to use games must know what content particular titles offer. Teachers should be as aware of the content of games as they are of the content of video, television, or film material [22]. Teachers found it difficult to identify how a particular game is relevant to some component of the curriculum and the appropriateness of the content within the game [23].
- The teacher requires some understanding of the controls, menus, and skill levels of the game to use it effectively. Playing the game is the only way to gain these skills [22]. Teachers with little experience in the use of video games are reluctant to use them because they feel insecure and require significant support during the process and available time to familiarize themselves with the game and the methods of producing the best results for its use [23].
- Teachers who reported using games were usually enthusiastic, already familiar with the game, and could foresee the game's learning potential [22]. Teachers with little knowledge showed fundamentally reactive, while the teachers that had expertise in the game were able to assume a proactive role [23]. Teachers took more ownership of the resources, had higher confidence in integrating the unit as a teaching tool, and were more likely to believe that the curriculum resources would have a positive impact on student achievement [25].
- Teachers, who were mainly accustomed to subject matter exposition followed by assigning students worksheets to complete, found they had to work in real-time with ideas that students were contributing based on their gameplay experiences; they found themselves having to think on a mode of behavior they were unaccustomed to. The change triggered reflexivity and prompted the teachers to reflect more deeply on their past and present practices [24].
- Teachers found that using games could provide motivation, develop skills, and encourage collaboration [22].
- It was less common that school policy defined the introduction of games, and the study found no evidence at any State level of the introduction of computer and video games except as part of a research project [22].
- Working with elements or sections of the game may be more beneficial for some games and school contexts than the whole game. Isolating elements of games for use in lessons can be difficult. Most games have been designed for use over an extended time. Some titles offer shortcuts such as scenario builders, pre-defined scenarios, and the facility to save games [22].

Math Snacks Project

The First Suite and Research Study

Math Snacks is a suite of smart educational animations, games, interactive tools, and a series of activities grounded in constructivist learning, designed to support elementary and middle-school students to develop a conceptual understanding of mathematics. The first suite of *Math Snacks* products included six animations and five games, all available in English and Spanish and freely available to play online. Topics in the first suite included number sense, order of operations, placed value, ratios, proportion, scale factor, coordinates, measurement, fractions, and decimals. The products include a series of materials that can be used in various lessons to support teachers and students. Each animation and game have a printable teacher guide that helps teachers to use the tool and offers discussion questions, vocabulary, and companion activities. Each game has a gameplay video that will help teachers understand how the game progresses, even if they don't have time to play it all the way through.

In the research project on the first suite of the *Math Snacks* games in 2014, the research team conducted a randomized control trial study with a delayed intervention with 741 fifth-grade students and 48 teachers. Classrooms were then divided into two groups: teachers in the first set of classes integrating *Math Snacks* into their instruction during the first five months and teachers in the second set continuing instruction as usual. Then, teachers in the second set integrated *Math Snacks* into their instruction, while the first set continued instruction. This delayed intervention model allowed researchers to give all students access to the intervention, control for teacher differences that could influence pre-, post- tests results, and identify any potential drop-off in conceptual understanding from the first group two months after the intervention. This study showed a significant positive learning effect for students who received the intervention compared to students in the second group.

Moreover, when students in the delayed intervention were given the opportunity to use the games in class, they caught up with their peers after receiving the intervention [9, 26]. *Math Snacks* researchers observed classroom integration of the games in all classrooms as part of their fidelity measure (to track teachers' adherence to protocols). Through those observations, they noted anecdotal descriptions of changes in the way teachers used the games and taught math before and after the intervention. However, the research team had no documented evidence about how the use of *Math Snacks* tools impacted teachers' perceptions of games and pedagogical practices of game-based learning. It sought to investigate the impact of using *Math Snacks* tools on how teachers taught math even when not using the tools.

Focus of this Study: Math Snacks Early Algebra Project

In 2015, the Learning Games Lab received further funding from the National Science Foundation (1503507) for the development of three additional multimedia tools targeting early algebra concepts and conducting research on the impacts on 4th-5th graders and their teachers. Content focused on two major content domains: 1) Write and interpret expressions, and 2) Express patterns and relationships between quantities. Their proposed research mirrored the delayed intervention model used in the first study but added an additional objective to better understand how teachers used the games and what changes they made in their teaching.

The *Math Snacks* team developed two games and one interactive tool to support student learning of the two key learning concepts and support materials like those developed for the first suite. Curse Reverse is designed to teach the key learning concept of expressing patterns and relationships between quantities. It is a platform-style game where players travel to various temples and are charged with returning stolen treasures to advance to increasingly more challenging levels to collect up to three stars. As players progress to more advanced locations, they change pillar heights by adjusting different features of algebraic expressions. Agrinautica is a sandbox-style game where players can create a wide variety of numeric expressions using operations and parentheses. By exploring different ways to create expressions given a set of four numbers, they can create artifacts and plants to populate six different planets. The game addresses the primary learning concept by allowing learners to experiment with the syntax of writing expressions that match their original intent. In the Creature Caverns interactive tool, learners analyze the relationship between the creatures' numbers of horns, eyes, brains, and other variables. Students can look at the relationships of these variables through graphs, tables, and expressions. This tool also addresses the principal learning concept of expressing patterns and relationships between quantities.

Math Snacks Early Algebra Intervention

This study focuses on the second suite of *Math Snacks* for Algebra in which teachers were asked to integrate the tools into their existing instruction (like the intervention for research of the first suite). Before the teachers used the tools, the research team modeled the lessons for teachers; teachers then integrated the *Math Snacks* lessons in the classroom with their other instruction. The *Math Snacks* implementation modeled a specific approach to using the tools in lessons, and participants were asked to follow that approach when using the games.

1. *Introduce gameplay with discussion questions and initial play.* Students freely explore the game for about 15 to 20 minutes. The teacher then facilitates a whole class discussion about students' gameplay. Teachers can ask a few students to use the smart board and share game strategies.
2. *Engage students in support activities and discussion questions.* The teacher models and then facilitates a hands-on activity associated with the game's content. Each developed game or tool had its own designed activity in this *Math Snacks* intervention. For Agrinautica, the Sunburst activity was designed to start with a target number on the center of a circle, and different extended-expression forms burst out into multiple layers. For Curse Reverse, the Keys activity was designed to uncover a secret image hidden behind locks. Each lock has a value that must be matched by modifying the expressions on the students' key handouts. For Creature Caverns, the Creatures activity was designed to use different attributes of hand-made creatures to sort by something that can be counted, then think about quantities that are not directly counted, and finally plot the creatures on the coordinate grid, quadrant 1.
3. *Allow students to play again with guided discussion.* Students play the game for another 15 to 20 minutes. This second gameplay session allows students to discover or implement newly learned game strategies and to make use of new content learned from the supporting activity. The teacher then facilitates a class discussion about students' second gameplay strategies and math content.
4. *Engage learners in reflection and assessment.* The *Math Snacks*' teacher guide offers a list of questions that teachers can use for oral discussion, journal entries, or exit tickets. Teachers are encouraged to use the vocabulary words as they ask for any task.

Teachers took up research-based activities while teaching their lessons. An instrument called Observation of Learning Environments (OLE 2) [27], designed to measure teachers' inquiry strategies, was used during classroom observations.

Methods

This study uses a subset of teachers who participated with their students in a more extensive study. To research the experiences of teachers in using games in their classroom more deeply, this qualitative study investigates any changes in their use of game-based teaching strategies and inquiry-based pedagogies.

The following research questions guided this study:

- How did teachers adapt implementation strategies that fit their classroom?
- In what ways do teachers' perceptions of computer games in the classroom change as a result of a *Math Snacks* intervention?

Sampling of Larger Study

For the *Math Snacks* Early Algebra, larger study, researchers contacted principals in a public school district in the Southwestern US, inviting them to recruit 4th and 5th-grade teachers who might be interested in the research project. The research accepted teachers from ten schools representing a range of demographics, and after two teachers withdrew, the final *Math Snacks* research intervention included 28 teachers and approximately 580 students. Teachers agreed to receive a stipend at the end of the study if all activities were completed. For the larger study, researchers randomly assigned one of the three new games (Agrinautica, Curse Reverse, and Creature Interactive) to use in their classroom while being observed by researchers as part of a fidelity measure (to track teachers' adherence to protocols).

Participants for this Study

For this study, researchers sought to collect a subsample of teachers who reflected varying experiences in teaching, a range of skills in inquiry orientation, and grades taught. For the larger study, teachers each taught all three games, but participants were randomly assigned which class would be observed. When selecting the subsample, all three games needed to be represented. Therefore, a subset of 12 teachers was purposefully selected from this sample of 28, based on the scores of the first classroom observation, the years of teaching experience, the school where they taught, and the assigned game to be observed. Each teacher's OLE 2 score indicated their expertise and inquiry-orientation skills: 0 representing low skill and 4 demonstrating high skill. In the larger study, all teachers scored from 0-3, with no high skill scores. These OLE 2 results provided a way to create three levels of inquiry orientation: low – scores were mainly 0's; medium – scores were mainly 1's; high – scores were mainly 2's and 3's. For the subset of this study, teachers were purposefully selected from each of the three levels. With these considerations, the subgroup of subjects presented diversity in years of teaching experience and expertise in inquiry orientation. It allowed for observation of each game in the study with at least one teacher (see Figure 1). The set of 12 teachers taught grades 4 & 5 across ten different elementary schools. All but one were female. These groups also varied in range of expertise, ethnicity, and age, as well as the different schools participating in the study with at least one teacher from each school in the larger project.

Data Collection

This study focuses on the subset of teachers, using interviews as the primary source of data as well as two OLE 2 classroom observation instances, one pre- and one post-survey, and three self-reflection logs. Over a period of nine months (see Figure 2), teachers in the larger study (including the 12 in, the smaller sample) completed basic assessments on their experience, their comfort with technology, and their knowledge and views on games. Pre- and Post- Surveys were used to assess the teacher's perspective of the value of games in the classroom, if they have used games before as part of their lesson, and in what ways. The teachers then integrated the games into their lessons, following basic protocols set by the project.

Demographics of 12 participant teachers (pseudonyms used for teacher's names)

	Teacher	Grade	Experience			Inquiry orientation as measured by OLE	Game taught while observed
			Yrs. Teaching Exp.	License level	Educ. Level		
1	Adel	5	17	2	Bachelor	Low	Agrinautica
2	Alain	4	15	3	Master	Low	Agrinautica
3	Alba	5	20	2	Bachelor	Low	Agrinautica
4	Casey	4	10	3	Master	Low	Creature Caverns
5	Reagan	5	17	2	Bachelor	Medium	Curse Reverse
6	Cleo	4	12	2	Bachelor	Medium	Creature Caverns
7	Carson	5	15	2	Bachelor	Medium	Creature Caverns
8	Rylee	5	18	2	Master	Medium	Curse Reverse
9	Carly	5	16	2	Master	Medium	Creature Caverns
10	Ryan	5	3	2	Bachelor	High	Curse Reverse
11	Ruby	5	23	2	Bachelor	High	Curse Reverse
12	Cameron	4	15	3	Bachelor	High	Creature Caverns

Fig. 1. Demographic Information of Participants.

Researchers observed one of these lessons to measure teacher's fidelity of implementation (adherence to protocol). Teachers completed three self-reflection logs (one per each game-lesson) on their thoughts and comments about the lesson they taught using each game. A second OLE classroom observation informed researchers about changes in teaching strategies with technology after *Math Snacks* implementation. The subset of teachers for this study also participated in additional semi-structured interviews on how they developed their lessons, what worked and what did not work for them, and how their perspectives about using games have changed after the implementation.

Analysis Procedures

The researcher followed Braun and Clarke's [28] version of the thematic analysis technique in the analysis of the semi-structured interviews to construct a qualitative description of the research data set. When doing transcriptions, the researcher used a side Word document and a whiteboard to take notes about specific things from the interview sessions that could support the analysis, like recalling teachers' specific actions, gestures, and comments. The researcher analyzed all source documents — Pre and post-surveys, observers' notes, reflection logs, and interview transcripts — as a group using the same – reading sentence by sentence and coding – iteration process with two software MAXQDA 2020 [29] and ATLAS.ti 8 – Mac [30]. Initially, the researcher did not have a specific codebook and started coding data deductively but paid particular attention to features that would result in several themes around Technological-Pedagogical-Game Knowledge, which may include, speak to, or expand on something approximating teaching practices. Some initial codes included: walking around, asking questions, low-performing kids, years of experience, looking at screens, and games being powerful tools.

To determine the pedagogical practices that were used during the implementation of computer-based games, themes were classified concerning strategies teachers used to integrate computer games into their lessons and the different ways to assess the learning practice. To describe the changes in teachers' perceptions of being able to use computer games in the classroom, themes were related to things that teachers modified from the assigned lesson protocol and to teachers' opinions, challenges, and takeaways from the implementation. While searching and reviewing themes, it was important to recall that extra data sources from the *Math Snacks* larger project would support evidence for the emerging themes; therefore, themes were revised iteratively to be useful and accurate data representations. Results from this study are not meant to be read as generalizable but as potentially transferable to other game-learning contexts or technological interactions with similar paradigms.

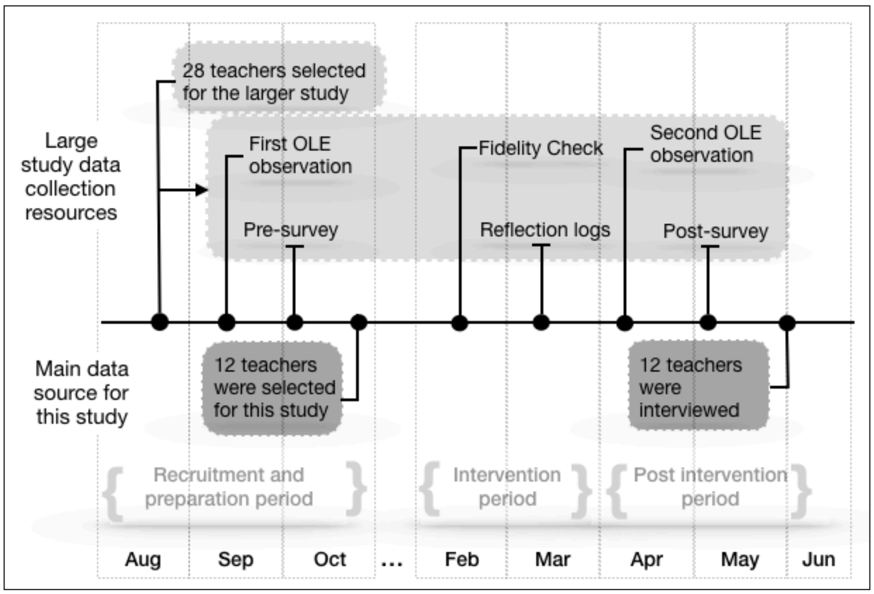

Fig. 2. Data Collection Timeline.

Validity and Reliability

To enhance trustworthiness different data sources were used. Triangulation was ensured by collecting different types of data that could describe different types of things concerning the themes that emerged from the interviews. The researcher consequently summarized the data collected and asked two persons to review the resulting sub-themes. Pieces of transcribed interviews and reflection logs' responses were given to two different persons, and they were asked to code them using an initial set of codes to verify their agreement on using a specific code for a particular piece of the transcript.

Findings and Discussion

Collected data from pre/post-surveys, reflection logs, interviews, classroom observations, and fidelity of implementation observations supported the understanding of how twelve participant teachers developed their lesson with the integration of *Math Snacks* games on.

RQ1:Teachers' Perceptions on the Use of Games in the Classroom

Findings showed that with an experience like the *Math Snacks* implementation, teachers would feel more comfortable and be more skilled in using computer games as part of their lessons. They viewed the introduction to game mechanics as helpful to guide students, especially those with different mathematical skills. Two main themes emerged from the analysis of all data sources:

i) Teachers saw *Math Snacks* games as powerful tools to explore mathematics concepts and to present content in a fun and engaging way

ii) *Math Snacks* games allowed for the inclusion of students with different mathematical skills

Math Snacks games changed teachers' views regarding the power and value of games.

Participant teachers noted that students are motivated when they learn through playing computer-based games. Being able to play and then having a brief discussion was an important contribution to the *Math Snacks* model. Responses to interviews showed that teachers agreed on how students could play the games, connect the mathematics content of the games with the learning in the supporting activity, and later apply these concepts to the reflections they were doing on discussion sessions. Ryan's answer to the question, "How would you describe your experience with *Math Snacks*?" was:

> "it was a good opportunity for us, as teachers, to present a concept without struggling to go and find how I can put all this together. So, it's a great tool to have. It's not limited to just math or that specific skill; it applies to different ones, even for reading. I mean, it is a good way to—or rather, it was a good opportunity to—integrate technology with hands-on activity and with paper and pencil" (Transcribed Interview Ryan, para. 216).

When asked, "Is there one game that sticks out in your mind as being sort of better?" Casey responded,

> "I thought that was a powerful game because they learned something; they were able to apply it, and then they were able to play and have discussions with each other. I'd say that one was, I feel, very beneficial—better—and it was engaging because they liked not only their little activity but also the game" (Transcribed Interview Casey, para. 30).

Teachers' responses to post-surveys showed evidence of positive change in teachers' perceptions on the use of games as there were zero teachers with 'strongly disagree' as their answer to four items related to how teachers view computer games: i) computers/tablets help students to understand mathematics concepts; ii) computers/tablets make sophisticated mathematics concepts accessible to students; iii) computer-based games are a good way for students to explore mathematics concepts, and iv) students are more motivated when they learn through playing computer games. Even after the intervention, teachers would allow students to play games and encourage them to play at home. For observation B, teachers were free to use any technology for their mathematics lesson, and one teacher implemented a different *Math Snacks* game from the intervention. Even when the other teachers did not use *Math Snacks* games for Observation B, they implemented other tools, such as videos, Istation, Kahoot, Online Jeopardy, and Brain Pop. However, they followed the *Math Snacks* intervention model (i.e., explore, discuss, supporting activity, reflection/assessment).

Math Snacks games allow for the inclusion of students with different mathematics skills.

Most teachers thought that the use of computer games was a beneficial tool for students who regularly struggle with paper and pencil activities. These students would often give up easily with paper exercises; however, on the contrary, they would feel motivated to continue trying when they were playing computer games like the ones in the *Math Snacks* intervention. Teachers mentioned being surprised that these low-performing students in a regular mathematics class were pulling above the group during the gameplay sessions. When asked, "Can you describe to me what was happening in the room in the first game session?" Reagan responded,

> "my lowest graded mathematics kids, who struggled, were actually doing better than my high scoring students in class. This pulled them up above that group, where they were actually showing their higher scoring peers shortcuts and how to maneuver through the game, and how to make these cool flowers or these cool trees. So, that was a confidence builder for those kids who struggle with a book, who struggle sitting at a desk with a pencil and paper" (Transcribed Interview Reagan, para. 60).

Other teachers saw implementing *Math Snacks* games as one way to help these low-performing or struggling students. They used the games as a reward whenever students had some free time or when they had finished their assigned work. After the question, "How would you think that the whole experience of *Math Snacks* would help you?" Adel responded,

> “even my B-most behavior kid, my special kid, enjoyed it because he would look at it as a reward for him. So, I would tell him, ‘you can get on computer, can I get on *Math Snacks*?’ Right away, that was the first question. ‘Sure, you can get on *Math Snacks*, but you’ve got to behave’. It was a reward for him, and he took it as a reward too” (Transcribed Interview Adel, para. 66).

Participants saw *Math Snacks*’ game session moments as the moment for struggling students to shine. For the question, “Can you talk to me about the second game session for Creature Caverns?” Casey responded,

> “I was amazed that some of my students who do struggle were able to get down into the medium tasks, even in such a short time” (Transcribed Interview Casey, para. 62).

RQ2: Pedagogical practices in the integration of games

This study extended findings and added further depth to how teachers perceived how gameplay sessions helped students foster deeper learning. Three main themes emerged from the analysis of all data sources:

i) Two separate gameplay sessions resulted in students building confidence and challenging themselves more

ii) Teaching with *Math Snacks* enhances student-to-student collaboration and communication

iii) Teachers integrated different teaching strategies into their *Math Snacks* lessons

Teachers view students building confidence and challenging themselves more because of two separate gameplay sessions.

Results showed how teachers who did two gameplay sessions showed an increase in students’ confidence to play the game and take risks to challenge themselves with more complex problems. Interviews responses described what differences teachers saw between the two gameplay sessions. Teachers talked about how students build confidence, use more vocabulary words, and challenge themselves to try more difficult game levels during gameplay session two. According to the teachers’ responses, having a second game session triggered students’ confidence.

> “In almost every game I made the two sessions, the biggest difference I found is the confidence of the children in the game, feeling more comfortable playing or looking for opportunities to understand the game, and get better scores” (Transcribed Interview Alba, para. 72)

> “they were using different vocabulary, and they were able to key in on those—you know, the specific math terms and stuff that went along with it—and they were making that connection” (Transcribed Interview Carly, para. 38)

> “For the second session, those who had not yet achieved that level in the first session, and yes, they could do more, and they felt a little more confident” (Transcribed Interview Alain, para. 32)

One difference between games sessions was the type of discussions students and teachers had. In the first game session, students talked about basic hints and strategies to play the game. However, in the second game session, students could use mathematics vocabulary they did not use during the first gameplay session (e.g., expression; set of parentheses; and value). Discussions after gameplay sessions also had an impact. During the second game session, students were able to use more mathematics vocabulary words that they learned during that day’s lesson.

Teachers enact teaching with Math Snacks games to enhance student-to-student collaboration and communication.

Findings exposed the different ways teachers saw students collaborating with each other. Teachers mentioned that students communicated their strategies while playing to help others get to the same level or achieve the same goals.

When asked, “What were their interactions with the students during the two game sessions and what did they see happening while students were playing?” Some of the responses were,

> “that is the good thing about it: that collaboration. Immediately, when one student would find a solution, they would tell the other student, and then that student would tell another. So, it was a collaboration with all of them” (Transcribed Interview Ryan, para. 28)

> “so, if somebody was struggling, they were able to teach each other how to get to that point. And then they loved when they actually got on the game and saw the plants and the different kinds. They were talking to each other a lot” (Transcribed Interview Casey, para. 28)

> "it was a lot of discussion with the students, to each other, because they were trying to figure out things like: What am I supposed to be doing? What are these numbers? How do I make the numbers move" (Transcribed Interview Cleo, para. 46)

Responses from teachers defined that each game and activity had its own way of integrating collaboration among students. A sandbox-type game like Agrinautica opened the classroom space for teachers to walk around the room and see how students use different methods to share their strategies (e.g., some used Post-it notes, and others explained by showing an example on their screen). It opened the space for student collaboration; they shared strategies for doing a specific plant, and students were not afraid to ask. While observing an Agrinautica lesson, some students were leading the playing strategies and teaching others during the lesson time. These leading students would walk across the room to show others how to execute a specific move. Agrinautica's supporting activity also offered an opportunity to make a gallery walk by hanging their final posters around the classroom. Students would observe all of them, and then the teacher asked students to reflect on what they saw in their classmates' work. In the interactive tool Creature Caverns supporting activity, the students used hand-made creatures to line up according to the number of a specific feature. Students collaborated to develop strategies to line up first by the number of antennae their creature had, then by the number of eyes, and later by the difference in the number of eyes and antennae. Students discussed how uniquely a creature can be created, and the teacher helped the students discuss strategies to make this interactive tool easier and more appealing.

Teachers integrated different teaching strategies to foster students learning.

Teachers could assess learning during gameplay sessions by looking at students' screens, hearing students' discussions, and prompting questions to students about why they were making specific moves in the game. When asked to describe what was happening during gameplay sessions, interview answers revealed different ways teachers assessed students while playing.

> "game session one was pretty much self guided, so I didn't offer assistance. It was more about just going around and listening to what they were saying and how they were helping each other" (Transcribed Interview Casey, para. 134)

> "I would walk and see what they were doing, and allow them to get up and say, 'this is how it is done' or 'look, you are missing this' or 'move here'" (Transcribed Interview Alain, para. 36)

> "The first time, I'm just walking around and kind of monitoring, and just encouraging them to keep trying and to struggle with it" (Transcribed Interview Carly, para. 25)

> "We're just walking around, listening to their conversations, making sure that they were using their math vocabulary. So, just listening, really. I couldn't help; I didn't want to help the first time. It's just listening and repeating after whatever they were saying" (Transcribed Interview Carson, para. 86)

The pedagogical strategy of using games to practice mathematics concepts has been widely used, but *Math Snacks* implementation introduced different ways of using computer games. These were to explore ideas and to launch a lesson for a new mathematics concept. After the *Math Snacks* implementation, all teachers reported exploring concepts as the preferred portion of a lesson where they would use computer-based games. Teachers usually think of using computer games to practice basic mathematics skills, but in this case, teachers started to use and think about computer games differently. Teachers began to see computer-based games as part of their future teaching practice and saw *Math Snacks* games as a new way to build conceptual knowledge.

When asked about their ways to assess learning during the supporting activity, teachers mentioned that they were walking around, ensuring students correctly used the vocabulary. It was mainly during the supporting activity that teachers integrated existing and everyday informal assessment strategies. Four teachers took the reflection assessment in the teacher guide as the only way to assess learning. They even mentioned to students that was the way they would reflect on what they learned. Only one teacher discussed the correctness of the students' answers with the whole class. This teacher reviewed five or six students' responses and asked the entire class to revise the procedure and the result. Teachers had the opportunity to use *Math Snacks* games and materials as homework or practice time after school because they are freely available online. Still, only four participant teachers encouraged their students to play at home.

Conclusion and Future Work

When using computer games in the classroom, teachers need the ability to facilitate the game because their role as facilitators is critical to the success of game integration. This study showed that with an experience like the *Math Snacks* implementation, teachers would feel more comfortable and skilled in using computer games as part of their lessons. After teachers got to experiment with the *Math Snacks* games, they saw these type of games as powerful tools to present mathematics content in a fun and engaging way. Teachers also saw professional learning workshops as a good introduction to game mechanics. These findings imply future research on using this type of computer games in different contexts, such as science, and modification of school policies with the intention of adopting computer games, as these games are believed to be adequate. Results on pedagogical practices in integrating games extend the idea that implementing games in the classroom employs more than one activity type to foster student learning and build student confidence. Teachers found in *Math Snacks* a new tool that can enhance student-to-student collaboration, communication, confidence building, and challenge.

This work confirms the assumption that teachers should explore the game themselves before directing their students to use the game. Participant teachers reported that they regretted not spending more time playing the games prior to implementation. Still, it is unknown whether teachers spending more time playing the game will change the way they interact with students. Future research should study this further by assigning teachers specific times before implementation and then making a comparison with participant teachers from this study. A comparison study of teachers implementing *Math Snacks* games during a specific amount of time vs. teachers using regular teaching materials might confirm what type of teaching skills *Math Snacks* enhance in teachers.

The *Math Snacks* intervention model included four sessions during a lesson: a gameplay introduction, supporting activity, gameplay enrichment, and reflection/assessment time. All participant teachers followed the teacher guide model when implementing their *Math Snacks* game, but only a few could have all four sessions during one class period. It is unknown whether the extended use of *Math Snacks* as homework will have an impact on the type of discussions that could follow a gameplay session. The effects of using *Math Snacks* games as homework can be determined with future research, and studies in other contexts should be conducted to understand whether the major findings extend to different contexts and other types of teachers.

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