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Teaching to Teach (With) Game Design: Game Design and Learning Workshops for Preservice Teachers

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Abstract

Engagement in game design tasks can help preservice teachers develop pedagogical and technical skills for teaching and promoting critical thinking and problem-solving skills. Through the design process, preservice teachers not only exercise critical-thinking and problem-solving skills, but also learn about an instructional method to support their future students' problem-solving skills. Becoming comfortable with games and game design, however, requires firsthand design experiences, which teacher education programs hardly provide. Given the limited opportunities and research, this study attempted to gain insight into the implementation of a game design workshop to teach preservice teachers how to integrate game design in their future practices. In this exploratory case study, we analyzed reflections and lesson plans from four preservice teachers who participated in a game design workshop. Overall, the preservice teachers found the workshop to be effective in teaching them the intricacies of the game design process. However, both the participants' learning experiences during the workshop and the level of pedagogical elements present in their lesson plans varied depending on their technology knowledge and teaching context.

Digital game design (referred to simply as "game design" throughout this article) has been commended as an authentic and meaningful method of teaching students thinking skills (Akcaoglu, 2014; Anderson & Barnett, 2011; Li, 2012). Learning game design has also been linked with important learning goals, such as improvements in science knowledge (Hwang, Hung, & Chen, 2013), math concepts (Ke, 2014), and motivation to learn (Vos, van der Meijden, & Denessen, 2011).

For young students, game design tasks have been found to be good contexts conducive to practicing and developing complex problem-solving skills, which are difficult to situate in K-12 learning environments (Akcaoglu, 2014; Akcaoglu & Koehler, 2014). Despite the scarcity of research and training opportunities, game design tasks can also help preservice teachers both to engage in critical thinking and problem-solving skills and to learn an effective pedagogical approach for teaching these skills (Li, Lemieux, Vandermeiden, & Nathoo, 2013).

Integrating games or game design activities into regular classroom contexts is a challenging task and does not always lead to success due, in part, to the existing culture and perceptions surrounding games (Kenny & McDaniel, 2011). While students extensively engage in game-related activities outside of school, teachers tend to see games as noneducational rewards (Becker, 2007; Li et al., 2013). In addition, most teachers do not know the pedagogical potential and benefits of using games in education (Li et al., 2013).

Similar to in-service teachers, preservice teachers fall behind in terms of their knowledge of games and game design. According to Kenny and McDaniel (2011), preservice teachers often feel negative about games. For instance, 75% of the preservice teachers in their study indicated that they would rather do other things than play games, and 60% did not see how games could be used in classrooms. As such, it would be unreasonable to expect preservice teachers to consider game design as a viable instructional method, especially if they lacked positive attitudes toward games and the awareness of their educational potential.

Perceived value of instructional technologies determines teachers' decisions to use them (Kenny & McDaniel, 2011). Initiatives in teacher education programs to use games and game design in classroom are, therefore, an important step to support the preservice teachers' development in attitudes, pedagogical knowledge, and technical skills (Li et al., 2013). Considering that (a) preservice teachers are not very familiar with games and their potential in classrooms and (b) preservice years significantly impact future teachers' teaching practices (Anderson & Barnett, 2011), future teachers should have opportunities to see how games and game design can be used to create effective instructional activities (Kenny & McDaniel, 2011).

Earlier research indicated that game design courses may help preservice teachers develop more positive attitudes toward facing challenges, problem-solving, and design process (Li et al., 2013). However, how their experiences with learning game design may differ and how they might develop instructional strategies using game design are yet to be examined.

In this study, a workshop to teach basics of game design and ways to integrate game design into various school content was offered to a group of preservice teachers as a means to familiarize them with both the process of designing games and the pedagogical affordances of game design tasks. The focus of this study was twofold: (a) examine preservice teachers' experiences during a game design workshop and (b) evaluate the lesson plans they created to understand how effectively they were able to integrate game design into their courses. Given the limited research and educational programs preparing future teachers to teach (with) game design, our primary purpose was to provide insight into the implementation of the game design and learning workshop.

Review of Literature

Learning Outcomes From Designing Games

Design tasks make good contexts for complex problem-solving (Bonnardel & Zenasni, 2010; Goel & Pirolli, 1992). Solving complex design problems requires the problem solver to bring together a number of interrelated variables to produce artifacts (Simon, 1995). During this process, problem-solving, problem-finding, and inquiry skills are practiced (Kafai, Franke, Ching, & Shih, 1998; Smith & Boling, 2009). As engaging contexts to give students opportunities to practice design and problem-solving skills, game design activities have been increasingly used by researchers and educators as contexts to teach important thinking skills (e.g., Akcaoglu, 2014; Baytak & Land, 2010, 2011; Denner, Werner, & Ortiz, 2012; Hwang et al., 2013; Kafai et al., 1998; Li et al., 2013).

Akcaoglu and Koehler (2014), for instance, conducted a quasi-experimental study in which a group of middle-school students participated in an afterschool game design course focused on designing games and solving complex design problems. Compared to a control group, the students who attended the workshops showed significant increases in their system analysis and design, troubleshooting, and decision-making skills.

In another study, Denner et al. (2012) analyzed the games created by middle-school students and observed that game design activities helped students who had no programming backgrounds to acquire basic programming concepts. In a recent study, Ke (2014) found that through game design activities, middle-school students developed more positive attitudes toward learning mathematics. Further, the study by Vos et al. (2011) showed that students who actively worked on designing their own games had higher levels of intrinsic motivation and deep strategy use than did their peers who only played games developed by others.

Despite the increasing attention from both researchers and educators to use game design to teach important thinking skills, research on how preservice and in-service teachers learn to use game design in their own teaching contexts is scarce. Research is especially limited regarding understanding and analyzing teachers' experiences during their game design and learning process.

Game Design by Preservice Teachers

Although using game design has potentials and benefits in teaching, preparing preservice teachers to employ it in their future practices can be challenging. Even though preservice teachers could be considered enthusiastic users of new technologies (Bennett, Maton, & Kervin, 2008; Dutt-Doner, Allen, & Corcoran, 2005), they rarely see how to incorporate them effectively in their future practices (Albion, 2008; Kumar & Vigil, 2011). Successful technology integration goes beyond technology knowledge but necessitates "a nuanced understanding of the complex relationship between technology, content, and pedagogy" (Mishra & Koehler, 2006).

Effective technology integration requires an understanding of the affordances of technology and pedagogical strategies in relation to maximizing student learning. Expert teachers with such a developed understanding can often repurpose the use of technology to support their teaching approaches as a means to further their students' learning (Mishra & Koehler, 2009, p.16). Novice teachers, on the other hand, are not likely to execute such effective teaching decisions due to their limited teaching experiences (Le Maistre & Paré, 2010).

Using game design in lessons may even be a more challenging technology integration practice for future teachers for several reasons. First, only a few teacher education programs and limited resources are guiding future teachers' game design activities (at least, that was the case when last documented by Becker, 2007), and gaming devices are among the least frequently used technologies by preservice teachers (Hur, Wang, Kale, & Cullen, 2014).

Second, incorporating game design into educational contexts requires a complex technology-integration process (Akcaoglu, in press). As an innovation, game design is more than a technology but a learner-centered pedagogy that promotes design and problem-solving skills through the creation and representation of artifacts, rules, relations, and ideas in the form of a game (Kafai et al., 1998; Simon, 1995; Smith & Boling, 2009).

These complexities likely add to the requirements of teaching with game design and call for further preparation of preservice teachers. For example, planning and conceptualizing games, knowing and teaching how to use software to program games, connecting the game design principles with content, and still promoting relevant design and problem-solving skills can be challenging tasks for novice teachers. Thus, preservice teachers need help in becoming familiar with the game design process, understanding the complexities inherent in design and problem-solving, and finding meaningful ways to use game design in their teaching.

Theoretical Framework

Constructionism

Game design and learning workshops are grounded in constructionism. Constructionism as a theory refers to learning, where learners create socially meaningful artifacts (Ackerman, 2001). Constructionism highlights the importance of learning to learn and to making things. Learning is necessarily situated and pragmatic. In other words, the situated nature of constructionism lets "individuals develop their own ways of thinking in given situations and nonetheless remain excellent at what they do (Papert & Harel, 1991). In all cases, situated approaches to learning revalue the concrete, the local, and the personal!" (Ackerman, 2001, p. 7).

Similarly, during our game design courses in the current study, learning was designed to be situated and contextualized, whereby the learners worked to create their own understanding of game design through making games, and this process may unfold differently for different individuals.

Game Design as Problem Solving

Problem-solving is a cognitive process whereby individuals try to achieve a goal and no solutions are apparent (Mayer & Wittrock, 1996). To solve problems successfully, one must first understand a problem, create a mental or physical representation of the problem, plan a solution path, and execute the effective solution (Mayer & Wittrock, 2006). Problem-solving, therefore, requires skill, metaskill, and will (Mayer, 1998), where skill refers to cognitive skills, metaskill refers to metacognitive skills that help individuals plan and monitor the use of skills, and will refers to an individual's interest in solving the problem.

Design tasks are ill-structured problems (Bonnardel & Zenasni, 2010; Jonassen, 2011). While providing various learning experiences for each individual, the nature of designing games and playing games reflects a problem-solving process, which involves identifying problems and generating, justifying, and evaluating solutions. Game designers start the design process by determining the goal of the game, which entails developing the problem that players would need to work on. In other words, they reverse-engineer complex problems.

The problem can be well defined and lead to one solution or ill defined, requiring the completion of more complex tasks for multiple solutions. The designers, accordingly, set the rules and provide opportunities for players to engage in various activities toward accomplishing a goal (i.e., solving the problem).

The players also go through a problem-solving process by generating and trying solutions to accomplish the goal. During this process, the players evaluate their solutions at hand and choose others based on the outcomes of their actions. These outcomes are developed by the designers, who plan what the players encounter next based on their tried solutions.

Pedagogical Elements for Teaching With Game Design

Due to the inherent connection between problem solving and game design, designing games for teaching purposes requires not only the knowledge about games and game design as a technology but understanding the pedagogical elements to support students' problem-solving skills. Research studies on preservice teachers' game design experiences (i.e., Li et al., 2013) and studies on preservice teachers' technology-enhanced lesson plans (i.e., Kale, Wu, & Convey, 2013; Ozogul, Olina, & Sullivan, 2008) provide a useful guide to identifying such elements.

Li et al. (2013) developed a pedagogical rubric to examine the educational aspects of games designed by preservice teachers. While the focus of the rubric was to evaluate the characteristics of educational games created by teachers, various categories in the rubric highlight thinking, exploration, inquiry, active learning, reasoning, and strategy skills also inherent in the problem-solving processes. Additionally, collaboration and motivation, among the categories of the rubric, likely influence students' engagement with the learning process as they solve problems. As such, they should also be taken into account when teaching with game design.

By using Mishra and Koehler's (2006) technological pedagogical content knowledge framework (later referred to as technology, pedagogy, and content knowledge, or TPACK), Kale et al. (2013) and Ozogul et al. (2008) developed rubrics to examine preservice teachers' technology-enhanced learning activities. These rubrics did not specifically address game design as a technology, but the categories emphasized the importance of student content learning. While problem-solving skills can be promoted through game design, the subject matter to be learned or taught is still important (Mishra & Koehler, 2009). As such, the understanding of how to contribute to students' content knowledge should also be part of the pedagogical approach behind teaching with game design.

Purpose

Given the limited research on preservice teachers' experiences in game design (Li, 2012; Li et al., 2013), in this research we attempted to provide a detailed account of both the design and implementation and the outcomes from our Game Design and Learning

workshop for future teachers. Specifically, we sought to evaluate the participants' ability to integrate game design in their lesson plans and examine their experiences over time during the workshops. The research questions guiding this study were as follows:

1. To what extent were the pedagogical elements supporting student problem-solving present in preservice teachers' lesson plans?
2. What were preservice teachers' experiences with learning game design over time during the workshop?

Methods

An exploratory case study (Yin, 2003) guided the research design. We collected data in the form of postworkshop reflections and lesson plans. We grouped and reported our findings around cases for each research question.

Game Design and Learning Workshops

As a first step in exploring and developing methods to support preservice teachers' efforts to teach with game design, this study focused on implementation of a game design workshop, called Game Design and Learning (GDL). Particularly, we offered six game design sessions, each of which was 3 hours long. Based on early research on designing game design curricula (Akcaoglu, in press), the first three sessions focused on teaching participants the basics of game design and programming (Table 1).

Table 1
GDL Program Session Progression

Session(s)	Objectives
1-3	Practice basics of: 1. game design 2. programming 3. game design software (Microsoft Kodu)
4	Practice: Game design integration into lesson: using game design to teach problem-solving
5	Explore: Sample lesson plan integrating game design, student brainstorming
6	Create and Share: Participant lesson plans

The subsequent sessions emphasized how game design activities can be designed, developed, and used to reach various instructional objectives. For instance, in Session 5, preservice teachers explored a detailed sample lesson plan, provided by Kodu Academic Resource Compilation (found at http://bit.ly/1xaSP6B) on using game design to teach the lifecycle of a salmon. In the final session, the preservice teachers created and shared lesson plans incorporating game design activities into their specialized content areas with the rest of the group.

The workshop was offered as one of the alternative professional development activities that the preservice teachers in a mid-Atlantic university could attend during their final year. A solicitation email about the workshop, its objectives, and a timeline of the sessions

was sent to the final year student cohort (n = 102), and a few posters were displayed in the building to increase their awareness of the offering.

Participants

Four preservice teachers (one male, three females) showed interest and agreed to participate. As a requirement for their field experiences, participants had already been placed in various schools based on their specializations. Alyssa was in a prekindergarten setting, and Ken was placed in a seventh-grade classroom, while Terri and Mary were working with third graders. Pseudonyms were used to keep each participant's identity anonymous.

Data Sources

Lesson Plans. At the end of the workshop, preservice teachers were asked to create lesson plans using game design activities, based on their current teaching objectives in their placement classrooms. They used a template document to develop lesson plans, detailing the description of target learners, learning objectives, standards, assessment strategies, and the timeline of planned events and procedures describing the teaching and learning tasks. The procedure section included question prompts about ways to get students engaged in the lesson; what teaching, classroom management, and transition strategies to use; and ways to bring closure to the lesson. The preservice teachers were familiar with the template, as it had already been used as part of various courses in the teacher education program.

Postsession Reflections. At the end of each session, participants filled out an online survey to reflect on their learning process. Particularly, they answered two open-ended questions regarding (a) what they learned in that day's session and (b) what else they needed to learn to have more meaningful and beneficial learning experiences in the workshops. On average, participants' responses were around 60 words, with answers ranging from one word (e.g., "Nothing") to 169 words (SD = 29.30 words).

Data Analysis

Lesson Plans. We developed and used a rubric to analyze the lesson plans in terms of their inclusion of pedagogical elements supported by game design (see Table 2). The rubric was created by drawing from the literature on preservice teachers' game design experiences (Li et al., 2013) and technology-enhanced learning activities (Kale et al., 2013; Ozogul et al., 2008).

We adapted several categories from Li and colleagues' (2013) work, which examined the extent to which various pedagogical elements of problem-solving processes are present in the games designed by teachers. Because Li et al.'s rubric referred to the characteristics of game content, we reworded the categories to put the emphasis on lesson plans. Three categories (user friendliness, feedback/assessment, and the support system within the game setting) were also excluded, since the main focus of the current study was to examine the lesson plans, not the games.

Table 2
Comparison of Rubrics

Current Study	Li et al., 2013	Ozogul et al., 2008; Kale et al., 2013
Enhances student content learning		Enhances understanding at a subject area. Supports the objectives.
Entails problem-solving activities	Problem Solving	Supports student-centered instructional strategies.
Allows for student exploration	Exploring & Reasoning	
Allows for student reasoning		
Requires students to develop a strategy	Strategy	
Students actively engage in game design	Participation	
Motivates student participation in activities	Engagement/Motivation	
Promotes active learning	Active Learning	
Enables students to relate to real world context	Connections	
Allows for student collaboration	Collaborations	

The rubrics from Kale et al. (2013) and Ozogul et al. (2008)'s research that focused on examining preservice teachers' technology-enhanced learning activities and lesson plans were also incorporated. Although these two rubrics broadly encompass the categories adapted from Li and colleague's (2013) work, they informed the addition of a new category that emphasizes student content knowledge, which reflects the teacher content knowledge aspect of Mishra and Koehler's (2006) TPACK framework. The finalized lesson plan rubric can be accessed at the rubric website (http://bit.ly/1KsDauw).

We individually applied the rubric to the lesson plans and scored the extent to which each element was present by using a scale ranging from 0 to 3 (0 = *Not at all*, 1 = *To a minimal degree*, 2 = *To a fair degree*, 3 = *To an extensive degree*). Then, we discussed and compared our analyses until we agreed on all the scorings.

Student Reflections. In order to analyze students' postworkshop reflections, a data-driven thematic analysis was followed, as suggested by Boyatzis (1998). To this end, we first independently read the student reflections and identified keywords for each individual reflection. During this process, we allowed the themes to emerge from the dataset, rather than forcing our own ideas onto it. Next, we created a profile for each participant by combining common keywords and common themes that eventually represented the patterns in the preservice teachers' perceptions.

Having identified the themes and the profiles for each participant, we met to discuss our findings and reached a consensus by discussing minor differences. The themes and individual profiles reported are, therefore, agreed upon by each of us and reflect each participant's overall progression through the GDL workshop.

Findings

Case 1 - Alyssa

Alyssa was specializing in prekindergarten (pre-K) education, and was placed in a pre-K classroom for her field experience. She did not have much gaming experience (i.e., she indicated she did not play any games for recreational purposes). Although she was able to perform basic computing tasks, she seemed to be uncomfortable with more complex ones, like designing digital games.

For her final project, Alyssa created a game design lesson for a pre-K classroom, focusing on counting in sequence to 10 and beyond. The goal of her lesson was to get students to play a game created by her. The game involved collecting and counting a specific number of apples. By removing the onscreen counter, students would tally the number of apples they collected using their hands and practice their counting skills.

In our analysis of the lesson plan using our rubric, we found that the lesson plan did not allow for student exploration, collaboration, or game design (see Figure 1). Although the lesson could lead to some increase in student engagement and learning of the target concepts, it would not provide students with opportunities to collaborate and explore or to engage actively in game design.

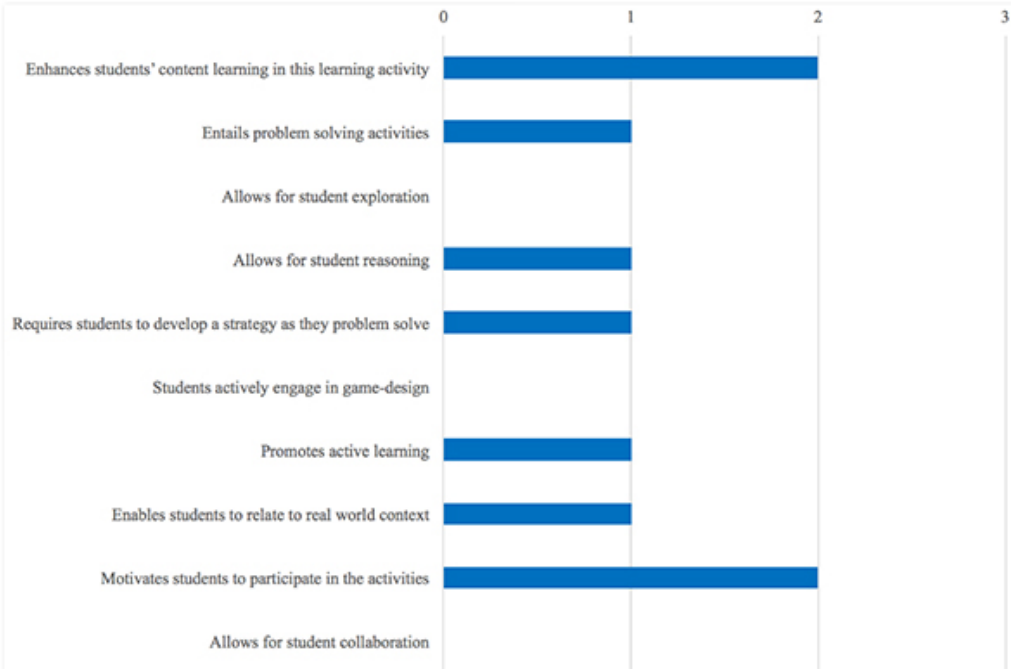

Figure 1. *Level of pedagogical elements present in Alyssa's lesson plan.*

The analysis of Alyssa's post-session reflections revealed that she struggled with the game design activities during the GDL workshop.

> I was also becoming frustrated when doing this, and I feel that frustration is something that teachers have trouble coping with....I am not a big computer/gaming person at all. I feel that if I had more knowledge about computers and what all goes into them it may help me figure out how to design games. I have a hard time understanding what certain things mean, but that is just because I do not have a lot of background knowledge when it comes to computers and games.

While struggling with technical issues, Alyssa also found game design to be a challenging task. Her initial frustration was even more amplified by the perceived challenges of learning a new program to design games:

> After today, I really thought about how much work goes in such a small game. I was so frustrated this week with just trying to catch a fish and some coins. I am really enjoying this class, but I definitely do not have the patience or talent to be a professional game designer....I need to learn the lingo. I barely know anything about computers, so I think [if] I knew more technical terms, I may be better off.

A combination of personal and contextual variables seemed to limit Alyssa's understanding and application of game design concepts and processes in her lesson plan. As revealed in her reflections, Alyssa' lack of initial interest and technical skills, although they in time dissipated, prevented her from fully exploring the basics of game design. Further, teaching basic skills at pre-K level might have caused her to target a low level cognitive skill (e.g., procedural knowledge), and eventually this objective might have led to the creation of instructional activities that were not amenable to collaboration, problem-solving, or hands-on activities that incorporated game design and exploration.

Case 2 - Terri

Terri specialized in elementary education and was placed in a third-grade classroom for her field experience. Terri did not have a strong gaming background and her technical skills were low, although she was able to perform basic computing tasks.

Terri designed her lesson plan to enhance third graders' understanding of fractions. Her main instructional activity emphasized solving word problems. During the activity, students would design and create a game with the goal of collecting 10 objects in order to help an in-game character build a castle. The castle would be successfully built only if a specific number of various objects were collected: rocks (6/10), fan (1/10), coins (3/10). The lesson would start with a brief discussion about word problems, followed by students working individually to create their games. The teacher would be monitoring student progress and help as needed.

Although Terri's lesson plan had a clear content focus and features to engage students in designing their own games, the prescripted nature of the word problem would limit students' creative design and not provide students with opportunities to explore game design concepts and to collaborate with one another (see Figure 2). In addition, the given problem is procedural and well defined (i.e., there is only one possible solution), requiring little or no effort to develop strategies and to justify solutions.

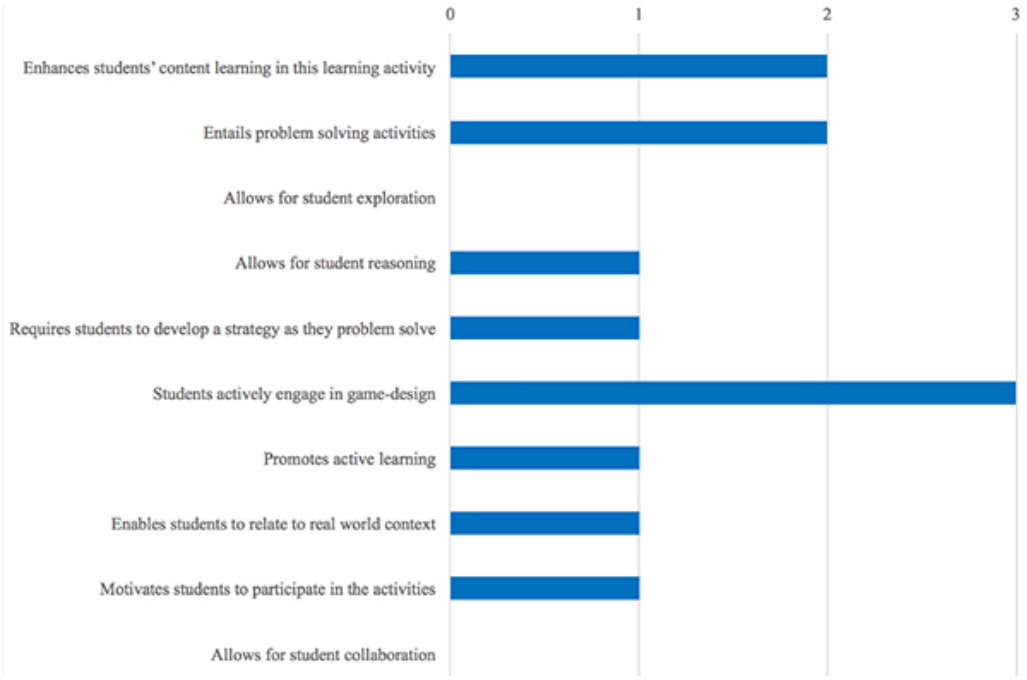

Figure 2. *Level of pedagogical elements present in Terri's lesson plan.*

Starting from the first workshop session, Terri had positive feelings toward learning game design: "I think this would be a great way to interest my students in learning and thinking critically as well as seeing math in a different light." While Terri noticed the difficulty of designing games after the second session, she kept positive attitudes toward it and showed willingness to explore more functions:

> I realized that it is quite difficult to make a game that seems so simple. It takes critical thinking skills to understand how to make the game work and how to fix a problem that arises. I think we would need to know all that Kodu has to offer and what the game design program actually does.

This line of thinking was also present in her subsequent reflections. Terri considered the difficulty inherent in the game design process as a potential means to engage students in critical thinking:

> You can use [game design] in math....For example, we wanted to make 7 seconds [in today's session] but [software] only had 1, 2, 5, 10 [as second options]. So, we had to have 5 seconds plus 2 seconds [to make up 7]. You can use game design to have students explain reasoning and problem solve.

During the rest of the workshops, Terri continued to think of ways to use game design in teaching math: "I would like to learn how to use game design and simulations towards math lessons in middle school." She also developed positive ideas about the use of game design in her classroom: "There are many ways to use Kodu in a classroom through instruction and assessment." Overall, Terri seemed to think that her learning experiences at the workshops were meaningful and she was prepared to use game design in her future teaching.

Although Terri did not play games frequently and had low-level technical skills, she had a positive experience during the workshops. Unlike Alyssa, Terri considered technical issues and the difficulty inherent to the game design process as opportunities to practice critical thinking skills. She also identified possible ways to use game design in her teaching during the workshops, which was reflected positively in her lesson plan. Although the contextual limitations (i.e., teaching to young students) might have caused her to limit student exploration and collaboration aspects in the lesson plan, overall, she had a stronger plan to engage her students in game design and problem-solving tasks.

Case 3 - Ken

Ken studied to be a middle-school science teacher and was placed in a seventh-grade classroom for his field experience. Ken possessed high levels of technical skills and was interested in digital games (i.e., he often talked about building his own personal computer, helping troubleshoot his friends' technical problems, and playing the most recent games). Ken planned a lesson for his middle-school science classroom, focusing on creating a simulation for the lifecycle of a star. The main activity in this lesson was to get students to create the simulation. For this task, rather than engaging in a bottom-up design process (i.e., starting from scratch), students would complete a template created by the instructor.

Due to its heavily structured nature, the lesson plan did not have the elements that can allow students to explore, develop strategies to solve problems, learn actively, and collaborate (Figure 3). On the other hand, we considered the lesson plan to be strong and engaging to teach this specific content. The game design process in the lesson would support students' understanding of abstract concepts (e.g., lifecycle of a star) by providing them visual and tangible representations. The process of deciding how best to represent the abstract concepts would serve as suitable contexts for problem-solving and reasoning skills. The lesson plan had elements allowing for a moderate amount of active and independent game design tasks.

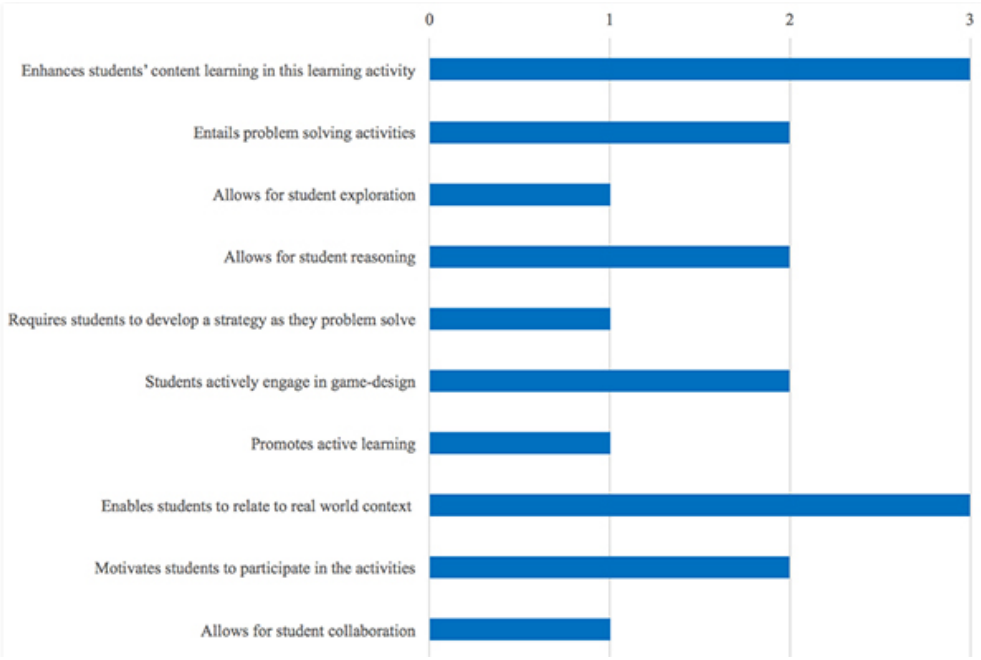

Figure 3. *Level of pedagogical elements present in Ken's lesson plan.*

The analysis of Ken's postworkshop reflections revealed that, starting from the first session, he considered ways to situate game design into his teaching, albeit generically. For example, after the first session he wrote, "I would love to use game design with my students as a form of differentiation," but he did not elaborate on *how* he would do so. In the later sessions, Ken either focused on purely technical features of the game design process or included generic comments on how game design can be used in education.

For example, he mentioned "implementation opportunities in the classroom" as areas that he needed to learn more about and "Story/dialog mechanics/Vehicles/Carrying stuff/multiple scores/time/water" as his biggest takeaways from the third session. In his final reflection, Ken expressed his belief in the usefulness and applicability of game design in regular school settings, as well as his increased ability in the integration process: "I really enjoyed this last session. It was incredibly interesting to see the numerous ways to integrate Kodu into our lessons....I learned a lot from all of our session and feel much more comfortable integrating Kodu into my classroom." Ken also mentioned that it would be more beneficial to have more sessions devoted to lesson plan integration activities during the workshop.

Given his strong technical and gaming background, Ken was not intimidated by the complexities introduced by game design tasks. Throughout the workshop session, however, his integration ideas were usually generic, showing a lack of connection between his technology and pedagogy knowledge. As revealed in his final reflection, Ken needed guidance in finding ways to connect game design activities with his instructional objectives. His lesson plan, which was limited in promoting exploration, collaboration, and strategy development, also showed his weakness in identifying the affordances of the technology to support student-centered pedagogies. These findings highlighted that technical skills alone may not be enough to achieve effective technology integration.

Case 4 - Mary

Mary was specializing in elementary education and was placed in a third-grade classroom for her field experience. Mary had a strong gaming background. She owned game consoles and often talked about her experience playing the most recent games. Her technical background was also strong. She talked about building her computer by herself and installing open-source operating systems.

Mary's lesson plan focused on a science simulation and was designed to improve third-grade students' understanding of how organisms interact with one another in an ecosystem. The lesson would start with an introductory explanation clarifying the meaning of various terms such as *ecosystem*, *organisms*, *preys*, and *predators*. Next, she would show an example, which she would create using the game design software, that simulated the interaction among three organisms (rabbits, foxes, and grass).

A discussion on the predator-prey relationship among these organisms would follow. Then, students would be asked to create a similar simulation, recreating the same interaction pattern with different teacher-selected organisms. Mary planned the individual design stage of the lesson to be a few days long. She would assist students in troubleshooting as needed. Students would also be encouraged to discuss and brainstorm with one another about their observations of each simulation developed.

Our analysis, as seen in Figure 4, indicated that Mary's lesson plan included a majority of the pedagogical elements to a fair or an extensive degree. The lesson plan had elements to engage students in active design by giving them tasks replicating conditions from a real

world context. This activity would be not only motivating for students, but also a powerful way to teach the science content at hand.

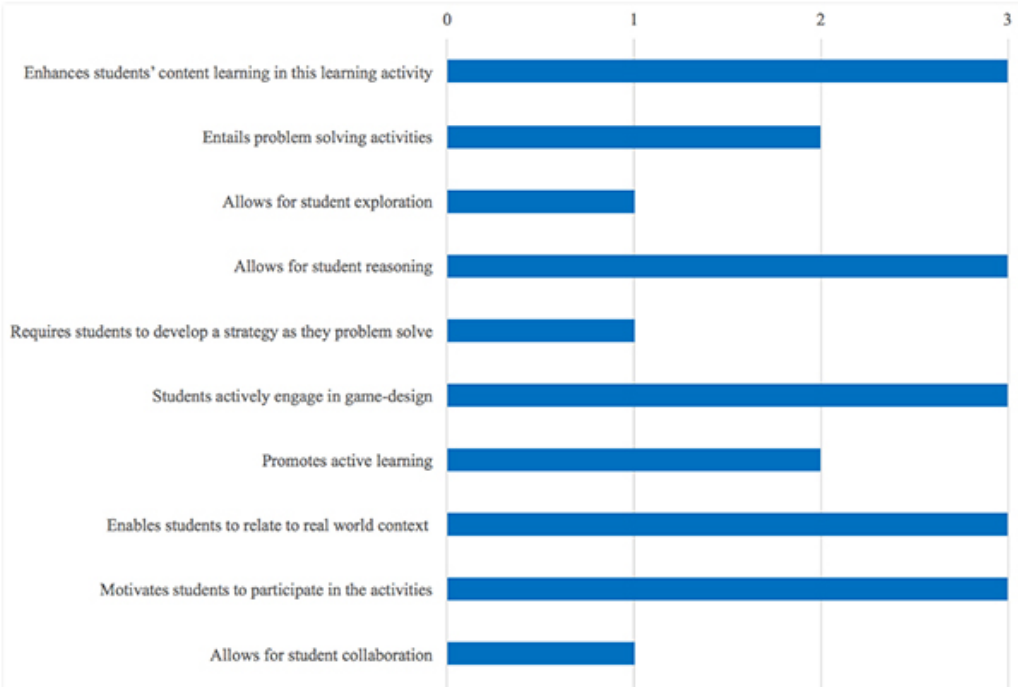

Figure 4. *Level of pedagogical elements present in Mary's lesson plan.*

The lesson plan was also designed to support students' reasoning skills, especially through the recreation of a simulation replicating the dynamic interaction pattern of different species as observed in real world. However, the lesson would have provided more opportunities for exploration if it had been designed to allow the selection of different organisms and predator-prey relationships from an ill-defined, real-world case. Such an improvement would enable students to develop their own plans for game design and provide them further opportunities to strategize for programming.

Mary's initial workshop reflections showed her awareness of the potential of game design tasks for teaching and learning. As she described her intention to use game design activities in her future classes, she mentioned game design as a good platform to create student-centered and engaging activities for teaching students programming skills: "I feel that programming is going to become a big part of education [and] Kodu is a great way to introduce programming. It really made it engaging and it was fun to create our own game."

Like the other participants during the later sessions, Mary noticed the challenging aspects of programming, but she also reflected on how she could overcome them in her actual teaching: "When designing games, you really have to think through how you program things....Your game needs to have a small tutorial for students to understand the concepts."

Overall, Mary had a positive experience during the GDL workshop. Her strong gaming and technical backgrounds helped her focus her efforts more on the pedagogical aspects of using game design for teaching and learning. Although Mary's teaching context was similar to Terri's setting (i.e., 3rd grade classrooms), she had a higher level of technology skills, and her lesson plan had pedagogical elements with stronger presence, which can give students the agency to create their own designs and to tackle problems. As observed in her lesson plan and reflections, Mary was able to emphasize the importance of students' active roles as designers: "[The lessons] should also allow for students to program and create their game or simulation." She mentioned her comfort with using the game design tool and even desire to "hold workshops for teachers to educate them on this program."

Discussion and Implications

In this study, our purpose was to provide insight into the implementation of a game design workshop for preservice teachers. The first research question focused on the extent to which the pedagogical elements supporting student problem-solving were present in preservice teachers' lesson plans after attending our game design workshops. Our findings indicated that the participants' lesson plans, in general, had room for improvement in terms of allowing students to take ownership during the game creation, design, and problem-solving processes (Figure 5). Instead of giving students freedom and agency, our participants seemed to be more focused on teacher-led activities (e.g., worlds premade by the teachers). The lesson plans did not allow high levels of collaboration and exploration, although they entailed problem-solving activities to a moderate degree. The level of strategy development, reasoning, and active game design in the lesson plans ranged from minimal to a fair degree.

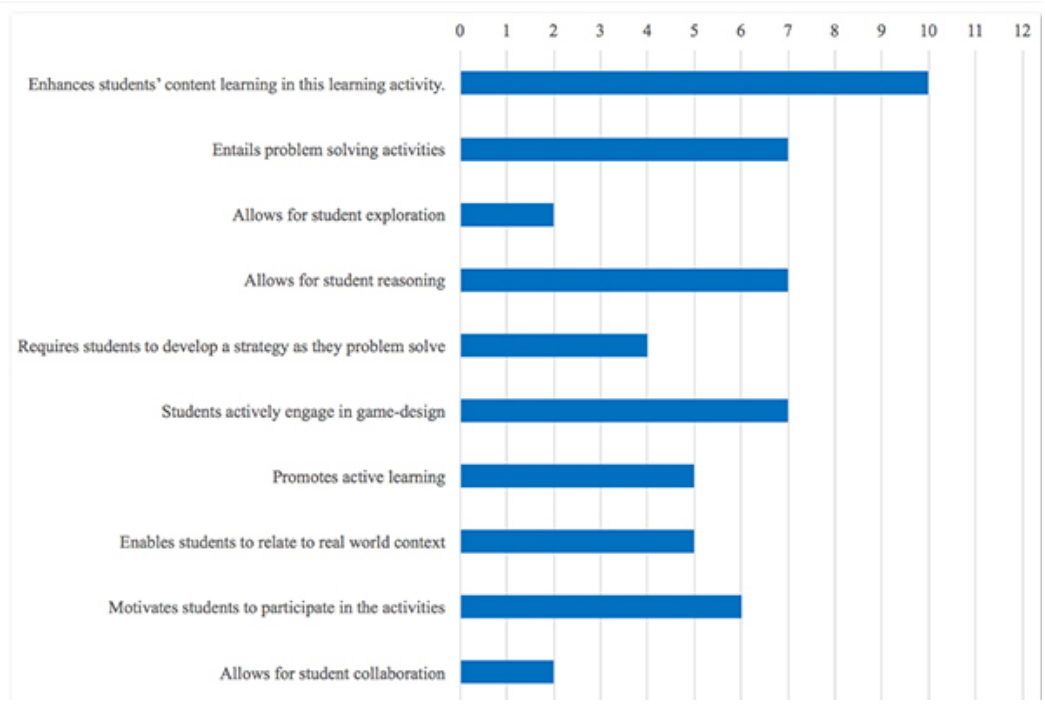

Figure 5. *Tallied level of pedagogical elements present in lesson plans.*

The second research question focused on preservice teachers' experiences with learning game design during the workshop. Our analysis of the reflections helped us describe participants' varied experiences and identify challenges faced during the GDL workshops. At the end of the workshops, all participants indicated that they developed a basic understanding of game design and programming and felt comfortable with the process. In addition, they developed a basic understanding of how to integrate game design into their lessons, which entailed being able to use the game design software to create games and lessons utilizing game design as a core hands-on component.

Depending on their technology backgrounds, however, the participants had different learning experiences. For example, Mary, who was confident with technology and described herself as an avid gamer, had a quicker learning curve, fewer frustrations during the process, and was able to focus on planning and implementation aspects of game design in a classroom context. She even mentioned providing professional development opportunities to her colleagues in the future.

Alyssa, on the other hand, had limited technology skills, and her reflections emphasized her struggle and frustration with the technical aspects of game design. She devoted less of her thinking about integrating game design into a lesson.

Although successful technology integration requires a distinct understanding about how technology, pedagogy, and content are related (Mishra & Koehler, 2006), these findings highlighted the importance of technology knowledge as one of the key factors influencing novice teachers' ability to plan lessons incorporating game design. An implication from this finding can be to offer additional and flexible workshop sessions to help preservice teachers who lack technical skills develop these skills.

Flipping the initial GDL workshops, where the focus is teaching of the basic skills with the use of online instructional videos, for example, may help preservice teachers learn and practice basic skills at their convenience and pace and, thus, may enable them to allocate more time to discussing in face-to-face sessions how to connect GDL to their teaching context.

Our findings also indicated that the grade level, as a contextual variable, might have played a role in shaping the lesson plan activities. For example, Alyssa, who was teaching math for pre-K students, chose to have her students play a game that she designed instead of allowing her students to design the game. As such, exploration and engagement elements in game design were not present in her lesson. In contrast, participants teaching upper elementary and middle school students designed lessons that required them to engage in deeper levels of design (e.g., design simulations and games on their own).

These variances can be explained by considering technology integration as a contextually bound and situated process (Mishra & Koehler, 2006; Zhao & Frank, 2003). "Context-neutral approaches to technology integration encourage generic solutions to the problem of teaching....Technology use in the classroom is context bound and is, or at least needs to be, dependent on subject matter, grade level, student background, and the kinds of computers and software programs available" (Mishra & Koehler, 2006, p. 1032).

Likewise, the lesson plans in this study were bound by the context in which the participants were teaching at their placement classrooms. The participants teaching at lower grades might have been more concerned about their young students' abilities to handle complex design and problem-solving processes. Consequently, they may have

chosen to design their lessons in more structured and well-defined manners, limiting opportunities for students to explore, collaborate, and create.

These findings suggest that future efforts need to find ways to encourage preservice teachers to promote designing and problem-solving skills for younger students. Given enough time, preservice teachers can start ways of integrating game design activities in their classes to fully utilize their affordances in promoting student creativity and problem-solving. Future GDL curriculum efforts may assist preservice teachers in realizing the problem-solving nature of game design and identifying opportunities to facilitate students' problem-solving.

The later workshop sessions where participants designed and developed lessons incorporating game design activities, for instance, can emphasize students' problem-solving processes, such as identifying and working on problems (e.g., goals) through testing and modifying solutions (e.g., actions). Preservice teachers may also be asked to reflect specifically on how future students would exercise problem-solving skills during their activity as outlined in the completed lesson plans. Increasing the number of such sessions, however, would be necessary to cover this expanded scope and to help strengthen the connection between game design and lesson planning.

Preservice teachers must become familiar with both digital games and game design in order for them to be able to use these tools effectively for teaching (Becker, 2007). Hands-on experiences with technology and design are a strong factor impacting teaching with technology (Koehler & Mishra, 2005). Preservice teachers often have limited experiences and negative attitudes toward using games and game design in educational contexts (Anderson & Barnett, 2011; Kenny & McDaniel, 2011; Zimmerman & Fortugno, 2005). Without proper opportunities for game design as learning activities, they are even less likely to use game design in their future practices (Anderson & Barnett, 2011). To this end, Becker (2007) noted that "...expecting teachers to use games without having played games is similar to expecting teachers to use novels and other books without them ever having read one" (p. 486).

To provide future teachers with hands-on experience, teacher education programs need to encourage them to play games (Becker, 2007; Kenny & McDaniel, 2011) and explore new technologies. More specifically, future GDL curriculum efforts can provide opportunities for preservice teachers to play both commercial games (e.g., Minecraft) and those created by others using open-access game design tools (e.g., Kodu, Scratch, or Alice). A group of computers in a computer lab may be allocated for this purpose.

Preservice teachers may also be required to play a certain number of games each week while they can reflect on the educational potentials, ideas, or features that they can incorporate into their games. A GDL workshop may not easily cultivate a culture of playing games, but it can definitely provide the initial steps, especially for those who have no experiences with games.

Conclusions

Overall, this study showed that through the GDL workshop we were able to help preservice teachers become more comfortable with dealing with an unknown context such as game design and see how the design and creation process can become messy. Our cases may share commonalities to be found in teacher education settings. Given the participants' diverse technology backgrounds and grade-level foci, the findings can provide initial directions as to how personal and contextual variables impact preservice

teachers' experiences with GDL. Despite the small sample size, which can be a limiting factor in generalizing our results to other contexts, this study offered a few key possible future directions regarding how a GDL curriculum may be implemented, as summarized in Figure 6.

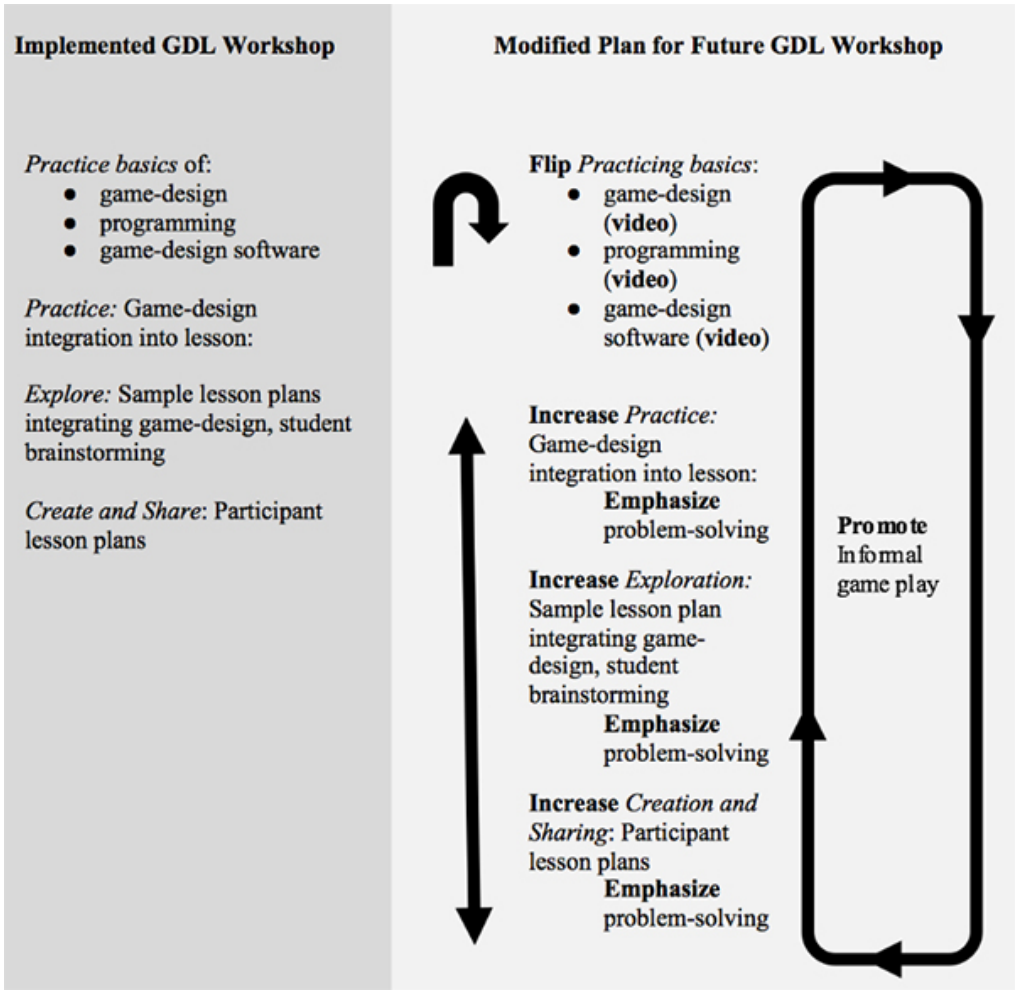

Figure 6. *Revised GDL curriculum.*

The GDL workshop was an initial effort to have preservice teachers explore and become comfortable with game design as tools for teaching. By flipping the initial GDL workshop sessions with the use of online instructional videos, increasing the number of workshops to emphasize problem-solving skills that game design activities promote, and providing opportunities to play games and relate to learning, future GDL curriculum efforts can be transformed into a more effective preservice professional development model.

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