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REVIEW PAPER

The need for digital game-making education for pre-service and in-service teachers: a review

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Abstract

Digital games offer opportunities for students and teachers through designing, coding, and playing. The maker movement via digital games in education has become popular. Although the maker movement is challenging to accomplish in the classroom environment, digital game-making, which is digital game development under the maker movement approach, produced favorable results among students in formal education. This paper reviews digital games, learning through digital games, digital game-making, theories behind game-making, what digital game-making is for, the importance of helping teachers to get ready for making, and digital game-making in class practices. Digital game-making is for (a) supporting various identity developments, (b) increasing digital literacy, and (c) embracing object-to-think-with. Preparing teachers for digital game-making integration enables teachers to (a) use game-making as a means for Technological, Pedagogical, and Content Knowledge, (b) get more confident and empowered, and (c) form learning communities. Teachers' roles while digital game-making in classrooms are a) managing collaboration and communication, (b) assessing learning, and (c) scaffolding.

Keywords Classroom · Constructionist gaming · Game-making · In-service teachers · Pre-service teachers

Introduction

Time, the most critical variable in the equation of life, affects many aspects of human life. The ways people work, communicate, learn, and teach are changing as time goes by. Today, technology as the means of time changes many aspects of life. Technology is rapidly evolving, and people naturally integrate technologies into their lives. If educators had not taken action to incorporate technology into the most prominent aspect of human life, which is education, they would have missed a

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great opportunity. People are inundated with a vast amount of available technology, so educators try to bring those technologies into classrooms to provide meaningful activities related to the real-world, which is a more effective teaching method than lecturing (Ruiz-Gallardo & Reavey, 2019).

This paper focuses on pre-service teacher learning and in-service teacher training for digital *game-making* in a classroom setting, along with details of digital games and *game-making*. Pre-service and in-service teachers are defined as those who are in the process of studying how to teach and have not taken the responsibility of a classroom yet and those who are currently licensed and teaching in a classroom (Fox, 2020). With that, answers to *What does game-making bring to learning and teaching in classrooms?* and *Why do pre-service and in-service teachers need to get prepared for game-making integration?* were sought by consulting game-making and teacher education literature. This review synthesizes *game-making* and teacher education literature on what *game-making* brings to classrooms, the utility of preparing teachers for integrating *game-making*, and teacher roles during digital *game-making* in classrooms.

Significance of digital games, game-making, and teacher education

Digital games are one of the digital technologies brought into the education field (Clark et al., 2018). Digital games have motivational (de Jong et al., 2018) and interest-driven aspects (Fields & Kafai, 2018). Digital games also support and enable students to effectively learn problem-solving, decision-making, collaboration, and literacy (Akcaoglu & Koehler, 2014; Fields & Kafai, 2018). *Digital game-making* in a classroom setting also increases students' engagement and collaboration (Boulton et al., 2017; Hughes-Roberts et al., 2020). Most studies focus on the act of playing digital games in educational settings (e.g., Clark et al., 2018; Holbert & Wilensky, 2019), while some (e.g., Bowden & Aarsand, 2020; Wake et al., 2018) emphasize the learning process through game development (i.e., design and coding). However, Holbert and Wilensky (2019) argued that some aspects are unclear, such as the nature of learning via games and what types of design and game mechanics ensure effective learning.

There are critical points in the academic literature that need to be investigated. First, although some studies (Bowden & Aarsand, 2020; Clark et al., 2018) were conducted under the learning sciences concept with in-service teachers and their students, the focus has been predominantly on K-12 students' learning with and through game design. The learning of pre-service teachers in the roles of both students and future teachers has not been investigated thoroughly for and through game-making. Second, game development was inscribed as a hardly possible practice in classrooms because of time constraints in curricula for activities (Clark et al., 2018) and freedom in the nature of games (Holbert & Wilensky, 2019). Devoted time on curricular activities in classrooms and freely deciding and making games based on personal choices under curricular activities in classrooms secure the difficulty. However, game development, which is a way of *making*, can be achievable in the classroom. Third, teachers need to be prepared in game-making for technical

and pedagogical skills to enable and manage *game-making* in a classroom setting. Mainly, what pre-service teachers learn and in-service teachers practice (e.g., pedagogy) differs from PreK-12 students' learning. Thus, there is a need to look for pre-service teachers' learning process and in-service teachers' training with and through game development in a classroom setting. With these in mind, looking at how digital games are defined in education and made for educational purposes will enable us to see the need to look for the impact of game development in teacher education and teacher training.

Various types of digital games

Computer games have been highlighted and studied because of their educational capacity (Wake et al., 2018). Some digital games are considered educational video games due to their education and entertainment features (Holbert & Wilensky, 2019). Digital games are a broad term covering games from "multimillion-dollar complex titles" (Clark et al., 2018, p. 266) to basic, primitive forms, such as those which center on classroom tasks. Clark et al. (2018) defined educational games as games supporting academic content, serious games as adding entertainment as a value to a game to use this value for general objectives (e.g., education, health, communication), and typical educational games as cost-effective to create, including simple recreational games' features/mechanics and covering more than receiving points/badges. Fields and Kafai (2018) also mentioned indie games created with a limited budget and not by major game developers (e.g., teachers). Indie games allow thinking more about new learning scenarios, such as ethical decisions during gameplay.

Clark et al. (2018) grouped games under five categories:

(a) Basic ungated games were defined as the "least sophisticated category" (Clark et al., 2018, p. 281). Basic ungated games provide the necessary information and material to users. Still, a lack of mastery is apparent with a basic ungated game having features such as the act of running. Although mastery is absent on a user's side in basic ungated games, *makers*' content knowledge gains importance to transmit the necessary and factual information into this game type.
(b) Gated progress games have different levels, as understood from their name. A user needs to complete tasks to go to the next level in gated progress games. Quiz shows are given as examples in this category.
(c) Deeper content games were constructed around answering questions. However, contextualization, interpretation, and connection of the pieces of evidence collected during deeper content games were underscored. Interpreting content-related photos to answer questions is an example. The difference between deeper content games and ungated and gated games is that *makers* pay attention to students' knowledge levels and how students process the given material in deeper content games.

(d) Interactive stories enable students to act during the game by clicking the related location to get into the place and responding by clicking to get involved in the game's dialogue. *Makers* develop this type of game by considering the interaction between users and the game. Teachers *make* this type of game for their students to use higher-order thinking skills more than in *gated progress games* (An & Cao, 2017).
(e) Intrinsic design games are the most complex game type. Users explore content not by answering multiple-choice questions but by engaging with simulations that enable users to take critical roles in games. Users in intrinsic design games, for example, control a farm by modifying a farmer's choices. This game design is complex for users and *makers*. Educators and students are not major game developers; therefore, developing intrinsic design games is not feasible, especially in *classrooms*.

For example, the Wake et al. (2018) participants designed location-based competitive games related to history content. Students created narratives and placed hints to locations on a map to match places and locations' names. The games, in this matter, were an *interactive story* that Clark et al. (2018) defined. Further, these games also are structured games based on specific learning goals and mechanics. There also are relatively unstructured games. Relatively unstructured games allow users to construct a game based on their choices. *Minecraft* offers students freedom to create materials and buildings in the game (Fields & Kafai, 2018). *Particles!* is a game designed and utilized by Holbert and Wilensky (2019). Users created molecules in *Particles!* and put those molecules into the game environment to reach the diamonds. *Minecraft* and *Particles!* can also be attributed to *relatively unstructured games*. Structured and relatively unstructured games in education have an important place for students in *making*.

Different ways of making digital games

Making activities can be non-digital (e.g., Oh et al., 2018), digital (e.g., Bowden & Aarsand, 2020), and mixed (e.g., Dishon & Kafai, 2020). Accordingly, maker movement comprises hands-on activities (Ku et al., 2021) for learning-by-doing while working on real-life concepts (Morado et al., 2021). Digital game development is a form of *making*. Digital *game-making* is integrated into various disciplines, such as mathematics, history, chemistry, literacy, and art (e.g., Liao et al., 2016; Wake et al., 2018). Activities, such as artifact design, construction, and modification, aiming practical and playful nature to interact, use, and demonstrate, are *making* activities and practices under the maker movement (E. Halverson & Peppler, 2018; Martin, 2015). *Making* is a way of showing how and what people learn. Learning occurs when one participates in a design process, creates an artifact, and shares the created artifact (Halverson & Peppler, 2018). With that, *game-making* gives control to students and enables them to have various experiences beyond games' predetermined goals (Holbert & Wilensky, 2019). Games as shareable artifacts designed with

educational and playful nature, and the *game-making* process with learning purposes reflects the maker movement.

There are different ways, practiced before in classrooms, to develop digital games (i.e., making activities): (a) Programming a game from scratch in block-based programming platforms (e.g., Scratch, code.org, Alice), (b) modifying an existing game in a game development platform, and (c) creating a game with web-based game authoring tools without programming. *Game-making* is one of the predominant learning processes that underscore creating an artifact (Fields & Kafai, 2018). Creating an artifact through *game-making* enables makers to reflect on their experiences and abstract thinking process, generate new ideas and solutions as active learners, and make their learning visible (Morado et al., 2021).

When game makers use a programming platform to develop a game, the use of complex programming concepts in computational thinking practices increases (Repenning et al., 2015). Students who make games on programming platforms get better at using programming concepts (e.g., variables, loops, logic) with complex programming structures (Denner et al., 2012, 2014; Reynolds & Caperton, 2011). Programming a game enables *makers* to connect the programming concepts and elements in the created game; this improves the ability to interpret game content (Krinks et al., 2019). Most importantly, getting expertise in programming is not the only advantage of *making games* on such platforms. Students' knowledge of academic content development increases (Fields & Kafai, 2018) while planning, coding, and designing the game content. Knowing the basic level of programming and game design knowledge is a necessity for today's technology-centric society (Werning, 2019).

Modifying an existing game to *make* a new game is another approach. This approach is technically more accessible since *makers* adjust games with other games or change the existing game structure and theme. In a game-design study (Bowden & Aarsand, 2020), fourth-grade students modified existing games in the Scratch block-based programming platform. Students considered aesthetic design, technical details, and ethics in design (Bowden & Aarsand, 2020). Modifying an existing game to make a new one saves time for *makers* to focus on other aspects of created games, such as ethics in design. Although programming coincided with their research site's mathematics and technology curriculum, the study was conducted in an art classroom. That would have affected students' aesthetic design and ethical considerations. Werning (2019) argued that understanding design choices within a game is as important as being good at the given game. Therefore, modifying an existing game enables students to think more about the game itself and its design.

Another way of developing games is using web-based game authoring tools, such as SILO (https://nevercenter.com/silo/). SILO enables a designer to construct storylines and connect them. Games created in such tools are potentially more complicated; however, they can be seen as the games that Clark et al. (2018) defined as typical. Wake et al. (2018) utilized SILO as a platform to design history-related location-based games. The researchers and the teacher worked together to develop the game scenarios. The students were grouped and given content-related scenarios to match themes and locations and write about each theme and location. It was unclear whether the students were familiar with SILO, but the researchers provided

a user manual for the tool. A list of learning goals, task descriptions, and relevant historical resources was also provided to students. Each student group *made* a game to offer to other groups to play. Therefore, *making activities* add responsibility for the group members to ensure other students' learning in the gameplay.

Theoretical perspective for game-making

The maker movement is grounded in learning theories and provides an example to show how learning theories are merged in learning sciences (Halverson & Peppler, 2018). Because *game-making* falls under the definition of the maker movement, the learning theories supporting the maker movement may apply to *game-making*.

Learning is seen from the constructionist perspective "as building relationships between old and new knowledge, in interactions with others, while creating artifacts of social relevance" (Kafai, 2006, p. 35). As seen from this definition of learning, constructionism emphasizes individual and social dimensions of knowledge construction. It adds that students are getting engaged in a socially constructed end-product, which is publicly reachable. Papert thought that physical and digital objects help students construct, examine, and revise the connection between their existing knowledge and their newly formed knowledge, meaning students make the knowledge their own (Kafai, 2006). Although constructionism is connected to the notion of constructivism by seeing "learning as the product of play, experimentation, and authentic inquiry" (Halverson & Sheridan, 2014, p. 497), learning also occurs "by constructing knowledge through the act of making something shareable" (Halverson & Sheridan, 2014, p. 498). Therefore, bringing personal experiences to a *game-making* environment and incorporating the previous knowledge with what is being learned through game development by engaging with others enables us to see the constructionist aspect of *game-making*. Kafai and Burke (2015) brought up constructionist gaming, which is about students *making* their games that support personal, social, and cultural aspects of learning with constructionism. These aspects were about what one learns, *making* collaboratively by considering the audience, and demographics such as race and gender affecting *making* activities and their outcomes. Constructionism was adopted as a learning theory in the majority of educational game design studies (Weitze, 2021).

Learning scientists focus on *the individual cognitive approach* and *the interactional approach*. The individual cognitive approach focuses on information structures that individuals have as models "to construct, store, retrieve, and modify patterns of information" (Greeno, 2006, p. 81). Greeno (2006) argued that the interactional approach underscores the participation structure while individuals have interactions with each other and the learning material. Deep interaction between students is necessary to be aware of one's thinking process (Ruiz-Gallardo & Reavey, 2019). Considering both approaches, Greeno (2006) defined *distributed cognition* as a group of people planning, solving problems, and reasoning together over a complex artifact with the representations they created during the process. So, learning is dependent on individuals, tools, and setting (Halverson & Peppler, 2018). Game-making in a classroom to reach a shared understanding in a group through

conversations and interactions with the artifact demonstrates a ground for distributed cognition.

Situated learning (Brown et al., 1989) is another theory that supports *game-making*. Knowledge can be acquired by engaging in authentic activities supported by context and culture. People learn through interactions with each other and the environment by discussing the topic, sharing their knowledge, and solving problems. Studies focused on history learning via *game-making* and playing (Clark et al., 2018; Wake et al., 2018) can be examples because students collaborate while *game-making* and playing by engaging with the tools in authentic activities and considering the content and the culture of the learning environment.

Constructionism, distributed cognition, and situated learning may provide a basis for *game-making* in teacher learning and teacher training by considering personal experiences, individual and interactional approaches, authentic, contextual, and cultural activities, the connection between the old and new knowledge, and creating a shareable product (e.g., game).

What is digital game-making for?

Digital games, under the definition of typical educational games and educational video games, serve in education in three ways: (1) games support learning the core content, (2) games are used as a means to motivate to engage in the learning process, and (3) games are used for assessment (Fields & Kafai, 2018). Games are motivational tools to engage in learning (Clark et al., 2018). Teachers adopt *game-making* and playing to evaluate students' competencies that curricula address (Wake et al., 2018). Clark et al. (2018) deduced from their review that digital games could support conceptual understanding, identity development, practices and process skills, and engagement.

Game-making for supporting various identity developments

Digital tools that enable designing and authoring the materials and the content (e.g., games) are easily accessible and on the rise (Wake et al., 2018). Accordingly, users of digital tools are provided an opportunity to become consumers and producers. *Game-making* within this scope is a way to support students' identity development as producers. Students design, play, and evaluate games and discuss the *good game* concept (Bowden & Aarsand, 2020). Noteworthily, when *makers* integrate their personal identification into their artifacts, they create meaningful artifacts. In meaningful games, reaching success advances makers' identities as a gamer, such as being good at games, which means likely understanding game mechanics and content (Holbert & Wilensky, 2019). In Wake et al. (2018), students designed location-based games for their peers to play and learn in a history class. Students were told that their peers would play the games and learn through them, so students as game makers felt more responsible and contemplated as a teacher would while creating game narratives and using information sources. Students consider game mechanics,

learning content, difficulty level, and providing factual knowledge (Wake et al., 2018) while *making games* for their peers. Students can act as designers, players, learners, and teachers during the *game-making* process.

Game-making for digital literacy

Students' producer identities lead educators to discuss students' digital literacies more. The change from playing to *making* games brought programming forward, and computer programming has found a place in the national curricula (Bowden & Aarsand, 2020). Although programming is one of the 21st-century skills for *game-making*, other required dimensions are needed to complete the process. Four dimensions are argued (Kafai & Peppler, 2011): (a) *technical practices* include programming skills, tackling technical problems, and being able to think algorithmically, (b) referencing, remaking, evaluating, and reflecting are *critical practices*, (c) considering artistic features falls under *creative practices,* and (d) taking the community's problems into account and generating solutions within the community are *ethical practices*. It can be said that *making* a digital artifact is also a process of developing digital literacies. When students are involved in digital literacy practices, they discuss and experience (a) what forms a good game, (b) how to complete assignments competently, and (c) how their personal experiences and knowledge can be related to the educational content (Bowden & Aarsand, 2020).

Game-making for object-to-think-with

Further, *game-making* can be used as object-to-think-with (OTTW) (Holbert & Wilensky, 2019). The fundamental model embraced by OTTW is knowledge resources in cognition. OTTWs activate the knowledge resources (i.e., resource activation) when students see something "likely relevant or useful for the given situation or context" (Holbert & Wilensky, 2019, p. 35). Reasoning and experimenting are significant ways of constructing knowledge resources. *Making games* allows students to "think through games" in addition to "think[ing] about games" (Werning, 2019, p. 59). Tinkering, which enables developing ideas through *making* (E. Halverson & Peppler, 2018), would provide standard or nonstandard constructions. The point is that makers appropriate the constructions because they create them based on personal experiences (Holbert & Wilensky, 2019). The knowledge constructions developed with personal experiences can be achieved through game development (Werning, 2019).

According to Papert, OTTWs need to have a cultural presence, embedded knowledge, and personal identification. In the Constructible Authentic Representation design principles (Holbert & Wilensky, 2014), *authenticity* aligns with the cultural presence, *being conceptually integrated* coincides with embedded knowledge, and *meaningful construction* corresponds with personal identification (Holbert & Wilensky, 2019). In the Particle! game (Holbert & Wilensky, 2019), students individually explored the game components and the tool, which is Atomizer. After exploring the functions in the game, students conducted experiments by engaging in and with the

game. The Atomizer, which is the platform the students used to tinker and create molecules, acted as a means to *reason*. To see the game as an OTTW, the researchers emphasized that the reasoning started with the Atomizer should continue after the game (i.e., beyond the game). During the interviews, students cited the *Particle!* game while reasoning over the questions related to the content. In Clark et al. (2018), which utilized history-based games in the classroom environment, some teachers reported that students role-played as the character after playing the games and learned the content better. Students approached new situations with the sense of what they learned before through playing. Students created or shaped game narratives according to their *personal choices* and *experiences* throughout some games. Therefore, students in Clark et al. (2018) also used the games as OTTWs.

Importance of preparing teachers to get ready for game-making

Teachers need to be well-prepared to make *game-making* work in classroom settings. Teachers need to understand the *game-making* notion while pursuing their undergraduate degrees and have experience in *game-making* and *scaffolding in the game-making process*. Nevertheless, there is a need to separate pre-service teacher education and in-service teacher training (i.e., professional development). A recent study (Hughes et al., 2020) showed that pre-service and in-service teachers have different perceptions of utilizing technology and different reasons for using technology. While integrating technologies, the study revealed that pre-service teachers focused on less student-centered activities with more presentation and engagement-oriented approaches. In contrast, in-service teachers took student-centered activities into account with more knowledge acquisition, higher-order thinking skills, and collaboration-oriented strategies.

Game-making: a means for TPACK

Pre-service and in-service teachers pay attention to technological pedagogical knowledge in technology-integrated activities (Hughes et al., 2020). TPACK is a model to use as a framework for technology integration, consisting of technological knowledge, pedagogical knowledge, content knowledge, and different combinations of the three (Mishra & Koehler, 2006). Pre-service teacher education is the starting point for learning and developing pedagogical, technological, and content knowledge. Pre-service teachers are getting trained to be ready for the components of TPACK, and pedagogy is one of the three components. Pre-service teachers are trained to learn and teach, and *making* is one of the effective practices that gives importance to learning while creating. *Making games*, specifically, was demonstrated as a significant way for a pedagogy to spur enthusiasm for learning content, writing codes, collaborating with others, and *making* a product creatively (Kafai, 2018). Constructionist gaming (Kafai & Burke, 2015), which is *making games to learn*, demonstrates the content-focused approach (Werning, 2019). *Making activities* through programming continuously improve

content knowledge, technological content knowledge, and technological pedagogical content knowledge (Kong et al., 2020).

Game-making: confidence/empowerment

Making games is a way of public expression (Kafai, 2018; Werning, 2019); therefore, pre-service and in-service teachers could shape their pedagogy and teach their students how to use *game-making* to express their ideas in the classroom environment. *Making games* has a playful nature, a content-focused approach, and a technical aspect in light of affordances and constraints (Werning, 2019). Constructionist game-making in K-12 education is unpopular because of the technical part of learning programming (Kafai, 2018; Kafai & Burke, 2015). As stated in the Different Ways of Making Digital Games section in this paper, there are some specific ways for constructionist game-making, including programming a game from scratch (particularly with block-based coding), modifying an existing game, and tools such as SILO. None of the three ways is too technical. Constructionist *game-making* was defined as an approach that allows students to develop games by aiming to learn (Kafai & Burke, 2015). The ways to *make games* in the Different Ways of Making Digital Games section in this paper allow students to design a game for entertainment and educational purposes.

The constructionist approach adopted for teachers' professional development (PD) workshops increases (a) teachers' satisfaction levels with the content and (b) teachers' classroom practices with the projects made within the workshops (Hickmott & Prieto-Rodriguez, 2018). After integrating the constructionist approach in computing workshops for teachers, Hickmott and Prieto-Rodriguez (2018) created more open-ended problem-solving activities with more hands-on practices, mirroring students' classroom experiences and maker movement approach. The constructionist approach allowed teachers in professional development workshops to work with more meaningful projects for their learning and teaching and to take these projects to their classroom for their students' learning. Teachers who adopted the technological content knowledge approach in technology-integrated activities (Hughes et al., 2020) show readiness and willingness to *make* meaningful projects with *constructionist making*. Confidence levels of novice teachers who are not *computing teachers* and have limited knowledge of programming increase after *making games* in their specific disciplines (Boulton et al., 2017). This increased confidence in *making games* would show itself in technological, pedagogical, and content knowledge and their applications in classrooms.

Game-making: forming learning communities

Kafai and Burke (2015) argued that constructionist making activities create learning communities. This can be seen in Hickmott and Prieto-Rodriquez's (2018) computing workshops, where experienced teachers and novice teachers worked collaboratively and scaffolded each other. PD experiences are valuable for students and teachers (Darling-Hammond et al. 2017), and teachers give importance to the PD opportunities, including *making* (Kong et al. 2020). Workshops designed for

teachers by Hickmott and Prieto-Rodriquez (2018) provide good examples to see the perceptions of teachers and designers of the workshops for the *making activities*.

Game-making education for preservice teachers could help prepare them to be experienced in incorporating making into education when they start teaching at school. Therefore, *game-making* education can create learning communities for the moment and the future. Experienced pre-service teachers, when they begin teaching, not only design and utilize *game-making in their classrooms* for their students but also scaffold other novice colleagues in the community.

Pre-service teacher learning and in-service professional development focusing on *game-making* help teachers learn how to *make games* and teach *game-making* in classrooms. Teachers highlight two points in PD workshops: higher-order thinking and tinkering (Hickmott & Prieto-Rodriquez, 2018). Tinkering in *making* activities supports higher-order thinking skills and allows generating and communicating ideas while *making* (Alden, 2016). For pre-service teachers, tinkering is also significant because a recent study (Kim et al., 2021) indicated that tinkering supports the hypothesis-driven reasoning process while computing. The importance of preparing teachers for game-making directs us to think about making games in classrooms and teachers' roles while game-making in classroom environments.

Class practices with game-making

Making can be achieved in classrooms

Students get more satisfied with *game-making* activities than other methods such as presentations and group discussions in classrooms (Hamzeh et al., 2017). Bringing *game-making* into classroom practices is not easy. For learning purposes, *game-making* in class practices is complex for teachers (Weitze, 2021). *Makerspaces*, by their nature, are defined as informal spaces "where people of all ages blend digital and physical technologies to explore ideas, learn technical skills, and create new products" together (Sheridan et al., 2014, p. 505). Makers in makerspaces work on different goals, and everyone does not need to learn a concept simultaneously (E. Halverson & Peppler, 2018). Therefore, classrooms as formal educational settings can hardly be makerspaces. However, Halverson and Peppler (2018) recommended that *making* and makerspaces should be treated and taken into account separately. Werning (2019) also indicated that *making games* is a way to shape the social environment, such as classrooms, in terms of diverse cultures, identities, and personal experiences.

Teachers' approaches are essential in integrating *game-making* into formal education (Clark et al., 2018), and teachers' pedagogical beliefs affect learning activities brought into learning settings (Weitze, 2021). However, we cannot deny that teachers need to follow a standardized curriculum in formal education. This makes *game-making* integration into classrooms difficult but not impossible. Encouragingly, teachers are willing to use digital games and digital *game-making* in education. Some recent studies have already focused on integrating *game-making* into a classroom setting (Bowden & Aarsand, 2020; Holbert & Wilensky, 2019; Wake et al., 2018).

Teachers' roles while game-making

Learner-generated designs (e.g., through *game-making*) provide an atmosphere to bring out students' goals and ideas and let students discuss with their peers and teachers (Kim et al., 2015). *Game-making* allows students to collaborate and meaning-make with others in learning settings (Wake et al., 2018). Teachers' roles in achieving these goals are critical because challenges while *making games* cannot be denied. Creating a storyline for a game, making a game educational and fun, assessing students' learning, and encouraging collaboration in the classroom were reported as challenges that teachers encounter (An & Cao, 2017).

Managing collaboration and communication

Teachers' roles in the classroom for *game-making* can be seen during interactions, communications, and collaboration. The conversational interactions in the classroom occur when students respond to the teacher and peers have conversations about their presentations or ideas (Greeno, 2006). These interactions would happen by turn-taking, introduction/closure of a topic, and correcting mechanism for a misunderstanding (Sawyer, 2006). A teachers' role in the classroom is to support developing skills, such as turn-taking, listening to each other, and respect while someone else speaks (Krajcik & Shin, 2014). Teachers run feedback activities while students evaluate game designs by (a) opening the feedback activity with a question, (b) organizing the turn-taking, (c) letting students take the authoritative position while critiquing, (d) managing embodied action, and (e) warning others when one of the students was sharing their ideas (Bowden & Aarsand, 2020). Critique and feedback during *making* activities increase student engagement with content in the classroom (Litts et al., 2019). Teachers in the classroom also introduce the language related to the game design field (Bowden & Aarsand, 2020). Inherently, teachers embrace the apprenticeship model by providing idea sharing, sharing their expertise, letting students share their knowledge, and distributing responsibilities (Kafai, 2006). Considering the role of *game-making* as connecting students (Kafai & Burke, 2015), a teacher's role, knowledge, and experience for *game-making in classrooms* and for collaboration and communication gain more importance.

Assessing learning

Positively, teachers are willing to have *game-making* practices in their classrooms to assess student interest and student understanding of the learning content (An & Cao, 2017). In project-based learning, which has a goal to create an artifact as an end-product, teachers generate the driving question (or students generate the driving question with the help of the teacher) and link the driving question to the concepts that students explore during the *making* process (Krajcik & Shin, 2014). Krajcik and Shin (2014) signified the assessment aspect by stating that teachers use the end-products (e.g., games) and the *making* process to assess students' understanding development. A recent systematic literature review showed that designed games and game design processes are used for measuring learning outcomes (Weitze, 2021).

For example, the teacher in Wake et al. (2018) used the game development process and the end-product as a way for assessment.

Scaffolding

Teachers need to have an orientation to *game-making* that allows them to utilize *game-making* in classrooms and scaffold students *making* games. Scaffolding is a mediator that supports students who cannot perform a task without help and enables students to complete a task without help (Belland et al., 2011; Belland & Drake, 2013). With these in mind, scaffolding teachers to get familiar with design tools and have experience designing games and learning/teaching the content via game design is essential (Wake et al., 2018; Weitze, 2021). Teachers tend to use *game-making* as a way of assessment, so they need to be knowledgeable and have experiences. Teachers need to define the learning goals, assessment criteria, and competencies in their classrooms while utilizing games. Teachers should decide the level of support based on student groups' background knowledge (de Jong et al., 2018), get better at giving feedback (Krajcik & Shin, 2014), and learn how to scaffold students during the *game-making* process.

Teachers prefer providing scaffolding to their students through an avatar, pop-up messages, or a virtual resource such as an online library for instant feedback when developing a game (An & Cao, 2017). Interactive stories that Clark et al. (2018) identified as a game type also underscored in-game dialogues and interaction between users and avatars. Getting better at scaffolding and putting the experiences and knowledge into practice during conversational interactions in *game-making* would prevent frustration (Tabak & Kyza, 2018) and apprehension and tension (Wake et al., 2018), which students likely have in classrooms. Scaffolding by an expert (e.g., teacher) during *making* activities increases makers' perspective-taking attitudes (i.e., learner attitude, maker attitude) in classrooms (Dishon & Kafai, 2020). Teachers favor integrating *game-making* practices into classroom practices because *game-making* positively affects student attitudes and self-esteem (An & Cao, 2017).

Recommendations and limitations

As a final note, Ruiz-Gallardo and Reavey (2019), with pre-service teachers, focused on the long-term effects of *learning-from-peers*, *learning-by-teaching,* and *lecturing* on most likely misunderstood science concepts. *Knowledge gain* was more stable on learning-by-teaching and learning-from-peers than lecturing in the long term. Learning-from-peers shows significant results in critical thinking, skills in systemizing the learning, improvement of cognitive and metacognitive strategies, and attitude towards school (Ruiz-Gallardo & Reavey, 2019). As for *game-making* practices in teacher learning and teacher training, the long-term effects of learning-from-peers, learning-by-teaching, and lecturing on *gaming* and *making* knowledge gain needs to be investigated. The suitable approaches that pre-service and in-service teachers prefer and benefit from need to be researched to shed light on teacher education

programs and professional developments. Notably, there is little research conducted with pre-service teachers regarding their learning with and through *game-making* under the learning sciences lens. Also, teachers are the primary scaffolders for students in game design settings such as classrooms (Weitze, 2021). Therefore, considering teachers' needs in terms of expertise, experience, and skills in *game-making*, investigating pre-service and in-service teachers' *game-making learning processes* would enrich the teacher learning and teacher training practices and teaching practices in the classroom.

This paper did not focus on a specific subject (e.g., mathematics), a specific student group (e.g., middle school students), or a specific game-making tool (e.g., Scratch) while synthesizing the literature. There could be different advantages of integrating *game-making* into classrooms, different use of *game-making*, and different teacher roles while making games in specific subjects with specific student groups and tools. This review provided teacher roles and advantages and uses of *game-making* in any subject with every student group and any tool.

Data availability There were no data used.

Declarations

Conflict of interest There are no potential conflicts of interests.

Informed consent There were no participants; therefore, no informed consent was needed.

Research involving human participants and/or animals There were no human participants and/or animals.

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