CONSTRUCTIONISM AND GAME-MAKING FOR LEARNING IN THE AGE OF ROBLOX. AN ANALYSIS OF CURRENT EVIDENCE AND FUTURE PERSPECTIVES

COSTRUZIONISMO E GAME-MAKING PER L'APPRENDIMENTO NELL'ERA DI ROBLOX. UN'ANALISI DELLE ATTUALI EVIDENZE E DELLE PROSPETTIVE FUTURE

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ABSTRACT
The use of digital games for learning encompasses a range of pedagogical approaches and practices. Game-making as a learning strategy has gained interest. This approach, inspired from the work of Piaget (1951) and Papert (1980), uses game design as a means for students to "externalize thinking and problematize focusing on the product" (Kafai & Burke, 2015). However, existing evidence is mostly descriptive (Denner et al., 2019), and there is a lack of comparative studies (Vos et al., 2011) and evidence-based frameworks. The aim of this article is to review and discuss current evidence and frameworks.

L'uso dei giochi digitali per l'apprendimento comprende una serie di approcci e pratiche pedagogiche. Il game-making come strategia di apprendimento ha guadagnato interesse. Questo approccio, ispirato al lavoro di Piaget (1951) e Papert (1980), utilizza la progettazione di giochi come mezzo per gli studenti per "esternare il pensiero e problematizzare concentrandosi sul prodotto" (Kafai & Burke, 2015). Tuttavia, le prove esistenti sono per lo più descrittive (Denner et al., 2019) e mancano studi comparativi (Vos et al., 2011) e quadri di riferimento basati sull'evidenza. L'obiettivo di questo articolo è quello di rivedere e discutere le prove e i framework attuali.

KEYWORDS
Game-based learning; Game design tools; Constructionism

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Introduction[1]

The use of digital games in education is a hotly debated topic for several reasons. First, video games are ever more present in the popular culture: in 2021, 15.5 million italians played video games, contributing to a market worth 2 billion and 243 million euros (IIDEA, 2021). Second, the awareness of video games social and cultural relevance has grown in parallel: more than 50% of italians agree not only that video games are fun, engaging, and social, but also that they can develop skills such as problem solving, decision making, and that they can be useful tools for teaching and learning in schools (IIDEA-CENSIS, 2021). At the same time, however, the effective presence of video games in instruction, especially in schools, is limited (Allsop e Jensen, 2015; Loperfido et al., 2019). To explain this contradiction, it is mandatory to develop a more in depth understanding of the possible approaches to the use of video games in education, to assess their risks, advantages, and opportunities.

The goal of this article is to discuss a particular approach to the use of video games in teaching and learning, called game-making. The principle of game-making is to have students create video games as an instructional strategy.

What is game-making? Even taking aside approaches that use only specific elements of video games to promote engagement and motivation (gamification) or to make learning more fun (playful learning; see Plass et al., 2020), there are many ways in which games can be employed in learning contexts, depending on the learning objectives. In line with the principles of media education (Rivoltella, 2019), when used as a learning instrument or environment (game-based learning) games can be used:

- as an item of reflection: as a product of a specific time and culture, games can be investigated as texts that reflect the intentions, values, and characteristics of the society that produced them.
- as a learning tool: the experience of playing a game can be used to develop, train and or/assess relevant knowledge, skills and competencies (Tinterri and Andreoletti, 2023).

[1] [1] The article is the result of a joint work of the four authors. The *Introduction* was written by *Sabrina A*nnoscia, the paragraph *1. Methods* and *2. Results* was written by *Mariasole Antonietta Guerriero*, the paragraph *3. Discussion* was written by *Andrea Tinterri* and the paragraph *Conclusions* by *Anna Dipace*.

- as a language, with whom to create new meaning and artifacts, to explore the expressive possibilities, solve problems, and develop expertise.

Game-making refers to the latter, of which it represents a specific instance. In game-making, students use the language of games, or game design, to modify existing games or create new games in order to solve a design challenge (Ejsing-Duun et al., 2019). In the case of digital games, this usually entails some form of programming, or coding. This approach has been heavily influenced by the seminal work of Seymour Papert. He coined the term "constructionism" as an extension of constructivism, a learner-centered approach in which students build not only mental constructs but actual artifacts as part of the learning process (Papert, 1980). As a teaching philosophy, it builds upon Vygotsky's (1962) social constructivist theory and Piaget's constructivist theory (Reynolds, 2019). Since the early '70s, when computers were still scarcely diffused and extremely expensive, Papert foresaw "a world in which children not only learn to use new technologies, but become truly fluent with new technologies…children should be able to design, create, and express themselves with new technologies" (Resnick, 2012) and envisioned video games not just as a product or an educational tool, but as an "object-to-think-with": something external, shareable, and meaningful to the learner (Papert, 1990). To reach this goal, together with his group at MIT he created a programming language called Logo which is in many ways the ancestor of the popular game-making software Scratch (Resnick, 2012). In the following years, the diffusion and use of personal computers and digital games boomed, thus leading to a significant increase in opportunities and tools for young people to design and make their own digital games (Earp, 2015). For this reason, various environments are being used in education and programming in recent years (Kormkmaz, 2016) Crucially, most of the currently popular game-making tools, such as Roblox and Scratch, do not require students to learn complex programming languages, as they use either graphical interfaces or "language block" approaches.

Scratch is "a visual programming environment that allows users (primarily ages 8 to 16) to learn computer programming while working on individually meaningful projects such as animated stories and games" (Maloney et al., 2010). It allows users, whether students or teachers, to approach programming by accomplishing what motivates and engages them most. The layout and interface are 2-D, the commands are very simple and intuitive so as to motivate even the most skeptical user to approach programming; Scratch's block language eliminates syntax errors, allowing users to focus immediately on problems that are relevant to them, without having to concentrate on making the program work. Scratch's programming environment and language "work together to create an extremely quick-to-learn system that allows users to program in fifteen minutes, but with enough complexity and variety to keep users engaged for years" (Maloney et al., 2010). The Scratch program can

produce learning media equivalent to the quality of Flash programs, but its complexity is comparable to that of a PowerPoint program (Bernard et al., 2020).

Roblox is the world's largest multiplayer game community, considered a part of the Metaverse (Dwiwedi et al., 2022). This virtual gaming platform includes virtual worlds, leisure communities, and, crucially, self-built content (called *experiences* in the game jargon) which users can create and share with the rest of the community, using a lightweight programming language called Lua. In 2021, Roblox had 150 million users and 40 million daily active users, with users under 13 years old accounting for more than half of the total number (Han et al., 2023). In spite of its great commercial success and emerging potential for educational use (Jawad et al., 2021), the platform has raised concerns related to cyberbullying, cybersecurity, lack of adequate teaching design (Han et al., 2023), as well as monetization of user-made content (Plunkett, 2021).

Those are just two examples; there are many more game-making tools available, many of which use visual alternatives to programming languages (including Kodu Game Lab, Unity, Javascript, Flash, GameMaker, Shiva, Unreal, Stencyl, GameSalad, Scratch, Globaloria, Taleblazer, Microworlds, Nintendo's Game Builder Garage etc., see Reynolds, 2019). Therefore, the context appears particularly promising for the adoption of digital game-making in learning environments such as schools. On the one hand, education systems are undergoing a shift from a traditional, knowledge-centered approach to a student-centered approach to meet the cultural and social and economic needs of society with a focus on the development of skills such as a high level of thinking skills, creativity and/or innovation, productivity, collaboration and communication (Hava et al., 2020) for which game-making seems especially suited (Gee, 2003; Kafai and Burke, 2015). On the other end, the technology required for implementation is more and more widespread and economic, as most tools only require a PC and Internet connection; finally, many children are growing up using digital environments as major sources of entertainment, socialization and self-expression, including Roblox or Minecraft (which is not strictly speaking a game-making tool, but rather a "sandbox" video game, which allows players to create, within the virtual world, buildings, landscapes, quests, game modes, and even working Turing machines).

Still, while there is extensive literature on the subject of the use of game-based learning and gaming in formal and non-formal contexts, the same cannot be said for the field of game-making, especially if we move from an analysis of scientific evidence of a theoretical nature to more empirical and comparative aspects of the use of game-making compared to other forms of media and conventional didactic materials, and of GBL itself. In a 2015 study, researchers Kafai and Burke lamented a lack of evidence for game-making and game design as a form of learning. In the same year, a systematic review by Earp (2015) found a reduced presence of mainly empirical studies in the area of game-making, which clashes with such a massive presence for game-based learning. Game-making, in comparison to the attraction of GBL in academia, remains a niche, albeit a very active one.

The goal of this study is to discuss evidence for game-making as an instructional strategy, to identify the main advantages, drawbacks, risks and opportunities of this approach in the light of this mutating scenario. To this aim, we initially focused on recent developments in the literature according to three research questions, adapted from Mayer (2020):

- RQ1 (Value added): which features of game-making effectively promote learning?
- RQ2 (Cognitive consequences): is game-making more or less effective than other forms of game-based learning?
- RQ3 (Media comparison): is game-making more or less effective compared to other forms of media?

1. Methods

For each RQ, we performed a bibliographic search focusing on articles published in English after 2015, the year in which the last systematic review on the topic was published (Earp, 2015). We gave priority to journal articles but included conference papers and proceedings in the search. The search terms for RQ1 were: “game” AND “making” OR “build*” OR “construct*” AND learn*. Search terms for RQ2 were: “game” AND “making” OR “build*” OR “construct*” AND “game-based learning” OR “compar*”. Search terms for RQ3 were: “game” AND “making” OR “build*” OR “construct*” AND “learn*” OR “compar*” OR “conventional” OR “traditional” OR “media” OR “tools”. The search was made on Scopus and Google Scholar and integrated with Elicit and Semantic Scholar using both snowball and citational methods.

With distinctions according to the databases, the results showed many works related to the use of Gamification, GBL and gamified environments, both in terms of learning outcomes and in comparison with traditional teaching However, very few articles addressed game-making directly or in comparison with other GBL approaches. Furthermore, we found very little work concerning comparison of game-making with other forms of media production. Since several studies included the name of the software employed in the title or abstract, we opted to integrate the research by searching for specific game-making software, including terms.

2. Results

The first finding of the bibliographic research is that in recent years, very few articles, with exceptions such as the works of Akcaoglu (2019) and Weitze (2017), address game-making without making explicit reference to specific software or

tools. This is maybe unsurprising, as Pelletier (2007) already noted that "the recent interest in learning-oriented computer games has conceptualized games as interfaces (forms) rather than practices, and therefore does not perceive ... the making of games as relevant'. Consequently, the following results are concerned both with the general aspects of game-making as well as evidence related to specific software.

Features of game-making that promote learning. Student-centred learning is one of the main drivers behind modern-day educational policies and practices (Coleman et al., 2019). Studies in the literature indicate that the benefits of game-based learning are greater and more robust than the problems it entails and that education is much more fun and fruitful when the content is gamified (Osipovskaya et al., 2023). Thus, a new impetus for analysis and research in this area is therefore the need to observe and research the best strategies for developing skills needed for the 21st century, digital millennium, such as computational thinking and coding (Gee et al., 2015). In his work on digital game-based learning (DGBL), Gee establishes that "effective games, by their very nature, provide high-quality learning by teaching players, through gameplay, the skills they need to complete the game, even if it is not necessarily traditional educational content" (Gee, 2003; Coleman et al., 2019). Game-based learning aims to teach something beyond gameplay itself, motivating students to participate through active engagement and developing behavior and values, motivation, analysis and problem-solving, decision-making and social skills (Fu et al., 2020). Earp (2015) carried out a systematic review of the scientific literature that has been published from the 1980s to 2015 on the topic of game-making and its application in learning contexts. The research showed an exponential growth of publications in the period between the two millennia with a particular increase in the first decade of the 2000s, coinciding with the increased presence in the literature and learning contexts of concepts such as 21st century skills, computational thinking and applications of GBL for several decades already. In his review, he found that the scope of game-making spans a very relative range, keeping most of the literature found in a formal learning context. In fact, Earp noted that "research on game-making has focused primarily on young school-age students, particularly those attending middle school in the 11 to 14 age group. Outside this range, the focus is mainly on primary school and, to a lesser extent, high school" (Earp, 2015). Other evidence points to different contexts, in particular clubs, camps and community activities of a more technical nature in the IT field. In primary school, GBL has proven to be a competitive learning tool to conventional teaching materials for learning abstract concepts such as mathematics (Ergul et al., 2022). In Ergul and Dogan's study (2022), it is observed that the learning process through play motivates students through the perception that they are responsible for their own learning, allowing, in addition, the development of metacognitive awareness. In the same study, it was observed that in primary school pupils, learning is strongly stimulated by GBL as a stress- and anxiety-free working environment is created, students are inclined to learn,

enthusiastic and involved, especially in achieving success in a collaborative group and fun way. In addition to such evidence, GBL is strongly supported by some relevant aspects such as the level of engagement in learning (Chen et al., 2019) and the principles identified by Gee: learner empowerment, problem solving and the aspect of understanding (Gee, 2003; Coleman et al., 2019). In learner empowerment, which sees the aspect of enhancing the learner's learning, very important are the factors of co-design and player identity, understood respectively as the perception that one's own choices are the main driving forces of one's learning and the personalization of gameplay and decisions, and the aspect of identity related to impersonation (embodied) and thus the translation of the situation into a personal context (Coleman et al.,2019). In the same contribution by Coleman and Money, the other aspects taken into account by Gee's principles are those of problem solving and understanding. Students show interest in challenging but not impossible situations, bordering on 'challenging frustration', which allows them to perceive the development of competence and expertise and not to lose interest. Again, Coleman and Money identify, on the basis of Gee's theorizing, the importance for students that the game has real-world elements and can be based on the use of the participant's background of real experiences. In light of such strongly positive and significant evidence of the GBL experience within the gamified, school-based, formal and non-formal context, the question emerged as to whether this could not be complemented by a process of a constructivist nature, game-making, to develop 21st Century Skills (Earp, 2015; Ejsing-Duunet al., 2019). In the study conducted by Bernard and Setiawan, (2020), it was analyzed how Scratch can help the teacher to analyze the activities of students' thinking patterns in order to understand the field of mathematics, so that students can develop strategies for new ideas that arise and understand mathematical concepts. This goal directs future teachers or students to focus on developing students' computational thinking, from understanding to problem solving, so that students can learn mathematics while having fun (Bernard et al., 2020). In the study by Chiang et al., (2018) students believed that creating games with Scratch could positively influence their performance in solving equations and their attitude towards learning mathematics. "They could learn mathematics by playing games. Most students felt pressured and bored during maths lessons. However, learning through games fostered feelings of relaxation and curiosity. Secondly, they felt more confident after creating a game. Creating a game is not an easy achievement for students. As a result, they felt proud and confident when they were able to create a complicated game and share it with their peers'' (Chiang et al., 2018). These studies also demonstrated a better and greater approach to learning when collaboration and sharing with peers took place through game building and game design. In a study conducted on the analysis of students programming through the use of Scratch an English e-book for children with low language proficiency, it was

found that the students' learning motivation was high, with a significant improvement in self-efficacy and overall learning outcomes; furthermore, the post-test revealed that Scratch programming and learning English from the culture-based picture book had a significant correlation, suggesting that the overall programme successfully integrated these two subjects (Li et al., 2023). The use of Scratch in programming, going back to the oldest scientific evidences up to the most current ones such as those mentioned above, is a game making and design tool particularly preferred by teachers and students as it meets the need to use the precepts of constructionism and programming, with the ease provided by the absence of coding and a simple and accessible interface. The benefits of combining lectures and face-to-face and game building through Scratch are particularly evident in STEM subjects but there is no shortage of clear examples in the linguistic and literary fields as well; significant results are present on learning motivation and engagement and sharing (Bernard et al., 2020; Chiang et al., 2018).

Game-making and other forms of game-based learning.

Compared to traditional games, game making seems to be a more complex and cognitively demanding approach: the process of designing and structuring games conceals a significant increase in participants' intrinsic motivation and involvement and allows immersion in contexts where constant problem-solving skills are required. Thus, the need for designers is to make decisions, create and analyze complex systems, encounter new problems and solve them as they emerge. The international literature presents evidence to compare game making with other types of approaches. As early as 2011 Vos et al., conducted quasi-experimental research on a sample of young students (ages 10-12) divided into two groups: one group developed memory games and the other played an existing game. The results showed that levels of intrinsic motivation toward learning were significantly higher in the designer group (reported as more competence, more interest, and more engagement), and that building a game turned out to be a better way to increase student motivation and learning than just playing the game. Later, in 2014 Ke conducted a study of some students who took a game design course for 6 weeks, creating games to teach math concepts to younger students. The data showed significant improvements in their attitudes toward mathematics and greater engagement during design, something that does not happen frequently in normal school learning. Despite this, the approach structured on the idea that game design can be more meaningful for learning is still not widespread as a methodological-didactic approach in school settings. One of the probable barriers causing the slowdown in this diffusion may refer to the difficulty of access to technologies. Not all students come from families from favorable socioeconomic backgrounds, and this may be a limitation of the application of GM's approach. In addition to students' personal backgrounds, teacher training and development of teaching skills are not always such that intentionally structured GM interventions can be applied. However, aside from these studies we did not find recent evidence specifically addressing the comparison between game-making and other aspects of GBL.

Game-making and other media. The last research question that this contribution set out to research concerns the presence in the literature, in the last decade in which there has been a boom in the use of GBL and game making, of evidence comparing learning outcomes through the use of game making and compared to the creation of other tools and media. We were unable to provide an effective answer to this question as the literature is lacking in this respect, as already reported by Kafai and Burke (2015). Rather than comparing the effectiveness of different tools or media, an interesting perspective that arises from few studies concerns the synergistic use of game-making and other "hands-on" instructional strategies, which are more related a playful learning approach (Plass et al., 2020); these include robotics (Leonard et al., 2017) and LEGO serious play (Papavlasopoulou et al., 2019); although the latter is mostly used and studied in adult educational settings, it also applies to the school setting (Resnick, 2012; Roos et al., 1998; Zenk et al., 2022).

3. Discussion

Overall, the most important finding of this study is the relative lack of research evidence concerning game-making, especially considering how the current situation seems favorable to the adoption of constructivist instructional approaches. Whereas a few studies addressed the features of game-making that promote learning (RQ1), there is little new evidence concerning the comparison of game-making with other forms of GBL (RQ2) or creation through other media . This finding might also underlie a more issue in game studies, whereas there is a need for a coherent framework to classify play- and game- based approaches and instructional strategies. Furthermore, to our knowledge no existing study has directly compared game-making with the creation of other media (writing, podcasting, drawing, etc.) in terms of effectiveness of learning, student and teacher adoption and perception (RQ3). In many ways, it seems that, despite favorable policies and technological development, the field of game-making has made little substantial advancements in terms of empirical evidence compared to where it was in 2015, when the works of Kafai and Burke and Earp provided a good roundup of the state of the art and already lamented the relative lack of empirically grounded studies. For this reason, it is important to reflect on the aspects that might limit the implementation of constructionist approaches to the use of video games in formal learning environments, and consequently drive the acquisition of more empirical evidence. Kafai and Burke theorized that a main motivation is found in the desire of teachers to possess a finished, downloadable educational product to be used as the medium primarily responsible for student learning. Another barrier was related to students' and teachers' lack of expertise in computer game development (Hava

et al., 2018) particularly given the association of game making with learning programming (Kafai et al., 2015). Lastly, a plausible reason was related to the game industries' intention to maintain a certain monopoly on the design and programming of games and any game-making tools or the modification of products already on the market and therefore covered by copyright. To update this view, we derived from the literature an analysis of strength,weaknesses, opportunities and threats linked to the adoption of constructionist learning environments for game-making activities (Table 1).

	Strengths	**Weaknesses**
Intrinsic	Student-centered approach (Papert, 1990). Promotes computational thinking (CT) and digital competencies (Denner et al., 2019). Promotes student creativity and problem solving skills (Davis, 2011). "Hard fun" approach (Earp, 2015) which promotes student motivation. Provides opportunities for peer mentoring and feedback (Chiang et al., 2018).	Time-consuming (Ejsing-Duun e Hangoj, 2019). Demands digital and game design skills from the teacher' side (Kafai and Burke, 2015). Demands digital skills on the students' side (Kafai e Burke, 2015).
Contextual	Digital content-creating and -sharing environments are part of the culture in young generations (Dwivedi et al.,2022). Availability and accessibility of game-making platforms for education (Gajewski et al., 2022). Demand from the education system and society for digital and XXI century skills (Earp, 2015). Peer tutoring opportunities from experienced students when working with popular entertainment software (e.g. Roblox; Lai et al., 2022)	Lack of empirical evidence on the effectiveness of the approach (current study). Inclusivity and gender equality in coding and gaming culture is still an open issue (Robertson, 2012). Risk of focusing on the instrument (coding) rather than other learning goals (Pelletier, 2007). Desire for teachers to have "ready-made" instructional activities and material (Kafai and Burke, 2015). Popular entertainment software (e.g. Roblox) has intellectual property and monetization issues (Han et al., 2023; Plunkett, 2021)

Table 1 - SWOT analysis for the adoption of game-making as an instructional strategy

Conclusions

This study analyzed current literature on game-making as an instructional strategy. We found that, despite strong theoretical background for the benefits of a constructivist approach and the diffusion of content-creation and modding culture amongst the younger generation, game-making still appears to be a niche approach whose application in formal education relies heavily on the success of the Scratch

platform. Current literature seems to be still divided between advocacy for the approach and case study reports focusing on specific software and/or limited empirical evidence. In order to transition to a mature field, there is a need for (a) more empirical evidence (b) more encompassing and software-independent pedagogical frameworks which might streamline and simplify the job of teachers and educators willing to implement this approach (c) more clarity in the language of game studies related to education; outside of academic discourse (and sometimes, even there) game-making tends to become synonymous with other concepts such as game design (which relates to the system of rules that make game work), coding (which is referred to the instrument through which digital games are made and modified), playful learning (such as the maker movement) and other forms of content creation within games such as modding (Ejsing-Duun & Hanghøj, 2019). Some of these issues were already mentioned by Kafai and Burke and Earp, and our study suggests that the needle hasn't moved much since then. However, reaching those goals is instrumental to help not only students, but also teachers stop thinking as consumers and start thinking like designers.

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