BUILDING A NEW WORLD IN EDUCATION

Exploring *Minecraft* for Learning, Teaching and Assessment

Microsoft Dream Space CARPE Centre for Assessment Research, Policy and Practice in Education

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Paula Lehane, Deirdre Butler and Kevin Marshall

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FOREWORD

Computer games have changed how we learn. The truth is that computer games are fulfilling genuine human needs in a way that the current real world is unable. This was the case before the pandemic and it has been accelerated by the pandemic. Computer games have change how we come together, how we interact, how we learn and how we are inspired. This is an uncomfortable fact for many, who can either embrace it and shape learning through games or ignore it and suffer the consequences of the opportunity lost.

For some this will all sound hard to believe, even over dramatic. But we are a society where an increasing part of our time is devoted to playing games. 69% of all heads of households play computer games. 97% of young people play computer games. At least 1 in 4 computer gamers is over the age of fifty. The average computer game players are thirty-five years old and have been playing for at least twelve years. Over 60% of CEOs say they take daily game breaks at work. Yet this is a hidden culture, as these statistics do not represent how we talk about gaming or play. We often view computer gaming as entertainment, rather than learning. Fun, rather than work. Why should this be the case?

Imagine a world where work was fun and deep learning was best achieved through play. Imagine a world where students could not wait to engage in learning and became deeply engrossed in the content they were learning. Imagine if this learning appealed to students of all ability ranges, of all background and made accessibility for those with disabilities easier. As this report demonstrates, computer games are changing this vision of learning into reality. Game based learning is quantifiably more immersive, learners spend more time involved in serious content, they retain more knowledge about a subject afterwards, it is increasing participation from under-represented groups including those with disabilities, and it is enjoyable. The single biggest issue we face is how best to deploy such learning into schools and overcoming this is the last hurdle we face to bring benefit to all students.

Justin Edwards,
Director, *Minecraft: Education Edition*

1.0 EXECUTIVE SUMMARY

Attention on digital game-based learning (GBL) has been heightened in recent times as it became an opportune way to support distance education and remote learning during the COVID-19 pandemic. To assist educators in their efforts to ensure continuity of learning using digital games, *Microsoft* released the '*Minecraft* Education Collection' in March 2020, resulting in more than 63 million downloads within six months[1]. Following a general overview of the field of GBL (see **Sections 2** and **3**), this report (as summarised in **Figure 1**) synthesises and critically reviews the current literature on GBL and, more specifically, *Minecraft: Education Edition* (*M:EE*) in primary and post-primary settings.

While the theory underlying the use of sand-box type games like *M:EE* in classrooms is promising (see **Section 3**), robust empirical evidence pertaining to their effectiveness in addressing learning outcomes is still rather scarce.

However, some evidence in relation to their value for teaching, learning and assessment activities has been noted (see **Section 4**):

- *M:EE* can enable more accessible learning experiences for diverse groups of learners e.g. second language learners, learners with special educational needs.
- *M:EE* can support project-based learning and the development of key competences such as problem-solving and collaboration.
- *M:EE* and other digital games can support formal and informal classroom assessment practices. As technology progresses, they may also be a way for teachers to measure 'hard-to-assess skills' like problem-solving.

One clear message from the literature is the need to investigate what game characteristics and contextual elements can influence learning using sound research methodology (see **Section 5**). One way to support such research may be contained within the Irish context. In November 2021, on foot of a series of TV programmes featuring *M:EE*, the Irish national broadcaster (RTÉ) and *Microsoft Ireland* launched a competition challenging primary school students and their teachers to imagine and represent Ireland's future using *M:EE*[2]. This competition may offer a unique platform to 'mine' a more comprehensive understanding of how *M:EE* can support learners.

1 https://news.xbox.com/en-us/wp-content/uploads/sites/2/2021/04/Minecraft-Franchise-Fact-Sheet_April-2021.pdf

2 https://www.rte.ie/learn/2021/0915/1246913-irelands-future-is-mine-register-here

MINECRAFT

Game-Based Learning (GBL) refers to the use of games for some educational purpose. What is the potential role and value of *Minecraft*: Education Edition (*M:EE*) in supporting GBL in Irish schools?

Game-Based Learning (GBL)

Recent meta-analyses have indicated that GBL can address learning outcomes if **serious games'** are chosen. This requires digital games that are **interactive**, based on a set of **agreed rules**, and provide feedback to users as they move towards their goal. The most recent generation of these games align with the learning principles of constructionism.

Constructionism

Constructionism asserts that learning occurs through the making of an **artefact**. **Sandbox-type games** like *M:EE* align closely with this learning theory. *M:EE* involves open-ended worlds through which there is no one single, correct pathway to completion. Users create their own artefact in the form of their gaming environment. This becomes their '**object-to-think-with** which can be shared with others.

M:EE & Learning

M:EE can help develop **21st century skills** like **collaboration** through **project based learning**. Digital games like *M:EE* support learners' perspective-taking skills, a key element of collaboration Project-based learning can be a way for learners to **synthesis and apply their knowledge** to recreate historical events (e.g. 1916 Rising) or create appropriate habitats.

M:EE & Assessment

M:EE can support teachers' **formative** and **summative** assessment practices. Oral or written feedback on learners' work can be provided using **Non-Player Characters** (NPCs) or **boards**. Learners can chart their progress with pictures (**self-assessment**) *M:EE* also has the potential to measure '**hard-to-assess**' skills. The data recorded in *M:EE* could provide important insights on learners' problem-solving strategies but more research is needed to realise this.

M:EE & Teaching

Teachers can use *M:EE* to promote the development of knowledge or skills by designing innovative and complex activities that promote curricular based **gameplay**, **exploration** or learning **representation**. *M:EE* may also support the development of social ski ls with groups of **neurodiverse** learners as it adopts a multi-modal approach to **social interaction** and **communication**.

Future Directions

Future research using *M:EE* should address the current shortcomings in the field in terms of **research design and focus** in order to better understand how *M:EE* can be most **effectively deployed** in Irish primary and post-primary classrooms. **Professional learning programmes** for teachers should also be considered to ensure that they feel confident in engaging with *M:EE* for GBL.

Figure 1: Executive Summary Graphic

2.0 INTRODUCTION

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When it was released in 2015, the *Rethinking Education* (United Nations Education, Scientific and Cultural Organisation [UNESCO]; 2015) publication strongly advocated that education systems worldwide emphasise the teaching of ‘21st century skills’. To address these ‘transversal’ skills and core competences (Organisation for Economic Co-Operation and Development [OECD], 2019), primary and post-primary educators are now being encouraged to engage in ‘new types’ of teaching; specifically, those involving technology-based approaches (Redecker, 2017). In line with this global movement, the *Digital Strategy for Schools* (Department of Education and Skills [DES], 2015) provided a rationale and plan for the embedding of digital technology into the teaching, learning and assessment practices of all teachers in Irish schools from 2015 onwards. The aim of this policy was to ensure that ‘Ireland’s young people become engaged thinkers, active learners, knowledge constructors and global citizens’ (DES, 2015, p. 5) through the use of suitable digital tools and technology-based methodologies.

While this move towards the use of digital technology to support teaching and learning in schools in line with government policy had been gaining traction (e.g. Scully et al., 2021), it became the *only* option for the Irish education system in March 2020 as schools began to close as a result of the COVID-19 pandemic. Ireland, like many other countries, faced an ‘unanticipated and accelerated move’ (Starkey et al., 2021, p. 1) to online learning. Digital tools and technology-based methodologies became a necessity overnight. While this rapid transition to remote teaching and learning revealed and amplified the ‘fault lines’ in most education systems (Squire, 2021), it also demonstrated the willingness of teachers and students to engage with innovative technologies and pedagogies. Game Based Learning (GBL) was particularly attractive to educators as this approach capitalised on the resources available to students at home during remote learning (Squire, 2021). Research indicates that the majority of children and teenagers living in Europe (Europe’s Videos Games Industry/European Games Developer Federation, 2021), Australia (Brand et al., 2017), the United States (Internet Matters, 2019) and the United Kingdom (Association for UK Interactive Entertainment, 2018) play some form of digital game on a daily basis. A recent *Growing Up in Ireland* (2021; *n*=8032) report revealed that 81% of Irish nine-year olds in 2018 played some form of a computer game in an average week, with 50% reporting that these games were played with others. While rates of play can vary according to geography, gender and age group, the findings of these studies show that digital games are a fundamental part of young people’s online worlds.

Approximately 81% of Irish nine-year-olds play computer games every week.

Growing up in Ireland (2021)

16% of Irish primary school children said *Minecraft* was their favourite application.

Everri & Park (2018)

For many students, these digital games became part of their schooling lives as a result of remote teaching during the COVID-19 pandemic. With over 176 million copies sold (Microsoft, 2019), *Minecraft* is one of the most popular digital games ever among children and teenagers, with 16% of Irish primary school children naming *Minecraft* as their favourite application (Everri & Park, 2018). During the COVID-19 pandemic, access to the *Minecraft: Education Edition*, (*M:EE*; a version of the game optimised for classroom use), was extended to all educators and learners with a valid Office 365 Educational account (*M:EE* Blog, 2020a). This allowed educators to explore how *M:EE* could support learning. For example, students in Wales explored architecture through research-informed *Minecraft* projects and a rural school in Malaysia used the game to keep students connected to each other using 'Monthly Build Challenges' (*M:EE* Blog, 2020b).

The COVID-19 pandemic revealed the prospective value of Game-Based Learning (GBL) in education. The purpose of this report is to provide an overview of the current literature available on GBL in order to better understand its potential impact for Irish learners and to identify what actions are necessary in order to further progress this field of research. To achieve this, the theoretical foundations underlying GBL will first be interrogated (**Section 3**). How *M:EE* is situated within such literature will also be highlighted and examples of how this particular game can support teaching, learning and assessment practices will also be provided (**Section 4**). The current report will conclude with a clear research agenda that aims to advance the field of GBL within Ireland, Europe and the wider world using *M:EE* as the primary research tool (**Section 5**).

3.0 'SERIOUS' GAMES AND GAME-BASED LEARNING (GBL)

3.0 'SERIOUS' GAMES AND GAME-BASED LEARNING (GBL)

This section will address the following questions:

- What is Game-Based Learning (GBL)?
- What is a 'serious' game?
- What is the value of GBL and serious games for learning?
- What is a digital game and how can they be classified?
- What learning theories underlie GBL?

A comprehensive search strategy was deployed to understand GBL (see Appendix 1). Schrier's (2018, p. 3) definition of GBL was one of the most straightforward available with the author stating that GBL involves the use of 'games for some educational purpose'. Although games have always been connected to learning, the role of *digital* games in education has seen significant growth over the past 20 years. For example, a study in the United States found that up to 90% of primary-school aged children play some form of digital game on a daily basis (Internet Matters, 2019). This trend is replicated amongst children and teenagers in other English-speaking countries, including Ireland (Growing Up in Ireland, 2016; 2021). The near ubiquitous presence of digital games in the lives of young learners has triggered interest among educators about the possible use of digital games as a medium for learning (Takeuchi & Vaala, 2014). In fact, Clark et al. (2018) acknowledged that while the use of digital games for learning was once a 'niche' area, it is now currently a major focus of research and an increasingly important facet of the educational technology industry. This is now likely amplified as a result of the COVID-19 pandemic. While digital games were once stigmatised as 'edutainment' and considered to hold no real value beyond being used as a motivational tool for learners (as outlined by Charsky, 2010), recent meta-analyses in the field have demonstrated that GBL[3] can successfully support learning if appropriately 'serious games' are chosen.

The concept of 'serious games' was first put forward by Abt (1987, p. 9), who argued that serious games 'have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement'. A meta-analysis by Wouters et al. (2013), involving 39 studies conducted between 1990 and 2012, certainly provided support for the assertion that serious digital games can support learning in schools and occupational settings.

SERIOUS GAMES have an educational purpose and are not just for amusement.

Abt (1970)

3 The word 'digital' is occasionally dropped from references to digital GBL and digital games. Where this occurs, it can be assumed that the authors are referring to digital games and digital GBL unless otherwise stated.

Wouters et al.' s (2013) meta-analysis aggregated the findings of 39 studies involving pretest–post-test and post-test-only comparisons of learning outcomes, learner retention, and motivation. These studies, involving a wide range of age groups, compared the effect of serious games and conventional teaching methods (e.g. lectures, reading text-books, knowledge drills) on these variables. In this meta-analysis, the stated learning outcomes in the included studies were classified in terms of 'knowledge' or 'cognitive skills'[4]. Of the 39 studies used in the meta-analysis, 77 pairwise comparisons on learning outcomes were available for examination. Wouters et al. (2013) noted that GBL in classrooms and occupational settings was indeed more effective in terms of learning (d=0.29, p<.01) when compared with conventional teaching methods. The effect sizes of learning outcomes in relation to 'knowledge' and 'cognitive skills' also showed that serious games were superior to conventional instructional methods (knowledge [25 comparisons]: d=0.27, z=2.00, p< .05; cognitive skills [52 comparisons]: d=0.29, z=4.12, p<.001). Similarly, the use of serious games and GBL in classroom and occupational settings was considered more effective in terms of learner retention[5] (16 comparisons; d=0.36, z=2.41, p<.05) but not for learner motivation (31 comparisons; z=1.77, p<0.5).

A more purposeful meta-analysis by Clark et al. (2016) systematically reviewed research on the value of digital games for primary and post-primary learners only. The authors recorded an adjusted mean post-test effect size of .33 in favour of the use of digital games to enhance learner outcomes (cognitive[6], intrapersonal[7] and interpersonal[8] dimensions) relative to non-game approaches. While Clark et al. (2016, p. 115) highlighted concerns regarding the potential validity of interpretations associated with aggregated studies like those where 'variations exist across contexts [and] interventions…', they still claimed that sufficient evidence in favour of a positive impact of GBL on learning was observed. Acquah and Katz (2020) made a similar claim in their systematic review investigating the relationship between digital GBL and second language learning outcomes for primary and post-primary students. Their review of 26 studies found that digital games appeared to support players' language acquisition, affective/psychological state, contemporary competences, and participatory behaviour. However, digital games and GBL cannot automatically enhance learning. Instead, digital games should be 'used because they are the most appropriate design solution and contribute to the best experience for specific educational needs' and learning overall (Schrier, 2018, p.5). Understanding how digital games can do this requires an examination of the theoretical foundations of the same.

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4 'Knowledge' was used when the identified study used a test or measure involving 'the knowledge of concepts, principles, definitions, symbols or facts' (Wouters et al., 2013, p. 4). The second type of learning outcome explored was 'cognitive skills', which included studies in which learners had to 'solve problems, make decisions, or apply rules to a situation' (Wouters et al., 2013, p. 4).

5 Studies that compared the use of serious games and conventional instruction using delayed measures for learning (e.g. when data from the test or measure involved was collected 1-5 weeks after the intervention) were included in pairwise comparisons for the 'learner retention' variable (16 pairwise comparisons).

6 Clark et al. (2016) defined student outcomes in accordance with the definitions outlined in an American report by the National Research Council entitled 'Education for Life and Work' (Pellegrino & Hilton, 2012). Cognitive outcomes included cognitive processes and strategies (reasoning, problem-solving, memory), knowledge, and creativity.

7 The intra-personal domain for student outcomes, as used by Clark et al. (2016), includes intellectual openness, work ethic and conscientiousness, and positive core self-evaluation.

8 The interpersonal domain included teamwork, collaboration, and leadership.

3.1 Understanding Digital Games

Defining digital games can be difficult given their diversity. In an attempt to address this, Wouters et al. (2013) crafted a definition of digital games that focuses solely on the *essential* characteristics of games. They defined digital games as those that are:

- **i** Interactive,
- **ii** Based on an agreed set of rules and constraint,
- **iii** Directed by the game or the player towards a clear goal or challenge and
- **iv** Provide feedback in the form of a score or changes to the game world.

Features like competition, plot and entertainment are not a pre-requisite for serious games. They are an 'added value' and not a core characteristic (Wouters et al., 2013, p. 2). Digital games that meet such criteria come in a wide range of styles, formats and topics. Squire's (2008) taxonomy of game types (Figure 2) distils such games into four genres.

TAXONOMY OF GAME GENRES

(Squire, 2008)

	Targeted	Linear	Sandbox	Virtual World
Features	Targets one skill of a domain.	Involves a storyline and/or puzzles	Uses tools/context to construct items	Engages user in problems/quests
Purpose	Test specific skills or knowledge	Support learning of concepts/skills	Skill development eg. planning	Skill development eg. collaboration
Completion	Levels	Machinema	Solution Paths	Modding*
Commercial Game	*Angry Birds*	*Ninja Garden*	*SimCity*	*World of Warcraft*
Educational Game	*Supercharged!*	*DragonBox*	*MinecraftEDU*	*Quest Atlantis*

*There is no 'game completion' within this genre of gameplay.
Players complete their activities by 'modding' (modifying) the game to suit their needs

Figure 2: Taxonomy of Game Genres (based on Squire, 2008; Groff, 2018)

As suggested by Figure 2, each game type is distinguished by certain features and characteristics that teachers can use to design certain learning activities. Traditionally, targeted and linear games were more popular amongst educators because they are quickly completed by students and align easily with curricular or lesson objectives (Groff, 2018). However, virtual world and open-ended sandbox games are becoming more popular as they potentially offer some of the richest learning environments, as demonstrated by McCall's (2011) use of *Civilization V* in post-primary schools in the United States. *Civilization V* is a commercial sandbox game that leads players through the growth of a civilisation and empire. McCall's (2011) work identified how teachers used this game to target numerous learning goals including knowledge of historical trade routes and ethical thinking. This increasing interest in the use of sandbox and/or virtual games in classrooms has likely emerged because these genres of games have a clear relationship with relevant learning theories. Rather than classifying games by genres, Egenfeldt-Nielsen (2007) has identified different 'generations' of games based on their connection with learning theory (Figure 3).

THE THREE GAME GENERATIONS

Egenfeldt-Nielsen (2007) has identified three different 'generations' of digital games that reflect the historical prominence in learning theories alongside the progression of video game development.

1st GENERATION 'Edutainment' 1980s

- Associated with the **Behaviourist** approach to learning.
- Games designed around the idea that skill and knowledge acquisition occurs through practice, reinforcement and conditioning.

2nd GENERATION 'Educational Games' 1990s/2002s

- Designed in line with the cognitive approach of **Constructivism**
- Accepts that people have underlying *schemas* that represent current knowledge.
- Provides a range of scaffolds and supports in the form of multimedia stimuli.

3rd GENERATION 'Games for Learning' 1990s/2000s

- Based on the theory of **Constructionism**.
- Learners make meaningful artefacts in the digital environment that provide a platform for learning.
- The learning process is often mediated in a social context.

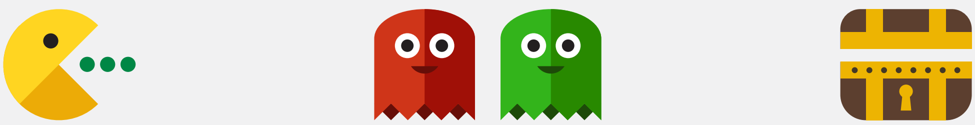


Figure 3: Evolution of Games and Learning Theory (based on Egenfeldt-Nielsen, 2007).

The first generation of digital games originated in the 1980s. These were designed based on the behaviourist idea of 'edutainment', whereby it was assumed that learning would occur through repetitive and relatively simplistic behaviours (e.g. *The Oregon Trail*[9]; Groff, 2018). Egenfeldt-Nielsen (2007, p. 274) then noticed a shift in digital games at the turn of the century, whereby the learner became the 'centre of attention' and the cognitive structures underlying their responses (schema) were taken into consideration. Games in this generation are characterised by a clear focus on applying the constructivist approach to learning as demonstrated in their use of scaffolding techniques and interest in more complex skills like problem-solving (e.g. BGuilE[10]). Presently, more and more games are providing a particular social context or virtual world that requires learners to 'employ academic content knowledge skills such as computer science, mathematics, or arts to create viable games that are intended first and foremost for their peers rather than their teachers' (Kafai & Burke, 2015). This third generation of games (e.g. *Minecraft*, *Minecraft: Education Edition*) are based on the ideals of constructionism and are most closely associated with the Sandbox type video games contained within Squire's (2008) taxonomy.

3.2 Games for Learning – Constructionism and Sandbox Games

Papert's (1991) expansion of Piaget's (Piaget & Indehelder, 1956) cognitive theory of constructivism[11] resulted in the principles of constructionism. While constructivism asserts that learning involves the 'building of knowledge structures irrespective of the circumstances of learning' (Papert, 1991, p. 11), constructionism is a more situated approach to learning, involving the personal, social and cultural dimensions of an individual as they engage in making an 'object-to-think with' (Papert, 1980). Within constructionism, learners 'make knowledge their own and begin to personally identify with it' (Kafai & Burke, 2015, p. 315). However, this does not occur in a vacuum. Social interactions and norms help the learners' 'appropriation' of the targeted knowledge. Cultural contexts also help learners decide what 'way of knowing is valued over others' (Kafai & Burke, 2015, p. 316).

CONSTRUCTIONISM asserts that learning occurs through the making of an ARTEFACT which is anything another will SEE or USE.

9 The Oregon Trail was designed to teach school children about the realities of 19th Century pioneer life in North America. The game was released in the 1970s and became popular in most US elementary schools in the 1980s (Groff, 2018).

10 BGuILE (Biology Guided Inquiry Learning Environment) allows students to construct, evaluate, iteratively refine, and then communicate explanations for a range of scientific processes and natural phenomena. Students are supported in their work by a range of analytical tools and inquiry prompts.

11 Although it can be erroneously described as a teaching pedagogy, constructivism is a learning theory which asserts that learning is a process where learners are active constructors of their own knowledge which is contextually bound and based on individual experiences (Bada, 2015). Originally conceptualised by Piaget (Piaget & Inhelder, 1958), constructivism asserts that when learners encounter something new or something that challenges their previous understanding of a topic, the learner's mental framework or 'schema' on that topic will then be updated.

Given its emphasis on 'learning through making rather than overall cognitive potentials' (Ackermann, 2001, p. 4), constructionism asserts that learning occurs 'most felicitously' through the learner's construction of a particular *artefact*. This can be 'a sandcastle on the beach or a theory of the universe' or even their own game or gaming environment (Papert, 1991, p. 1). Constructionism argues that learners will be more deeply involved in their learning if they are constructing something that others will see, critique or use. Through the construction of this meaningful artefact, learners will subsequently become 'active builders of their own knowledge' (Butler, 2007, p. 63) and enjoy an enhanced learning experience.

Kafai and Burke (2015) acknowledged that there was some evidence to support this viewpoint in their qualitative review of 55 studies that explored the issue of children's learning while making their own digital games or gaming environments. The majority of these studies focused on teaching computational thinking[12]. Kafai and Burke (2015) noted that the benefits of 'constructionist gaming' could be classified into personal and social dimensions[13]. The authors also claimed that 'making games proved to be a compelling context for learning computational concepts and practices and broadening participants' perspectives' (Kafai & Burke, 2015, p. 325).

12 Wing (2010, p. 1) defined computational thinking as 'the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent'.

13 Under the personal dimension, Kafai and Burke (2015) noted that the key benefits of GBL included its ability to help students learn content, learn about learning and learn coding. Under the social dimension, the main learning benefits related to its ability to allow students to learn to work collaboratively with peers and to learn how to become part of an online community.

As highlighted by Egenfeldt-Nielsen (2007), sandbox-type games align closely with the principles of constructionism. Sandbox type digital games like *Minecraft* and *Minecraft: Education Edition* are open-ended worlds, through which there is no one single, correct pathway to completion. These sandbox games enable increased creative expression by allowing players freedom to move within the game to design and build their own gaming environment e.g. homes, communities, settlements, landscapes. As they require learners to create their own 'objects to think with' (Papert, 1980, p. 12), these games are an ideal tool for teachers to design learning experiences that align with constructionist principles. Furthermore, modern sandbox games offer teachers and learners the flexibility to design tasks and learning activities that allow learners to create artefacts independently or collaboratively. Therefore, sandbox games can allow others (e.g. peers, teachers) to become involved in a learner's thinking process through their discussion or use of the artefact. In this way, 'the learner's thinking benefits from multiple views and discussions' (Butler, 2007, p. 63), an important facet of constructionism according to Papert (1980). While sandbox games allow learners to create artefacts in a way that is consistent with the key tenets of constructionism, they also support effective teaching, learning and assessment practices. This assertion is best explored by analysing research related to one of the most popular sandbox games of all time – *Minecraft*.

Summary

- Game-Based Learning (GBL) involves the use of games for an educational purpose.
- 'Serious' games are not played for amusement – they have a clear educational purpose that can support learning if properly deployed.
- Digital games are interactive, have clear rules, are directed towards a particular challenge or goal, and provide feedback to the player.
- Games can be classified by genre (targeted, linear, sandbox, virtual world) or generation (1st, 2nd or 3rd generation)
- Sandbox-type digital games generally align with a constructionist view of learning.

4.0 MINECRAFT

Figure 4: *M:EE* (Microsoft, 2019)

4.0 MINECRAFT

This section will address the following questions:

- What is *Minecraft*?
- How can *Minecraft* support teaching?
- How can *Minecraft* support learning?
- How can *Minecraft* support assessment practices?
- What are the inherent challenges of each?

In 2009, Zachary Barth created the game *Infiniminer* whereby users who entered this randomly generated gameworld, 'mine' and place blocks to construct whatever structures they wish[14]. Inspired by the game's simplicity, Markus 'Notch' Persson created his own java-based version, which was eventually called *Minecraft*. Persson's company *Mojang* released this game to the public in 2009 and, by 2015, more than 19 million copies had been sold, placing the game on the all-time best-seller's list (*Mojang*, 2015). Microsoft acquired the Swedish-based *Mojang* in 2014 for over $2.5 billion and the game is now available on a variety of platforms with a range of editions and versions including the *Minecraft: Education Edition* (*M:EE*) which is specifically designed for classroom use.

14 Available to view at http://www.zachtronics.com/infiniminer

In *M:EE*, players control a virtual avatar ('Steve'; Figure 4, overleaf) who is able to move freely around the virtual world of *Minecraft*. This avatar is customisable (using 'skins'). Unlike many other commercially available games, the graphics in *Minecraft* are purposefully simplistic (8-bit graphics), making the world appear as if it is made up of *Lego*™-like blocks (where colours and patterns represent different materials like wood, dirt, stone etc.,). These blocks can be manipulated to create infinite items and structures e.g. houses, airplanes, cities etc. The game can be played online, offline or within a local network. Players, if they choose, can communicate in real time or leave messages using asynchronous communication methods. Each player has their own avatar in *M:EE*. However, there are also other game entities within this environment that can interact with the players called 'mobs' (*Minecraft* Wiki, 2021). These 'mobs' are living creatures that move around the game like animals or zombies. Depending on what mode the game is in (e.g. 'Creative' or 'Survival'), these mobs may or may not attack a player's avatar. These different 'game modes' can place or remove restrictions on resources and/or player activities (*Minecraft* Wiki, 2021).

The open-ended nature of *M:EE* and the different game modes available allow educators the flexibility to modify the game to suit their own particular needs and objectives. *M:EE* has been marketed as 'a versatile platform that educators can use across subjects to encourage 21st century skills' (Microsoft, 2016). Research conducted in Canada involving 118 Canadian elementary school students (aged 9-12) aimed to explore this claim and identify the main advantages associated with the use of *M:EE* in schools (Karsenti & Bugmann, 2018). Using a range of data collection tools (e.g. research surveys, weekly diaries, observation and gameplay analysis), the study observed a number of educational benefits including the development of collaboration skills and increased digital literacy skills (e.g. computational logic, information search). This exploratory work by Karsenti and Bugmann (2018) indicates that *M:EE* could indeed assist and enhance the teaching, learning and assessment practices in many primary and post-primary classrooms across a range of subjects. Other research also offers tentative support for this assertion. This will now be discussed under the core classroom practices of teaching (**Section 4.1**), learning (**Section 4.2**) and assessment (**Section 4.3**).

Teachers should use strategies that are
RICH, IMAGINATIVE, INNOVATIVE

Irish Primary School Curriculum (DES, 1999, p. 14)

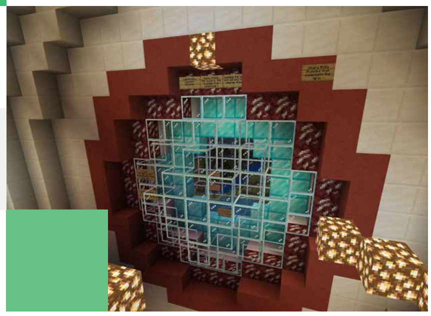


Figure 5: Three-dimensional model of the human eye. Includes labels for key parts of the eye (*Minecraft: Education Edition*, 2019).

4.1 *M:EE* to Support Teaching

Teaching involves the careful selection of content, the appropriate design of activities that maximise learning and the subsequent facilitation of inclusive lessons (Kyriacou, 2007; Westwood, 2011). This requires a ‘rich, imaginative and innovative range of strategies’ (DES, 1999, p. 21). According to international (e.g. Redecker, 2017) and national policies (e.g. DES, 2015), these strategies should involve technology when appropriate. Ensuring that children have ‘opportunities to use modern technology to enhance their learning in all subjects’ has been enshrined within the Irish Primary School Curriculum (DES, 1999, p. 29) since its inception. Research has also demonstrated several ways in which *M:EE* can promote and enable a wide range of practices and activities that can support teaching. This is evidenced by the role of *M:EE* in studies of curricular curation and its use by teachers to support children with Special Educational Needs (SEN).

4.1.1 Curricular Curation

Dezuanni and Zagami (2017, p. 68) note that the term ‘curatorship’ is a useful way to conceptualise teachers’ ‘expert co-ordination of various classroom resources to provide curriculum-aligned learning experiences’. In modern classrooms, the teacher designs learning experiences based on a cohesive dialogue between the available resources (e.g. curricular content, classroom, time, digital tools) and the learner’s needs. When the teacher is a ‘curator’ looking for resources that align with planned learning experiences, *M:EE* can be a valuable repository. Teachers can have quick access to digital resources on a range of curricular topics such as spatial geometry (Förster, 2017), biology, physics, chemistry (Short, 2012) and literacy (Marcon, 2013). Bar-El and Ringland (2020) examined 627 online lesson plans devised for *M:EE* and found that teachers used *M:EE* for a range of subjects with *Technology*, *Art & Design*, *Math* & *Economics* and *Science* being the most common subject tags. Figure 5 illustrates how *M:EE* can be used to make and present interactive biological models. These worlds allow teachers to immerse their students in the desired content and provide an opportunity to make abstract concepts or complex worlds more relevant and accessible.

Bar-El and Ringland's (2020) analysis of the corpus of online *M:EE* lesson plans revealed that there are three main 'profiles' or descriptions of how teachers create learning activities using these resources from *M:EE*. Teachers can use *M:EE* as a way to get their students to play '**A Game within a Game**'. Here the teachers create 'complex worlds with multiple NPCs, with either textual information, or large structures representing natural phenomena or cities' (Bar-El & Ringland, 2020, p. 2). Students must participate in a game or complete a quest. The Ngā Motu world requires students to explore a traditional pā (settlement) and ride waka hourua (boats) in their efforts to learn more about the indigenous culture of the Māori people of New Zealand (*M:EE* Blog, 2021). Another way for teachers to use *M:EE* involves the '**Game as a Lab or Expedition**'. Students must perform tasks within the *M:EE* world and take notes in an accompanying worksheet e.g. exploring *M:EE* biomes and then using a Venn diagram to compare and contrast geography, wildlife and vegetation. For example, Jensen and Hanhøj (2020) used the co-ordinate system embedded in *M:EE* as a means to explore mathematical problems and to develop students' understanding of co-ordinate geometry. This way of using *M:EE* allowed students to make strong connections as to how mathematical knowledge can be relevant in multiple domains. The final profile calls for *M:EE* to be used as a '**Game for Student Representations**'. Here, the teacher uses *M:EE* as an environment where students can represent their learning e.g. constructing ancient landmarks, using boards and non-player characters to communicate their learning. Andrade et al.'s (2020) work in using *M:EE* to engage older and younger children in urban planning is one example of this approach. This taxonomy of teachers' learning designs with sandbox games aligns well with the anecdotal descriptions of the ways in which teachers used *M:EE* during the COVID-19 pandemic to engage their students in remote learning (e.g. *M:EE* Blog, 2020b).

A multiple site case study by Pusey and Pusey (2015) in Australia, involving science classes from an all-girls school (*n*=47 participants) and a co-educational public school (*n*=29), illustrates the value of such digital resources and engaging with *M:EE* in the three ways outlined by Bar-El and Ringland (2020). In this study, *M:EE* was used in conjunction with 'offline' teaching methods (worksheets, teacher presentations, videos and practical experiments) to teach a 6-week Earth Science programme (Pusey & Pusey, 2015). The researchers curated a learning experience that allowed the students to experience curricular content in three ways – through traditional 'book knowledge', through physical interaction (practical experiments) and through interaction with digital materials (*M:EE*). Research has shown that repeating and revisiting key topics and concepts across multiple sessions using different techniques can aid long-term memory and recall (Dunlosky et al., 2013). Therefore, the inclusion of *M:EE* in the design and 'curation' of their students' learning experiences ensured that the teachers were providing multiple modes for 'meaning making'. This strategy is recommended widely by teaching practitioners (e.g. Kryiacou, 2007; Westwood, 2011) and is also advocated in the Irish primary school curriculum (DES, 1999, p. 15), where teachers are encouraged to have learning experiences that 'take place on a number of planes simultaneously ... and return to them at regular intervals'.

While positive feedback from students (using surveys) was recorded, other measures, like test scores, were not used in Pusey and Pusey's (2015) exploratory study to determine the impact of *M:EE* on learning. However, it is important to note that the teachers in Pusey and Pusey's (2015) study deployed *M:EE* in a highly structured manner, complementing online activities with worksheets and other off-line tasks. Wouters et al.'s (2016) meta-analysis indicated that digital games are more effective in enhancing learner knowledge and skills when they are supplemented with other instructional methods (e.g. lectures, readings, activities etc.,) than when they are used as the sole instruction method (*d*=.41). As the learning experiences designed by Pusey and Pusey (2014) aligned well with Wouters et al.'s (2016) findings, it is possible that *M:EE* did have a positive impact on learner's knowledge and skill acquisition. Further research that directly addresses this research area needs to be conducted. This research is needed to determine ***if***, ***when*** and ***how*** exactly *M:EE* should be used in classrooms to facilitate effective learning experiences that have a positive impact on student learning outcomes (See **Section 5** for more details).

4.1.2 Supporting Children with Special Educational Needs (SEN)

According to the Irish primary school curriculum (DES, 1999), all children have the right to a high quality education, appropriate to their needs, in an inclusive setting alongside their peers. Ensuring that educational provision is flexible enough for individual children at various stages of their development in a mainstream setting can be difficult for teachers to achieve. For example, the Diagnostic and Statistical Manual (5th Education; DSM-V) asserts that autistic learners[15] often have difficulties with social communication and social interactions (American Psychiatric Association [APA], 2013). However, despite public misconceptions, autistic learners do indeed have a desire to forge social connections and relationships with others (Ochs & Solomon, 2010). Therefore, specific supports for social interactions can sometimes be needed in schools to support an 'increased generalisation of necessary social interaction skills and positive social play with peers' (Stone et al., 2018, p. 209). Other research has shown that playing video games like *M:EE* may help with this as it seems to be particularly well-suited to supporting the development of social and educational skills in other groups of neurodiverse learners such as those with dyslexia and Attention Deficit Hyperactivity Disorder (ADHD; Granic et al., 2014).

> ***Minecraft* can help learners develop**
> **SOCIAL LINKS AND FRIENDS**

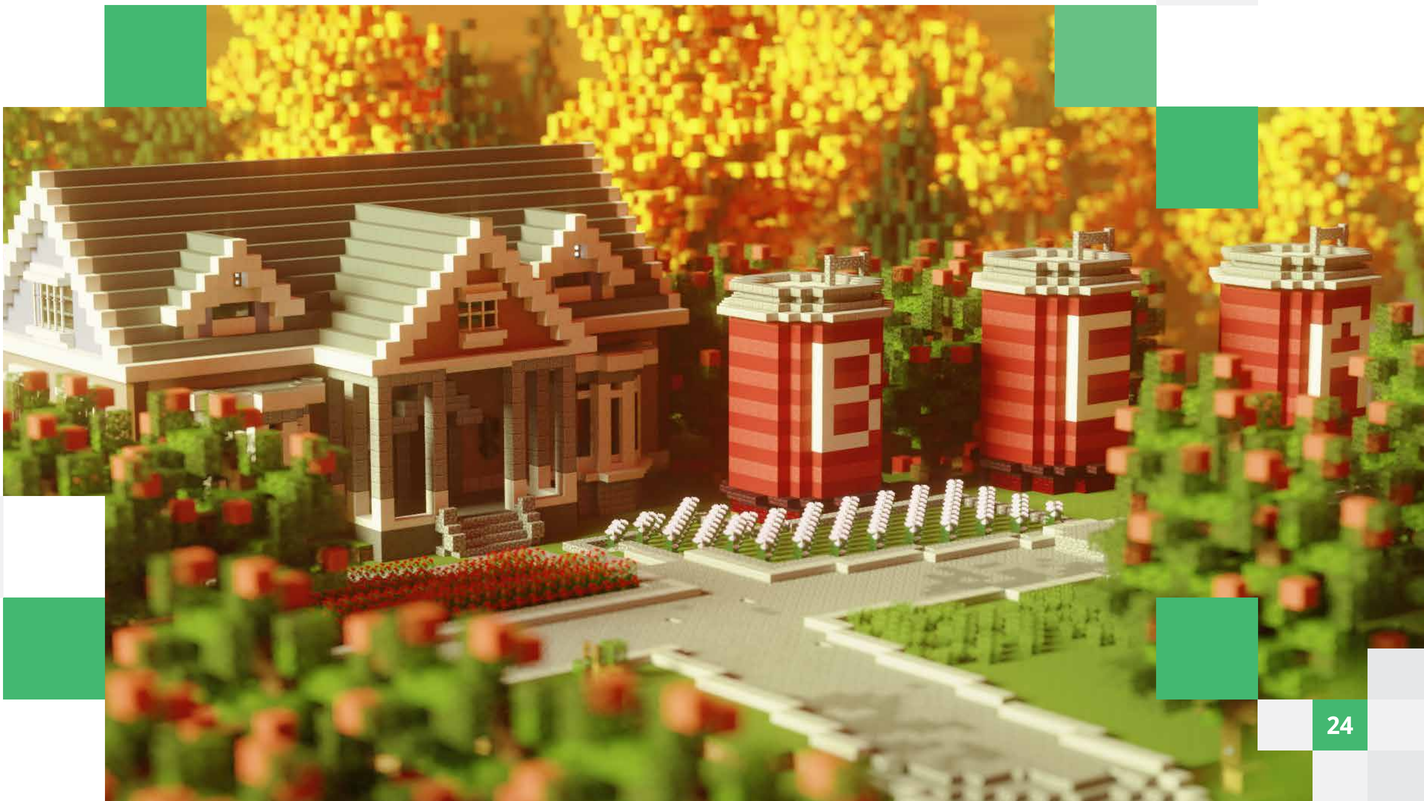
Research recommends 'multi-modal' ways of providing neurodiverse learners with opportunities to engage in social interaction and communication (Stone et al., 2018; Westwood, 2011). *M:EE* facilitates this. For example, within *M:EE* players can communicate with each other by sending texts or by talking directly using external programmes or applications. *M:EE* also links in with a range of other social media platforms like YouTube or Wiki software. As a result, learners do not need to confront every aspect of face-to-face communication (e.g. eye contact, facial expressions, gestures) when attempting to develop social links and friendships with their peers. Stimulation in the form of feedback, reward and consequences can be achieved through game play which is often highly beneficial for neurodiverse children (Granic et al., 2014).

In their exploratory study on the topic involving a very small sample of three autistic learners, Stone et al. (2018) found that *M:EE* was able to support social interactions for autistic learners in ways that face-to-face contexts could not provide. They argued that *M:EE* allowed learners to 'engage in reciprocal conversations, to share information, to make requests… send messages, communicate rules and maintain engagements with others' (Stone et al., 2018, p. 209). Work by Wen-wen and Kuen-fueng (2018) in Hong Kong involving 15 autistic learners playing *M:EE* also noted similarly positive results in relation to students' social skills. Using a qualitative approach, Hobbs et al. (2020) evaluated outcomes from a science-

15 In line with recommendations from autism advocacy groups, identity first language will be used (e.g. AsIAm, 2019).

themed *M:EE* Club for children with SEN over a four-year period. Particular focus was placed on the benefits of playing a shared-interest game in a social and educational context. The children and guardians involved highlighted a number of benefits to their long-term involvement in the club including 'making friends, fitting in, and feeling valued without judgement regardless of completing tasks or conforming to expected social behaviours...improved confidence and well-being' (Hobbs et al., 2020, p. 91). O'Sullivan et al. (2017) investigated the use of *M:EE* for the design of inclusive learning experiences for twice exceptional learners in Ireland. Twice exceptional (2e) learners 'are intellectually or creatively gifted' in areas like maths, science or the performing arts but 'also experience one or more learning difficulties' including specific learning disabilities, speech and language differences (O'Sullivan et al., 2017, p. 2). As discussed by Reis et al. (2014, p. 222) 'their gifts may mask their disabilities and their disabilities may mask their gifts'. To help 2e learners manage the unique challenges they face in classrooms, O'Sullivan et al. (2017, p. 41), on the basis of work by Nielson (2002), recommended a number of strategies to assist in the design of appropriate and inclusive learning experiences such as providing freedom and variety, using simulated and real-world problems and using adaptable environment/tools that are sensitive to any specific learning needs. *M:EE* can help educators successfully implement these strategies. The sandbox nature of *M:EE* facilitates the freedom and open-endedness that 2e students require in their education. While this means that students can create and discover projects that interest them, O'Sullivan et al. (2017) also acknowledged that teachers can also create simulations of real-world problems and artefacts that learners can engage with in a way that can be adapted to their particular needs. O'Sullivan et al.'s (2017) exploratory study demonstrates the range of ways that *M:EE* can be used to help 2e students explore topics related to literature (e.g. *Charlotte's Web*, *Fantastic Mr. Fox*; Figure 6), history (Norman Castles) and geography (stratigraphy). These learning experiences take place in an inclusive learning environment that can support effective teaching for 2e students as outlined by Nielson (2002) and O'Sullivan et al. (2017). Again, much of the work relating to this aspect of teachers' use of *M:EE* is small scale and exploratory in nature. Future research needs to address such shortcomings (see **Section 5**).

Figure 6: A scene from Roald Dahl's Fantastic Mr. Fox recreated in *Minecraft* (*Minecraft Education Edition*, 2019)



4.1.3 Challenges in using *M:EE* to Support Teaching

M:EE has significant potential to support the work of teachers in designing learning activities that can maximise students' success and achievement. However, incorporating *M:EE* into classrooms still requires some specialist technical and pedagogical skills that may not be addressed in initial or continuing teacher education (Nebel et al., 2016). In their survey of 694 elementary teachers in the United States, Takeuchi and Vaala (2014) noted that teachers usually learn to teach with digital games using informal means (e.g. colleagues, self-teaching). This means that teachers may not be 'getting exposure to the broader range of pedagogical strategies, resources, and types of games that can enhance and facilitate digital game integration' (Takeuchi & Vaala, 2014, p. 5). To ensure that the potential of *M:EE* as a learning tool is fulfilled in Ireland, teachers will need specific guidance on how to design effective learning experiences using *M:EE* or other sandbox-like games and how these games align with relevant learning theories. Hanghøj and Hautopp (2016) note that teachers need this to inform their "game literacy". Without this literacy, teachers will be unable to 'select relevant curricular aims and assignments that relate meaningfully to particular game goals, game practices and assessment criteria' (Hanghøj & Hautopp, 2016, p. 266). 'Game literacy' will need to be addressed in Irish pre- and in-service teacher programmes in a manner that is informed by best practice research. The recommended structure for such programmes is outlined in Section 5 of this report.

Summary

- *M:EE* can allow educators to create resources across multiple subject areas that can provide curriculum-aligned learning experiences.
- At present, there are three main profiles of how teachers can use *M:EE* with their learners: as a (1) 'game within a game', (2) 'game as a lab/expedition' and (3) 'game for student representation'.
- *M:EE* can support learners with a wide range of strengths and needs due to its multi-modal approach to social interaction and communication and its use of feedback.
- Teachers' effective use of *M:EE* and other digital games is highly dependent on their own 'game literacy'.

21ST CENTURY SKILLS:

Creativity, Metacognition, Responsibility, Communication, ICT Literacy, Critical Thinking, Problem Solving and Collaboration.

(Binkley et al., 2012)

4.2 *M:EE* to Support Learning

The Irish primary school curriculum (DES, 1999, p. 14) defines learning as 'an experience that contributes to the child's development'. With this in mind, a number of principles guiding the design of learning experiences exist within the Irish primary school curriculum. These include the child as an active agent, the reinforcement of higher order thinking and problem solving, the value of technology, and the importance of collaboration (DES, 1999). While the Irish primary school curriculum is more than two decades in existence, many of the principles and values underpinning it align well with recent changes in international educational policy, where the teaching of '*21st Century Skills*' are now prioritised. The phrase '*21st Century Skills*' is commonly used in education to refer to the recent shift in curricula towards a 'rigorous skill-based instruction [approach], often embracing new technologies and modes of communication' (Bellanca, 2017, p. 793). While countries and districts can vary in their conceptualisation of these skills (e.g. Partnership for 21st Century Learning [P21], 2019; Assessment and Teaching of *21st Century Skills* (ATC21S), Binkley et al., 2012; Ananiadou & Claro, 2009), some common elements emerge. These include, among others, critical thinking, collaborative problem solving, communication and digital literacy. These skills are now being targeted in national curricula worldwide, including Ireland (DES, 2015, see page 66; DES, 2016). Preliminary research indicates that *M:EE* can offer an ideal environment for students to develop key 21st century skills by facilitating high-quality, project-based learning experiences that supports the learning principles of Irish curricula, such as the use of collaborative learning techniques.

4.2.1 Project-Based Learning

A project can be defined as 'an act of creation over time' (Lenz, Wells, & Kingston, 2015, p. 67) and within the context of a primary or post-primary classroom may include posters, dioramas, musical compositions etc. Project-based activities are consistent with the learning principles outlined in Irish curricula as they support an integrated, thematic approach to learning (DES, 1999). Closely aligned with constructionism (Papert, 1981), learning experiences that are centred around the use of projects are considered an 'active, student-centred form of instruction which is characterised by students' autonomy, constructive investigations, goal-setting, collaboration, communication and reflection within real-world practices' (Kokotsaki et al., 2016, p. 268). According to Blumenfeld et al. (1991), there are two essential elements to projects:

- **i** A question, problem or task that organises and drives the learning activity and
- **ii** The presentation of a final artefact that represents students' new understandings, knowledge, skills and attitudes.

It is important to recognise that the use of projects in classrooms have historically encountered resistance and criticism by those who incorrectly conflate it with 'discovery learning' – where students uncover key principles or information on their own (Kirschner et al., 2006). However, project based activities can have significant educational value when designed properly and facilitated by teachers who are aware of the key principles underlying them (Hmelo-Silver et al., 2007; see Condliffe et al. (2016) for a summary of the design principles necessary for project-based learning). In their research on project-based learning, Han et al. (2014) discovered that low-performing high-school students (*n*=505) participating in science, technology, engineering, and mathematics (STEM) project-based learning activities had significantly higher growth rates on math scores over a

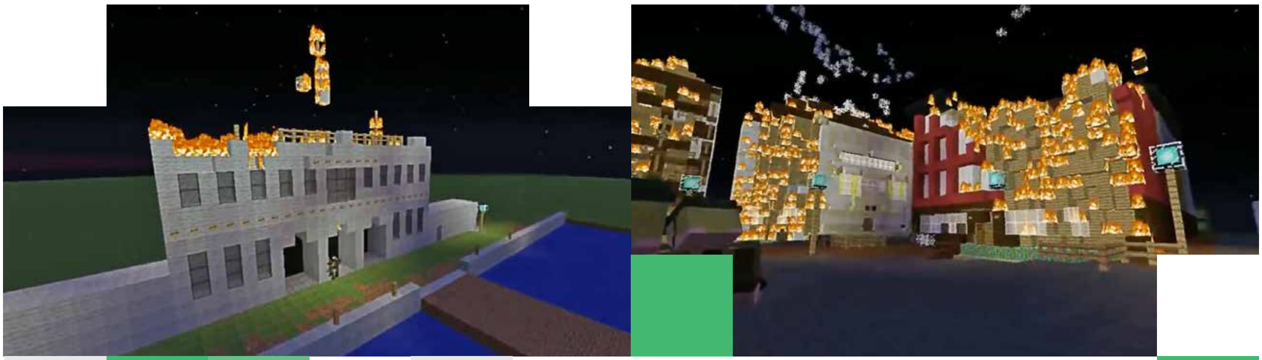


Figure 7: Scenes from a submitted *MindRising* Project entitled '*The Burning of Cork City – 1920*'

three-year period and a reduced achievement gap overall. Project-based learning can also be a useful way for students to synthesise and apply their newfound content-based knowledge and skills (Hmelo-Silver et al., 2007) while simultaneously developing other skills like collaboration, time management and critical thinking (Kokotsaki et al., 2016).

M:EE provides an ideal environment for project-based learning activities. Callaghan's (2016) work investigated the use of *M:EE* with 168 Australian students in Years 7-10 (aged 12-16) using a collective case study approach involving qualitative data. One group of Year 7 students were enrolled in a Technology and Applied Studies module which involved the use of projects to learn the principles of house design using a range of appropriate software (e-Folio, Google Sketch-Up etc.,). The students were then required to turn their designs into an architectural structure in *M:EE*. Their *M:EE* house became, as Papert (1980; 1991) would say, their 'object to think with'. This allowed the students to determine if their structure was feasible, realistic and designed in accordance with previously learned design principles. In analysing teacher observations and student feedback sheets, Callaghan (2016, p. 253) acknowledged that 'once students began building their ideal home in *M:EE*, they were able to quickly visually identify any flaws in their design and make necessary modifications'. This demonstrates the power of project work using *M:EE*. It allowed students to create an artefact that demonstrated their learning but also provided them, and their teacher, an opportunity to identify any errors or misconceptions and then enact the necessary modifications. The use of *M:EE* in this study encouraged the students to think more deeply about the concepts being taught in their Year 7 Design class. *M:EE* can therefore be a powerful tool in facilitating project-based learning if the game-play encourages students to engage with key curricular concepts and skills as identified by their teachers. This is further demonstrated by the Irish *MindRising* initiative (see Figure 7 and Figure 8). *MindRising* was a competition launched in 2016 to support the 100-year commemoration of the 1916 Easter Rising – the armed rebellion against British rule that took place in April 1916 (beginning on Easter Sunday) which eventually led to the foundation of the Irish Republic. According to Butler et al. (2016, p. 287), MindRising 'was about telling digital stories... reflecting on the events of 1916 and reimagining what the next 100 years could bring for Ireland' using *M:EE* as their storytelling medium. The submitted projects (available online at: http://www.mindrising.ie/) showcase the value of using *M:EE* to support project-based learning in non-science subjects.

Figure 8: *MindRising* Summary

The *MindRising Games* initiative was launched in February 2016 as a competition for young people aged 6 to 14 years. The initiative was used to involve school children in the State’s 100-year anniversary celebrations of the Easter Rising, a key event in the foundation of the Irish republic.

The *MindRising Games* project involved an exploration of the past, present and possible future of the island of Ireland using *Minecraft*. Children were encouraged to develop their own virtual worlds in *Minecraft* to remember the past 100 years and reimagine what the next 100 years could bring to Ireland. Sample lesson plans were developed to support teachers along with sample *Minecraft* worlds.

To create these virtual worlds in *Minecraft*, the children first had to research different aspects of Irish history and Geography. For example, some projects required students to have a deep knowledge of the key events in 1916 to map the movement of troops, design buildings etc., to ensure that their *Minecraft* world mirrored historical fact. Some of the projects were based in the children’s own locality (e.g. ‘*The Burning of Cork*’), allowing the projects to take on a more personal and authentic dimension.

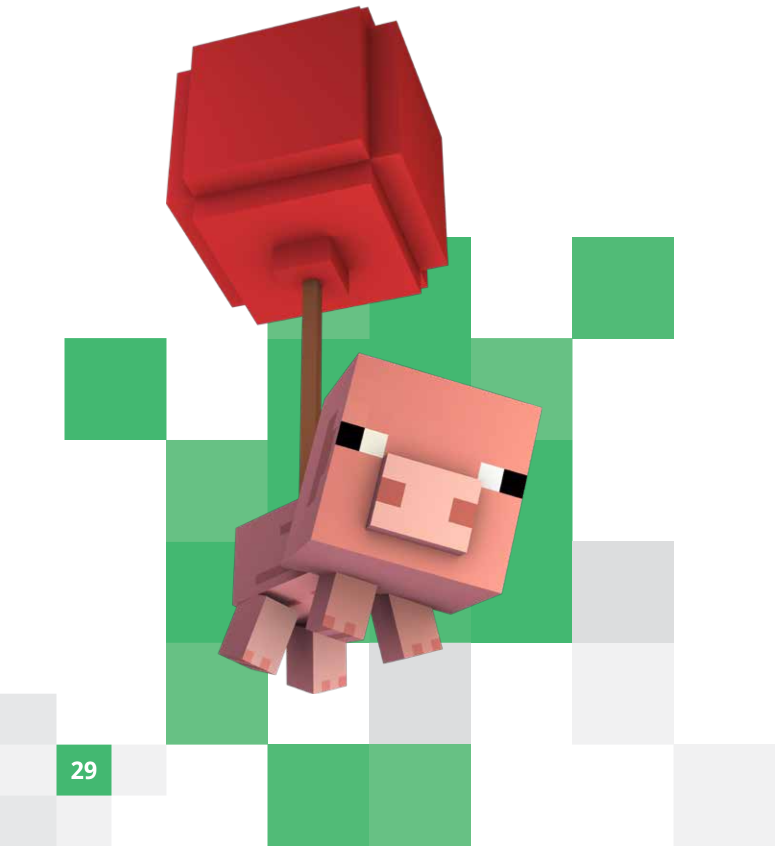
All participants were invited to a one-day *MindRising Games* celebration in May 2016 to share their worlds and learn from each other.

In creating their *Minecraft* worlds, the children involved in *MindRising* were able to create a meaningful artefact, as advocated by Papert (1991), that was informed by their own research. This research was recorded in a digital portfolio. The children worked with their peers in creating the *Minecraft* worlds. This ‘act of creation over time’ (Lenz et al., 2016, p. 67), helped the children to develop important *21st Century Skills* like collaboration, communication and digital literacy skills (DES, 2015; 2016). The children were also required to create short videos explaining their worlds. When narrating these videos, the children had to employ a clear structure in their oral reports and recall relevant historical facts. As a result, it can be argued that ‘playing’ *Minecraft* helped the children involved in this initiative to engage with and build their understanding of key curricular content and skills from the History and English curriculum for primary and post-primary schools (DES, 1999).

To view sample projects, visit **www.mindrising.ie**

Minecraft rendering of the General Post Office 1916 and a *Minecraft* rendering of Pádraig Pearse reading the Proclamation of Independence in 1916.

The 2016 *MindRising* initiative involving the use of *M:EE* for project work was, in many ways, ahead of its time. When schools around the world began to close in March 2020 due to COVID-19, the physical classroom became a virtual one (Scully et al., 2021). Educators' use of *M:EE* during this period increased (Squire, 2021) and consequently, there is now a wealth of anecdotal evidence available to demonstrate how *M:EE* can support project-based learning (*M:EE* Blog, 2020b). For example, one teacher from Canada used *M:EE* to teach biodiversity. While working from their devices at home, Grade 6 students had to design an ethical zoo in *M:EE* that took into consideration the habitats, needs and living conditions of the animals under discussion. Students took responsibility for one animal's habitat and students were able to visit each other's habitats as the zoo was hosted on a shared server. This project also spawned a number of other projects, including the design of relevant and appropriate YouTube ads for the *M:EE* zoo. The project encouraged students to develop research skills and maintain relationships with their peers, despite being physically separated from each other. While this anecdotal evidence is valuable, a more rigorous approach to research the value of *M:EE* related projects is necessary to determine its true value.



4.2.2 Collaboration Skills

As society has recognised the necessity of people thinking and working together to solve critical global issues in the 21st century, education systems have begun a shift in emphasis from individual efforts to group work (Binkley et al., 2012). To maximise the success of current and future group activities, schools are now trying to develop the collaboration skills of their learners using collaborative learning activities (e.g. DES, 1999; 2015; 2016). Collaborative learning involves 'groups of learners working together to solve a problem, complete a task, or create a product' (Laal & Laal, 2012). Digital games, and in particular multi-player online games, are an ideal context for facilitating and studying collaboration as they provide an environment that encourages social interaction in the pursuit of a shared goal (Squire, 2008). The value of using collaborative learning approaches in primary and post-primary classrooms has been consistently stated in literature and is foundational within the Irish curriculum (DES, 1999). Within the context of digital settings, this value appears amplified. Dave et al. (2018, p. 58) note that players in digital games must '…negotiate conflict, explain and persuade, and coordinate ideas with other players…' to achieve a particular goal. In this way, digital games can allow learners to acquire relational and interpersonal skills, some of which may be transferable beyond the immediate gaming environment.

As a sandbox-type, multi-player game with a range of communication functions, *M:EE* can support collaborative learning practices among students. Within *M:EE*, communication can occur using synchronous (direct messaging) or asynchronous (leaving messages on boards etc.,) methods. Other user-generated content also exists to support and extend game-play e.g. discussion boards (*Minecraft* Wiki, 2021). Unfortunately, having multiple modes of communication does not guarantee collaborative learning or the development of improved collaboration skills as demonstrated by Davis et al.'s (2018) exploratory study which focused on the collaborative practices of three groups (4 participants per group) of middle-school children. The authors asserted that in digital environments, the task or 'stimulus' for collaboration has to be planned and structured within the group; interaction does not just happen naturally. Perhaps this is why more advanced collaborative practices were only observed under very specific conditions in Callaghan's (2016) work. As mentioned previously, Callaghan (2016) observed the practices of students in a Year 7 technology and design class. Similar aged players in a voluntary, after-school *M:EE* club were also observed. Those in the *M:EE* club were 'more likely to inform one another of their specific skills and not actually assist their peers in developing those particular skills' (Callaghan, 2016, p. 252). In contrast, students in the Year 7 were more generous in sharing expertise and more likely to listen to and learn from others in order to ensure that their building met the stated assessment criteria. This echoes the work of Karsenti and Bugmann (2018, p. 210) who asserted that *M:EE* can only support collaboration and learning if it is used in an 'intentional, planned and supported' manner. In their experiment with 164 sixth-grade students in South Korea, Baek and Touti (2020) very effectively illustrated how the design of collaborative and cooperative gameplay[16] can support or hinder academic and gaming achievements in *M:EE* pending a range of factors (e.g. gender). It is clear that further work is required to understand how teachers can design activities and experiences which can maximise the positive outcomes associated with collaborative learning (see **Section 5**).

Dishon and Kafai's (2020) work offers some guidance on how effective learning experiences for the development of collaboration skills can be designed using *M:EE*. Perspective-taking – the consideration of others' mental states and subjective experiences – is a key component of collaboration and an essential aspect of all interpersonal interactions (Hesse et al., 2015). Dishon and Kafai (2020) argue that video games can effectively support students' development of perspective taking. Playing games allows students to occupy another's world and 'walk a mile in another's shoes' (Gehlbah et al., 2015). *Creating* games however, encourages a more in-depth development of perspective taking skills as building games is 'intrinsically other-oriented – created with the intent of being used by others' (Dishon & Kafai, 2020). Making games involves analysing one's work from the perspective of future players and then 'translating abstract insights... to concrete design decisions' (Dishon & Kafai, 2020). The game is, in line with the constructionist principles outline in **Section 3**, 'an object to think with'. To better explore how GBL can support this aspect of collaboration, Dishon and Kafai (2020) designed and conducted a collaborative game design workshop with high school students (16 participants; 10 boys, 6 girls, ages 14–15). Although the participants involved in this study were asked to design offline games or games with *Scratch*[17], the insights from the study could easily be applied to other online settings and games like *M:EE*. The authors offer guidelines on how to design and support perspective taking with game design (e.g. 'productive framing of failure') that should inform the design of collaborative learning experiences with *M:EE*.

16 Collaboration in learning is broadly defined as 'a process that involves sharing knowledge, ideas, and feelings with group members' (Baek & Touti, 2020, p. 2111). In contrast, cooperative learning is 'a process that leads to an assembled product by splitting the workload' (Baek & Touti, 2020, p. 2111).

17 Scratch is a free programming language and online community where you can create your own interactive stories, games, and animations (MIT, 2021).

4.2.3 Challenges in using *M:EE* to Support Learning

According to recent marketing literature, game sales in 2020 and 2021 are up '35% over a year prior' (Squire, 2021). This is hardly surprising given that games allowed people to 'go' somewhere else to socialise and have new experiences while still staying safe during the COVID-19 pandemic. *M:EE* gave students an opportunity to maintain or develop relationships with each other and celebrate important milestones. For example, a virtual UC Berkeley campus was created by Berkeley students in *Minecraft* (called 'Blockeley'). This was used to hold official graduation ceremonies that featured the Chancellor (Kell, 2020). The *M:EE* Blog, (2021; 2020b) managed by Mohan, has several examples of how educators used *M:EE* to support remote learning and teaching in the K-12 age group. However, Squire (2021) anecdotally noted that a co-ordinated effort at the institutional level to adopt technologies like *M:EE* did not appear to occur 'en masse' during the pandemic. Its use as a learning tool was down to the work of individual educators in K-12 or by groups of students in third level institutions. While it is difficult to support or deny Squire's (2021) assertions, it is likely that the use of *M:EE* for learning during the pandemic was hampered by a lack of appropriate infrastructure and educator confidence and competence in using *M:EE* for education purposes.

Indeed, one of the greatest challenges that restricts the use of *M:EE* in Irish classrooms relates to infrastructure. Lack of adequate access to technology, be it in terms of hardware or internet connectivity, has been a major and consistent barrier in many Irish schools towards the use of online tools like *M:EE* (e.g. Coyne et al., 2016). In her report outlining trends in technology usage in primary schools, Eivers (2019) indicated that between 2010 and 2017, there was no significant funding for technology resources available to schools. As indicated by surveys conducted by PIRLS[18] 2016 and TIMMS[19] 2015, this resulted in schools with inadequate or obsolete equipment at a time when significant efforts were being made to incorporate more technology into everyday classroom life (e.g. administration of large scale tests using computers). However, the infrastructure grant sanctioned by the *2015 Digital Strategy* (DES, 2015) which allocated a total of €210m to Irish primary and post-primary schools over a five-year period (2016-2021) should help to address some of these concerns. Yet, Eivers (2019, p. 12) does note that 'the costs and difficulties associated with managing and maintaining ICT resources in a school has been largely ignored' under this funding. Follow-up research (as outlined in Section 5) is required to confirm if Irish schools' access to basic equipment (e.g. computers, tablets) has increased and if this increase in devices and resources in classrooms is being managed and maintained in a way that supports teaching and learning using tools like *M:EE*. Inequities regarding the socio-technical infrastructure of students at home would also need addressing if tools like *M:EE* are to be used at home for schooling purposes (Squire, 2021).

Furthermore, while poor infrastructure can restrict the range of digitally-based learning experiences available to students, other unintended consequences also occur. A small-scale study by the Educational Research Centre (ERC) found that schools 'are investing [in] infrastructure and maintenance (hardware, technical support) to a much greater extent than [in] software and professional learning for teachers' (Cosgrove, et al., 2018, p. 10). If government funding is only being used

18 PIRLS (Progress in International Reading Literacy Study) assesses the reading achievement of fourth-class students. First conducted in 2001, PIRLS takes place every five years. The study collects detailed information about curriculum and curriculum implementation, instructional practices, and school resources.

19 TIMSS (Trends in International Mathematics and Science Study) assesses the maths and science achievement of students in Fourth and Eighth grades (equivalent to Fourth Class and Second Year in Ireland).

to address infrastructural issues in Irish schools, the professional learning experiences necessary to progress the confidence and competence of teachers in using digital tools to support learning outcomes may not be available. Coyne et al. (2016) acknowledge that insufficient professional learning opportunities and experiences result in practicing teachers being less likely to use digital tools when designing learning experiences for their students. Therefore, easy-to-access professional learning opportunities need to be available for in-service teachers. While the Professional Development Service for Teachers – Technology in Education (PDST-TiE) does provide high-quality professional learning experiences to assist schools in embedding digital technologies into learning and teaching, other learning experiences and opportunities should also be available to teachers. Recommendations on the content and structure of such professional learning experiences are outlined in Section 5 of this report.

Summary

- *M:EE* provides an ideal environment for project-based learning activities as it allows students to create digital artefacts that apply and demonstrate their knowledge, skills and abilities.
- *M:EE* is a multi-player game with a range of synchronous and asynchronous communication functions that can support collaboration.
- Digital games like *M:EE* can support perspective-taking – a key component of collaboration and all interpersonal interactions.
- The use of *M:EE* to support learning can be hampered by infrastructure and educator confidence and competence.

HOW CAN SERIOUS GAMES SUPPORT ASSESSMENT?

without 'domesticating games to the demands of schools and losing, in the process, the very features of gaming that can offer so much'?

Rowan & Beavis (2017, p. 173)

4.3 *M:EE* to Support Assessment

In the last number of years, the interest and efforts in using serious games as assessment tools in occupational settings (e.g. the US military etc.,) has increased significantly (Groff, 2018). This is hardly surprising as well designed games are often considered the next generation of assessments (de Klerk & Kato, 2017). This is because digital games can 'engage students in a seamless learning experience, assessing their learning... while (sic) providing critical feedback' and information about their knowledge, skills and abilities (Groff, 2018, p. 194). Unfortunately, it can be difficult for teachers to use serious games as assessment tools in educational settings without 'domesticating games to the demands of schooling and losing, in the process, the very features of games that appear to offer so much' (Rowan & Beavis, 2017, p. 173). Ensuring that teachers have sufficient agency to utilise digital games for classroom-based assessment practices could overcome the concerns of Rowan and Beavis (2017). This would also allow teachers an opportunity to collect data on their students' competencies in relation to those 'hard to assess' 21st century skills like creativity and problem-solving.

4.3.1 Classroom Assessment Practices with Digital Games

Assessment is often 'categorised' as 'formative' or 'summative' in nature (Lysaght, et al., 2019). Formative assessment refers to any activity that collects information about students to inform future learning experiences and summative assessment is the use of information to determine what learning has occurred (Lysaght et al., 2019). However, Lysaght et al. (2019, p. 3) assert that 'rather than immediately framing assessment through formative vs. summative lenses', it is more appropriate in modern education systems to conceptualise it 'as a central element of effective teaching'. In this way, teachers can view assessment as a natural part of what happens in the classroom and that their use of any assessment information occurs on a *continuum* depending on their own professional judgement. Therefore, any information related to a student's learning can be used for formative or summative purposes, or, under this new conceptualisation, a combination of both. This assessment information can manifest itself in various forms or types that can also be arranged on a continuum. Assessment information can arise from 'organic' types of assessment that emerge when 'a set of habits' is adopted (e.g. using success criteria to support self-assessment practices) or can come from more 'planned' (e.g. conferencing, rubrics) or 'visible' (e.g. teacher

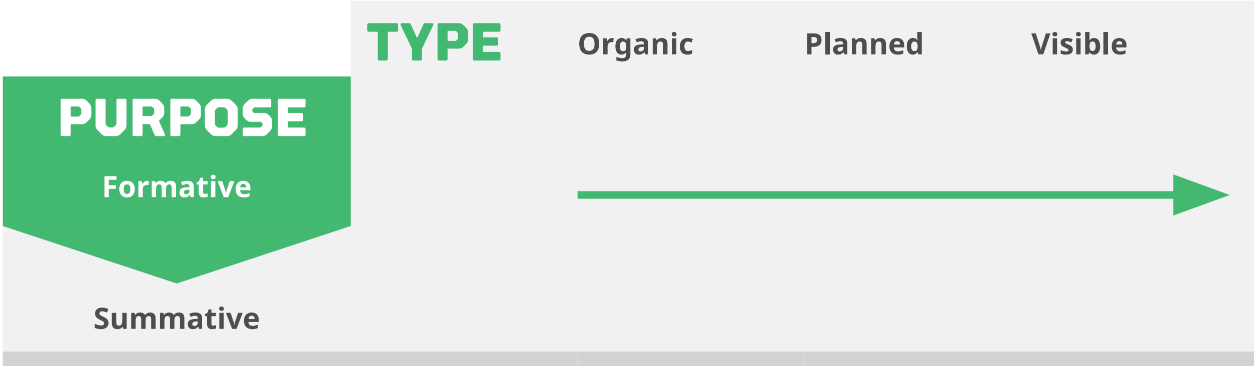


Figure 9: Types and purposes of assessment (adapted from Lysaght et al., 2019, p. 5)

designed tests, standardised assessments) types. This 'dual-continuum' approach towards the gathering and use of assessment information is summarised in Figure 9.

Lysaght et al.'s (2019) conceptualisation of the assessment process aligns well with the assessment practices that teachers in the Serious Play[20] project engaged in (Beavis et al., 2017). The Serious Play project aimed to explore the possibilities and challenges of teaching and learning with digital games in primary and post-primary schools (N=10 schools). *M:EE* was one of the main digital games used to investigate the project's research aims. When asked to discuss their approach to assessing student work in digital games, all of the teachers involved emphasised a 'flexible' approach where a range of assessment types were used for both formative and summative purposes (Rowan & Beavis, 2017, p. 183). The teachers in this study used their own professional judgement about what type of assessment was most appropriate at different times for their particular cohort of students in their chosen digital game. Teacher observations as an assessment tool were common as this did not interrupt the process of teaching and learning. This organic type of assessment informed teachers' future units of work in literacy in line with a formative approach to assessment. Some teachers also used these observations to make judgements about their students' skill development (e.g. collaboration skills). In this instance, an organic type of assessment occupied both a summative and formative role for teachers. Other types of assessments were also used to inform summative and formative assessment practices. For example, artefacts that the students produced naturally in the process of playing their games to meet lesson objectives were used for summative purposes (e.g. persuasive texts or oral descriptions produced within the game). These also helped to plan future units of work (formative assessment).

GBL requires assessment practices that allow teachers to function as informed professionals who make judgements appropriate to their own classroom context about *how* and *when* to engage in assessment and *what* the information arising from such assessments can be used for. Tools embedded into the *M:EE* can provide teachers with the freedom and flexibility necessary for such an approach to assessment. Teachers can then use this information for both formative or summative purposes. For example, *M:EE* can often be about creating a product, as was the case in Callaghan's (2016) work where learners had to design a house. This artefact can be used by the teacher to assign a summative grade, in line with the use of 'visible assessments' as discussed by Lysaght et al. (2019). In progressing towards this visible

20 Serious Play was a longitudinal, three-year research project involving collaboration between three Australian universities and teachers in ten schools across two Australian states. Six primary and four secondary schools participated in the project and represented a range of geographic and socio-economic contexts. Up to 400 students per year were involved in the project, with a 'core group' of 22 teachers working in the project schools.

assessment activity, students could also use the camera and portfolio tools to provide written and oral reflections on their progress towards any shared learning outcomes or success criteria. This form of self-assessment becomes an organic part of the learning process and can help teachers structure future learning experiences to address any issues that the students self-identified. Teachers can also use the same content to provide continual feedback to students within the *M:EE* environment using the range of chat and communication features available in *M:EE*. These planned interactions that are easily realised in digital games like *M:EE*, along with other more 'organic' and 'visible' assessments, can support a multi-faceted approach to assessment, such as that recommended by Lysaght et al. (2019). Therefore, assessment is possible in digital games. Further consideration is needed to determine how such classroom assessments relate to or support success in external assessments (e.g. state exams).

4.3.2 'Hard to Assess' Skills

Groff (2018) claimed that digital games have the potential to assess a range of 21st century skills. For example, collaboration skills are more readily assessed in online environments. This was clearly demonstrated by the 2015 Programme for International Student Assessments (PISA; 2017) which included a computer-based assessment of collaborative problem-solving skills using virtual computer agents and interactive simulations involving online chat interfaces. Digital games can offer an ideal context to assess the collaboration skills of students. As noted by Voorhis and Paris (2019, p. 40), 'a game can require cooperation, communication, and coordination of actions by multiple people'. Successful collaborators can be rewarded in games (e.g. 'levelling up', accessing new resources or gaming environments etc.) in ways that are not possible in traditional assessments. Furthermore, Voorhis and Paris (2019) specifically highlight the potential of *M:EE* to assess students' creativity. Sandbox games like *M:EE*, allow players the opportunity to experiment and create in an open and unrestricted world. Here, learners can design their own challenges and 'use their analytical skills to test and create' (Voorhis & Paris, p. 40). Work by Conforth and Adan (2015) explored how data collected from students playing *M:EE* can be used to provide insights into students' skills and problem-solving strategies across a range of areas. In digital environments, huge amounts of process data about how different skills, like creativity and collaboration, are generated (e.g. who initiated different tasks, how many times someone made a contribution). However, the presentation and visualisation of this data to teachers, as well as teachers' abilities to understand what the data is telling them, is a major challenge in the use of serious games for 'serious assessment' in educational contexts.

4.3.3 Challenges in using *M:EE* to Support Assessment Practices

Groff (2018) notes that digital games can provide a 'digital ocean' of learning data. In an attempt to make sense of this data, learning analytics is becoming more and more important to the field of GBL. Learning analytics relates to the use of 'data, analysis and predictive modelling to improve teaching and learning' (Groff, 2018, p. 194). Models and algorithms are used to process the huge amount of data obtained from GBL environments to provide more accurate descriptions of students' strengths and needs. It is hoped that learning analytics will help teachers to better understand student progress and ability in developing 'hard to assess' skills (e.g. OCED, 2016). Unfortunately, this field is still in its infancy which means that teachers are still not able to avail of the rich data that could be 'mined' from GBL environments. Furthermore, Mislevy (Educational Testing Service [ETS], 2016) notes that applying learning analytics to data collected in GBL environments can be problematic as student performance in a digital game may be influenced by 'other things that shouldn't play a big role for the results, like their familiarity with the game setting, the language and the representations that are used, and the familiarity with the cultural aspects'. This may call into question the appropriateness of the inferences being made by such algorithms. Extensive research needs to be conducted in this field before teachers can avail of learning analytics to support their assessment practices when using digital games.

The work of teachers in the *Serious Play* project (Beavis et al., 2017) indicates that there is still significant value in using GBL to support, enhance and diversify teachers' assessment practices (Beavis et al., 2017; Voorhis & Paris, 2019). Unfortunately, as with many educational advancements involving technology, lack of sufficient professional learning opportunities and support is a major barrier that limits the use of digital games like *M:EE* in supporting teachers' assessment practices. Takeuchi and Vaala's (2014) survey of American primary teachers found that while 74% of them used digital games to structure learning activities, only 12% stated that they used children's game play as a source of assessment information. This indicates that understanding the capacity of GBL environments to support assessment practices requires considerable support. These supports should address the needs of both pre- and in-service teachers and would likely required sustained investment.

74%

Approximately 74% of teachers in the US used children's game play as a source of assessment information.

Takeuchi & Vaala (2014)

Summary

- Any information gathered in *M:EE* can be used for formative or summative assessment purposes – or some combination of both.
- Tools like portfolios that are embedded within *M:EE* can support a flexible approach to classroom assessment.
- Digital games provide an ideal context to observe 'hard-to-measure' skills like collaboration.
- The ability to use data from games to support assessment practices is challenging as the field of learning analytics is still in its infancy in relation to game-based assessment.

5.0 RESEARCH AGENDA AND FUTURE CONSIDERATIONS

5.0 RESEARCH AGENDA AND FUTURE CONSIDERATIONS

This section will address the following questions:

- What gaps in the field of GBL should future research try to address?
- How should future research in the field of GBL be designed?
- How can we support educators' efforts in designing effective GBL experiences for their learners?

It is hardly surprising that there is a growing interest in the use of GBL in schools given the immense popularity of recreational gaming among children and young people. The COVID-19 pandemic has also encouraged educators to reassess the role and use of digital technology in education (Squire, 2021). Unfortunately, very few empirical studies describing ***how*** digital games can be used in relation to specific curricular aims and ***what*** they can contribute to effective teaching, learning and assessment practices actually exist. Therefore, more research is needed to justify and guide the use of GBL in primary and post-primary classrooms. Given the ease with which *M:EE* can be accessed by teachers and learners (i.e. a device and *M:EE* license), its familiarity amongst young people and the large range of educational resources available, *M:EE* is an ideal tool to investigate GBL approaches in Irish education. Future research using *M:EE* should address the current shortcomings in the field of GBL in terms of research design (**Section 5.1**) and help to advance educators' understanding of the value of *M:EE* in designing appropriate teaching and learning experiences (**Section 5.2**). If any GBL approaches are to be implemented in Irish primary and post-primary schools, teachers will need to be engaged in specific professional learning programmes. Such programmes would be subject to a number of considerations (**Section 5.3**).

5.1 Design Considerations for Future Research Studies Involving *M:EE*

While preliminary evidence from literature reviews and small-scale studies supports the *potential* effectiveness of learning through digital games, there is a lack of empirical evidence outlining the learning outcomes, if any, associated with using them to teach specific knowledge or skills. The conditions under which these possible benefits arise is also unclear. As noted by Davis et al. (2018, p. 57), 'efforts to incorporate *M:EE* ... into teaching and learning will be based on hunches and best guesses instead of empirically supported best practices' until more evidence has been collected. Based on the current review of the literature, four key recommendations have been formulated to ensure that high-quality research is conducted using *M:EE* as a tool to explore the efficacy of GBL in classrooms.

1. Use More Diverse Research Methods to Examine the Value of *M:EE* in Irish Classrooms

Many of the research studies reviewed for this report were not particularly diverse in terms of methodological approaches. Case studies (e.g. Callaghan, 2016; Pusey & Pusey, 2015; Beavis et al., 2017) exploring the use of *M:EE* in classrooms were the most common research design used. These case studies tended to use self-report methods to describe the experiences and opinions of students and teachers using *M:EE* (e.g. Pusey & Pusey, 2015). While case studies can provide valuable information on a topic and can effectively highlight the interplay between 'classroom culture, context plus the software' in GBL experiences (Klopfer & Squire, 2008, p. 224), there is a clear need to diversify the type of research available on GBL. High quality experimental or quasi-experimental research that aims to explore the value of *M:EE* in Irish classrooms in terms of learner outcomes (and not just their experiences) across a range of skills (e.g. collaboration, problem-solving etc.,) using a variety of measures (e.g. achievement of curricular aims) is required. This will help to better explain some of the findings of widely cited meta-analyses in the field (e.g. Clark et al., 2016; Wouters et al., 2013).

2. Investigate a Broad Range of Research Questions

Mayer (2011) has divided GBL research into three categories:

- i **Value-Added Research** aims to identify the game features that foster learning.
- ii **Cognitive Consequences Research** investigates what people learn from playing games.
- iii **Media Comparison Research** explores the idea of whether people learn better from games or other media.

While Wouters et al. (2013) addressed the final category in their meta-analysis (see **Section 3.0**), less value-added and cognitive consequences based research has been conducted (So & Seo, 2018). Research questions arising from each of these three categories should be investigated using *M:EE*. In particular, high-quality research studies that explore what specific *M:EE* features support learning and what knowledge, skills or abilities are best learned through the medium of *M:EE* should be prioritised.

3. Conduct Longitudinal Studies

This recommendation is heavily influenced by So and Seo (2018) who, in their review of GBL in Asian countries, highlighted that most research studies prior to 2017 examined the effects of games during a short intervention period, ranging from two days to two weeks. While there are some notable exceptions to this (e.g. *Serious Play* project; Beavis et al., 2017), the majority of research in this field relates to short-term, small-scale interventions. More long-term research studies are needed to understand how students and teachers 'accept, utilize, or misuse games' like *M:EE* (So & Seo, 2018, p. 408). While longitudinal studies may be expensive and difficult to co-ordinate and fund, the value of this research for the field nationally and internationally would be particularly significant.

4. Establish a Theoretical Framework

As argued by Rooney (2012, p. 41), the importance of underpinning games 'with a sound theoretical framework which integrates and balances theories from two fields of practice: pedagogy and game design' cannot be underestimated. The application of digital games in classrooms needs to be informed by reputable instructional approaches and pedagogical theories but also by well-informed game design strategies associated with the theories of engagement, motivation, flow and immersion (Rooney, 2012). Unfortunately, it has been difficult to balance the key aims of pedagogy and play in designing such a framework, which Rooney (2012) highlights in their analysis of key works in the field. Despite these difficulties, any efforts to establish and research a theoretical framework for GBL would be a major contribution to the field and would likely help design more robust and replicable research studies. The lack of a theoretical framework for GBL may partially explain why current research exploring the value of *M:EE* tends to describe *what* happened rather than explain ***why*** something happened. Therefore, future research in the field of GBL should aim to establish a theoretical framework that will assist in determining the value of GBL and *M:EE* for certain types of students or for different subjects; issues that have been previously addressed without any real level of satisfaction or generalisability (Mavoa et al., 2018; Schrier. 2018). This research could then help educators better understand how to structure *M:EE* based learning activities in order to maximise learning opportunities. Nadolny et al. (2020) have recently proposed two frameworks of design characteristics for GBL that make a greater effort to operationalise digital games than the previously described frameworks e.g. Squire (2008). They associated four primary 'categories' of games (*leveled games, problem solving games, open-world multi-player games, and immersive multi-player games)* with secondary characteristics *(paired positive and negative game mechanics, immediate feedback with technology, reward mechanisms that track progress, supportive multi-sensory learning, team structures, and teams with personalization*) that should lead to specific cognitive outcomes (e.g. classify, execute as per Anderson & Krathwohl's, 2001 taxonomy). While more time and research is needed to determine if this theoretical framework is appropriate, it provides a much needed starting point that could standardise research on GBL so that a better understanding of its value can be ascertained.

DESIGN CONSIDERATIONS

Future Research Studies Investigating *Minecraft* & GBL

Diverse Research Methods

Researchers need to explore diverse research methods in order to better understand the impact of games (like *Minecraft*) on learners. Both qualitative and quantitative research needs to be conducted investigating the impact of GBL on learner outcomes and experiences.

Broad Range of Research Questions

Research should aim to answer the following questions:

1. What game features can support learning?
2. What do people learn when playing digital games?
3. Do people learn better from games or other teaching approaches? Are there certain moderating or mediating factors that need to be considered?

Conduct Longitudinal Studies

Research exploring GBL needs to better understand how learners and teachers 'accept, utilise or misuse games' like *Minecraft* (So & Seo, 2018, p. 408). Long-term, large-scale research studies are needed to answer this question.

Establish a Theoretical Framework

Theoretically driven research could help identify the value of *Minecraft* and GBL for certain types of students or for different subiects and/or skills. This research could then help educators better understand how to structure GBL activities in order to maximise learning opportunities.

Figure 10: Recommendations for future research studies.

5.2 Understanding the Potential Value of *M:EE* in Classrooms

Work that will inform and support teachers' design of GBL experiences should also be conducted to better understand the potential value of *M:EE* in classrooms. A large scale study conducted by SRI International (2010) assessing 21st century skills acquisition in four different countries found that over 90% of the variances in student work scores was due to differences in the classroom learning activities that students completed. Therefore, the quality of learning experiences that a teacher designs strongly predicts the quality of the work that a learner completes. Most of the literature consulted for this review indicates that *M:EE* can be utilised to help design curricular based activities in a number of areas like science, maths, literacy, history, geography etc. However, to ensure the quality of these learning experiences, more rigorous research is needed to gain a more informed understanding of ***what*** content and skills *M:EE* is especially suited for, if any, and ***why***. Pre-service teachers in Gabriel et al.'s (2019) work also disclosed reservations on ***which*** age group this approach should be used with. For example, building scale models of buildings like the Egyptian pyramids or the Taj Mahel in India is a common activity in *M:EE* with those over the age of 10 years (Tromba, 2013). When building these models in *M:EE*, students need to use a range of mathematical skills (e.g. division, calculating surface area and volume) to ensure that their digital model is to scale. It is possible that playing *M:EE* can help students become more proficient at this particular aspect of the mathematics curriculum. This assumption should be explored using high-quality research studies that also examine other factors that may mediate or moderate the efficacy of *M:EE* such as student demographics (e.g. age, gender, SEN), teacher demographics (e.g. years' experience) and school context. Future research exploring the value of *M:EE* in primary and post-primary schools (particularly in relation to the teaching and learning of 21st century skills) should be conducted across all subjects (literacy, history etc.,) and involve a range of topics. This will help guarantee the design of effective learning experiences and activities for their students in the 'intentional, planned and supported manner' advocated by Karsenti and Bugmann (2018, p. 210). *M:EE* can also offer educational researchers a context to explore other 'big' questions in education. For example, the value of project-based learning in classrooms is still under discussion in research literature (e.g. Kirschner et al., 2006; Hmelo et al., 2007), but it is often used and recommended when deploying *M:EE* in science or history classrooms (e.g. Callaghan, 2016; Butler et al., 2016). In their review of research examining the relationship between project-based learning and student achievement, Condliffe et al. (2017) outlined the common methodological weaknesses of this research field. These included, but were not limited to, a scarcity of experimental studies, implementation inconsistencies, and a lack of validity and reliability of measures. Until more rigorous research is conducted, the effects of project-based learning are 'promising, but not proven' (Condliffe et al., 2017, p. iii). Given the range of resources and features that can support the design and implementation of project-based learning in *M:EE*, this could be a way to facilitate some much needed research on this particular pedagogy.

In relation to the topic of assessment, *M:EE* can also provide educational researchers an opportunity to develop new assessment frameworks that are appropriate for online contexts. Jenson et al. (2016, p. 36) assert that traditional, text-dominated assessment frameworks can often struggle to capture 'the forms of learning transpiring in multi-modal and ludic contexts and sites'. This is because they fail to take into consideration the implications of learning content or skills in a 'dynamic, game-based, socially-networked learning environment' (Jenson et al., 2016, p. 21). There is a need for new assessment frameworks that teachers can use to record 'non-traditional' forms of student learning arising from GBL. These 'non-traditional' forms of student learning include many of the 21st century skills identified by the P21 (2019) consortium and Binkley et al. (2012). *M:EE* is an ideal context for educational researchers to observe such skills in action to then inform the development of frameworks that guide the assessment of 21st century skills. For example, Sun et al. (2020) used student interactions in a *M:EE* themed coding activity to validate their generalised competency model for collaborative problem solving.

5.3 Supporting Teachers' use of GBL

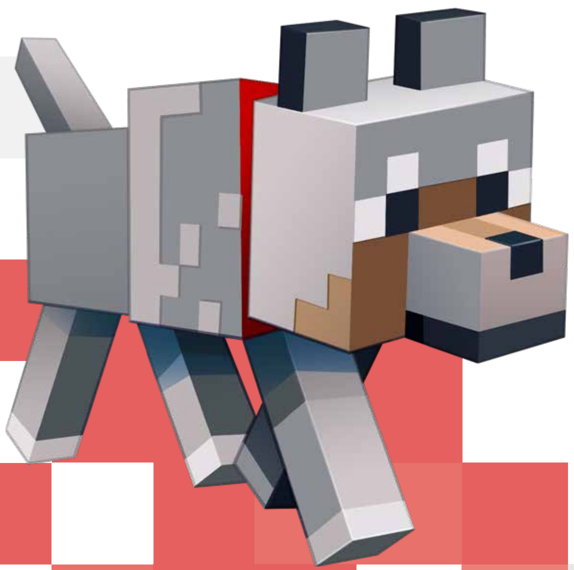
The demand for 'digitally competent teachers' has become more and more prevalent in recent times, coinciding with an increased demand for a 'new' kind of teaching that exploits technology to develop critical thinking, problem solving and communication skills in learners (Intsefjord & Munthe, 2017). The COVID-19 pandemic has also illustrated the necessity for teachers to have competence in digital pedagogies (Scully et al., 2021). However, many in-service and pre-service teachers feel that they do not have the 'digital competence' or confidence needed to use technology effectively in their teaching and are thus reluctant to integrate technology-based approaches into their classrooms (Gabriel et al., 2019; Murthy et al., 2015). This is particularly relevant in the Irish context. The 2014 National Assessments[21] asked Irish teachers about their confidence in using ICT (Information-Communication Technology) for English (2nd Class Teachers) and Mathematics (6th Class Teachers). In a secondary analysis of these questionnaire responses, Eivers (2019) noted that approximately 27% of students in 2nd Class were taught by a teacher who was 'very confident' using ICT to teach English and 42% of students in 6th Class were taught by a teacher who was 'very confident' using ICTs to teach mathematics. While this did represent a modest increase in teacher confidence from 2009, Eivers (2019, p. 28) highlighted that the

21 The National Assessments are periodic evaluations of the English reading and mathematics skills of Irish primary students. In 2014, over 8,000 2nd and 6th class students took part, as did their teachers and parents.

use of ICT (i.e. digital technology) ‘remained the teaching strategy… in which teachers expressed the least confidence’. This seems to have had an impact on ***how*** digital technology was used in the classroom. In the 2014 National Assessments, teachers were asked to indicate how often they used computers in their lessons. They were asked to distinguish between use by the teacher and use by the student. A majority of students were taught by a teacher who used computers in lessons at least weekly but, most interestingly, student use of computers was far less common. Eivers (2019) highlighted that only 24% of 2nd class students and 29% of 6th class students used computers themselves in English and mathematics lessons on a weekly basis and at least 40% rarely or never did so (Table 1).

Use by	Subject/Class	At least once a week	Once or twice a month	Rarely or never
Teacher	English (2nd Class)	77.2	13.5	9.3
	Maths (6th Class)	69.9	17.9	12.2
Pupil	English (2nd Class)	24.2	35.8	40.0
	Maths (6th Class)	29.2	28.6	42.2

Table 1: Percentages of computer use in lessons by teacher and by student (based on National Assessments 2014, as reported by Eivers, 2019, p. 23)



According to literature, if in-service teachers are to use technology-based teaching approaches in their classrooms, like GBL, a two-pronged approach is required. As teachers' positive beliefs and intentions towards technology are a major predictor of technology integration in the classroom (e.g. Ertmer, 1999), teachers should be given an opportunity to first 'see' the potential value of *M:EE* and GBL for their students. Suggested strategies for overcoming these barriers include 'modelling of good practice, reflection and collaboration between colleagues' (Ertmer, 1999, p. 54). In particular, Galvin (2015) suggests that teachers need to witness the use of digital technologies in the realities of a working classroom in order to believe that such integrated use is possible in their own context. Such a finding is of note as it indicates that the increased availability of digital technologies in a school may lead to a gradual change in teacher beliefs over time. Given the large investment in technology infrastructure undertaken as a result of the *Digital Strategy for Schools* (DES, 2015), it is possible that this will also occur in Irish schools. Other resources that may help teachers understand the possible value of *M:EE* could include the 'Case Study' videos available from Microsoft. These videos explain how teachers in New Zealand, the US etc., use *M:EE* to support the design of learning experiences that enhance learning outcomes.

Positive teacher dispositions towards technology-based approaches and tools like GBL and *M:EE* will not automatically result in teachers embedding their use into classroom practice. Teachers may be aware of the educational potential of digital technologies but require continued guidance and support to increase their digital competence so as to realise this potential in their classrooms (Redecker, 2017). If GBL is to become more common in classrooms, a systematic programme involving high-quality professional learning experiences supporting the digital competence and confidence of teachers is required. The digital competence of teachers refers to their ability to integrate and use technology for educational purposes (Redecker, 2017). Redecker (2017, p. 15) argued that, in addition to the general digital competences for life and work, teachers 'need educator-specific digital competences to be able to effectively use digital technologies for teaching'. Redecker's (2017, p. 16) framework (Figure 11) outlines the digital competencies teachers need to foster 'efficient, inclusive and innovative teaching and learning strategies' using digital tools like *M:EE*.

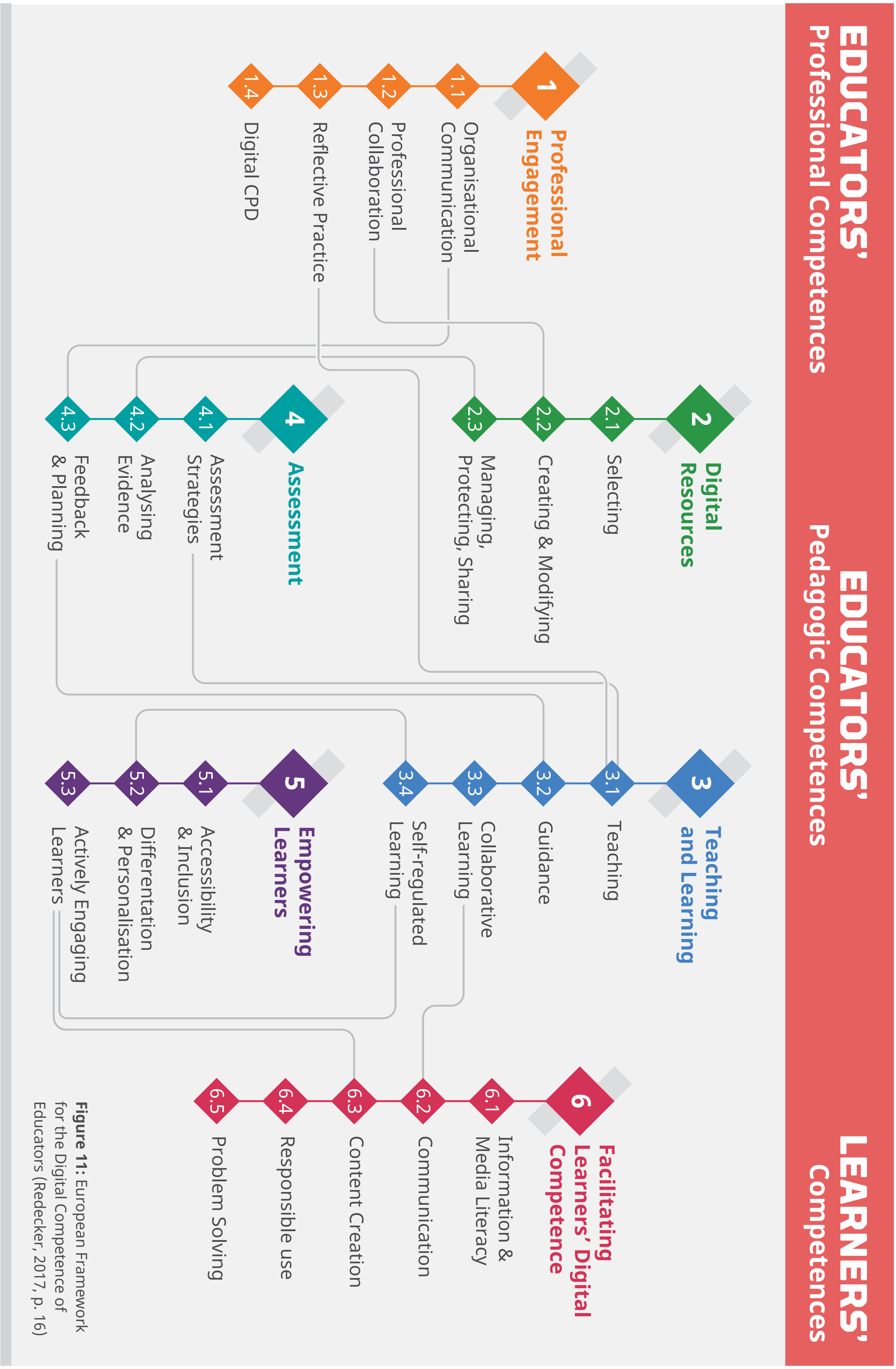
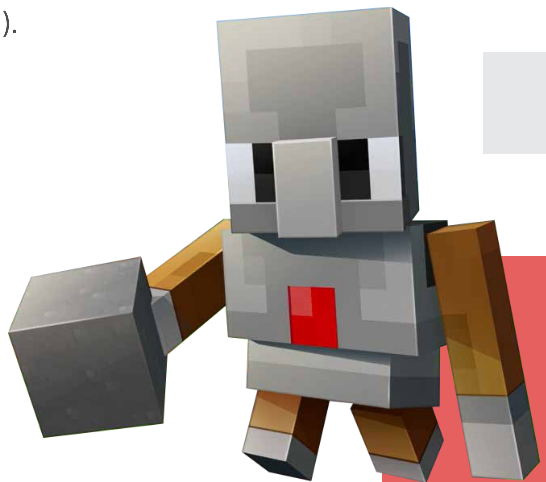


Figure 11: European Framework for the Digital Competence of Educators (Redecker, 2017, p. 16)

For example, Area 2 (Digital Resources) describes how competent teachers can select, create and adapt digital resources to suit the needs of their students in accordance with the content they are teaching. A teacher proficient in Area 5 (Empowering Learners) will design digital learning experiences that are accessible to all learners. Redecker's (2017) work provides a framework that can be used to structure professional learning opportunities for teachers that will develop their professional digital competence. Such learning programmes that target teachers' digital competence could have a major impact on teacher practice. Educational leaders (Principals, ICT Co-Ordinators; *n*=392) involved in Blau and Shamir-Inbal's (2017) work reported that as the competence level of class teachers increased, teachers were observed progressing from the consumption of pre-made digital resources, to the creation of digital content specifically designed to enhance the collaborative practices and higher-order thinking skills of their students. The provision of high-quality, professional learning programmes in supporting the digital competence and confidence of teachers should be prioritised if GBL is to be used in classrooms. Redecker's (2017) work could provide a structural framework for such professional learning opportunities. These could be provided by external agencies (e.g. the Professional Development Service for Teachers (PDST) or in collaboration with other teachers in geographically 'clustered' schools).

While certain teacher characteristics can predict GBL use in classrooms (e.g. age, teachers who play digital games for their own pleasure, professional learning opportunities etc.), the best way to ensure the embedding of GBL into classrooms is to provide universal learning opportunities for pre-service teachers (Takeuchi & Vaala, 2014). This will ensure that they have the basic 'game literacy' needed to use GBL in classrooms (Hanghøj & Hautopp, 2016) as well as the confidence in using such a methodology. Kay (2006) argues that Initial Teacher Education (ITE) is the natural place to begin the process of supporting teachers with the integration of technology in education. As a result, ITE should provide opportunities for pre-service teachers to learn about and engage with GBL if it is to be used successfully in future classrooms. This has already begun in many programmes of ITE[22]. Work by Butler et al. (2020) involving 344 Irish preservice teachers identified what should be considered when designing programmes to develop preservice teachers' confidence and competences in relation to GBL. The authors recommended that these programmes should last for at least one semester and should involve frequent gameplay across two different genres of games. Figure 12 offers a summary of the outlined research agenda in relation to *M:EE* and GBL along with some key issues that need to be considered for future classroom use.



22 For example, GBL is now a key component of the Digital Learning modules of the Bachelor of Education (B.Ed) programme at the Institute of Education in Dublin City University.

GAME-BASED LEARNING, MINECRAFT AND IRISH CLASSROOMS

Where do we go from here?

Conduct More Rigorous Research

Diverse Research Methods

Use a range research designs (e.g. case studies, quasi-experimental studies).

Broad Research Questions

1. What game features foster learning?
2. What do people learn from playing games?
3. Do people learn better from games?

Longitudinal Studies

Long-term research studies are needed to better understand how teachers and learners use or misuse) games.

Theoretical Framework

A theoretical framework is needed to explain why certain things do or do not occur in relation to learning in gaming environments.

Explore the Design of Learning Activities for the Classroom

What should be taught with GBL?

There needs to be an effort to identify the content and skills that can be learned using GBL approaches.

How should content be taught and assessed in digital games?

Teachers and researchers need to establish basic guidelines to ensure the design of high-quality GBL experiences. Procedures also need to be in place to assess what learning occurred in the game.

Support Teachers

See Potential Value of GBL

Teachers need to witness the potential value of GBL for their own students and professional practice (e.g. sample lessons, collaboration with colleagues).

Support Networks

Teachers' use of GBL should be supported by colleagues within and outside their school (e.g. PDST, 'cluster teachers').

Develop Competence and Confidence

Pre and in-service teachers need to engage in high quality professional learning experiences informed by appropriate research (e.g. Redecker, 2017) that will help them to develop the digital competence and confidence they require to use GBL in their own classrooms.

Figure 12: Summary of recommended research agenda and future considerations in relation on the use of *M:EE* and GBL in Irish classrooms.

Summary

- More diverse research methods (e.g. quasi-experimental, experimental, longitudinal studies) should be used to investigate the potential value of *M:EE* and GBL in classrooms.
- Research on *M:EE* should encompass value-added research (identifying WHICH game features encourage learning), cognitive consequences research (identifying WHAT can be learned by playing games) and media comparison research (identifying HOW GBL compares to other approaches or strategies).
- A theoretical framework on GBL needs to be established to support any research in the field.
- If digital games are to be used in Irish classrooms, technological infrastructure needs to be addressed as a matter of priority as does the development of teachers' digital literacy skills.

6.0 CONCLUSION

6.0 CONCLUSION

Considerable interest surrounding the possibilities of digital games and GBL as vehicles for learning in primary and post-primary classrooms is now evident in educational discourse (e.g. Groff, 2018) and has since been accelerated as a result of the COVID-19 pandemic. Despite some preliminary evidence indicating the potential of digital games for learning (e.g. Wouters et al., 2013), it is still unclear how games can be best deployed in schools to enhance learning and what this 'new' way of learning may even look like (Beavis, 2017). Research involving *M:EE*, the best-selling digital game of all time (Costa, 2019), could address such questions around GBL. As outlined in this report, the open-ended nature of *M:EE* allows teachers to design classroom experiences that align with appropriate educational theory and recommended teaching, learning and assessment practices. While *M:EE* may be the tool to determine the efficacy of GBL in classrooms, it should only be used to conduct high-quality, rigorously designed research studies. These studies should occur in classrooms and will thus require the support of teachers. Such support will only emerge if teachers are given the professional learning opportunities they need to develop their own competence in the use of technology-based teaching approaches like GBL. Until all this occurs, the true potential value of GBL in Irish classrooms will remain unknown.

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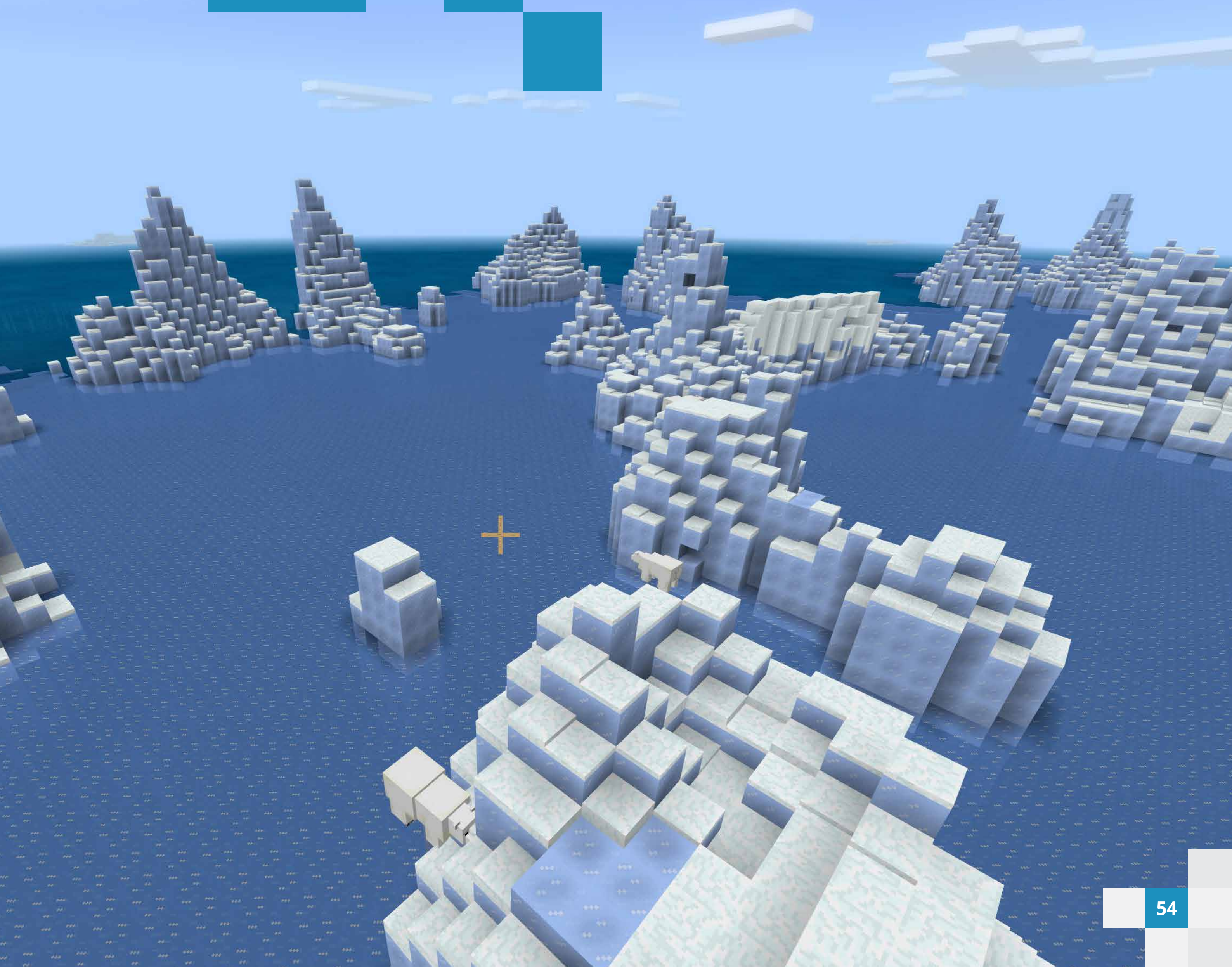

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APPENDIX 1

Search Strategy

A comprehensive search strategy was used to obtain studies relevant to this topic in October 2019. This was reviewed again in August 2021. Initial scoping searches included the exploration of a range of electronic indexed databases, including PsychINFO, PubMed, ERIC, EBSCO, Social Sciences Citation Index and Web of Science. Databases outside the discipline of education (e.g. Association of Computing Machinery [ACM]) were also explored given the relevance of the topic to other contexts and settings (e.g. game design, computing). Non-indexed databases including Dissertation Abstracts, Digital Dissertations and ScienceDirect were also used along with the electronic search engine Google Scholar. Key terms, and their synonyms, employed in the searches included '*Minecraft*', 'Game-Based Learning', 'digital games', 'benefits', 'limitations', and 'value'. The Boolean concepts of 'AND' and 'OR' with the terms 'school-based/ classroom' 'efficacy', 'value', 'learning outcomes', 'teacher/ student experiences', 'teaching', 'learning', and 'assessment' identified research that explored the relative value of *Minecraft, Minecraft Education Edition* and GBL as an approach in classrooms settings. No deliberate time frame was applied to the studies returned from this search. However, contemporary research that was written after the year 2009 was given priority, as were studies involving school-aged children or their teachers. A citation search of the reference lists of selected studies were also screened for other potentially relevant papers. Finally, the grey literature of unpublished manuscripts and other relevant outputs from *Minecraft* users (e.g. recordings of game play, blog posts) were consulted on an intermittent basis to develop a broader understanding of the topic as well as current and future trends within the field. A number of social media channels were also monitored for relevant conference abstracts and pre-prints.