

# Game-based approaches in the teaching and learning of critical and research skills in Higher Education

**Thesis submitted in partial fulfillment of the requirements of The Glasgow School of Art for the degree of Doctor of Philosophy (PhD by Published Works)**

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## Abstract

Game-Based Learning (GBL) is the integration of gaming elements into learning experiences. There are research gaps in GBL for adult learning, in particular for higher order learning outcomes within Higher Education. This leads to a lack of evidence-based approaches for GBL in postgraduate study, where the need for pedagogic innovation has been acknowledged.

This research comprises 13 publications, 9 supporting outputs (games and toolkits), and a critical reflection. Together they address the research question: “How can game-based approaches improve the teaching and learning of critical thinking and research skills in Higher Education?”

Research through Design, within a constructivist paradigm, integrates empirical and theoretical insights to propose evidence-based frameworks for GBL implementation. Publications are contextualised with up-to-date GBL and learning theories appropriate to developing research skills and critical thinking. Results demonstrate significant potential for GBL within research skills training. In particular, creativity, freedom to fail, community building, and personalisation of learning pathways are valuable outcomes of GBL in this context. Barriers to effective use are also analysed. Practical design principles to scaffold design processes are presented. All games and toolkits are freely available and are being used within research development, teaching, and game design communities.

There are three key contributions to knowledge and practice:

1. Evidence-based GBL practice for research skills and critical thinking training in HE.
2. Championing practical, authentic, analogue GBL.
3. Balancing rigour and usability in GBL co-design workflows.

Balancing theoretical rigour with practicality, this research provides a foundation for effectively integrating GBL into postgraduate learning, and beyond.

## Declaration of originality

I, Daisy Ann Healey Abbott, declare that the enclosed submission for the degree of *Doctor of Philosophy*, consisting of a critical reflection and thirteen Published Works, meets the regulations stated in the handbook for the mode of submission selected and approved by the Research Degrees Sub-Committee.

I declare that this submission is my own work and has not been submitted for any other academic award.

**Signed:** \_\_\_\_\_

**Date:** 12/05/2025

**For my Dad**

**Acknowledgements**

To playful learners near and far, thanks to everyone who has brainstormed, designed, authored, and play-tested with me, or inspired me through your own work.

To my GSA colleagues, thanks for being fun to work with, and supportive when life's complications get in the way.

Thanks also to my kids who have made me a much better and more inclusive teacher.



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## Glossary

<b>Action research</b>	an iterative method that simultaneously investigates and aims to solve an issue
<b>Active learning</b>	a method where students do something besides passively listening
<b>Affective outcome</b>	emotional reaction to learning content
<b>Andragogy</b>	self-directed, adult learning
<b>Behavioural outcome</b>	response made after understanding occurs
<b>Behaviourism</b>	a theoretical perspective that states learning occurs through conditioning/interactions with the environment.
<b>Cognitive outcome</b>	related to knowledge acquisition, understanding, and use
<b>Constructivism</b>	learners actively building their own understanding, rather than passively 'consuming' teaching. Not to be mistaken for constructionism.
<b>Epistemic/Epistemology</b>	theory of knowledge or its validation
<b>Flow state</b>	an optimal psychological state where people experience immersion and concentrated focus when engaged in an activity that is appropriately challenging
<b>Game-based learning (GBL)</b>	the intentional integration of gaming elements into learning experiences to deliver learning outcomes
<b>Gameplay loop</b>	a series of actions that is repeated whilst players play a game
<b>Gamification</b>	the layering of game design principles onto non-game contexts
<b>Heutagogy</b>	self-managed, learner-led learning
<b>Learning outcomes</b>	the specific knowledge, expertise, or attitudes that learners get from a learning activity
<b>Mechanics</b>	rules that define/guide interactions, as well as the game/learning system's response to interactions
<b>Metacognition</b>	thinking about your own thinking
<b>Pedagogy</b>	teacher-led learning
<b>Pragmatism</b>	philosophical approach that assesses theories according to whether their practical application is successful
<b>Self-determination theory</b>	ability to make your own choices and determine your own actions; requires competence, relatedness, and autonomy
<b>Serious Game Mechanics (SGMs)</b>	combinations of learning and game mechanics which link pedagogical practices to concrete gameplay
<b>Situative learning</b>	emphasis on learning as being situated in a specific context that includes environment, identities, and interactions
<b>Social constructivism</b>	constructivism incorporating other people, producing a common understanding from multiple perspectives. Not to be mistaken for social constructionism.
<b>Tabletop game</b>	any game physically played on a table, including board games, card games, dice games etc.
<b>Triadic Game Design (TGD)</b>	a GBL design approach based on balancing the three components of Reality, Meaning, and Play

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# 1 Introduction

Game-Based Learning (GBL) is a pedagogical approach that harnesses interactive elements of games to facilitate learning. I define it as **the intentional integration of gaming elements into learning experiences to deliver learning outcomes**. A GBL approach generally aims to increase engagement, motivation, and/or effectiveness and it is common to see uncritical assumptions that GBL achieves this goal automatically, by virtue of simply *being* game-based. This PhD by Published Works covers ten years of research which evidences that this is not the case! It comprises 13 published works (2015 – 2025)<sup>1</sup> and 9 supporting research outputs, alongside a critical reflection (this document.)

The application context of my research is Higher Education (HE), specifically, postgraduate research. Therefore, my focus is typically on higher order learning behaviours and outcomes such as critical thinking, research skills, creative idea generation, and behavioural change (rather than knowledge acquisition.) However, as will be seen, these capabilities extend beyond HE contexts. Furthermore, although I tend to use ‘pedagogy’ as a catch-all term within my published works and this reflection, GBL approaches within this context are in truth a complex interplay between pedagogy (institution or teacher-led learning), andragogy (self-directed, adult learning), and heutagogy (self-managed, learner-led learning) (cf. Friedman and Nash-Luckenbach, 2024.) GBL, when well executed, can potentially combine the clear presentation and structured learning content of pedagogy with the maximal learner control of heutagogy (which allows increased flexibility, creativity, and personalisation.)

As a PhD by Published Works, this submission is more disparate than a typical PhD. Each publication has its own research question, aims, and methods. However, my body of work is encapsulated in the overall research question: **“How can game-based approaches improve the teaching and learning of critical thinking and research skills in Higher Education?”**

## 1.1 About this document

This critical reflection forms part of the submission. It totals c.16,400 words (excluding references/appendices.) It synthesises and revisits my published works (which total c.75,200 words) alongside a range of practice-based research (games and GBL toolkits) and provides an up-to-date analysis of my contributions to knowledge and practice.

My aim is to make this document as accessible as possible, therefore I have tried to avoid an overly academic tone and, in the playful spirit of the research itself, included active engagement points, marked with a yellow question mark. These provide an (optional) interaction to enhance understanding.

Each **published** (and **supporting**) research output has an identifier which is hyperlinked to a tabular summary (e.g., [PW1](#), [SW2](#).) If you are reading this digitally, you can **CTRL click** links to go to the summary, then get back using **Alt+LeftArrow** (hold down Alt key and press Left Arrow key).

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<sup>1</sup> Seven publications are sole authored, six are co-authored, four with me as the primary author. My contribution to each co-authored paper is outlined in [Appendix 2](#).



*Try it now! Go to the [table of published works](#), then get back using*  +

## 1.2 Terminology

Definitions are not always consistent across disciplines, time, and/or geography, therefore, it is useful to clarify my understanding of GBL-related terminology and how I use it. As Hon states: “it’s easy to get mired in definitional quicksand [...] This partly stems from the subject being a rapidly moving target” (2022, p. 10.) Games are constantly evolving, as are the attitudes to (and acceptance of) play and the purposeful use of games or game-like techniques. Pedagogy too is a discipline that evolves relatively quickly, especially given the paradigm shift and rapid innovations that occurred as educators responded to the COVID19 lockdowns and developed their pedagogical and heutagogical practices since 2020.



*Before you look at the next page, try to map these terms into the conceptual diagram below: Learning; Game-based learning; Game-enhanced learning; Playful learning; Gamification; Serious games; Simulation*

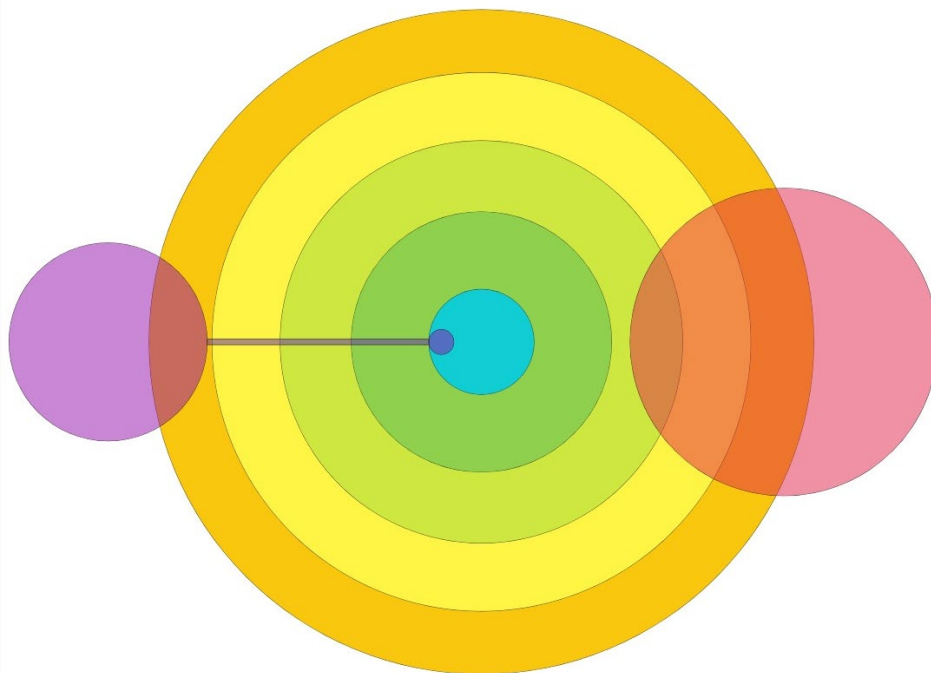
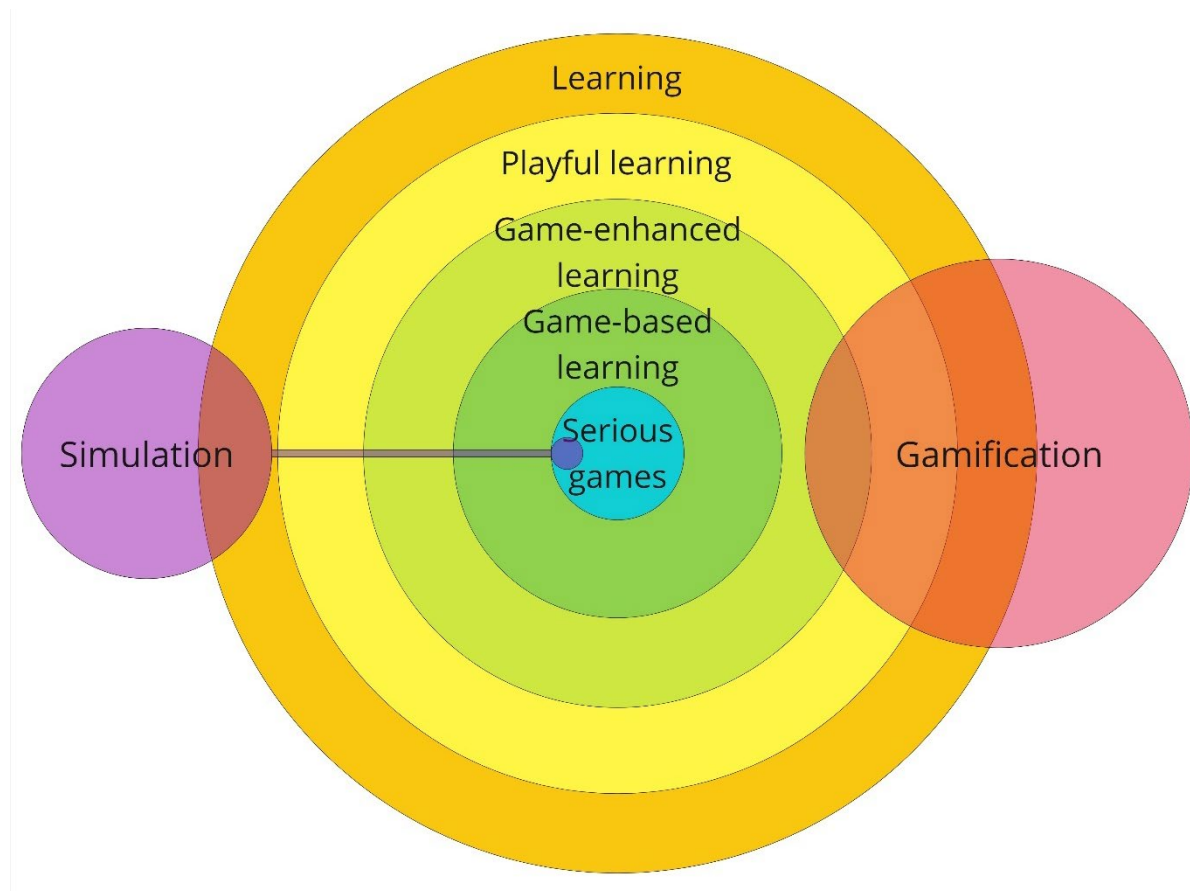


Figure 1 – conceptual diagram of terminology (empty.) Concentric circles show terms as subsets of other terms, overlapping circles represent when a term can, but does not necessarily, overlap.

Figure 2 shows my conceptual map of GBL-related terminology. The wide concept of **Learning** gets ever more focussed onto **Serious Games** at the centre. I have included **Gamification** as a related field that may overlap in some cases, and uses many of the same mechanics as games. I have included **Simulations** in Figure 2 only because they are often (erroneously) categorised as games.<sup>2</sup> Each core term is defined below, in relation to current literature.



*Figure 2 - my conceptual map of related terminology, showing relationships. The concentric circles show fields that are subsets of wider domains. Gamification can be involved in some learning elements but is distinct from GBL. Simulation is shown as not necessarily part of learning, or of GBL, but can be used a mechanic within serious games.*

### 1.2.1 Playful learning

Playful learning (PL) integrates playful elements into learning settings or educational activities in a variety of flexible ways. There is no single accepted definition as it blurs the boundaries classifying 'learning' and 'playing', 'thoughtful' and 'fun' (cf. Moseley, 2020, p. 35) and some say that an activity simply being perceived as playful is the only requirement (Glenn and Knapp, 1987, p. 52.)

<sup>2</sup> Simulations attempt to accurately model a system (real world or hypothetical) and use a rule set representing characteristics or behaviours of the thing being modelled to show how different variables (e.g., inputs or interactions) affect outcomes. Although they can be considered to be game-like, simulations without game mechanics are not games because although a user can 'play with' a simulation they are not necessarily playful, and in some cases have very little interaction beyond setting initial inputs (cf. Alvarez *et al.*, 2023. Allcoat and Evans, 2024), however, simulations can be used as a method to increase situated meaning (Bisz and Mondelli, 2023, pp. 161–162.)

Nevertheless, widely accepted characteristics are that PL is: voluntary; player-led; intrinsically motivating; lacks negative real-world consequences; and, most importantly, must be understood as play by participants (Cailliois, 2001; Sicart, 2014; Whitton and Moseley, 2019; Schell, 2020.) As I note in [PW6](#), playfulness is a core principle for increasing the emotional affordances of learning situations (Weitze, 2016; Park and Lim, 2019) and can contribute significantly to enjoyment and/or motivation. The literature convincingly defines huge advantages for PL (including in adults) such as: constructivist educational strategies; self-supported learning; signifiers of experimentation and exploration; motivation and engagement; focus on realistic contexts; creativity; and metacognition (Proyer, 2014; James and Nerantzi, 2019; Whitton and Moseley, 2019; Baecher and Portnoy, 2024 and many others.) Nevertheless, play is not automatically accepted by all learners and PL requires a “shift in frame” (Walsh, 2019, p. 1) in order to be successful, which forms part of the design considerations of approaches for adults (*cf.* Walsh, 2019; Moseley, 2020, pp. 24–25.)

### 1.2.2 Game-enhanced and game-based learning

Game-enhanced and game-based learning are subsets of playful learning which introduce games into the learning context. GBL can be thought of as 1) an interdisciplinary and multimodal pedagogical approach which uses games, and/or 2) the act of designing game-like learning activities (*cf.* Anastasiadis, Lampropoulos and Siakas, 2018; Bisz and Mondelli, 2023, p. 5.) But what is a game? Whilst (like play) there is no universally agreed definition,<sup>3</sup> my own understanding of a game (and what separates it from ‘play’) aligns with Juul’s six characteristics. Games:

1. are rule-based;
2. have variable, quantifiable outcome(s) (e.g., points scored);
3. have different potential outcomes that are assigned different values (e.g., win, lose);
4. require the player to invest effort in order to influence the outcome (by engaging with game mechanics to impact the game system or other players, often in an attempt to win);
5. require that players care about the outcome;
6. have negotiable real-life consequences (typically none beyond the memories/skills developed by playing) (extended from Juul, 2003.)

These six dimensions help to differentiate GBL from playful learning/interactivity, and the sixth dimension explicitly differentiates GBL from gamification (see below.) Games combine playfulness with specific game mechanics to structure activities in a way designed to facilitate learning. For example: game levels can allow gradual introduction/consolidation of content which helps manage complexity; repetition of gameplay loops may encourage memorisation; or a surprising narrative twist could provoke critical reflection on a topic.

Learning can be *enhanced* by games, where they are integrated and complement other learning methods, or *based on* games, where the game is the primary method. Where learning is game-based, the games are typically specifically created for (or adapted to align with) particular learning outcomes. Games created for this purpose can be called Serious games. However, GBL goes beyond the game itself as it is a holistic approach that incorporates the context of learning and learners, for example, the potential motivational benefits of a positive experience, the facilitation of social or

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<sup>3</sup> See Schell, 2020, pp. 34–49.



collaborative learning through games (*cf.* Hartevelde, 2011, pp. 4–5), or incorporation of learning mechanics that are not typically thought of as part of a game.<sup>4</sup>

Throughout this submission, I choose to use the phrase **Game-based learning**. In truth, some of the interventions I discuss are *game-enhanced* rather than *game-based*, but GBL is more commonly used throughout the literature, and the distinction is often so blurry that it is not useful to separate them.

### 1.2.3 Serious games

The term “serious games” is credited to Abt (1970), popularised by Sawyer (2001), however, as others have noted, games have been “purposed” for millennia using a range of interdisciplinary practices that have evolved into the current ecosystem (Wilkinson, 2016, p. 7.) Serious games are usually defined as “games with a purpose beyond entertainment” (Abt, 1970.) I prefer this to the sometimes-used “games with a serious purpose” (e.g., Hartevelde, 2010) as it avoids implying that play itself is trivial.<sup>5</sup> I refine this definition to “games *that are specifically designed for a purpose beyond entertainment.*” I explicitly reject any definition that claims a serious game must be digital:<sup>6</sup> Delivery platform is, of course, relevant to a game’s purpose, but is not a defining factor (see [PW3](#) for detail.) There are a range of prefixes used for subsets of serious games: educational (for imparting knowledge), persuasive, training (for practising skills or procedures), exer- (exercise), adver- (advertising), provocative, health, social impact, rehabilitation, and so on (*cf.* Hartevelde, 2011, p. 6.) Crucially, serious games are game objects/interactive systems and their study therefore is distinct from that GBL (which encompasses the wider pedagogical contexts and activities) and gamification approaches.

### 1.2.4 Gamification

The most common definition of gamification is “the use of game design elements in non-game contexts” (Deterding *et al.*, 2011, p. 9.) However, as I note in [PW11](#), the concept has existed for centuries to encourage/discourage particular behaviours and is continually evolving to encompass new techniques (often driven by technological development.) Literature shows that gamification can enhance various learning domains (Huang *et al.*, 2020; Sailer and Homner, 2020; Ritzhaupt *et al.*, 2021), however, despite assumptions that gamification automatically leads to improved outcomes, these meta-analyses demonstrate mixed results. Gamification is often uncritically applied (Woodcock and Johnson, 2018) resulting in ineffective results, unhelpful emergent behaviours, and even unethical learning or behaviourism (see Hon’s discussion of “generic” and “coercive” gamification (Hon, 2022) and the analysis by York *et al.* (2022).) Gamification can be thought of as focussed on the product/reward, compared to GBL which is focussed on the process/experience (Allcoat and Evans, 2024, p. 5; Baecher and Portnoy, 2024, p. 5.)

Another term is ‘gameful learning’ which extends gamification by focussing on the wider context of learning such as course assessment (Aguilar, Holman and Fishman, 2018.) “Gamefulness” can be usefully thought of as “a systematic complement to ‘playfulness’ ” (Deterding *et al.*, 2011, p. 11.) It

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<sup>4</sup> This last point is emphasised in many of my submitted publications (e.g., [PW5’s](#) detailed case study.)

<sup>5</sup> See also “games that do not have entertainment, enjoyment or fun as their *primary* purpose” (Michael and Chen, 2005 [my emphasis])

<sup>6</sup> Even now, many in the literature inexplicably include ‘digital’, ‘videogame’ or ‘software’ as part of their definition, including Sawyer (Sawyer, 2007 cited in; Djaouti *et al.*, 2011 who also note that many restrict the term to digital serious games.)

draws on self-determination theory (Ryan and Deci, 2000) using gamification as a design strategy to achieve this goal (cf. Nørgård, Toft-Nielsen and Whitton, 2017; York *et al.*, 2022; Cabral, 2024.)

### 1.2.5 Game mechanics and learning mechanics

I have already used the term **mechanic** to describe specific interactions, relevant to both learning design and game design (cf. Schell, 2020, p. 53.) This submission makes extensive use of the Learning Mechanic – Game Mechanic (LM-GM) Framework (Lim *et al.*, 2013; Arnab, *et al.*, 2015; Lamas *et al.*, 2017) so it is important to understand the nuances of this term. Game mechanics (GMs) are concrete elements that directly affect gameplay (e.g., drawing a random card from a deck.)<sup>7</sup> Learning mechanics (LMs) serve the same function within learning contexts; they are specific interaction systems used to facilitate the learning process (e.g., using flashcards to prompt recall, receiving feedback on your answer.) They are building blocks that combine in various ways to create learning/gaming experiences.



Figure 3 - an example of mapping Learning Mechanics (LM) to appropriate Game Mechanics (GM), first used within [SW5](#) and now part of [SW9](#). See [Appendix 3: large scale figures](#) for a larger version.

### 1.3 Summary of contributions to knowledge

This submission claims significant contributions to knowledge in GBL design and practice, outlined in Table 2, as well as the application of that knowledge i.e., how theory manifests in practice and research for specific disciplinary or sectoral contexts. This submission involved the categories of activity shown in Table 1.

<sup>7</sup> Cf. 'ludemes' (Digital Ludeme Project, 2023)

Table 1 - categories of research activity leading to this submission

CODE	Research Activity (RA)	Description
1	Design, implementation, evaluation, and analysis of game-based approaches for specific learning purposes.	GBL practice focussed on practical and authentic GBL for my own teaching contexts, and gathering empirical data in relation to established theoretical frameworks.
2	Theoretical development and innovation in harmonising and mapping educational context, instructional design, learner experience design, and game design.	Desk research and experimentation contributes to advancing understanding of how GBL functions at a mechanical level, its place within pedagogy/andragogy/heutagogy, and recommendations for effective approaches in different contexts of use.
3	Methodological development of accessible GBL workflows to improve the rigour of GBL design.	This activity arose organically from my GBL practice. Methods are designed specifically to close the disciplinary gaps between GBL co-designers. It addresses the central research gap of connecting learning outcomes with game design in a form accessible for novices.

Arising from these activities are significant contributions to knowledge within the broad categories shown in Table 2, analysed in detail in Chapter 6.

Table 2 - overview of contributions to knowledge, mapped to research activity and publications

Key contribution	Subcategories	Research Activities used	Publications
<b>Evidence-based GBL practice for research skills and critical thinking training in HE.</b>	Games for teaching research activity	RA#1 – GBL practice	<a href="#">PWs1,3,4,5,8,11,13</a> , <a href="#">SWs1,2,4</a>
	Emotional design for game-enabled reflection	RA#1 – GBL practice RA#2 –theoretical innovation	<a href="#">PWs4,6,7,8</a> , <a href="#">SW1,3,5,6</a>
<b>Championing practical, authentic, analogue GBL.</b>	-	RA#1 – GBL practice	<a href="#">PWs1,2,4,5</a> <a href="#">SWs1,2,5,8,9</a>
<b>Balancing rigour and usability in GBL co-design workflows.</b>	Applying and extending Triadic Game Design	RA#1 – GBL practice RA#3 – developing methods	<a href="#">PWs3-12</a> , <a href="#">SWs8,9</a>
	Inclusion of learning behaviours as an explicit ingredient in GBL workflows	RA#1 – GBL practice RA#2 –theoretical innovation RA#3 – developing methods	<a href="#">PWs1,3-9,12</a> , <a href="#">SWs8,9</a>
	Using, refining and streamlining the LM-GM framework	RA#3 – developing methods	<a href="#">PWs3-12</a> <a href="#">SWs8,9</a>
	Recommendations for effective GBL approaches for different contexts of use	RA#2 –theoretical innovation RA#3 – developing methods	<a href="#">PWs2-7,9-13</a> , <a href="#">SWs5,8,9</a>

Overall, this research has considerable originality, rigour, and significance relevant to the core topic: "Game-based approaches in the teaching and learning of critical thinking and research skills in Higher Education".

#### 1.4 Structure of critical reflection

Having defined the terminology, above, an up-to-date research context in which to situate the submission is presented in Chapter 2. Chapter 3 analyses my own interdisciplinary context and

clearly delineates the scope of the submission. Chapter 4 considers my key methodologies and summarises the main methods used across the submission. Chapter 5 considers the published works themselves, providing a thematic analysis under two broad headings: GBL approaches for higher order learning outcomes, and improving GBL design workflows. A critical reflection of each paper and its significance is provided, noting where theoretical innovation and/or empirical evidence is evident. I suggest that the published works are read in the order they appear in Chapter 5. Chapter 6 analyses, and provides a rationale for, the contributions to knowledge generated by this research.

The Appendices provide information to support the submission, including a tabular description of the Supporting Works, some of which are research outputs in their own right.

## 2 Brief research context

This research context is provided to fully update the ongoing context of research spanning over a decade.

### 2.1 Ways of learning

Before focussing on game-based learning, a key concept to explicitly outline is that there are different ways to learn. Memorising French irregular verb conjugations is completely different to learning to play a tune you can already sing on the piano, which is different again from understanding how (and why) to choose a secure password for your new online account. These differences are crucial in order to understand how to design GBL. My research draws on foundations from the extremely influential frameworks of Bloom, Anderson, and Krathwohl (2001.) Firstly, I make extensive reference to **learning outcomes**, which can be categorised into three domains:

- **Cognitive outcomes** focus on knowledge acquisition and intellectual skills (e.g., knowing a French verb, understanding what makes passwords strong, or critically analysing the reasons for using a strong password.)
- **Affective outcomes** are about emotional response (e.g., the pleasure of succeeding after a productive struggle getting your fingers to play the right notes, or anger when learning about a cyberattack.)
- **Behavioural outcomes**<sup>8</sup> result in observable actions (e.g., playing the piano is a psychomotor skill) or a change in future behaviours (e.g., a personal commitment to choosing strong passwords.)

It is clear that learning outcomes are combined differently in different learning situations. They also require different methods to measure and evaluate. GBL often focusses on knowledge acquisition, particularly in educational contexts. However, the literature now contains plenty of examples of intentional integration of affective and behavioural outcomes, either to support cognitive outcomes or as purposes in their own right (e.g., Huang *et al.*, 2020; Ritzhaupt *et al.*, 2021; Abbott, Louchart and Chatzifoti, 2022; Lovren and Jablanovic, 2023; Xu *et al.*, 2023.)

The second key framework I use is Bloom's Extended Taxonomy (Anderson and Krathwohl, 2001) which provides a categorisation of outcomes based on their cognitive complexity (Figure 4.)

The teaching and learning of research skills in Higher Education (my application context) combines cognitive, affective, and behavioural outcomes (e.g., learning about academic ethics, feeling confident and empowered, and behaving with integrity as a student researcher), as well as every level of Bloom's Extended Taxonomy (from remembering how to cite sources all the way up to creative design of an original research project.) Of course, as others have noted, no taxonomy can truly capture the complexities of learning processes (particularly in HE) and therefore the taxonomy should not be treated as a rigid hierarchy (*cf.* Hyder and Bhamani, 2016; Bisz and Mondelli, 2023, p. 48.) Research skills include capabilities that merge and combine various types of learning outcome and at various levels, as well as metacognitive skills such as reflecting on research biases, planning a literature review, or self-questioning the validity of results. Nevertheless, these frameworks are

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<sup>8</sup> Note, I use the broader category of 'behavioural' rather than Bloom *et al.*'s original category 'psychomotor' as it encompasses other potential behaviours that can themselves arise from cognitive or affective outcomes and is widely accepted in educational psychology.

fruitful throughout the submission as the basis for analysis and knowledge exchange on instructional design and the mapping of learning mechanics to game mechanics.

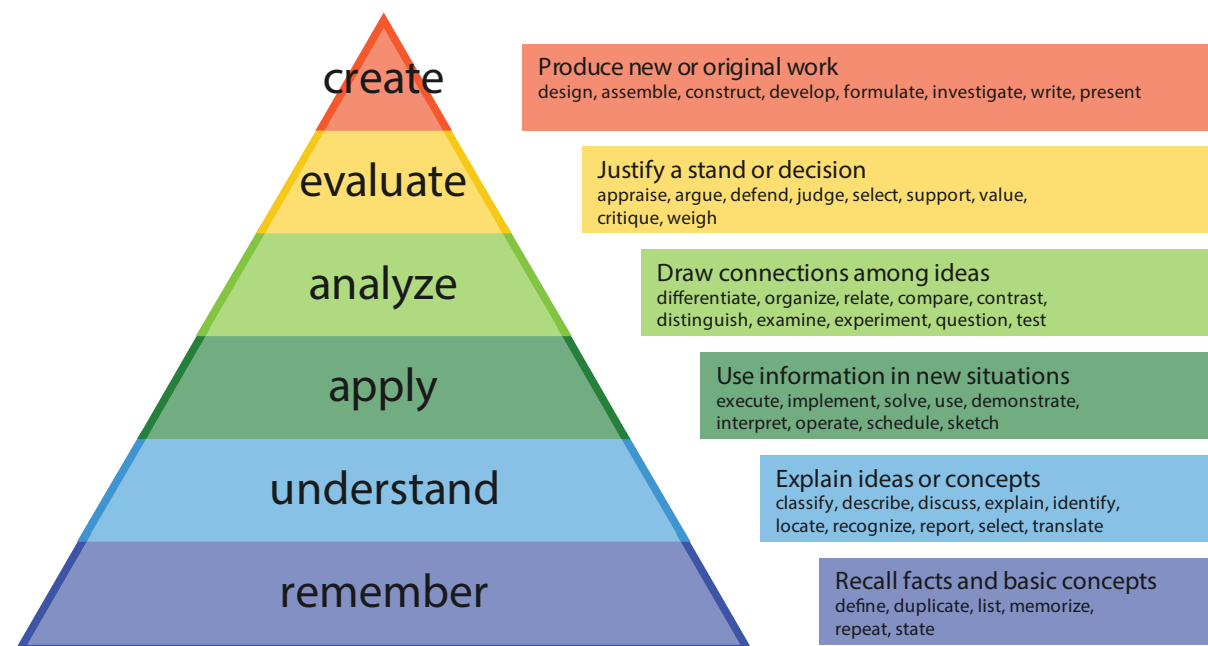


Figure 4 - Bloom's Extended Taxonomy, showing the types of learning outcomes at lower to higher levels. Image: Tidema, CC BY 4.0, <https://commons.wikimedia.org/w/index.php?curid=152872571>

## 2.2 GBL's development in recent decades

There is now a very large, and growing, amount of literature on GBL and serious games, of varying quality. Research has evolved over time, covering overlapping subtopics that I will, rather over simplistically, describe as:

- Does GBL work?
- How does GBL work? And
- How are we designing GBL to ensure that it works?

The overall conclusion from the literature is that GBL can have significant advantages for learning outcomes, in particular in terms of motivation and engagement, knowledge acquisition, and affective outcomes.<sup>9</sup> Meta-analyses generally support the hypothesis that GBL has a positive impact on learning (*if* it is well designed and well-integrated into learning contexts) and can (sometimes) improve knowledge retention and motivation (Wouters *et al.*, 2013; Clark, Tanner-Smith and Killingsworth, 2016; Lamb *et al.*, 2018; Zhonggen, 2019; Sailer and Homner, 2020; Maratou *et al.*, 2023.) Table 3 summarises the main conclusions from the literature.

<sup>9</sup> I acknowledge the biases inherent in both GBL designers who then evaluate and report on their own games (including myself!) and the publishing of positive vs. negative results in academic literature. Nevertheless, I believe this conclusion to be robust.

Table 3 - summary of common positive and negative findings from GBL studies

Positive	Negative
<ul style="list-style-type: none"> <li>• improved cognitive outcomes</li> <li>• more time spent engaging in the GBL activity than controls</li> <li>• flexibility</li> <li>• positive attitudes towards GBL</li> <li>• emotional affect</li> <li>• increased social/collaborative learning</li> </ul>	<ul style="list-style-type: none"> <li>• cognitive load (of learning to play a game whilst also trying to learn a topic) can inhibit learning effectiveness</li> <li>• no evidence of significant differences for 'deep' learning i.e., higher order learning outcomes</li> </ul>

Notably, studies are mixed in terms of results and how rigorous they are, leading to some scepticism. One 2017 review concludes that “Insufficient high-quality evidence exists to support the long-term benefits of gamification in educational contexts”, noting that different contexts have different needs and that more research was needed into theoretical foundations (Dichev and Dicheva, 2017, p. 25.) Recent reviews widened this scope beyond just gamification, taking GBL, serious games and gamification together, typically with a further theoretical focus. For example, a review of pre-game, game, and post-game pedagogies reported that there is a high majority of studies which show positive results for cognitive and affective outcomes when integrating digital games (Bado, 2022, p. 939.) A meta-review (Krath, Schürmann and Von Korflesch, 2021) attempted to analyse over a hundred diverse theoretical foundations relevant to GBL approaches in education and identified ten key principles common to many positive results, concluding that GBL has high potential for improving learning outcomes and that “scientific interest has successfully broadened and expanded by investigating *how* and *why* this takes place.” (2021, pp. 10–14.) Therefore, whilst research is still fragmented, it is a reasonable conclusion that GBL can, and often does, deliver learning outcomes both effectively and efficiently.<sup>10</sup>

Despite this, relatively little existing literature analyses ‘deeper’ learning in detail, or focuses specifically on higher order or more complex learning outcomes. GBL is not just about imparting knowledge – affective, attitudinal, and behavioural outcomes are also part of GBL’s evolution. A useful set of related examples is *The Landlord’s Game* (Magie, 1904) which aimed to promote the social values of Georgism. Far fewer people would be aware of this game if it hadn’t later become *Monopoly* (with almost directly contradictory social attitudes) (Pilon, 2015.) In the 1970s, *Monopoly* was repurposed into *Blacks and Whites*, a game about racial inequity in American society which aims to enhance empathy and co-operation by using extremely unfair game mechanics, depending on whether you choose to play as Black or White, now updated once again (Sommer *et al.*, 2023.) Coming full circle, a recent “homage” to *The Landlord’s Game* aims “to stimulate a frustration so comically absurd that gameplay evolves into a discussion among players about the inequalities inherent in contemporary U.S. capitalism” (Harrison and Kumar, 2019.)

Literature also notes the limitations inherent in assessing GBL approaches, which hamper claiming definitive results for such a varied domain (Clark, Tanner-Smith and Killingsworth, 2016; Zhonggen, 2019.) Notably, cognitive learning outcomes are typically simpler to evaluate (e.g., through post-tests of knowledge) than affective or behavioural outcomes which rely on self-reporting or detailed observation, sometimes over longer time periods. Therefore, the literature has more data pertaining to cognitive (rather than affective or behavioural) outcomes, although GBL is generally thought to

<sup>10</sup> See Hartevelde’s discussion of “external relevance” (effectiveness) and “internal relevance” (efficiency) for more detail (2011, pp. 166–168.)

have the potential for positive impacts on all three (Lamb *et al.*, 2018; Sailer and Homner, 2020.) It is also claimed that “students in the active classroom learn more, but they feel like they learn less” (Deslauriers *et al.*, 2019, p. 19251) which complicates interpretivist evaluations of GBL.

As GBL research developed in maturity, the focus moved from questioning *whether* GBL is effective (i.e., if it actually delivers its intended outcomes) to *how* GBL can facilitate different types of learning (Hanghøj and Hautopp, 2016; Abbott, 2019a; Krath, Schürmann and Von Korflesch, 2021.) Prior research agrees that success depends on the characteristics of each GBL intervention and that the design of each game (taking into account context and learning mechanics and how they are translated into game mechanics) has an instrumental impact (Nicholson, 2011; Lim *et al.*, 2013; Arnab, *et al.*, 2015; Hanghøj and Hautopp, 2016; Grey *et al.*, 2017; Lameris *et al.*, 2017; Westera, 2019, as well as most of my own research.) Clark *et al.* state:

“Although this conclusion may appear to be common sense, the role of design is often de-emphasized in debates [...] games as a medium definitely provide new and powerful affordances, but it is the design within the medium to leverage those affordances that will determine the efficacy of a learning environment.” (Clark, Tanner-Smith and Killingsworth, 2016, pp. 110, 114.)

Therefore, in recent years, GBL research (including mine) focusses on precisely *how* to design GBL that works for its intended purpose(s). Rather than “using certain pre-existing patterns of design elements with presumed motivational effects, regardless of the contexts of use” (Dichev, Dicheva and Irwin, 2020), the emphasis is now on GBL designers integrating specific pedagogical approaches into game design, with an acknowledgement that this improves effectiveness (*cf.* Lamb *et al.*, 2018, p. 165.) Nevertheless, it seems that this approach is still far from being widely practised (Kalmpourtzis and Romero, 2020, p. 78.)

Focussing on the literature on GBL *design*, key considerations are: methodologies used; educational theories; (game) factors that deliver the desired outcomes; and learning contexts (Lameris *et al.*, 2017; Gao, 2023; Hijkoop, Skovbjerg and Bekker, 2024.) These are varied. Constructivism and experiential learning feature prominently for improving learning outcomes, with self-determination theory (*cf.* Ryan and Deci, 2000) being thought crucial for enjoyment. Recent reviews demonstrate that: both design elements and evaluation scales are generally unstandardised (Yao and He, 2023); a large proportion of studies have limited links between playful learning solutions and theory, and between intention and realisation via design decisions (Hijkoop, Skovbjerg and Bekker, 2024); and GBL design often neglects established good practice in learning science (Westera, 2019.) Guidance does, of course, exist but often is not consulted in real-world practice.<sup>11</sup> Much of the literature still refers to a “presumed conflict between learning and play” (Westera, 2019, p. 60) i.e., ‘balancing’ the serious and gameplay elements of GBL, usually with the implication that 1) they are inherently opposed and 2) increasing one tends to reduce the other (see, for example, Soumia *et al.*, 2023 who treat Efficiency of learning and Engagement as mutually exclusive categories.) A much more useful approach is the concept of “harmony” (Harteveld, 2011, p. 35) where “Game Mechanics should be coherent in relation to the Learning Mechanics” (Kalmpourtzis and Romero, 2020, p. 78.) In other

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<sup>11</sup> This firmly reflects my own experience of many examples being opportunistic and enthusiastic but lacking in contextualisation within theory and without a rigorous understanding of the underlying mechanisms that allow learning behaviours to be successfully translated into game mechanics that deliver what is intended. I expand on this in Chapter 3.



words, game mechanic(s) should be linked to the learning outcomes allowing students to learn *through* games rather than merely *whilst playing* games (Arnab, *et al.*, 2015; Maratou *et al.*, 2023.)

Therefore, there is now a critical mass of rigorous research which underpins the growing use of playful and game-based approaches in education, with an indication that (in some spheres at least) GBL is recovering from its previous poor reputation. There are still a range of barriers of course: ever-relevant resourcing issues; some perceptions of games as trivial or inappropriate (Whitton and Moseley, 2012; Moylan *et al.*, 2015; Marfisi-Schottman, 2019; Abbott, 2024b); and gaps in the knowledge and confidence of educators in designing and using them (Bates, 2022; Sandí-Delgado, Sanz and Lovos, 2022; Valencia and Duque, 2023.) Therefore, in practice, GBL is still some way off becoming accepted as mainstream.

### 2.3 GBL in Higher Education

Playful approaches in HE are becoming increasingly common and accepted worldwide (Baecher and Portnoy, 2024, p. vi.) Academic work which focusses specifically on GBL and play in HE ranges from early foundational studies (typically focussed on digital games e.g., Whitton, 2009) to substantial recent publications (James and Nerantzi, 2019; Marfisi-Schottman, 2019; Lane, 2022 to name just a few), demonstrating that the last decade has seen rapid growth in research and practice. Lately, there is a growing number of GBL or gamified approaches in HE (see Marfisi-Schottman, 2019; Maratou *et al.*, 2023; Baecher and Portnoy, 2024) and a range of communities of practice.<sup>12</sup> There is also a re-acknowledgement of the value of non-digital approaches (Maratou *et al.*, 2023), reflecting my own research, and even a recent analogue game to help HE instructors playfully transform their courses (Cabral, 2024.) However, despite the burst of interest and activity, GBL in HE is less well-developed than in most other educational settings. This is not (necessarily) because adults are less inclined to learn playfully than children, rather, there are barriers to adoption which are specific to HE (Moylan, Burgess, Figley, & Bernstein, 2015; Whitton & Moseley, 2012), especially the aforementioned opposition (or perceived opposition) to using games within adult learning (*cf.* Marfisi-Schottman, 2019, pp. 2–3), associated lack of institutional support (Maratou *et al.*, 2023, p. 79) and a lack of clarity about the role of the teacher (Lameras *et al.*, 2017.)

Furthermore, GBL design for research and research-related skills such as problem solving, critical thinking, creativity, and metacognition<sup>13</sup> (amongst others) is still emerging and is of particular relevance to HE, especially postgraduate study. Foundational work demonstrates high expectations for GBL's interactivity, novelty, and dialogic learning in the realm of research support (Boyle *et al.*, 2014 (who focus on statistics); McCutcheon and Bray, 2020; Bray and McCutcheon, 2021), enhanced and reinforced by my own research ([PWs4, 11,13.](#)) Moreover, there are now a handful of examples of published research on GBL for developing research skills or critical thinking, albeit for very specific purposes (Halpern *et al.*, 2012; Markey *et al.*, 2012; Tekluve, Cowden and Myers, 2015; Kollars and Rosen, 2017; de Wit *et al.*, 2018; Walsh, 2018; Sundsbø, 2019; Deniozou, Dima and Cox, 2020; Sillaots *et al.*, 2020; Basol *et al.*, 2021; Hoffner *et al.*, 2021; McCarty, 2021; Secker and Morrison, 2022; Bunt *et al.*, 2024.)<sup>14</sup> However, quantitative evaluation is relatively scarce (Maratou *et al.*, 2023,

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<sup>12</sup> Such as: (Playful Learning Association, 2024; Playful Learning Alliance, 2024; JISCMail - GAMETO LEARN List, 2024; Ludic Language Pedagogy, 2024; Professors at Play!, 2024; North American Simulation and Gaming Association, 2025; Games and Learning Community Group, 2025.)

<sup>13</sup> Metacognition has been described as “the WD40 of learning.” (Childs *et al.*, 2024, p. 193.)

<sup>14</sup> A significant amount of the written information on games for research exists as (unpublished) scholarly blog posts which are particularly vulnerable to disappearing (along with the games themselves.) Scholarship that I

p. 81) and the difficulties of evaluating high-level cognitive outcomes results in little research addressing GBL for high-level expertise at the functional, adaptive, or generative levels (Whitton and Moseley, 2012; Swan, 2021), i.e., those that include *apply*, *analyse*, *evaluate*, and *create* levels of Bloom's Extended Taxonomy. There is less still specific to a postgraduate context. Therefore, there is a significant research gap in the application of GBL to research skills in HE.

To conclude this research context, the literature emphasises that GBL approaches in HE should complement, not replace, existing teaching methods (Maratou *et al.*, 2023; Soumia *et al.*, 2023; Abbott, 2024b; Baecher and Portnoy, 2024.) They are "not the solution to everything." (Kalmpourtzis, 2018, p. 49.)

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am aware of is presented as a table at the end of the References, however the number of broken links for both games and the creators'/users' reflections is a noted weakness of the community's ability to share practice.

### 3 Positionality (or: why I don't know everything about everything)

#### 3.1 Summary of my practice

My professional role is primarily as an interdisciplinary researcher, with teaching responsibilities focussing on research skills. I have extensive personal experience of games/playful approaches which led to memorable emotional and cognitive effects, forming the belief that creating powerful memories can be leveraged for enhancing learning. My professional interest in games for learning coalesced around 11 years ago when, whilst undertaking a Postgraduate Certificate in Learning and Teaching, I specialised in game-based pedagogies (a subset of active learning) and, seeing a clear need on a specific course I was teaching, produced the prototype of my first serious game: *How to Fail Your Research Degree* ([PW1](#); the final version is [SW1](#).) Since then, I have developed both my specialism in GBL and my experience as a GBL designer through a wide range of research, pedagogic practice, game design practice, educational enquiry, and critical reflection.



Figure 5 - prototype cards for *How to Fail Your Research Degree* ([SW1](#).)

Through both professional development and collaboration with a number of other practitioners and researchers, I have developed my conceptual position, namely:

- GBL is (conceptually and practically) difficult to do well;
- GBL exists in a wider educational context which is often ignored;
- Practitioners' enthusiasm for GBL can lead to uncritical and/or unhelpful applications;
- Overlapping expertise in the three facets of Triadic Game Design (Figure 8) is extremely rare;
- There is an, often counterproductive, focus on games in digital formats;
- Nevertheless, GBL presents an extremely fruitful opportunity for improving learning.

This chapter explains how this positionality came about and contextualises my submission within the interconnected fields in Figure 6.

### 3.2 Scope of this submission

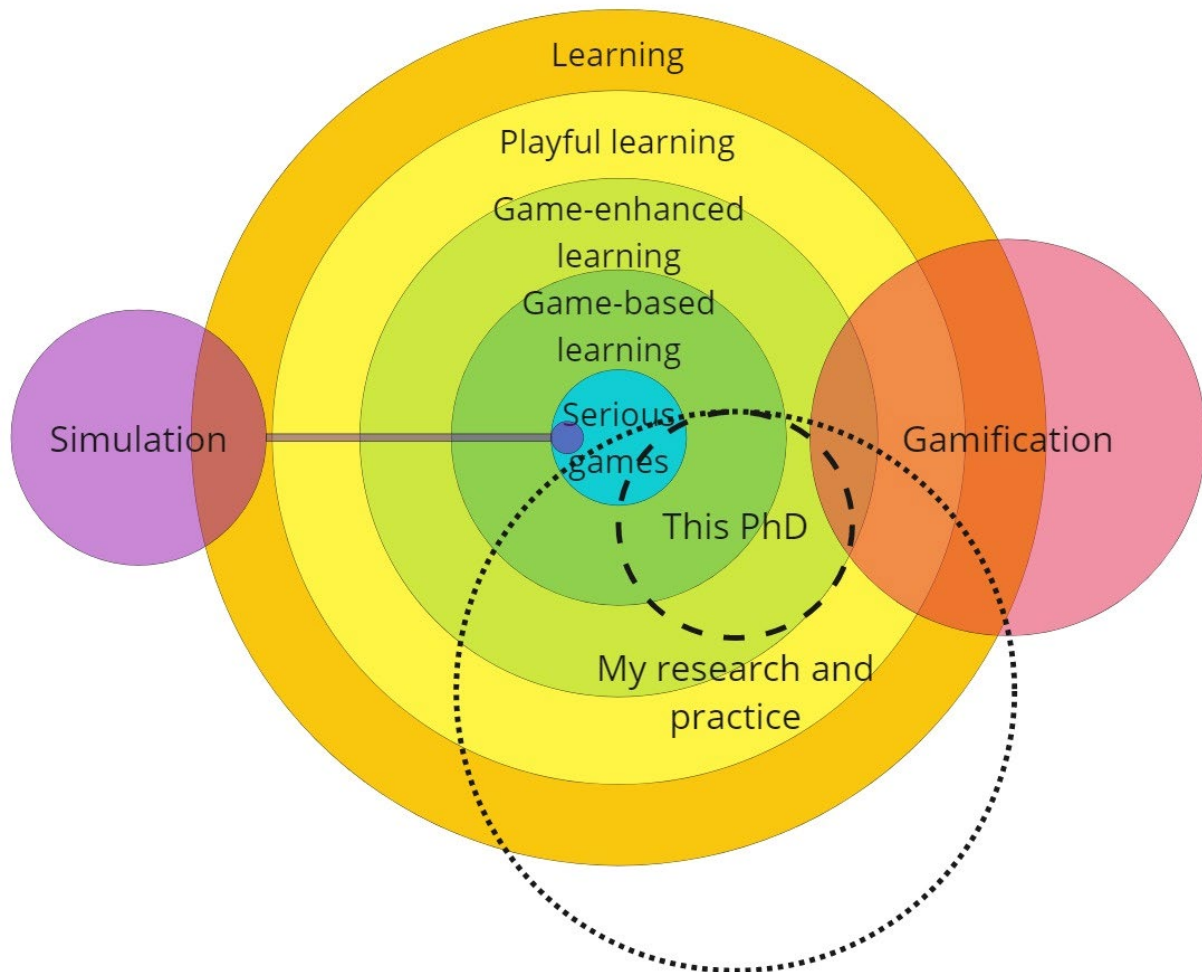
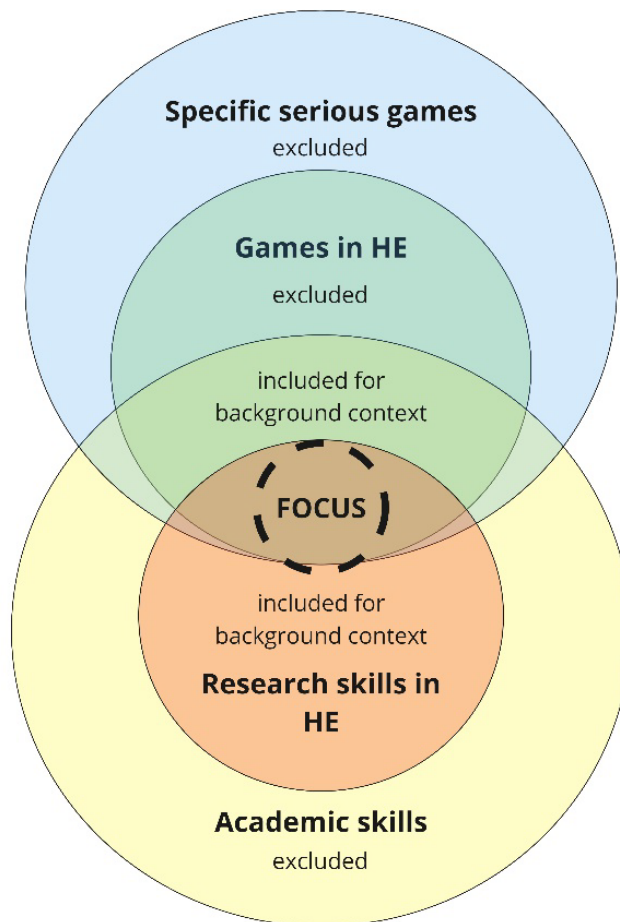


Figure 6 – the scope of this submission within a conceptual map of related terminology

Dashed lines in Figure 6 and Figure 7 show the precise scope of this submission. It is focussed on GBL specifically (sometimes incorporating gamification elements), within the context of related concepts. The main application area is higher order learning outcomes such as critical thinking and research skills in HE; under-researched topics which present particular challenges and opportunities. These capabilities are generically useful for learning in a variety of contexts so transcend disciplinary and sectoral boundaries, however, in HE, they are typically taught as a subject in their own right called variously: research skills; academic skills; metacognitive skills; learning development; researcher development; and critical thinking.

My practice and research extend beyond this topic (see dotted line in Figure 6), and naturally, whilst tendrils of complementary activity extend from this PhD into my wider work (and vice versa) I have tried to remain as focussed as possible in this submission. Furthermore, the value of my research depends on interdisciplinarity, and therefore the nuances of highly specialised related fields (whilst important) are outside my scope, as are the specifics of (non-educational) game design and non-game aspects of playful learning (e.g., learning through making.)

**Subject scope, focus of this submission  
marked with a dashed circle**



*Figure 7 - subject focus, showing the specific topic of GBL application and its related context, i.e., the overlap between game- based approaches within Higher Education and research, critical thinking, and metacognitive skills*

Figure 6’s mapping is not the only way to conceptualise GBL. Based on extensive experience in playful learning, Moseley describes three approaches:

- Applied/layered (explicit): the application of gamification or simulations to non-game activities which separate gaming and learning.
- Integration (implicit): play or game elements are designed to link to intended learning and learning is implemented through these designed activities.
- Playful design (inherent): playful or game-like principles are embedded in curriculum design. (Moseley, 2020, pp. 26–27.)<sup>15</sup>

As it (mostly) focusses on GBL rather than gamification or course design, my research falls into the second category: integration.

<sup>15</sup> See also the continuum of playful pedagogy in HE (Baecher and Portnoy, 2024, p. 5) and the “signature pedagogy for playful learning in higher education” (Nørgård, Toft-Nielsen and Whitton, 2017, p. 11.)

### 3.3 Conceptual position explained

GBL is a growth area. Its advantages are becoming clearer and its novelty can be attractive to both teachers and learners. However, a critical understanding of the field is less well articulated (partly because game creation is more popular than game evaluation and analysis) and GBL has struggled with a (somewhat deserved) poor reputation since it first started to go mainstream (Games and Learning Alliance, 2014.) The famous comparison to “chocolate-dipped broccoli” (Bruckman, 1999)<sup>16</sup> highlights the common situation of ‘edutainment’ which, as many scholars and practitioners have noted, is often neither educational, nor entertaining. The literature is in full agreement that educational content and game content need to be well-integrated for GBL approaches to be effective and rewarding. Nevertheless, this has not stopped educators continuing to make bad games, and game-makers continuing to make games that teach the wrong thing. (See also Grey *et al.*, 2017; Lameris *et al.*, 2017; Westera, 2019; Moseley, 2020.)<sup>17</sup>

The key issue here is that GBL is an inherently **interdisciplinary** practice (Schell, 2020; *cf.* Bisz and Mondelli, 2023.) Effective GBL requires blending subject expertise, pedagogic expertise, and game design expertise, a concept modelled effectively in the Triadic Game Design framework (Harteveld, 2011.) Practically speaking, this benefits from collaboration and collaborators will typically be novices in (at least) one of the overlapping domains (Figure 8.) This overlooked, explicit interdisciplinary link between subject, pedagogy and game design is crucial to synthesise player experience with instructional design.

When people play games they have an experience. It is this experience that the designer cares about. Without the experience the game is worthless. (Schell, 2020, p. 10.)

Games without strong pedagogical foundations are likely to fail (Lepe-Salazar, 2015; Westera, 2019) especially if design is undertaken with only a “fuzzy” notion of the role of the teacher and, without rigorous integration of learning and game mechanics *within the appropriate learning context*, games can create uncertainty and misalignments with outcomes (Bellotti *et al.*, 2013; Lameris *et al.*, 2017, p. 988.) Interdisciplinary challenges apply within design, furthermore the resource-intensive nature of GBL is exacerbated when actually producing the games. Game assets may require art, sound, and aesthetic expertise; narratives and rules documents require cultural, subject, and writing expertise; increased rigour in pedagogy and interactions comes from psychology and/or user-experience design; and of course, all GBL in formal learning environments needs to comply with organisational and national quality standards. Furthermore, significant (often expensive) computing expertise is required to make and test digital games. “How could anyone possibly master all of these things? The truth is no one can” (Schell, 2020, p. 4.) In depth understanding of every related field is outside the scope of one PhD, therefore, whilst it still is possible to produce good GBL as an individual “hero” game designer (Kalmpourtzis, 2018, pp. 3, 43), this is typically not ideal.

Understanding this interdisciplinarity is an excellent first step but understanding alone is not enough to create effective collaboration. Lack of time and money is a key barrier, as are: communication

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<sup>16</sup> See also the more famous “chocolate-covered broccoli” (Laurel, 2001), and the less-used “spinach sundae” (Jenkins, Squire and Tan, 2004.) A bit unfair to delicious vegetables in my opinion!

<sup>17</sup> It is the desire to improve the application of GBL that led to the ‘workflow’ strand that emerges from my research where the goal is primarily to achieve a tangibly better outcome for learners (and hopefully to repair some of the damage to the reputation of GBL along the way!) This pragmatic aspect is incrementally developed throughout the submission and covered in detail in [PWs3,5,6,7,10](#), as well as forming the core of the method for [SWs5,8,9](#).



between disciplines; a lack of follow-up evaluations to advance best practice; and as some have noted, a common power imbalance between Reality, Meaning, and Play when we make serious games (Moseley, 2020, p. 16) or between users and those who commission games (Hon, 2022.) Put simply, not everyone working on GBL is aware of the full range of interdisciplinary challenges that exist. “The practice of gamifying learning has outpaced researchers’ understanding of its mechanisms and methods” (Dichev and Dicheva, 2017, p. 1.)<sup>18</sup> Even when we do have this understanding, it can be impractical to apply interdisciplinary and collaborative methods in our day-to-day work, and even when we can, it is significant additional effort to properly evaluate and share our lessons to benefit others.

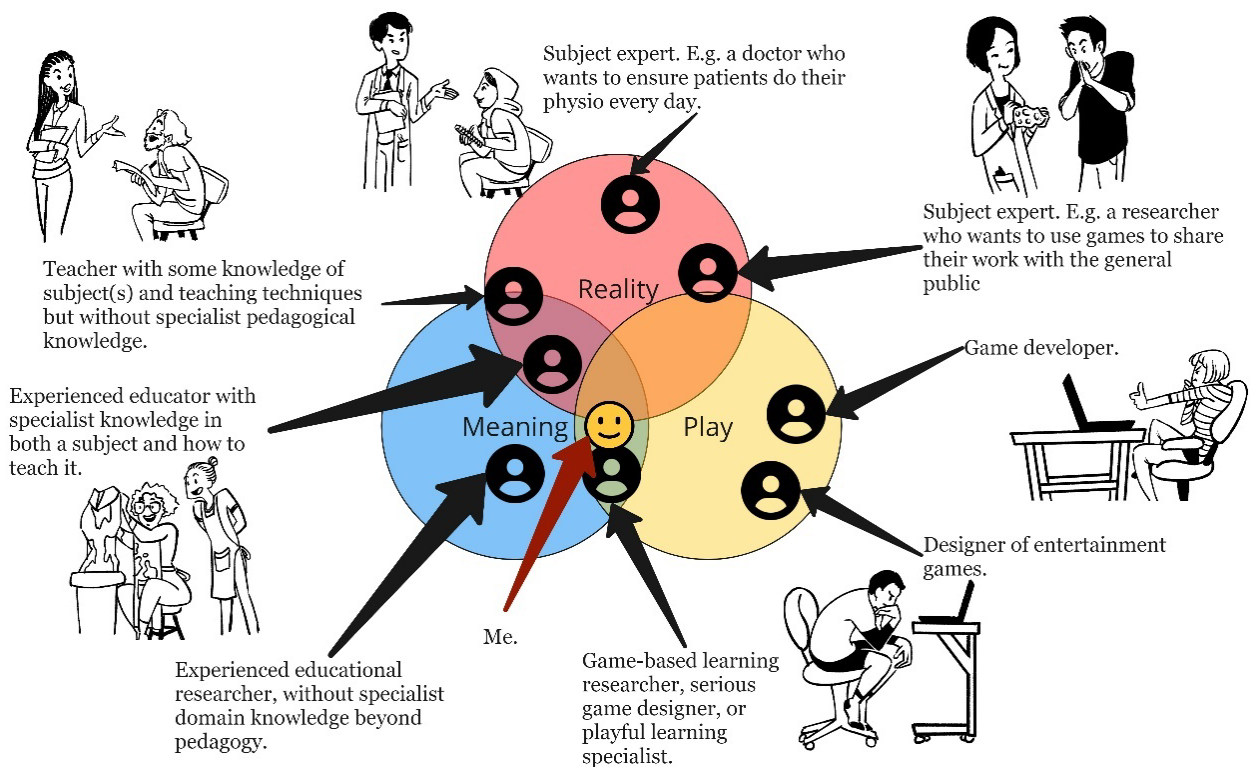


Figure 8 - a positionality diagram adapted from [SW9](#) showing where different roles exist within the interdisciplinary knowledge bases required in Triadic Game Design (Harteveld, 2011.) My own positioning is marked with a smiley face.

Figure 8 indicates where various roles exist in an interdisciplinary framework. I have positioned myself to show that I effectively combine pedagogical and game design capabilities, but would only occupy the centre of the diagram if the subject of the game happened to be a topic I am also an expert in (for example, teaching research skills.) Even then, my domain expertise is naturally lower than someone whose career is focussed on that topic. Possessing all three capabilities is exceptionally rare, and would still benefit from the expertise of specialists (depending on the rigour and depth of knowledge required by the game.) Finally, even within the relatively focussed position I

<sup>18</sup> None of us start out as expert GBL designers. Harteveld says “At the start of this journey, I was packed with (a) no knowledge or understanding of the subject matter at hand, (b) a basic understanding of the workings of the human brain and how people learn, and (c) little knowledge of games beyond playing them. Consequently, I found myself in quite some “challenging” position. [sic] Especially, since the “client” also had no experience with these types of projects at all.” (Harteveld, 2011, p. 1.)

occupy, at the overlap of pedagogy and game design, the sheer amount of academic literature in GBL (which has grown exponentially in recent years) means that it is impossible for any human to have a comprehensive knowledge of this interdisciplinary topic.<sup>19</sup>

To further refine my positionality, I propose that almost all challenges in GBL design are exacerbated when intended outcomes move beyond knowledge acquisition into critical thinking, affective, or behavioural outcomes e.g., those required for teaching research skills. This research gap is covered in Section 2.2, above, and informs the focus of this PhD. There are noted opportunities for GBL to effectively create lasting behavioural change through transformative reflection (Baumer, 2015; Khaled, 2018; Mekler, Iacovides and Bopp, 2018; Whitby, 2019; Abbott, Louchart and Chatzifoti, 2022) as well as enabling specific change processes, as explored in [SWs5,8,9](#) and, increasingly in recent years, in games that aim to address urgent, wicked, problems such as the climate crisis.<sup>20</sup> However, this remains a challenging prospect.

GBL design is *hard*.

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<sup>19</sup> A 2024 study (Tursunkulova, de Castell and Jenson, 2024) clearly articulates this problem, analysing whether an AI tool can be used to assist in surveying academic literature on GBL. It concludes that AI is not yet able to provide meaningful help: “Academic research and scholarship [is] so extensive that, even with the most cursory ‘scoping out’ kind of reading, it exceeds the capabilities of a human lifespan, let alone a doctoral fellowship. It seemed reasonable to look to AI for help, however we found InfraNodus [the AI tool tested] neither accurate nor, therefore, useful. It [is] severely limited in its ability not only to identify and represent conceptual networks across a large number of texts, but as well to do so even within a single text, leaving us with serious reservations about the kind of knowledge-representation any such GPT-enabled ‘big data’ analysis of academic research and scholarship would, or could, produce” (Tursunkulova, de Castell and Jenson, 2024.)

<sup>20</sup> A recent example covering cognitive, affective, and behavioural outcomes and drawing on doctoral research is *Climate Connected: Outbreak* (Fernández Galeote, Legaki and Hamari, 2023.)



## 4 Methodology and Methods

A PhD by Published Works is, by its nature, an assemblage of various related works, here encompassing game-related artefacts ([Supporting Works](#)), published theoretical and evaluative papers ([Published Works](#)), and this critical reflection. Therefore, methodologies and methods are themselves varied. The submission can be considered to be an annotated portfolio where “Artifacts are illuminated by annotations. Annotations are illustrated by artifacts” (Gaver and Bowers, 2012.) This is a core strength of the submission, as:

At times during the research, the game design researcher is also a game designer who produces the designed artifacts under consideration. While at other times during the research they need to act as a critical researcher whose aim is to produce knowledge by analyzing and producing insights based on their own experience of the process and from the analysis of the designed artifacts. To allow this dual identity to occur fluidly within the course of the research process requires flexibility within the adopted research methodology. (Hook and Coulton, 2017, p. 192.)

My submission includes research through design (RtD), which is considered to be a highly suitable form of academic research for games (Hook and Coulton, 2017, p. 174.) RtD has been criticised for the subjective role of the researcher; in my case this includes: adapting to the different learning, affective, and contextual needs of students at a range of levels; the practicality of game delivery and re-use; and the precise functionality of each GBL solution. However, as convincingly detailed by Hook and Coulton (2017), RtD requires a flexible, constructivist approach and subjective knowledge produced is critically assessed and validated by transparent definition and analysis of *how* and *why* design processes were undertaken, acknowledging the cultural background and motivations of the researcher (see Section 3.1, above.)

### 4.1 Overall approach

My overall epistemological approach is pragmatism. This is evidenced in action research cycles to design, implement, and critically analyse the successes, failures, and unexpected outcomes that emerge from my research, before using this knowledge to try again. This involves interfacing between theory, design, action research, and evaluation, underpinned by the ambition to create an impact both for learners who directly use my GBL, and within my field of practice. “In research through game design our aim is to produce knowledge which comes through the iterative critical and reflective practice and is likely represented through new methods, principles, and paradigms” (Hook and Coulton, 2017, p. 180.) Reviewing and improving my own practice alongside deepening my understanding of GBL theory has led not only to new methods and workflows but interdisciplinary (and intersectoral) collaboration has granted a clear understanding of the main difficulties and barriers faced by others. This in turn allowed further iterative reviews of methods making them robust both theoretically and practically.

Pragmatism also leads to some potentially controversial approaches which highlight the tension between (so-called) ‘best’ practice and ‘realistic’ practice. I have been in many an argument about whether, in fact, a game needs to be well-balanced and fair (an assumed no-brainer.) Is the effort of meticulously balancing a game justified if it’s designed to deliver its learning objectives in just one

play session? Is “fairness” always necessary for the game’s purpose?<sup>21</sup> Does a game have to be ‘really good’, or merely ‘good enough’? Should games for learning aim to be digital?

The answer to all of these questions is, of course, *it depends*. My research develops best practice according to GBL theory but I include pragmatic considerations *as an inherent part of best practice*, even when this results in compromise of theoretical best practice. I have co-designed minigames with schoolteachers in less than 4 hours ([SW5](#).) They are certainly not perfect, but evidence suggests they are good enough for their intended purposes ([PW7](#).) I defend non-digital GBL as a more practical (and often more effective) solution than digital games, despite much of the literature inexplicably including “digital” in the definition ([PW3](#).) I have collaborated on games that are genuinely annoying (for good reason... see [PW8](#).) In other words, there is no point making a perfect serious game if people can’t actually use it. In fact, the entire concept of an ‘ideal’ GBL intervention is problematic:

“For multi-objective problems an optimal solution does not exist. To solve these problems [...] people may find multiple “optimal” solutions.” (Harteveld, 2011, p. 35.)

Furthermore, “Since perceived usefulness, ease of use and goal clarity are important factors attracting learners to use serious games, designers should take them into serious consideration when designing serious games” (Zhonggen, 2019, p. 6.) Importantly, impact has always been a priority within my research. The submitted works evidence impact for students within my subject area and also offers clear and accessible ways to communicate best practice across contextual and disciplinary boundaries (in particular, [PWs3,6,7,10](#), [SWs5,8,9](#).) Therefore, sharing insights across relevant networks and international communities is a related outcome. As well as the obvious advantage of upskilling others by contributing knowledge to the field, maintaining an active relationship with the wider research context helps to reduce bias in GBL researchers and designers (*cf.* Hook and Coulton, 2017, p. 192.)

## 4.2 Summary of key methodologies and methods.

Figure 9 shows the approach of each of my publications. The core methodologies are GBL design, co-design, action research, learning experience design (LXD), and evaluation. The primary methods used for design and analysis are the LM-GM model (Lim *et al.*, 2013; Arnab, *et al.*, 2015), gameplay loop analysis (Guardiola, 2016), Triadic Game Design (TGD) (Harteveld, 2011.) TGD is also core to almost all of the [Supporting Works](#). Evaluation typically uses surveys. Key methodologies are summarised below.

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<sup>21</sup> See, for example, Dog Eat Dog (Liwanag Burke, 2012) or the previously mentioned Blacks and Whites, where obvious and awkward unfairness is key to the game’s outcomes.

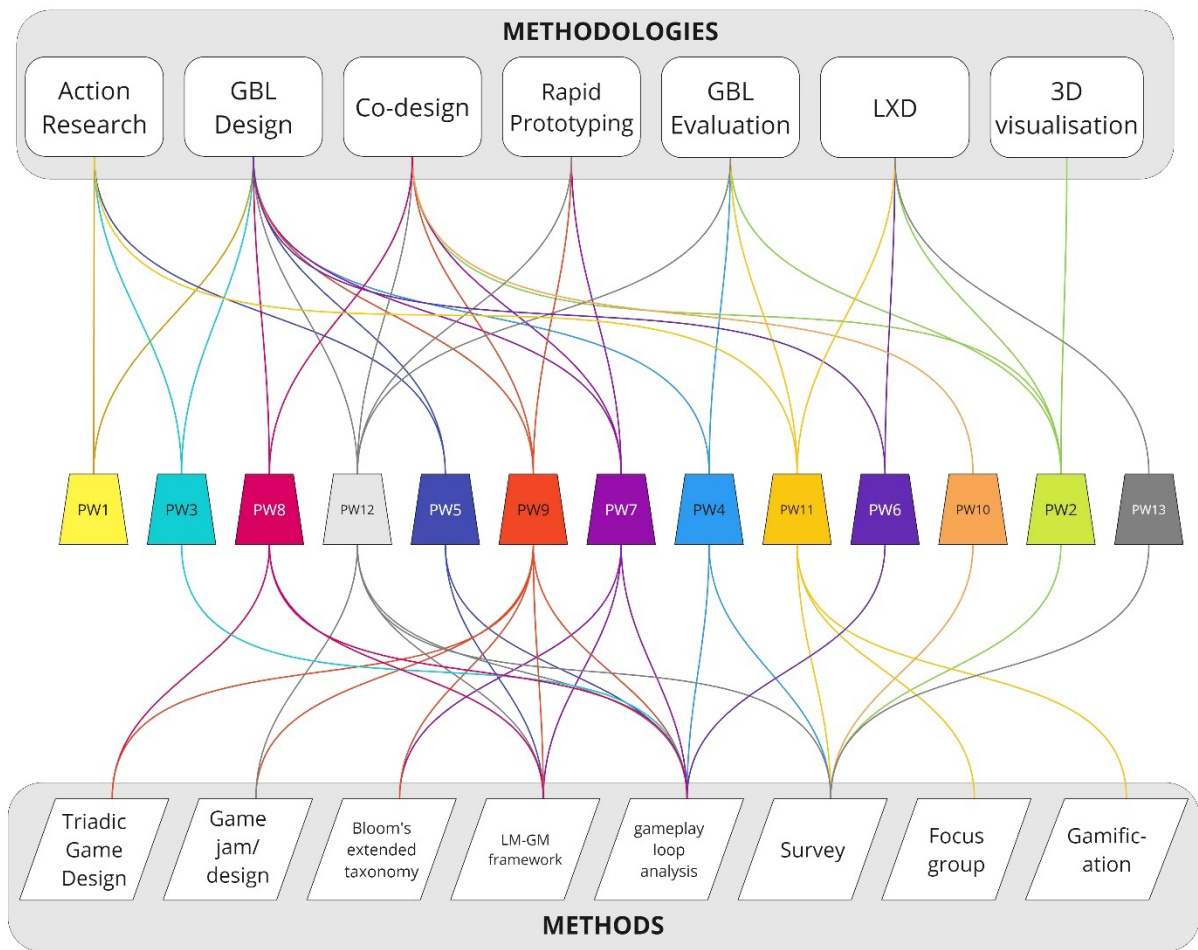


Figure 9 - mapping the methodologies and methods used in my 13 submitted publications. See Appendix 3 for [a larger image](#).



Please visit the [interactive version of this diagram<sup>22</sup>](#) to explore relationships in more detail

#### 4.2.1 Constructivism

Games are inherently constructivist. Like most other forms of active learning, games *require* players to engage, experience, and create their own meanings. A learning approach would not meet the definition of a game if it was not constructivist and GBL makes the individualised, experiential feedback loops, and the player's relationship with (and agency over) content, particularly visible. Furthermore, interactions in GBL span the range of Bloom's Extended Taxonomy, with gameplay typically including all levels up to Evaluate, often also including creative and strategic decision-making, and sometimes social learning.<sup>23</sup> Despite ongoing debates in the literature, constructivism, social constructivism, experiential learning, and behaviourism are not opposing theories but rather can be used in complementary ways in GBL, something I hope this submission achieves.

<sup>22</sup> <https://www.thinglink.com/card/1907849480762295140>

<sup>23</sup> See (Polin, 2018) for a detailed examination of games and social constructivism.

#### 4.2.2 Learning experience design

Learning experience design (LXD) is the design and creation of experiences that deliver learning through human centred, goal-oriented activities (Floor, 2023.) This goes beyond instructional and interaction design (respectively: creating learning experiences and designing interactions between users and products), and as outlined in detail in [PW6](#), LXD and GBL are conceptually very similar approaches. However, LXD as a theoretical framework places more emphasis on interactions being situated in a relevant learning context. Therefore, LXD has shaped much of the design and theoretical analysis in this submission, bringing in some of the less-researched sub-topics (e.g., emotional design) and challenges inherent in GBL.

#### 4.2.3 Action research

A methodology, widely used in educational research, that involves iterative cycles of planning, acting, observing, and reflecting. The focus is on making tangible improvements to practice in real settings (Reason and Bradbury, 2008.) More specifically, my work falls largely into the category of classroom action research (Kemmis, McTaggart and Nixon, 2014) with me acting as both the teacher and academic (e.g. [PWs4,5,8](#)) or academic collaborator ([PWs2,7](#).)

#### 4.2.4 Triadic Game Design, Serious Game Mechanics, and gameplay loops

These three techniques are complementary and target progressive levels of granularity within GBL design processes.

Triadic Game Design (TGD) is a core design philosophy that reflects the interdisciplinary nature of GBL design by blending three ‘worlds’: Reality, Meaning, and Play to produce good games with a purpose beyond entertainment (Harteveld, 2011.)

[W]hen we talk about games with a serious purpose, we talk about games that are based on and/or should have an impact on the real world. It is, however, not sufficient to only consider our “reality.” It is also required to consider how such an impact can be achieved. The game should have some “meaning” beyond the game itself and for this to happen, designers have to think about how this could take place. Finally, the third world has to do with the medium itself. A game is a tool or medium that is constituted by “play.”  
(Harteveld, 2011, p. 22.)

TGD is the design process that most clearly matches my own practice and is most appropriate for designing serious games.<sup>24</sup> The details of how I have applied TGD are reflected in [SW9](#), with each section of the workflow focussing on elaborating aspects related to each world in order to successfully blend them. Over time, my methods evolved to explicitly include, within the TGD philosophy, key design techniques from other pivotal GBL work. Firstly, the Learning Mechanic Game Mechanic (LM-GM) Framework to analyse and produce Serious Game Mechanics (SGMs) which “act as the game elements/aspects linking pedagogical practices (represented through *learning mechanics*) to concrete game mechanics directly related to a player’s actions” (Arnab, *et al.*, 2015, p. 393.) Secondly, gameplay loops which are a tool to “represent gameplay in action. We want to

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<sup>24</sup> Other frameworks include Mechanics, Dynamics, and Aesthetics (Hunicke, LeBlanc and Zubeck, 2004), Elemental Tetrad (Schell, 2020), Design, Play and Experience (Winn, 2009) and Design, Dynamics Experience (Walk, Görlich and Barrett, 2017). These are not used in my research.

convey the state of the player in the game system as accurately as possible, and to visualize the circulation between actions” (Guardiola, 2016, p. 2.)

A detailed analysis of how I have used, adapted, and extended these existing frameworks can be found in Section 6.3 Balancing rigour and usability in GBL co-design workflows , and these methods form the theoretical basis of [PWs3-10](#) and [PW12](#).

#### 4.2.5 Co-design

Co-design is a participatory approach whereby relevant actors are treated as partners rather than participants or users of research outcomes. As can be seen from previous chapters, I consider co-design between experts to be less of a methodological choice and more an inherent aspect of good GBL design (although again, pragmatism wins out when formal co-design is not practical.) My later publications explicitly focus on including different experts as co-designers, and on recommendations and workflows that facilitate their collaboration ([PWs7-10](#) and [PW12](#).) Note however, that co-design with end users is also recommended wherever possible and appropriate ([PW6](#)) as they are the experts of learner contexts and experience.

#### 4.2.6 Evaluation

Evaluation methods vary between different publications as appropriate to the specific research questions. As noted above, action research and RtD have significant advantages by enabling expert observation but have limitations, in particular the bias of the researcher. This limitation is present in all of the published works with the exception of [PW12](#) where the evaluation analysis was undertaken by the lead author who was not involved in the design of the process being evaluated. Evaluation is primarily quantitative, triangulated by qualitative analysis of text responses. Specific methods include survey, focus groups, pre-post-tests, and in [PW11](#), automated digital analytics. Specific frameworks for evaluation in this submission include Keller’s ARCS model (Keller, 2010), the NASA Task Load Index (Hart, 2006), and Intrinsic Motivation Index (McAuley, Duncan and Tammen, 1989.)

## 5 My Publications

This submission constitutes those parts of my research and practice which focus on GBL, primarily in postgraduate Higher Education (Figure 10 and Figure 11.)

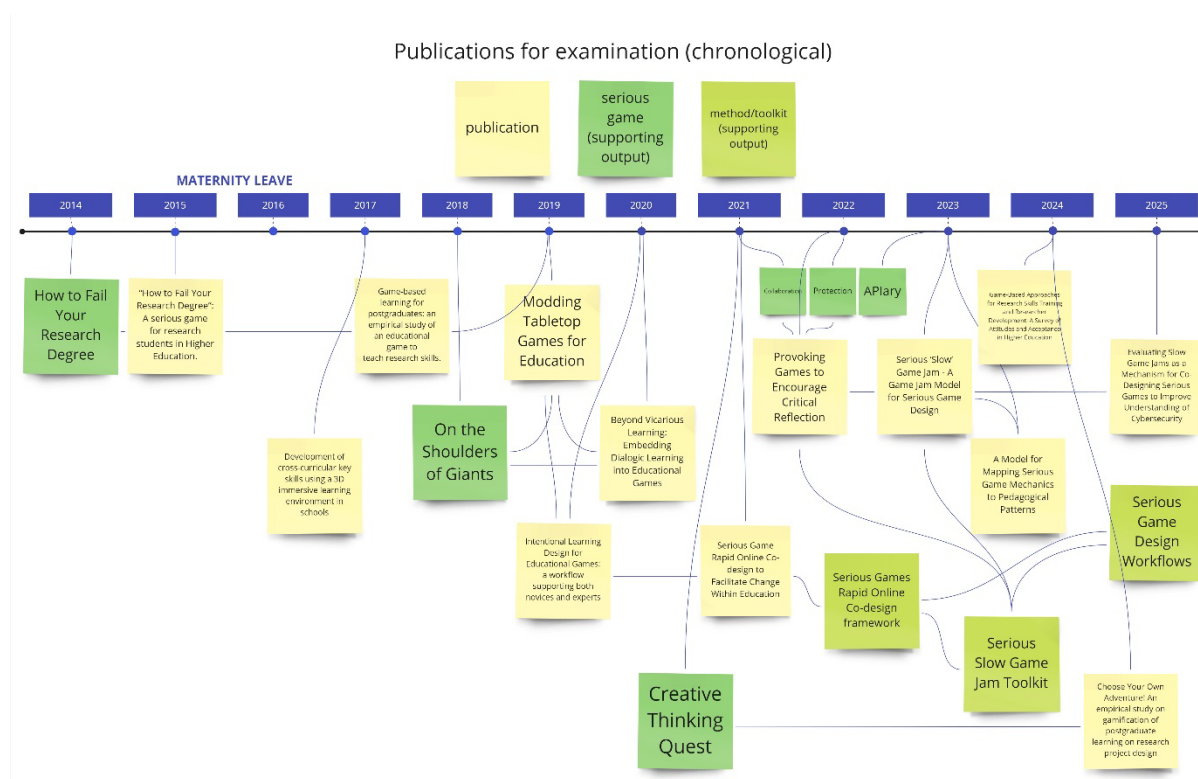


Figure 10 - chronological representation of the papers and supporting works, showing relationships. See Appendix 3 for [a larger image](#)

Figure 10 shows each publication (in yellow) by year. For ease of reference, this information is presented in [Appendix 1](#) with a summary of each paper's methods and contributions to knowledge. Each publication articulates its own specific context, methods, and sources; therefore, this chapter focusses on shared themes and relationships between the disparate publications.

### 5.1 Conceptual summary of my research

Figure 11 shows a categorisation of the publications by topic, which should be understood alongside the cross-cutting research activities and contributions to knowledge outlined in Table 1 and Table 2. There are two overlapping, complementary categories:

- 1) **GBL approaches for higher order learning outcomes** (primarily research skills but also encompassing dialogic learning and critical thinking), and
- 2) **Accessible interdisciplinary GBL design workflows**, aimed at improving collaboration.

Both categories include theoretical knowledge generation (through addressing research gaps, hypothesis development, and conceptual mapping) as well as the application of knowledge in practice (through empirical studies of how the new knowledge is implemented, and its evaluation within research, teaching, and co-design practice.) The interplay between conceptual categories is shown by lines indicating relationships between the different pieces of research, with many taking place concurrently, or being iteratively developed over time.



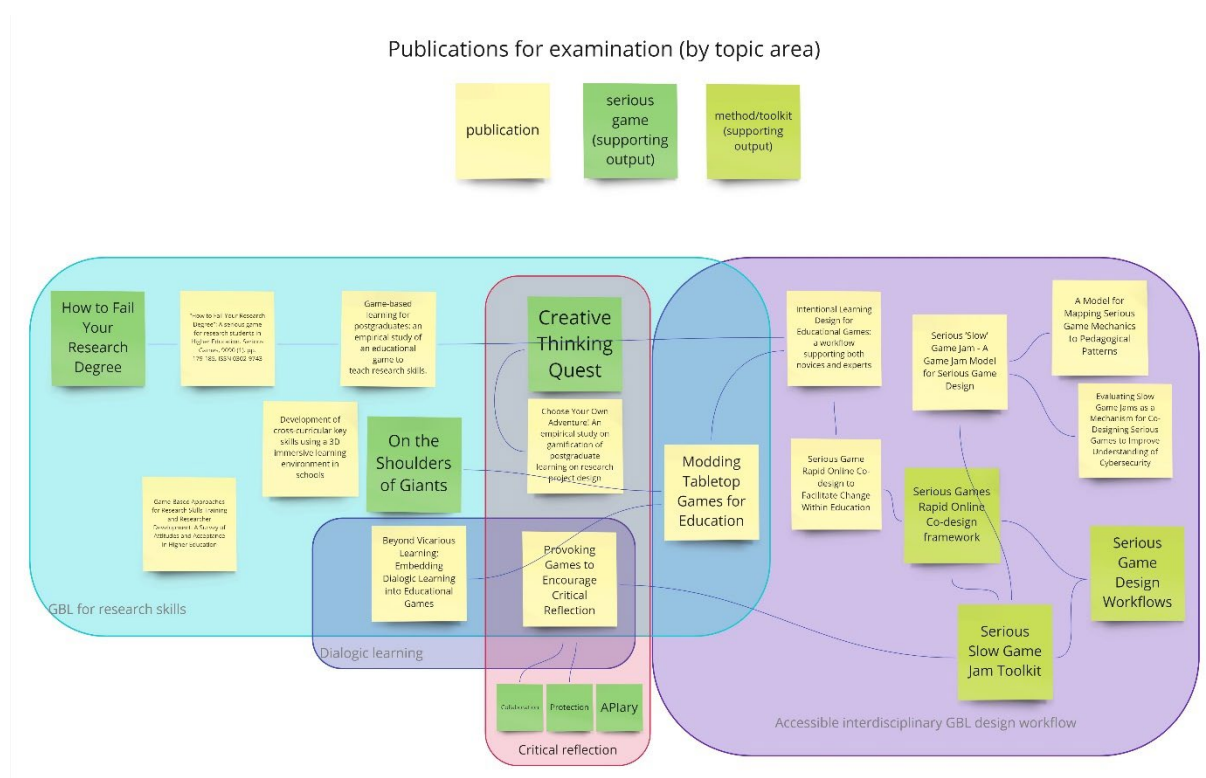


Figure 11 - diagram of submitted works categorised by topic. Arrows show conceptual and referential links, giving an indication of how the body of work developed. See Appendix 3 for [a larger image](#).

Below, I critically reflect on the published works within these categories, in their suggested reading order. Each publication is provided as a separate file within my submission. I have also created very short video abstracts for each publication (optional viewing but may provide a useful reminder.)<sup>25</sup>

## 5.2 Topic 1: GBL approaches for higher order learning outcomes

### 5.2.1 [PW1](#): “How to Fail Your Research Degree: A serious game for research students in Higher Education”

This paper illustrates my first steps in game-based learning. It analyses action research which aimed to improve delivery of a research skills course through GBL, resulting in a prototype of *How to Fail Your Research Degree* ([SW1](#).) It shows the nascent workflow developed in later research ([PWs3,6](#)), in particular the explicit analysis of context-informed learning behaviours. A key focus is learning through (safe) failure i.e., using emotional affect to create memorable learning outcomes. This preceded later studies (e.g., Fornós and Beier, 2024) although I had been influenced by the under-researched concept of “productive failure” (Kapur and Rummel, 2012) as a learning technique. Design also includes dialogic learning and Learner Experience Design (LXD) as important elements – both concepts would be later developed in [PW5](#) and [PW6](#) respectively.

Although this action research was somewhat opportunistic (it was conceived as part of my research for a Postgraduate Certificate in Learning and Teaching), it identified research skills training as a

<sup>25</sup> If you are reading in print format, all videos are in the suggested order as a playlist on my YouTube channel: <https://www.youtube.com/playlist?list=PLYSTIDobGINnZ8WU1fG62X7Z-cmCChWJb>

particularly appropriate topic for GBL approaches (cf. [PW13](#)), an area of urgent need, and a research gap. GBL approaches can be especially relevant for postgraduates, where metacognition and creativity are more prominent requirements of HE study (O'Donnell *et al.*, 2009; Bray and McCutcheon, 2021) and where *process* is often as important as product in learning outcomes related to postgraduate research.

The prototype won the Best Serious Game award at the Joint Conference on Serious Games, 2015.<sup>26</sup>



Figure 12 – receiving the Best Serious Game Award at JCSG2015 from Prof Eunice Ma and Prof Jannicke Baalsrud Hauge



### **PW1** [Video abstract](#) (2min)

#### 5.2.2 [PW4](#) “Game-based learning for postgraduates: an empirical study of an educational game to teach research skills”

This study substantially develops [PW1](#) by reviewing the issues specific to research skills in Higher Education, and convincingly evaluating (n=127) a finished version of *How to Fail Your Research Degree* ([SW1](#), Figure 13.) This addresses the research gap in empirical studies of GBL in HE. The contextual review underpins a range of later work ([PWs5,8,11](#), [SW4](#)) specific to critical thinking as part of research skills or behavioural outcomes.

This paper is one of the most significant within the submission, in terms of its scale, originality, and contribution to the field. It clearly articulates the need for innovative approaches when teaching research project design/management in a meaningful and memorable way, and, along with the

<sup>26</sup> <https://jointconference-on-seriousgames.org/>



game itself, has had significant impact in research development activities worldwide.<sup>27</sup> Theoretical developments include analysis of emotional design (Gee, 2013), intrinsic integration (Habgood and Ainsworth, 2011), cognitive authenticity (Kirkley *et al.*, 2011) and game-enabled reflection (Sandford and Williamson, 2005; Kirkley *et al.*, 2011; Khaled, 2018.) No similar approaches existed at the time for research skills development and the game overcomes some of the challenges inherent in learning and teaching postgraduate research skills, whilst raising some interesting discussion points about “painful learning” (Beard and Wilson, 2002), player agency, where learning actually happens in a gameplay loop, and the complex interplay between knowledge, confidence, and motivation.



## PW4 Video abstract (2min20)



Figure 13 - How to Fail Your Research Degree: finished tabletop game

### 5.2.3 PW3: “Modding Tabletop Games for Education”

This paper takes a particularly pragmatic stance (tabletop games were neglected in the literature at the time) articulating that as serious games become more widely accepted, the risk of novice designers making games that lack rigour increases. (This problem seems to have become even more pertinent in the years since... (cf. Marfisi-Schottman *et al.*, 2022.)) It brings together existing research to show that “educational game design is complex, resource intensive, and requires

<sup>27</sup> The paper has been cited over 100 times (as of Feb 2025), with clear evidence of enabling research by others. The game has been purchased (print-on-demand, non-profit-making) or downloaded for free over 200 times by academics in 40 countries, and in a range of sectors outside universities e.g., games companies and health organisations.

multiple interdisciplinary skillsets” (Abbott, 2019b, p. 318), a key theme of this submission. The paper makes the case that systematic analysis techniques (gameplay loops (Guardiola, 2016) and the LM-GM framework (Lim *et al.*, 2013)) can be used to increase: cross-disciplinary understanding; recognition of (as opposed to design of) appropriate learning mechanics (still a noted lack in teacher capabilities (Hu and Sperling, 2022)); and the speed and rigour of GBL design. A novel workflow to support educational modding is presented, with a focus on being accessible to less-game-literate educators. A worked example of a game to teach complex cognitive and affective learning outcomes related to students undertaking a literature review ([SW2](#)) reinforces the step-by-step guidance, along with a discussion of the kinaesthetic, social, and scaffolded learning experiences which can contribute to outcomes. Analysing learning context to establish desired learning *behaviours* (not just desired outcomes) is a key step. An important clarification is that the design process focuses on the *selection* and *validation* of an existing game that matches desired learning behaviours, which are defined first. A game should never be the “driving force” of GBL interventions (*cf.* Kalmpourtzis, 2018.)

Although I don’t return to modding in subsequent research, this influential<sup>28</sup> paper sets out the foundation for [PWs6,7,9](#), and [SW9](#), with their emphasis on learning behaviours, which develops previous GBL theory by considering context explicitly through an interaction design lens.



### *PW3 [Video abstract](#) (1min30)*

#### 5.2.4 [PW5](#) “Beyond Vicarious Learning: Embedding Dialogic Learning into Educational Games”

This paper addresses a research gap in the use of dialogic interactions in GBL (Arnseth, Hanghøj and Silseth, 2018) and, through action research, maps the characteristics of GBL to the interaction needs of dialogic learning. Using [PW3/SW2](#) as a case study, I analyse specific game mechanics that could be exploited for dialogic learning and propose a theoretically innovative interaction model for embedding dialogue *within* gameplay (as opposed to within a game debrief as is much more common.) The research includes direct recommendations for design principles to encourage dialogic learning. As part of this analysis, I extended the existing *Reflect/Discuss* Learning Mechanic (from the LM-GM model (Arnab, *et al.*, 2015)) to separate Reflection from Dialogue, and this is taken forward into future work ([PWs9,10,12](#), [SWs5,8,9](#).) As this paper was published during lockdown, it was not possible to perform experiments to validate the interaction model and its impacts. Nevertheless, the theoretical model was extremely favourably received by leading experts at a Special Track on Dialogic Perspectives on Games and Learning at ECGBL2020 (Hanghøj, 2020.)



### *PW5 [Video abstract](#) (1min50)*

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<sup>28</sup> Examining nearly 50 citations (as of Feb 2025) shows that the paper has underpinned research by others.

### 5.2.5 [PW11](#) “Choose Your Own Adventure! An empirical study on gamification of postgraduate learning on research project design”

Atypically for this submission, this paper focusses on gamification rather than GBL, resulting in the *Creative Thinking Quest* ([SW4](#)), action research focussed on creating direct benefits for my own students. (Initial design identified gamification as a more appropriate strategy in this specific situation due to the focus being on personalisation of a range of active learning tasks.) The paper covers design considerations, technical approach, and an evaluation of the tool focussing on personalisation and efficacy of particular gamification techniques. It addresses a clearly identified research gap for empirical studies on gamification in practical contexts, particularly for gamification that goes beyond “pointification” (*cf.* Ritzhaupt *et al.*, 2021.) Large-scale quantitative evaluation is triangulated with a user survey and focus group analysis. It identifies very positive feedback – yet this is from the very small percentage of users who actually engaged meaningfully with the Quest. This emphasises (again) the heterogeneity of learners in HE (particularly postgraduates) and that non-linear navigation in a quest format can be very beneficial for personalising learning (*cf.* Bisz and Mondelli, 2023), but does not suit all learners. The evaluation reinforces other recent findings regarding gamification’s impact on creative online engagement (*cf.* Zhang *et al.*, 2024) but also confirms much of the literature’s sceptical view of ‘generic’ gamification (Huang *et al.*, 2020; Ritzhaupt *et al.*, 2021; Hon, 2022.) This action research represents my steep learning curve (both technical and methodological), which is captured in practical recommendations for other educators.



### [PW11](#) [Video abstract](#) (1min)

### 5.2.6 [PW8](#) “Provocative Games to Encourage Critical Reflection.”

This paper is highly original in its investigation of reflective game design (*cf.* Khaled, 2018) and its application in the creation and use of two Small Provoking Games (SPGs: [SW3](#) and [SW6](#)) used within the SECRIOUS Toolkit ([SW8](#).) Games for transformative reflection and/or behavioural change (which were the goals of our SPGs within the cybersecurity domain) are very under-researched and have considerable untapped potential in GBL (whilst remaining very challenging to firstly achieve and then prove.) It has been noted that reflection can cause tension between learning outcomes and gameplay flow (Harteveld, 2011, p. 171) and this detailed analysis demonstrates our attempts to overcome this. The paper also considers short, single-use games and their potential for provoking critical reflection, when included in a wider reflective context (in our case, the SECRIOUS Slow Game Jam - see [PWs9,12](#).)

“Players were initially confused [...] however, continued experimentation allowed players to construct meaningful connections between game events and cybersecurity concepts. Players did express surprise (and sometimes frustration) during gameplay, especially at points that had been designed to challenge expectations or provoke ‘out of the box’ thinking” (Abbott, Louchart and Chatzifoti, 2022.)

Both SPGs (*Protection* ([SW3](#)) and *Collaboration* ([SW6](#))) were shortlisted for the ECGBL2022 Best Serious Game award but were “provocative” enough to really alienate one of the judges! The role of “positive negative experiences” is, in my opinion, one of the most misunderstood concepts in GBL, and therefore a fruitful area for continuing research (*cf.* Kalmpourtzis, 2018, pp. 98–99.) This concept is explored in my own previous work in the context of “productive failure” (Kapur and

Rummel, 2012) ([SW1](#), [PW4](#)) and emotional design ([PW6](#)), and in the wider literature, for example the excellent analyses of negatively valenced emotions and their impact on self-reflection (Bopp, Mekler and Opwis, 2016) and the “joy of immersing yourself in feeling like shit” (Wrigstad (2014) in his introduction to: Montola, 2010.) Although this is the only publication in my submission that explores the idea of non-fun games in depth, I explore this further in my wider work, particularly in relation to GBL design for critical thinking and behavioural change – already noted as a much-needed challenge in research skills and of course contemporary topics such as the climate crisis, fake news, and AI. As Montola puts it:

“The cognitive dissonance produced through experiencing positive negative experiences [...] is not a problem for these games: In fact it is an implicit design goal and a reason for players to participate [...] and] the scope of playful experiences is broader than most models suggest” (Montola, 2010, pp. 160, 166)

Therefore, the paper contributes significantly to the development of theory and practice for facilitating critical thinking and reflection, a crucial part of higher order learning outcomes.



### **PW8 [Video abstract](#) (1min50)**

#### 5.2.7 [PW2](#): “Development of Cross-Curricular Key Skills Using a 3D Immersive Learning Environment in Schools”

Although somewhat different from other papers in my submission due to its focus on digital heritage data, this article clearly articulates the metacognitive skills that can arise from student engagement with an exploratory, game-like 3D learning environment: collaboration, leadership, creativity, and emotional intelligence. It analyses the strong similarity between ‘game-like’ 3D environments and games in terms of exploratory and experimental learning, and uses a range of empirical data from comparative case studies to identify key risks and opportunities (for school-based learning.) The study addresses a research gap in focussing on cross-curricular competencies (rather than subject-based cognitive outcomes), thereby clearly linking with research capabilities for learners of all ages. Evaluation provides clear evidence that ‘game-like’ learning is highly motivating for schoolchildren, and that playful engagement leads to exploration, discovery, and experiential learning. To emphasise the relevance of this paper to the development of independence in critical skills, I will quote directly:

Boydell’s assertion that experiential learning “involves the learner sorting things out for himself” (Boydell, 1976, p. 19) was almost directly repeated by one student when he said “We mainly try to sort it out ourselves.” (Abbott *et al.*, 2017, p. 72.)



### **PW2 [Video abstract](#) (1min30)**

#### 5.2.8 [PW13](#) “Game-Based Approaches for Research Skills Training and Researcher Development: A Survey of Attitudes and Acceptance in Higher Education”

To round off Topic Category 1, this paper analyses the results of my 2024 study to gather original empirical data about attitudes towards GBL for research skills, directly from the UK HE staff that

deliver research training (n=92.) This paper fills a research gap on attitudes and acceptance for GBL within the particularly complex and dispersed academic research development community and directly addresses issues identified within the literature and raised in previous papers ([PWs4,11.](#)) The valuable insights arising from the data itself are enhanced by an analysis of the existing provision of GBL for research and the findings consolidate and add detail to literature on GBL acceptance in HE more generally. As one of the most recent papers in the submission, the focus is on creating insights to enable effective knowledge exchange and tangible impact.



### *PW13 [Video abstract](#) (1min40)*

## 5.3 Topic 2: Accessible, interdisciplinary GBL design workflows

This strand of the submission draws on implicit and explicit processes from the publications above, however, the following publications focus on practical implementation of novel GBL methods, rather than particular GBL interventions.

### 5.3.1 [PW6](#) “Intentional Learning Design for Educational Games: a workflow supporting both novices and experts.”

This book chapter demonstrates the ongoing evolution of my conceptual approach, framing GBL explicitly within a Learning Experience Design (LXD) theoretical framework. I map concepts between GBL and LXD, synthesising design processes from these two domains to develop the workflow from [PW3](#). I argue that each conceptual framework (LXD and GBL) can be used to improve practice in the other, when considered holistically (*cf.* Westera, 2019); this is borne out in the paper’s impact in LXD scholarship.<sup>29</sup>

The aim was to make rigorous GBL design more accessible even for complete novices, therefore, the chapter includes a very simple worked example with guidance on design and validation using a choice of techniques at different levels of granularity and suitable for different audiences. The example focusses on a primary school context, demonstrating the intersectoral impact ambitions that become part of later work ([PWs7,9,10](#), [SW5.](#)) This research was instrumental in developing the workflows and toolkits used on subsequent research projects where serious game co-design was a method ([SWs5,8,9](#), [PWs9,10,12.](#)) It also clearly demonstrates the evolution of my research from pedagogy towards heutagogy – although I didn’t know in 2020 that this was the name for what I was doing! Finally, the explicit mapping of relevant design fields (Figure 14) allows designers to better understand their own skills and establish where knowledge exchange or collaboration is required, a key theme of my future work.



### *PW6 [Video abstract](#) (1min40)*

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<sup>29</sup> 20 citations (as of Feb 2025) in various educational sectors.

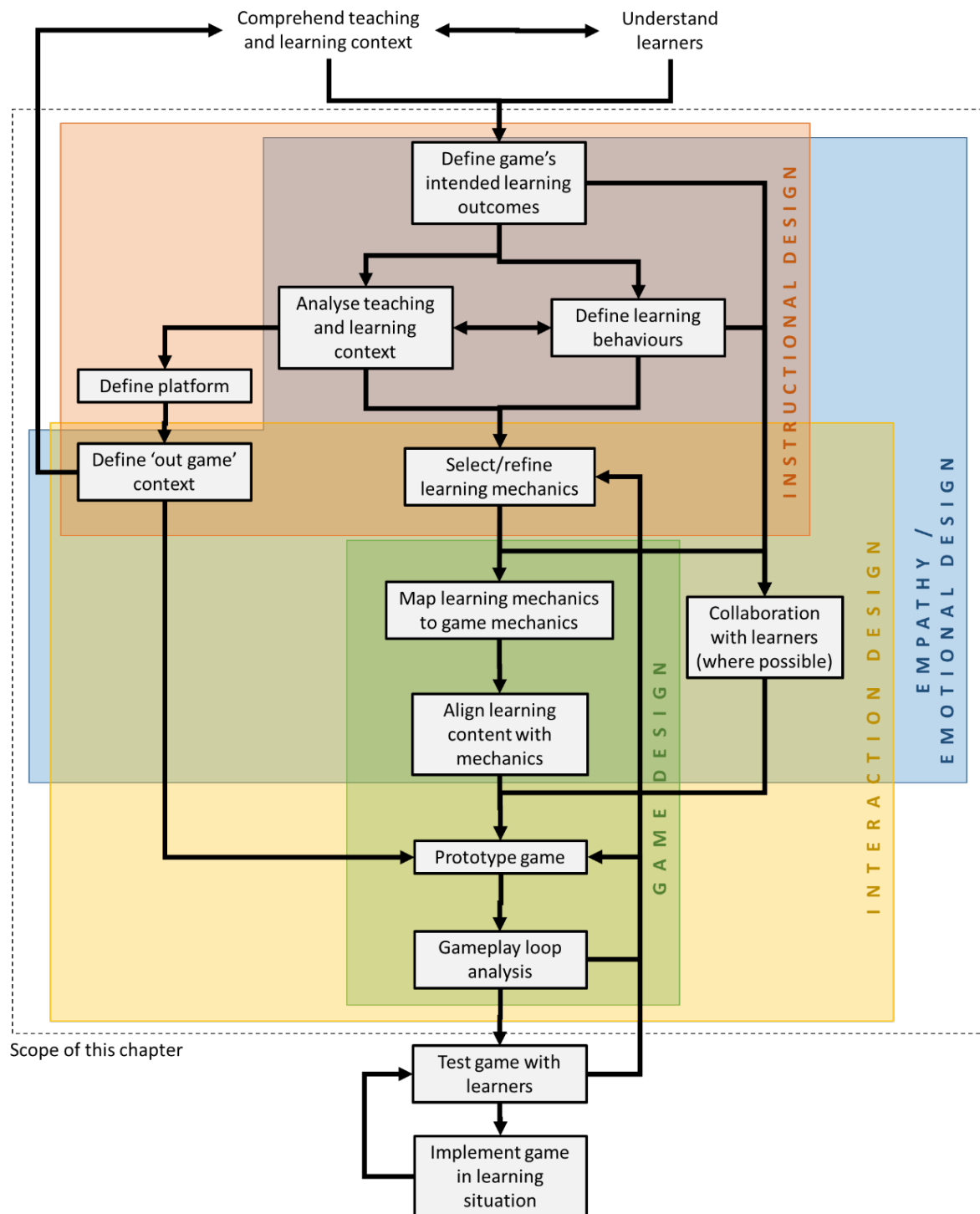


Figure 14 - mapping of different theoretical frameworks to a GBL workflow (Abbott, 2020b.) View image online at [https://edtechbooks.org/ux/11\\_intentional\\_learn](https://edtechbooks.org/ux/11_intentional_learn)



### 5.3.2 [PW7](#) “Serious Game Rapid Online Co-design to Facilitate Change Within Education.”

After a very rapid pivot to online methods during the COVID19 lockdown,<sup>30</sup> this paper analyses a framework for co-design between school-based educators and serious game designers. Making explicit the interdisciplinary skills required for good GBL, here the workflow transparently supports those skills as coming from different participants. The method and workshop was devised by myself (with significant visual design contributions from co-author Olga Chatzifoti), building on [PW3](#) and [PW6](#) workflows and adapting them to a specific project ([SW5](#).) Unlike previous workflows, here the theoretical focus is *online* co-design for change processes, which was novel at the time as no other guidance helped to map required changes/outcomes to game mechanics in a practical way for remote, dispersed users. Through applied use of this method to co-produce eight ‘minigames’ aimed at school improvement,<sup>31</sup> and a small-scale evaluation, we were able to identify strengths and weaknesses of the process which was instrumental in providing insights for developing the online and hybrid workflows used in the Serious Slow Game Jams ([SW8](#), [PWs9,12](#)) which also started during lockdown.)



[\*Global Science Show video about the workflow described in PW7 \(4mins\)\*](#)

### 5.3.3 [PW9](#) “Serious ‘Slow’ Game Jam - A Game Jam Model for Serious Game Design”

This paper presents a Serious Slow Game Jam (SSGJ) methodology, scaffolded workshop template, and supporting resources ([SW8](#).) We challenge the notion that Serious Game Jams are simply a subset of game jams (as previously categorised by some in the literature.) The inherent interdisciplinarity of GBL design forms the centre of our argument, contextualised by existing theory on game jams, and clearly demonstrating the different needs of a multi-disciplinary co-design team. The paper identifies elements that need to be markedly different from entertainment game jam formats: personnel (integration of domain experts); time (longer); and scaffolding (across disciplinary boundaries.) The paper navigates the blurry edges of what constitutes a game “jam”, with our position being that the key components of a game jam are collaboration, creation without preparation, and improvisation, not (necessarily) intense time pressure. For transparency, I will note that not all of the paper’s reviewers agreed with us!

Initial evaluation data is presented (a fuller evaluation is in [PW12](#)) and confirms that participants being novices in at least one of the facets of Triadic Game Design is common. Participant motivations were predominantly around gaining knowledge and skills (in both game design and the subject domain: cybersecurity), collaborating with experts, and having fun, which reinforces my previous argument that *process* (both educational and experiential) is at least as important as *product* for participants. The main contribution (apart from [SW8](#) itself) is the importance of framing serious game jams as explicitly process-based (educational) activities and potentially embedding them into existing learning contexts. There is already convincing evidence<sup>32</sup> that this paper is contributing to the field, in particular in increasing wellbeing and quality in game jams.

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<sup>30</sup> Note that Glasgow had one of the longest periods of level 3 restrictions (over 9 months, lasting until June 2021.)

<sup>31</sup> <https://www.agentsofchangetoolkit.org/games/>

<sup>32</sup> 12 citations in less than a year.





## PW9 Video introduction (2mins)

### 5.3.4 PW12 “Evaluating serious slow game jams as a mechanism for co-designing serious games to improve understanding of cybersecurity”

This co-authored paper is particularly valuable as it presents rigorous evaluation results for the approach taken previously (PW9, SW8.) It is firmly situated within the unique needs of cybersecurity education, which forms the context of the paper, whilst building on the game jam theory and context presented in PW9. The substantial evaluation focusses in detail on one game jam with 16 adult participants.<sup>33</sup> The key objective of the SECRIOUS project was to explore game approaches for behaviours related to cybersecurity practices. “Existing studies and reviews often report the effectiveness of game interventions on behaviour change without offering any insights into why and how games and gameplay are effective on a granular design level” (Hammady and Arnab, 2022, p. 3) therefore, we aimed to gain insights into knowledge, motivation, and engagement, alongside workload and reflections on the novel ‘slow’ aspect of the jam through both quantitative and qualitative analysis. Results show substantial gains in knowledge and, importantly, gains in behavioural intentions e.g., confidence to raise a security issues with a manager increases from 37.5% to 62.5% (Stals, Baillie, Ferguson, *et al.*, 2025, p. 3.) It provides further evidence that construction (of a serious game) enhances intrinsic motivation and topic engagement (*cf.* Lamas *et al.*, 2017, p. 980) and gives a very detailed view of which elements of GBL design are most challenging for designers in terms of cognition, workload, and/or motivation and therefore may need to be even further scaffolded in future processes. “A contribution of this research is that it provides other researchers with an evaluation protocol to measure workload and motivation levels [and] a benchmark for both workload and motivation levels in other types of game jams to be compared against.” (Stals, Baillie, Ferguson, *et al.*, 2025, p. 23.) The evaluation also covers the sub-methods used within the jam (e.g., LM-GM framework implementation through the use of card decks) and their positive impacts on independent learning and knowledge exchange.

Suggestions for improvements have been incorporated into the final toolkit, SW9. SW9 is currently being used in undergraduate and postgraduate teaching (at and beyond my institution), interdisciplinary research projects, and by individuals across UK learning development networks, with positive results (from direct informal feedback and formal course feedback.)



## PW12 Video abstract (1min40)

### 5.3.5 PW10 “A Model for Mapping Serious Game Mechanics to Pedagogical Patterns.”

Pedagogical Patterns (PPs) are a subset of design patterns (Bergin *et al.*, 2012), and this paper uses 12 serious games co-produced on the SECRIOUS research project<sup>34</sup> to map patterns for cybersecurity games to PPs. The focus is on creating a method to identify links between serious game mechanics (SGMs) and the more established (but under-used) research on PPs. The paper demonstrates

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<sup>33</sup> The project ran three jams in total: an evaluation with school-aged participants is presented in (Stals, Baillie, Shah, *et al.*, 2025) and further discussed in one of my co-authored publications that does not form part of this submission (Maarek *et al.*, 2025.)

<sup>34</sup> <https://secrious.github.io/>

challenges in GBL design which arise from lack of expertise in one or more aspects of Triadic Game Design and blurry terminology, whilst also providing clear evidence that there definitely is no one 'correct' way to design GBL (cf. Hartevelde, 2011.) The paper articulates how we developed the LM-GM framework to refine concepts and streamline its use with multidisciplinary teams. The main contributions are reflection on the mapping method used (which could be applied in any subject domain) and the conclusion that PPs offer another avenue for potentially improving cross-disciplinary communication when designing GBL. Lamas *et al.* note that "there is no comprehensive taxonomy that classifies game attributes with initial categories as to specifically depict how these elements can be translated into actual processes in SGs" (2017, p. 987) therefore this preliminary mapping provides a valuable complement.



PW10 [Video abstract](#) (1min50)

#### 5.4 Summary of publications

Figure 15 summarises the key topics explored in my submission, with annotations of where specific contributions lie within each topic. It shows that the situated knowledge<sup>35</sup> of my action research has led to theoretical innovation, and that theoretical investigations have reciprocally led to improvements in GBL practice. My varied professional roles (teacher, researcher, course designer) have allowed the research to be closely focussed on the actual needs and contexts of learners and subsequently integrated into real learning contexts. Key themes will be analysed in terms of their contribution to knowledge in the next chapter.

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<sup>35</sup> "The artifacts or systems, which are a product of an RtD approach, can be considered as a form of situated knowledge (Suchman, 1987) in that that they are bound within a particular instance of design." (Hook and Coulton, 2017.)

## Thematic analysis of submitted papers

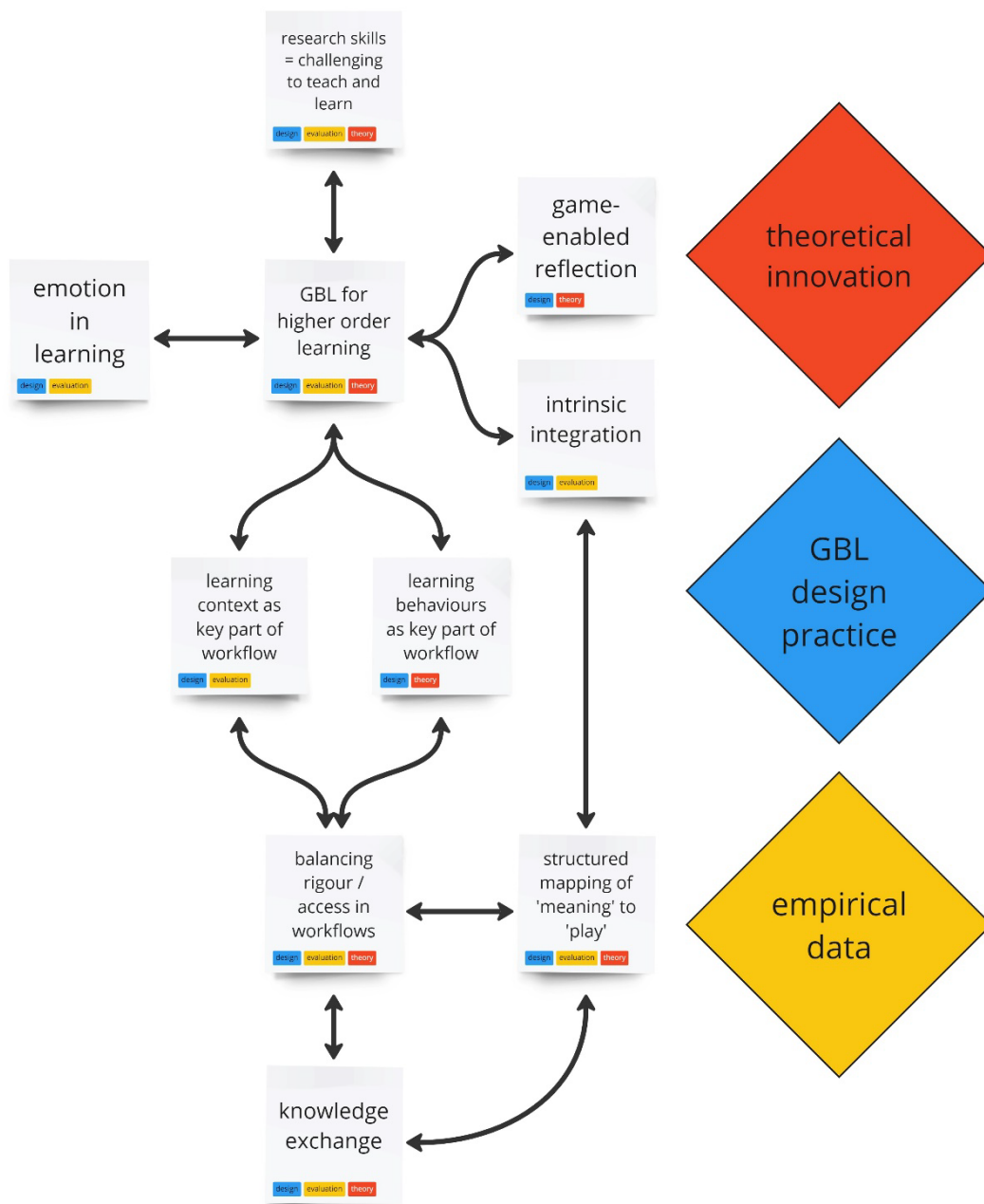


Figure 15 - key topics explored within the submitted papers, annotated with an indication of where the theme has been substantially developed in the submission in terms of theory, design practice, and/or provides empirical data.



Please visit the [interactive version of this diagram](https://www.thinglink.com/scene/1926318290729173669)<sup>36</sup>

<sup>36</sup> <https://www.thinglink.com/scene/1926318290729173669>

## 6 Contributions to knowledge and practice

This chapter articulates my main contributions to knowledge and practice, taking into account the research context that has been developing alongside my own work over the last decade. Table 2 (in the Introduction) summarises contributions alongside the research activities involved (Table 1) and publication/supporting work evidencing it. Each contribution is explored in detail below.

### 6.1 GBL for research skills and critical reflection

I have created, analysed, and evaluated a range of game-based approaches for the teaching and learning of higher-order thinking skills, covering research design and implementation ([PWs1,4,5,11](#), [SWs1,2,4](#)) and critical reflection for behavioural or institutional change ([PW8](#), [SWs3,5,6,8](#)). Specific application areas are: Higher Education postgraduate contexts ([PWs1,4,5,11](#), [SWs1,2,4](#)); dialogic learning ([PW5](#)); school change towards the sustainable development goals ([SW5](#), [PW7](#)); and cybersecurity practices ([PWs8,9,10,12](#)). My submission also analyses the current context of GBL for HE research skills, highlighting this topic as both an important focus for teaching innovation and a major research gap ([PWs1,3,4,5,8,11,13](#)). With the exception of the excellent curation and practice sharing activities of Bray & McCutcheon (2020; 2021), I am not aware of anyone else specialising in GBL for research skills in HE (supported by this meta-analysis: Aripin *et al.*, 2021.) “As noted in (Sandí-Delgado, Sanz and Lovos, 2022), no prior studies focus on acceptance of serious games for the development of academic competencies – and that study focusses on technological competencies” (Abbott, 2024b, p. 1441.) Additionally, outside of my own work, very few GBL approaches tackle research processes at a holistic level (as opposed to sub-topics such as data management, publishing, or library search.) Furthermore, many of the topics taught within research skills are metacognitive and therefore more difficult to directly address, in particular the ‘in demand’ topics of academic integrity, literature search/review, and now, Generative AI (Abbott, 2024b, p. 1447.) This focus is a key contribution of the submission.

My GBL practice is outlined in Table 4. [SW1](#) and [SW4](#) have had very wide reach, including extensive international use. Their effects and impacts are noted in the related publications and Chapter 5. The reach and use of [SW2](#) is unknown but expected to be much lower, at it relies on the purchase of a commercial board game.

Table 4 - my games for supporting teaching and learning research skills in HE. All are freely available online.

Game title	Refs	Topic	Taxonomy levels
How to Fail Your Research Degree	<a href="#">SW1</a> , <a href="#">PWs1,4</a>	Research project overview, risks and mitigations, required activities	Evaluate, Analyse, Apply, Understand, Remember
On the Shoulders of Giants	<a href="#">SW2</a> , <a href="#">PWs3,5</a>	Literature search	Metacognitive, Create, Evaluate, Apply, Understand
Creative Thinking Quest	<a href="#">SW4</a> , <a href="#">PW11</a>	Project design (both research and creative): ideation, development, refinement, scoping, de-risking, brief writing.	Create, Evaluate, Analyse, Apply

A further contribution is rigorous evidence ([PWs4,12,13](#)) of GBL’s potential to create useful affective outcomes supporting student wellbeing for a subject that is often considered to be boring and/or

intimidating, and the way in which it can facilitate and improve community-building. This is an outcome well-understood by researcher developers who identified GBL's positive impacts on dialogic learning, teambuilding, and collaboration ([PW13](#)), reflected in recent literature:

Utilizing the magic circle not only fosters a more supportive learning environment but also cultivates a shared understanding and sense of purpose among [participants], extending to their abilities and inclinations to engage and collaborate with one another. (Baecher and Portnoy, 2024, p. 4.)

My key contribution is to bring together all the specific research described in this submission to create a holistic understanding of the wider contexts of research skills training in HE and how it can be improved through GBL that is designed for these particular learners, their contexts, and approaches.

### 6.1.1 Emotional design for game-enabled reflection

As emotional design is increasingly acknowledged in pedagogical research, its corresponding inclusion and development within GBL is vital. The clear contribution here is the inclusion of emotional design as a structured input into defining Serious Game Mechanics (SGMs)<sup>37</sup> for critical reflection and applied guidance on creating the conditions for experiential learning: experience, reflection, abstract conceptualisation, experimentation (Kolb, 2014.) Some guidance includes aspects of emotional design (e.g., Schell, 2020; Bisz and Mondelli, 2023), however, the focus tends to be on motivation or flow (*cf.* Csikszentmihalyi *et al.*, 2014), rather than the impacts of emotional design on deep learning. The need for better techniques to approach critical and/or transformative reflection is covered in detail in [PW8](#), which made significant strides in advancing the theory and practice of GBL as more than “fun” affective experiences. It builds on the (sparse) existing theories of game-enabled reflection (Khaled, 2018; Mekler, Iacovides and Bopp, 2018; Whitby, 2019) as well as previous commentary on “positive negative” experiences (Montola, 2010; Bopp, Mekler and Opwis, 2016) as I touched on in Heading 5.2.6. This thread runs from the very beginning of this research (in particular [PWs1,4,6](#), [SW1](#)) and has resulted in both the inclusion of an explicit section on emotional design in [SW9](#), and in depth analyses of “stress alongside fun as a useful emotional response” (Abbott, 2019a) and “pleasantly frustrating” experiences (Gee, 2005, p. 10) ([PWs4,8](#).) This concept draws directly on previous research into experiential learning, productive struggle/failure and intrinsic motivation, cited in my publications. However, [PW8](#) expands the theory, formulating design principles for cognitive dissonance to create a range of emotions which support both dialogic learning and behavioural change, with indications of success. [PWs8,9,12](#) provide an understandable baseline whilst, as noted above, [SW9](#) emphasises the impact of emotion on both SGMs and out-of-game actions, within the TGD process.

## 6.2 Championing practical, authentic, analogue GBL

The research gap for analogue GBL is noted in Section 2.2. My work has drawn significantly on the concept of *intrinsic integration* which is defined as “an intrinsic link between a game’s core mechanics and its learning content” (Habgood and Ainsworth, 2011, p. 170), or in other words, that

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<sup>37</sup> Emotion is important enough to be the first of Schell’s Lenses (Schell, 2020, p. 19), albeit still largely framed through “fun”. See also <https://deck.artofgamedesign.com/#/?lang=en>

learning behaviours are required for, and happen simultaneously with, gameplay behaviours.<sup>38</sup> The authors also note that this allows learning to happen in the flow state (Csikszentmihalyi *et al.*, 2014) and the game should not interrupt this state. Furthermore, in relation to the cognitive authenticity of GBL, it is important that it creates realistic epistemic frames, clearly connecting its purpose to its application outside the game. Moseley calls this idea:

“an epistemic game: where activity operates within the realm of realistic context. The fidelity of the ‘reality’ is then not in generated graphics or scenes [...] but in the realism of the activity itself.” (Moseley, 2020, p. 28)

In this sense, “immersion”, noted by the literature as so important for deep and extended engagement (Hsu and Cheng, 2021) refers not to visual fidelity but to intuitive use of real-world tools, situations, and approaches. [PWs3,6,9,13](#) in particular make a robust case for using the most appropriate delivery method for GBL, which is often, for reasons of practicality, a tabletop game or playful activity. However, in both GBL and gamification, the concepts of intrinsic integration and cognitive authenticity can (and, I argue, should) also be applied to social and physical interactions, appropriate environments, non-digital tools or instruments, and player-to-player interactions. Put simply, analogue GBL is not only cheaper, it can also be better. When situated in ‘natural’ contexts, it can leverage the advantages of e.g., kinaesthetic (physical) learning whilst simultaneously removing cognitive overload issues common to GBL by using interactions that do not themselves have to be learned. To develop this point, GBL that increases cognitive load is typically because the presentation of learning content as a game creates *extraneous* load, or ‘overhead’. The goal is to reduce this extraneous load as much as possible whilst also reducing the *germane* load (mental effort required to learn) (*cf.* Childs *et al.*, 2024, pp. 130–138, 210), at which analogue GBL can excel (although often still does not (*cf.* Heikkilä, Paasivaara and Lassenius, 2016.)) Analogue approaches also reduce the need for potentially expensive equipment and introduce opportunities for vicarious learning (see [PW5](#)) (whilst of course having their own disadvantages such as potential lack of scalability.) As always, designers’ choice of platform depends on content, contextual, and behavioural parameters (*cf.* Kalmpourtzis, 2018, pp. 34–35), but don’t ask your players to learn how to flip a card on a computer screen if it could be flipped on a table instead.<sup>39</sup> It is notable that the advantages of tabletop games for accessibility has been emphasised much more in recent literature (e.g., Maratou *et al.*, 2023; Allcoat and Evans, 2024.)

### 6.3 Balancing rigour and usability in GBL co-design workflows

A wide range of guidance is now available for GBL design (recent substantial works include Kalmpourtzis, 2018; Bisz and Mondelli, 2023; Allcoat and Evans, 2024) alongside a range of playful practical tools, frameworks, and games (Marfisi-Schottman, 2013; Padilla-Zea *et al.*, 2018; Cable and Laurutis, 2022; Fotaris and Mastoras, 2022; Cabral, 2024; Gillaspay and Thompson, 2024) and the occasional online course (*Design and Development of Games for Learning*, 2018 (now no longer available); ‘Ludifik’action – Laboratoire d’Informatique de l’Université du Mans’, 2019.) However, “the process remains very complex and time-consuming for results that are not always satisfactory” (Marfisi-Schottman, 2019.) Furthermore, it is a clear trend of recent literature to consider: exactly

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<sup>38</sup> My favourite illustrative example is to compare SumDog (<https://play.sumdog.com/>), where players do lists of sums to earn access to a short game, and DragonBox (<https://dragonbox.com/>), where playing the game and learning algebra *are the same thing*.

<sup>39</sup> Another memorable real-life experience: during lockdown a group of playful learners spent nearly 40 minutes learning to use Tabletop Simulator controls before we could even start playing the serious game...

how GBL is integrated into educational and pedagogical contexts (Dichev, Dicheva and Irwin, 2020; Bado, 2022); implementation of ‘out of game’ instructional/reflective techniques (Bado, 2022); individual learner journeys (*cf.* Kang, Moon and Diederich, 2019); and practicality (Bisz and Mondelli, 2023). Despite this, very little research or knowledge exchange to date (apart from my own) provides a framework with enough scaffolding to be accessible for multidisciplinary novices (and achievable within their time constraints), yet with enough rigour to convincingly produce effective and practical games, aligned with the wider context of LXD and educational context. Schell’s Lenses (2020) remain inspiring, albeit not focussed on serious game design, and the ALLURE method (Bisz and Mondelli, 2023) is extremely useful from an instructional design conceptual framework, however, it is primarily aimed at school-level learning and, despite clearly making the point that “Not many people read manuals any more” (2023, p. 2), still requires aspiring GBL designers to read an academic book.<sup>40</sup> The iterations of the Serious Game Rapid Co-Design Workflow presented in this submission combine and adapt a range of useful theories and techniques with practical methods of knowledge exchange between designers with different expertise, focussing firmly on social constructivism to produce the most robust GBL solutions.<sup>41</sup> It does so in an approachable, visual format that requires no prior expertise and facilitates documentation of processes and decision-making as designers progress through the workflow.

Of course, rigour in design does not only improve results, it can increase confidence in GBL approaches as a whole:

Educating teachers about game mechanics and how they can be used for teaching and encouraging them to brief/debrief their students are both good ways to help teachers convince Learning Game skeptics among their students and colleagues. (Marfisi-Schottman, 2019, p. 8.)

Knowledge exchange is crucial to help GBL users understand if and how a game could suit their contexts and learners; this is one reason why I make efforts to share design rationale as much as possible. For example, every minigame within the [SWS](#) toolkit has a section called “Understanding [Game Title] better” which describes the underlying mechanics of how the game works, in understandable terms, and aims to assist users if they need to adapt the games.<sup>42</sup>

In each subheading below, I have analysed how my research helps to drive contemporary understanding of the nuances of GBL implementation, and make it more pragmatically achievable for a wide range of educators.

### 6.3.1 Applying and extending Triadic Game Design

Table 5 compares TGD’s overall philosophy, structured to embed the most appropriate other techniques (selected/tested through my 10+ years of Research through Design.) Each of these elements can be clearly seen in the structure and guidance of [SW9](#) (an extract from which is shown in Figure 16.) Specifics are further analysed in subsequent subheadings.

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<sup>40</sup> The ALLURE method includes many of the same processes as my workflows but from a different conceptual framework and with a markedly different understanding of what comprises a game or learning “mechanic.”

<sup>41</sup> Note that structured social constructivism can also encourage inclusion and diversity (Bisz and Mondelli, 2023, pp. 10–11, 43.)

<sup>42</sup> <https://www.agentsofchangetoolkit.org/games/>



Table 5 - the (adapted) application of TGD in my research. Aspects marked with an asterisk are either original or have been significantly added to in [SW9](#).

World	Related aspects (from Hartevelde, 2011)	Implementation in <a href="#">PWs7,9,12</a> , <a href="#">SWs5,8,9</a>
<b>Reality</b>	The problem that has to be dealt with	<ul style="list-style-type: none"> <li>• Describe problem</li> <li>• Pinpoint specific area of intervention and designer motivation</li> </ul>
	Factors involved in the problem	<ul style="list-style-type: none"> <li>• Identify and describe problem factors</li> <li>• Collaboration with subject experts*</li> </ul>
	Relationships between factors	<ul style="list-style-type: none"> <li>• Identify and model relationships</li> </ul>
	How relationships evolve over time	N/A
<b>Meaning</b>	What the game needs to achieve	<ul style="list-style-type: none"> <li>• Define desired change</li> <li>• Define Intended Learning Outcomes*</li> </ul>
	The context in which the value creation takes place	<ul style="list-style-type: none"> <li>• Define learner context in terms of who/when/where/with and additional factors.</li> </ul>
	The strategy of how purpose will be achieved	<ul style="list-style-type: none"> <li>• Categorise change as Cognitive/Affective/Behavioural *</li> <li>• Identify desired emotional reaction(s)</li> <li>• Describe desired and contextual learning behaviours*</li> </ul>
	Concrete operations to achieve this purpose	<ul style="list-style-type: none"> <li>• Analyse learning using Bloom's Taxonomy verbs/levels*</li> <li>• Categorise learning behaviour qualities* <sup>43</sup></li> <li>• Define Learning Mechanics to achieve desired behaviours</li> <li>• Collaboration with pedagogy/GBL experts*</li> </ul>
<b>Play</b>	Gameplay e.g., challenges and actions	<ul style="list-style-type: none"> <li>• Map LMs to appropriate GMs to create SGMs, note how each will be implemented</li> <li>• Sketch gameplay loop*</li> <li>• Establish evaluation criteria*</li> <li>• Add 'Out Game' interactions*</li> <li>• Collaboration with GBL experts*</li> <li>• Iteratively refine to ensure SGMs remain central to process</li> </ul>
	Game world	<ul style="list-style-type: none"> <li>• Define based on SGMs and emotional design</li> </ul>
	Delivery medium/technology	<ul style="list-style-type: none"> <li>• Confirm based on context, behaviours, and SGMs</li> </ul>
	Goal of the game	<ul style="list-style-type: none"> <li>• Define, based on ILOs, SGMs, behaviours, and context.</li> </ul>

<sup>43</sup> This specific aspect of the workflow is 90% credited to Olga Chatzifoti as part of her work with me on the Agents of Change Toolkit, see [PW7](#) and [SW5](#).

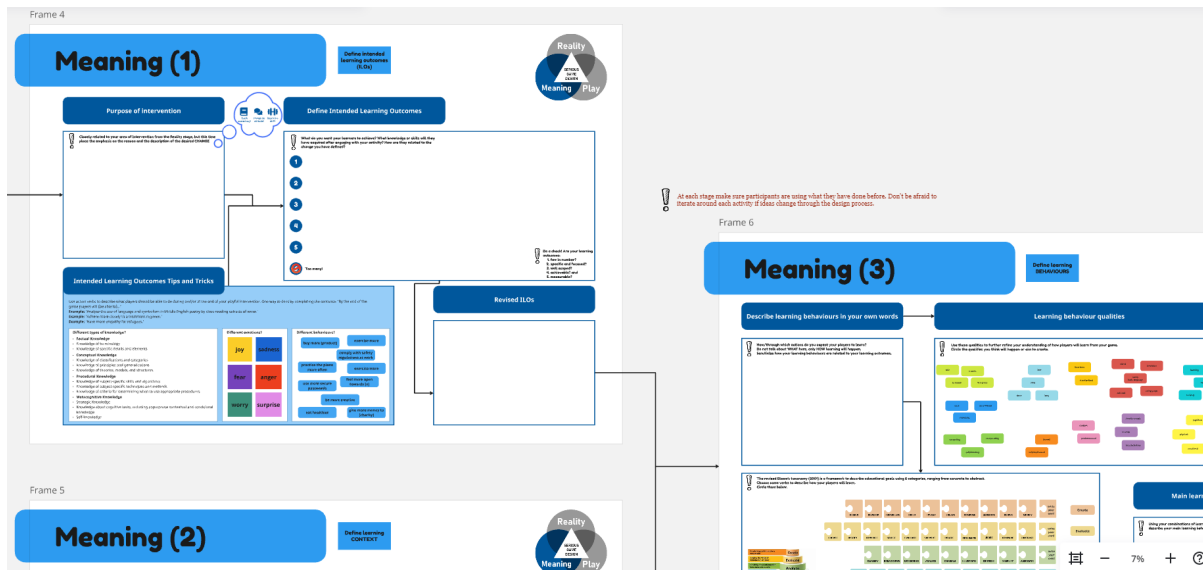


Figure 16 - screenshot of [SW9](#), a structured workflow which builds on Triadic Game Design



Please explore SW9 via the [interactive whiteboard](#)<sup>44</sup> for a comprehensive understanding of the method

It is important to be clear that “all three [TGD] worlds need to be considered at (more or less) the same time” (Harteveld, 2011, pp. 23, 36–39) in order to address any tensions that arise. TGD does not offer a step-by-step process to learn the craft of serious game design (2011, p. 33.) However, as acknowledged within TGD, it is actually impossible to consider all the nuances and relationships simultaneously (2011, pp. 36–39.) This is especially true where different co-designers have different expertise and priorities. Therefore, carefully scaffolding Reality, Meaning, and Play as sequential, but with explicit iterations and revisions, and a focus on the interplay between the three, alongside learner interactions (*cf.* Harteveld, 2011, pp. 81–83), is crucial to make the process accessible to the (now very wide) range of existing and aspiring GBL designers. During facilitation of this workflow throughout my research, I have found that participants find it all too tempting to come in with a preconceived idea of what their game will be<sup>45</sup> – a practice which I vigorously discourage until Reality and Meaning have been fully considered! Harteveld also states “at the start [...] no discussion should take place about what the rules of the game are. The discussion should be about defining the problem and purpose” (2011, p. 38.) My research extends TGD from “design philosophy” (2011, pp. 23, 36) into applied guidance for realistic working contexts that that are more likely to be authentic and effective (*cf.* Moseley, 2020, pp. 31–32.) It takes into account recent changes in practice and, in particular, a more developed understanding of the concept of Play as not necessarily synonymous with ‘fun’, but rather with ‘reward’ (*cf.* [PW8](#)) Furthermore, the workflows include careful visual design<sup>46</sup> and leverage the “drag and drop” interactivity of online collaborative whiteboards to increase their ease of use, as recommended by Lamas *et al.* (2017, p. 989.)

<sup>44</sup> [https://miro.com/app/board/uXjVK0ePzaU=](https://miro.com/app/board/uXjVK0ePzaU=/)

<sup>45</sup> It is very common for ‘define change’ to result in “We’re going to make a deck-building game to–”

<sup>46</sup> I am indebted here to the excellent visual design skills of co-author Olga Chatzifoti.

My research also offers a useful narrowing or shifting of the focus of some aspects of TGD relevant to its contexts of use. Harteveld discusses that Reality in games refers to a “model of reality” that requires domain-specific knowledge and is variable and subjective (Harteveld, 2011, pp. 40–41.) In education the conceptual model of reality is already an interpretation by subject experts – for example, existing curricula, or the acceptable baseline of a skill – which is then further interrogated and refined during GBL design. Therefore, Reality already encompasses representation through pedagogy to a greater or lesser degree. Harteveld broadly equates Meaning with *value* to both the player (Knowledge, Skills, Attitude) and to others (through Assessment, Data Collection, Exploration, and Theory Testing.) As can be seen in [SW9](#) and Table 5, I have shifted the “value proposition” (how the GBL will impact the world) to the Reality phase to help transition into defining the main purpose of the GBL. My “Meaning world” is also significantly extended with additional techniques for pedagogical and contextual analysis, emotional and behavioural design, and the detailed design of serious game (or serious play) mechanics and structures for what Harteveld calls “operationalizing the plan” (2011, pp. 130–160) (see subheadings below.)

Furthermore, [SW9](#) extends the focus of TGD back out again from serious games to the wider context of gameful and playful learning (see Figure 2) and evidence of its appropriateness for designing playful approaches that are *not* games, in an equally rigorous fashion, can be found in [SW5](#).

### 6.3.2 Inclusion of learning behaviours as an explicit ingredient in GBL workflows

In my workflows learning *behaviours* are separated from learning *mechanics* (LMs.) This helps to emphasise the role of context (and specific learning settings (Kalmpourtzis, 2018, pp. 19–20)) and how it affects the learner’s approach and engagement. For example, doing Duolingo for five minutes on the bus is very different from learning a language in a classroom, or through immersion. When learning context is mentioned in GBL design guidance, it is often de-emphasised in terms of its impact on the learner behaviours which become a)possible and b)likely within a GBL interaction system. In previous work, context tends not to be approached from an interaction design lens. For example, Kalmpouritz’s “magic triangle” (2018, p. 54) is placed within learning contexts but there is no clear link from context to learning mechanics; and using a framework that doesn’t mention context at all (Yusoff *et al.*, 2009), Allcoat and Evans suggest that instructional content is what should shape game mechanics (2024, p. 29) whereas my position is that it is actually behaviours. Even Harteveld places context as “the fourth and final aspect from the world of Meaning” (2011, p. 160) rather than a crucial factor that contributes to defining the problem. My approach, from the LXD conceptual framework (Figure 14, [PW6](#)) is that LMs and GMs must be defined *before* learning content can be designed, themselves requiring an understanding of context, learners, and overall learning objectives which lead to learning behaviours (Figure 17.) In other words, *how* learners will behave is more important than *what* they are learning when designing effective SGMs.

[SW9](#) includes the definition of both desired and contextual learning behaviours (e.g., repeatedly glancing out of a bus window is contextual behaviour that is not designed into a system, yet should be taken into account) and scaffolds their categorisation. There is no scope here to go into situative learning theory in detail, however it is important to recognise that this perspective encompasses intentional and unintentional learning, and relies on context, environment, learner identities, and interactions (Childs *et al.*, 2024, pp. 248–253), all of which are fundamentally affected by the design of learning systems in GBL and, for example, online learning. This makes it a particularly useful (albeit under-used) theoretical foundation for a GBL workflow.

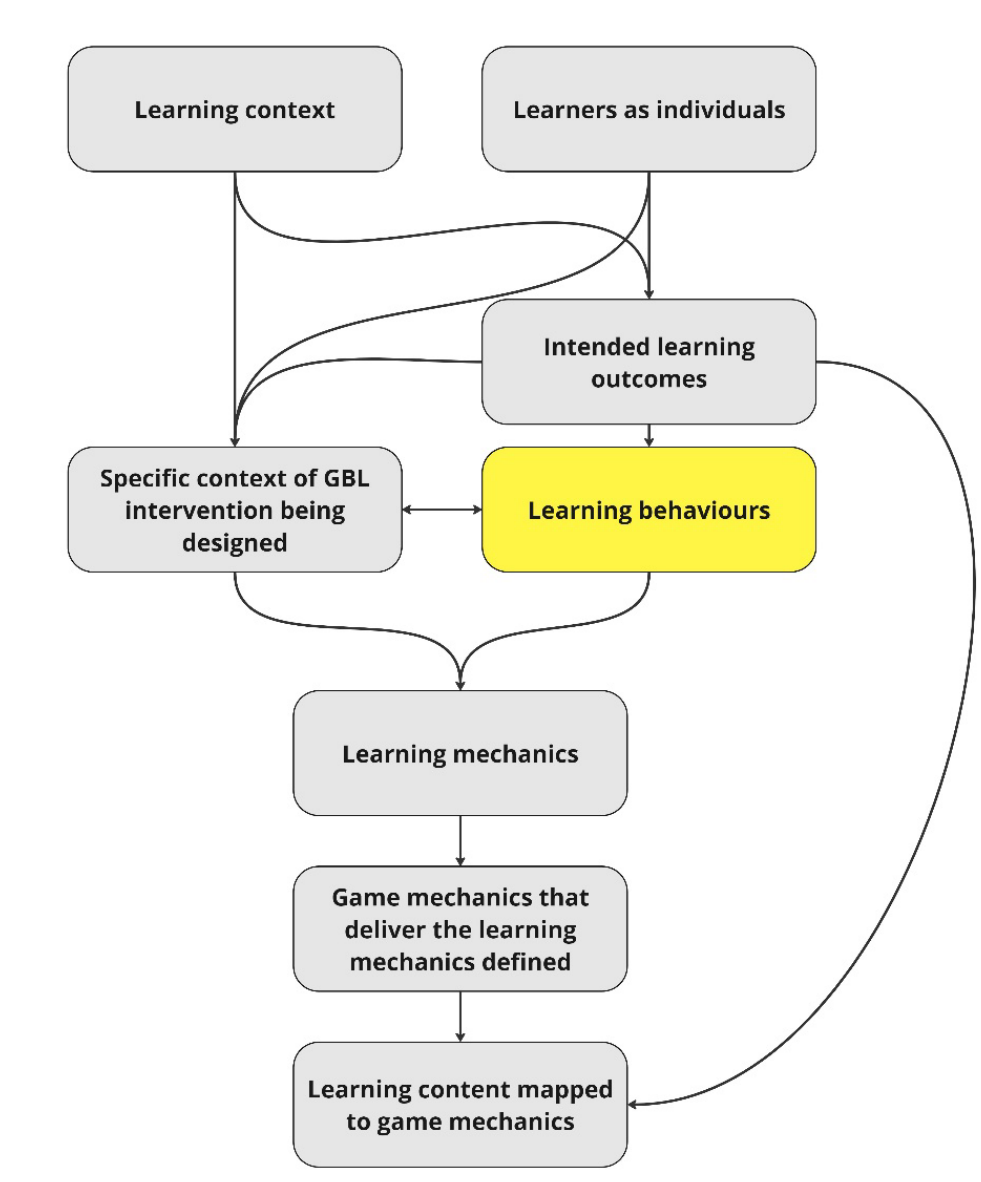


Figure 17 - positioning learner behaviours as a crucial part of GBL design

It is notable that games, unlike other media, tend to be categorised by interaction behaviours (e.g., ‘deck builder’, ‘button masher’) rather than content (Harteveld, 2011, p. 71; Bedwell *et al.*, 2012; Gameopedia, 2025; *BoardGameGeek*, 2025, amongst others), yet the specifics of contexts and behaviours are often omitted in GBL guidance. As noted previously, a “contextual gap” (Brookes and Moseley, 2012) can affect the quality and transference of learning if GBL design does not align well to content and context – the same is true for the less-emphasised behaviours within GBL.

Furthermore, my workflows also emphasise interactions which are not formally part of the game (but are part of the holistic learning system.) These Out Game Actions “do not have an immediate representation on screen<sup>[47]</sup> but should provoke further In Game Actions” (Guardiola, 2016, p. 2.) They could include explanation or demonstration by a teacher, or designed-in explicit player reflection. Once again, this shifts design emphasis onto the learning behaviours and context the

<sup>47</sup> Or within the game system, digital or otherwise.

game is being designed to support, decomposing the “framework for linking learning with play” (Lameras *et al.*, 2017, p. 981.)

This focus on learning behaviours is particularly relevant for the key contribution: GBL for research skills. Behaviours involved in higher order learning can be quite distinct, and providing clear and accessible guidance is crucial to undo the misunderstandings still common in the field, for example, calling a quiz a “learning game” when the behaviours involved do not in fact involve learning, but rather testing existing knowledge.

### 6.3.3 Using, refining and streamlining the LM-GM framework

The LM-GM framework (Arnab, *et al.*, 2015) has proved invaluable in understanding, analysing, and designing how mechanisms for learning are mapped to pedagogic goals, as well as a prompt for knowledge exchange and dialogue within my research projects ([SWs5,8.](#)) The combination of TGD with the LM-GM framework and gameplay loops is not entirely original to my work (see Lim *et al.*, 2013; Arnab, *et al.*, 2015), however there is nowhere else where these techniques are so fully embedded in the TGD process to validate learning mechanics or used to communicate across disciplinary boundaries (cf. [PW10](#) and the documentation within [SW5.](#)) However, from extensive use throughout my research, it was clear that there was a need to refine some of the concepts and language to make the LM-GM framework more precise and easier to use in interdisciplinary teams. For example, [PW5](#) details the rationale for separating Dialogue from the original Reflect/Discuss LM:

“the LM Reflect/Discuss has been separated into Reflect and Dialogue, acknowledging that Dialogue could take place across all of the identified LMs, if the circumstances encourage it.” (Abbott, 2020a, p. 8)

Additionally, whilst adapting the framework into card decks that form part of the SECRIOUS Toolkit ([SW8](#)), I reduced the number of LM cards by combining similar concepts, clarified the definitions and language used, provided examples, and explicitly linked the LMs with Bloom’s Extended Taxonomy using coloured cross-references to suggest likely level of learning and by selecting appropriate learning verbs to further clarify concepts. I also supervised the same process for the GM cards.<sup>48</sup> This streamlining process is described in detail in [PW10](#) (p.7.) I also produced explicit guidance as part of the LM deck which introduces Bloom’s Taxonomy and provides a colour key (Figure 18.) It is notable that the evaluation of these tools shows that 50% of users in one specific context still felt that the number of LM cards was too high and 30% found the colour coding unclear, however, overall, the refined LM-GM model was thought to be extremely helpful. The LM and GM cards have been formally evaluated ([PW12](#)), and results show that they provide knowledge about Learning or Game concepts and scope (90% agreement from participants), relationships between concepts (80% and 73% respectively) and terminology (80%, 91% respectively) (Stals, Baillie, Ferguson, *et al.*, 2025, pp. 15–16.) Similarly positive results are reported for a cohort of schoolchildren using the cards in a separate event (Stals, Baillie, Shah, *et al.*, 2025.) The adapted LM-GM card decks also provided a means for independent learning and an interface for knowledge exchange. Participants felt that they provided inspiration for and assisted with the Serious Game Design process (Stals, Baillie, Ferguson, *et al.*, 2025; Stals, Baillie, Shah, *et al.*, 2025.)

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<sup>48</sup> GM card new wording by Jamie Iona Ferguson.

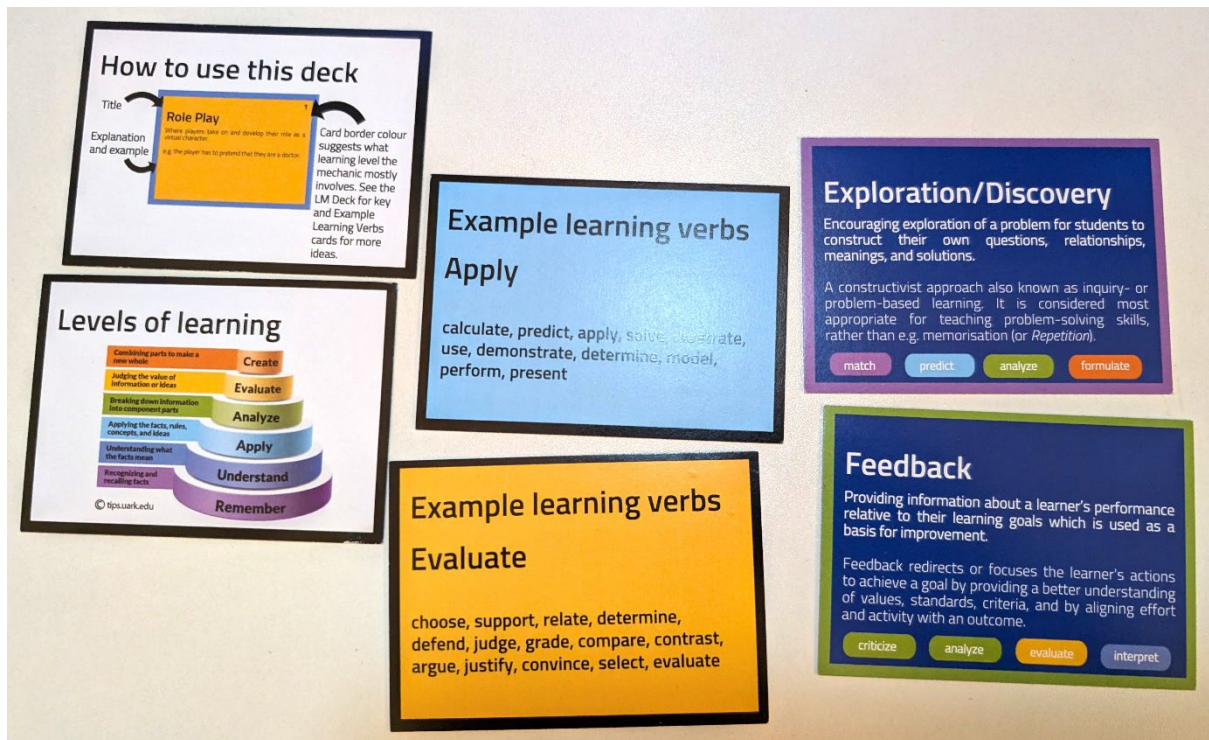


Figure 18 - cards from the revised LM card deck showing guidance cards (the four on the left) and two examples of particular LMs. This deck is available along with all of [SW8](https://serious.github.io/) at <https://serious.github.io/>

Taken as a body of work, this submission evidences significant contributions for designing GBL that is rigorous yet practical, and applying this knowledge in a range of contexts, primarily in the teaching and learning of research skills and critical thinking in Higher Education.



## 7 Conclusion

This critical reflection covers just over ten years of my research into game-based learning and its applications. I have updated the research context and how it has evolved over the period of my research, focussing on GBL in HE. I have analysed my own positionality and interpretation of the different terminology, theories, methodologies, and methods used for GBL, with a focus on interdisciplinarity and pragmatism. I have also reflected directly on each publication and its place within the wider literature and practice, with a thematic analysis of the holistic body of work that foregrounds higher order and metacognitive learning outcomes such as research skills alongside rigorous yet accessible methods for supporting interdisciplinary GBL design. Finally, I provide an analysis of the main contributions to knowledge, which are:

1. Evidence-based GBL practice for research skills and critical thinking training in HE.
2. Championing practical, authentic analogue GBL.
3. Balancing rigour and usability in GBL co-design workflows.

This document forms one part of the total PhD submission. Each of the 13 Published Works analysed and linked in Chapter 5 should be read as chapters that contribute to this submission, supported by the evidence of practice presented in [Appendix Table 2: Supporting Works](#).



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## 8.1 Unpublished scholarship

Table 6 - unpublished blog posts and games that contribute to research context

Title	Still available?
<a href="http://www.chemug.eu/">http://www.chemug.eu/</a> (2014)	Expired
Hannan, E. & Neame, C. (2017) SOTL Research Design Game, Manchester Metropolitan University	Expired
Ball, A and Simango, S. (2018) Serious Gaming: Creating a Research Data Management Adventure. 15th Stellenbosch University Library Symposium.	Expired
Morrison, C. & Secker, J. (2018) The Publishing Trap, CILIP	<a href="#">Available</a>
Morely, C. (2019) #Take5 # 43 The best way to game-ify Learning Development?	<a href="#">Available</a>
Ball, A. (2020) Fancy a Game of Research Data? University of Bath: Library News	<a href="#">Available</a>
Yeomans, J. <i>et al.</i> (2020) Learn about data management concepts in this online Data Horror Escape Room. Leiden University Libraries	<a href="#">Available</a>
Pyman, H. (2020) Copyright Dough: a game to teach, and bring discussion, about copyright licences and exceptions. University of Essex	<a href="#">Available</a>
Roozenbeek, J. & van der Linden, S. (2020) Breaking Harmony Square: A game that “inoculates” against political misinformation	<a href="#">Available</a>
Wake, P. & Illingworth, S. (2021) Games in the Curriculum	<a href="#">Available</a>
Cable, L. & Laurutis, A. (2022) Educational and Intercultural Escape Games: A Methodology	Expired

## Appendix 1: Table summaries of published works and supporting works

The tables below summarise all published works submitted for examination, and the supporting research outputs, in chronological order.

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Appendix Table 1 - published works with PW identifiers

ID	Published Work (PW)	Short title	Word count	Brief description	Methodology & methods	Main findings/contribution
1	"How to Fail Your Research Degree: A serious game for research students in Higher Education" (Abbott, 2015)	HtF-design	2,500	This paper describes the design process of a prototype of <i>How to Fail Your Research Degree</i> ( <a href="#">SW1</a> ) and shows the nascent GBL design workflow developed in later research ( <a href="#">PW3</a> , <a href="#">PW6</a> ). It also analyses preliminary testing and evaluation and iterative game design, showing very promising cognitive and affective outcomes.	<ul style="list-style-type: none"> <li>• Action research</li> <li>• GBL design</li> <li>• GBL evaluation</li> </ul>	<ul style="list-style-type: none"> <li>• Identification of research skills as an area of particular need.</li> <li>• Acknowledgement of (and focus on) process over product and affective learning outcomes.</li> <li>• Importance of relevance to learner goals.</li> <li>• Positive initial results.</li> </ul>
2	"Development of Cross-Curricular Key Skills Using a 3D Immersive Learning Environment in Schools" (Abbott <i>et al.</i> , 2017)	Key-skills	6,200	This paper focusses on the generic skills for learning that arose from a project which used 3D research data to create innovative tools for schools. It analyses the strong similarity between 'game-like' 3D environments and games in terms of exploratory and experimental learning, identifies key risks and opportunities, and addresses a research gap in focussing on general key skills rather than subject-based cognitive outcomes.	<ul style="list-style-type: none"> <li>• 3D visualisation</li> <li>• Co-creation</li> <li>• GBL evaluation</li> <li>• Comparative case studies</li> </ul>	<ul style="list-style-type: none"> <li>• Educational context is crucial for adaptation of materials.</li> <li>• Confirms the challenges of curriculum alignment (relevance, time, support, technology, flexibility.)</li> <li>• 'Game-like' learning is highly motivating for schoolchildren.</li> <li>• Exploration is fruitful for developing cross-curricular skills for effective learning: collaboration, leadership, creativity, and emotional intelligence.</li> <li>• Playful engagement leads to discovery and experiential learning</li> </ul>

3	"Modding Tabletop Games for Education" (Abbott, 2019b)	Modding	4,400	This paper articulates the problem in GBL practice that as serious games become more widely accepted as effective, this increases the risk of novice designers making games that aren't. It proposes modding existing tabletop games as a practical solution to minimising barriers for educators, and outlines some advantages of tabletop. A novel, accessible, workflow to support educational modding brings together the pedagogic and game design activities necessary with useful existing theories and frameworks. A worked example (of <a href="#">SW2</a> ) reinforces the step-by-step guidance.	<ul style="list-style-type: none"> <li>• GBL design</li> <li>• Gameplay loop analysis</li> </ul>	<ul style="list-style-type: none"> <li>• Modding games for education relies on recognising and adapting learning mechanics, not conceiving from scratch.</li> <li>• A novel and rigorous workflow for effectively modding tabletop games for education is presented, analysed, and justified.</li> <li>• It explicitly includes the learning context, not just the serious game design.</li> <li>• Aimed directly at educators (more accessible).</li> </ul>
4	"Game-based learning for postgraduates: an empirical study of an educational game to teach research skills" (Abbott, 2019a)	HtF-eval	8,200	This paper describes a theoretically robust framework to align game mechanics with learning mechanics for How to Fail Your Research Degree ( <a href="#">SW1</a> ) and its evaluation (n=127). It focusses on the topic of teaching research skills in a meaningful and memorable way, and key concepts of emotional design, intrinsic integration, cognitive authenticity, and game-enabled reflection.	<ul style="list-style-type: none"> <li>• Action research</li> <li>• GBL design</li> <li>• GBL evaluation</li> <li>• Surveys</li> <li>• Longitudinal</li> <li>• Gameplay loop analysis</li> </ul>	<ul style="list-style-type: none"> <li>• No other similar approaches exist.</li> <li>• The game conclusively met cognitive learning outcomes related to research activities, risks and their impact (all 4 showed over 80% agreement).</li> <li>• It conclusively met attention, relevance, and satisfaction affective outcomes (over 83% agreement) and met the 'increase confidence' outcome (63%)</li> <li>• Overcomes some of the challenges of teaching postgraduate research skills.</li> </ul>
5	"Beyond Vicarious Learning: Embedding Dialogic Learning into Educational Games." (Abbott, 2020a)	Dialogic	4,400	This highly original paper considers GBL from a dialogic learning perspective, showing strong relevance to postgraduate learning contexts. Dialogical interactions are a research gap. The paper uses <a href="#">PW3</a> and <a href="#">SW2</a> along with other examples to analyse precisely which game mechanics could be exploited for dialogic learning.	<ul style="list-style-type: none"> <li>• Action research</li> <li>• Gameplay loop analysis</li> </ul>	<ul style="list-style-type: none"> <li>• Interaction model focussed on embedding dialogue within gameplay.</li> <li>• Categorisation of prompts, initial learning, subsequent learning mechanics.</li> <li>• Recommendations of specific Serious Game Mechanics and game design principles that can encourage or inhibit dialogic learning.</li> <li>• Adapts/improves LM-GM model definition of Reflect/Discuss</li> </ul>

6	“Intentional Learning Design for Educational Games: a workflow supporting both novices and experts.” (Abbott, 2020b)	Workflow	6,600	This book chapter considers GBL within the Learning Experience Design (LXD) theoretical framework and builds on the workflow presented in <a href="#">PW3</a> to synthesise GBL and LXD design processes into direct guidance suitable for novices and experts. It articulates activities within Instructional; Interaction; Game; and Emotional Design disciplines and brings in the key concepts of learning context and learner behaviours. Every step is illustrated with a clear example.	<ul style="list-style-type: none"> <li>• GBL design</li> <li>• Gameplay loop analysis</li> </ul>	<ul style="list-style-type: none"> <li>• Aims to make rigorous GBL design more accessible.</li> <li>• Uses LXD principles to address challenges in GBL.</li> <li>• Provides clear, practical guidance on systematic mapping of LMs and GMs, within an LXD framework.</li> <li>• Explicit inclusion of learning context and learner behaviours as a crucial step in the method.</li> </ul>
7	“Serious Game Rapid Online Co-design to Facilitate Change Within Education.” (Abbott, Chatzifoti and Craven, 2021)	Rapid-co-design	1,900	This short paper analyses the effectiveness of a framework for very rapid co-design between teachers and serious game designers. Co-design is crucial for bridging disciplinary boundaries in GBL but there is little practical guidance. Through initial evaluation, identified design challenges included: short timescale; appropriate scaffolding; remote online interaction; and interdisciplinary communication. It also analyses 8 prototype games produced for facilitating change towards the Sustainable Development Goals in schools, with very positive evaluation results.	<ul style="list-style-type: none"> <li>• Online co-design</li> <li>• GBL design</li> <li>• GBL evaluation</li> <li>• Gameplay loop analysis</li> <li>• Games for change</li> </ul>	<ul style="list-style-type: none"> <li>• Addresses a research gap in online co-design methods for serious games with practical guidance on mapping required changes (in a school improvement context) to game mechanics.</li> <li>• Eight ‘mini-games’ each addresses a specific change towards the SDGs in schools, see <a href="#">SW5</a> for more detail. Documentation highlights rigour and adaptability.</li> <li>• Recommendations for online co-design for GBL.</li> </ul>
8	“Provocative Games to Encourage Critical Reflection.” (Abbott, Louchart and Chatzifoti, 2022)	Provocative	4,900	This paper analyses the design and use of Small Provoking Games (SPGs) in the context of cybersecurity. The games are <a href="#">SW3</a> and <a href="#">SW6</a> . It is highly original, substantially developing the cited work on reflection and reflective games design to aim to create constructivist challenging of misconceptions and behavioural change for security practitioners. Design principles are rigorously analysed and design choices are explained, using methods developed in <a href="#">PW7</a> , <a href="#">PW6</a> , and <a href="#">PW3</a> , emphasising metaphors in game objects and mechanics and ambiguous, exploratory gameplay. Preliminary evaluation shows broadly positive results for the games’ goals.	<ul style="list-style-type: none"> <li>• GBL design</li> <li>• Reflective game design</li> <li>• Triadic game design</li> <li>• Gameplay loop analysis</li> <li>• Games for change</li> </ul>	<ul style="list-style-type: none"> <li>• Synthesises previous literature to produce recommendations for reflective game design.</li> <li>• Provocative games are proposed to challenge misconceptions and create revised understandings.</li> <li>• SPGs as an integrated part of a GBL co-design toolkit (<a href="#">SW8</a>) to encourage dialogue/reflection, develops co-design research methods.</li> <li>• Provides good evidence of games as a technique to focus on critical relationships to topics, from a single play experience.</li> </ul>

9	“Serious ‘Slow’ Game Jam - A Game Jam Model for Serious Game Design (Abbott <i>et al.</i> , 2023)	Jam-method	6,500	This paper justifies and analyses the creation of a new jam method, challenging with evidence the misconception of SG jams as a subset of jams. The paper identifies personnel and time as being jam characteristics that need to change for serious purposes and provide a rationale from literature and our research for the ‘slow’ jam format which includes mentoring, reflection time, and focus on pedagogy. The paper also analyses implementation of the new method in 3 jams, outlining its advantages and challenges. Empirical data on participant motivations is also presented.	<ul style="list-style-type: none"> <li>• Game jam</li> <li>• Method design</li> <li>• Triadic game design</li> </ul>	<ul style="list-style-type: none"> <li>• Game jams for serious purposes require scaffolded interdisciplinarity, more emphasis on topic and pedagogy, and more time for reflection. Therefore, an alternative game jam model is presented (<a href="#">SW8</a>).</li> <li>• Provides recommendations for further deployment and adaptation of the method.</li> <li>• Participant data provides further evidence of jams as an educational process which requires enhanced support (and that novice skill levels is common amongst aspiring serious game makers.)</li> </ul>
10	“A Model for Mapping Serious Game Mechanics to Pedagogical Patterns.” (Ferguson, Abbott and Louchart, 2023)	Patterns	5,400	This paper maps serious game mechanics (SGMs) of 12 co-designed games (developed using <a href="#">SW8</a> , <a href="#">PW9</a> ) to pedagogical design patterns and proposes that the interplay of these conceptual frameworks could be fruitful for enhancing interdisciplinary communication and the quality of SGs. The problem space is GBL for cybersecurity, and the paper builds on work about gamification to consider GBL more comprehensively identifying the most common Pedagogical Patterns and their relationships with SGMs. Future improvements are suggested.	<ul style="list-style-type: none"> <li>• Case study</li> <li>• Method design</li> <li>• GBL design</li> <li>• Game analysis</li> </ul>	<ul style="list-style-type: none"> <li>• Pedagogical Patterns for the analysis and design of GBL is a research gap. Despite being common in computing science, PPs had never previously been used in cybersecurity pedagogy.</li> <li>• A new, repeatable, subject agnostic method is presented.</li> <li>• Adaptation of the LM-GM framework for understandability and usability (see <a href="#">SW8</a>.)</li> <li>• Most common PPs for cybersecurity games are analysed and practical, discipline-specific recommendations for use of the research is outlined.</li> </ul>
11	“Choose Your Own Adventure! An empirical study on gamification of postgraduate learning on research project design” (Abbott, 2024a)	Gamification	7,000	This paper analyses empirical data from a range of methods related to a gamified tool ( <a href="#">SW4</a> ) to support the learning of research (or creative) project design. Main gamification techniques studied are non-linear navigation for self-directed personalization, digital badges, and the role of narrative. The results were generally positive and emphasised the heterogeneity of learners.	<ul style="list-style-type: none"> <li>• Action research</li> <li>• Gamification</li> <li>• Case study</li> <li>• Survey</li> <li>• Focus group</li> </ul>	<ul style="list-style-type: none"> <li>• Empirical data on gamification in practice is a research gap.</li> <li>• Data identifies a ‘long tail’ of usage suggesting that quest approaches aren’t suited to many learners but work extremely well for some.</li> <li>• Personalisation of learning content is particularly appropriate for self-directed learners and had a positive impact on learning.</li> <li>• Narrative and badges were less successful.</li> <li>• Recommendations for gamified approaches in similar contexts are proposed.</li> </ul>

12	Evaluating Slow Game Jams as a Mechanism for Co-Designing Serious Games to Improve Understanding of Cybersecurity (Stals, Baillie, Ferguson, <i>et al.</i> , 2025)	Jam-eval	13,500	Building on <a href="#">PW9</a> , this paper analyses the context of increasing need for cybersecurity education and practice and provides the results of a formal evaluation of the SSGJ discussed in <a href="#">PW9</a> when implemented within the SECRIOUS research project (one game jam, n=13). The results are broadly very positive, with high levels of knowledge increase, motivation, and relevance, albeit with high workload.	<ul style="list-style-type: none"> <li>• Case study</li> <li>• Game jam</li> <li>• Quantitative evaluation</li> <li>• Survey</li> </ul>	<ul style="list-style-type: none"> <li>• Empirical data on serious 'slow' game jam method being a useful method for knowledge and skill development</li> <li>• Empirical data on the levels of motivation and workload in learners undertaking game jams</li> <li>• Suggestions for further improvements to specific parts of the toolkit.</li> </ul>
13	Game-Based Approaches for Research Skills Training and Researcher Development: A Survey of Attitudes and Acceptance in Higher Education (Abbott, 2024b)	GBL-survey	3,700	This paper analyses the results of a survey of attitudes towards GBL specifically for improving research skills training in UK HE institutions (n=92.) Analysis presents a clear overview of the attitudes, opportunities, barriers, and concerns of HE staff regarding the use of GBL to complement existing research skills training provision in universities. It contextualizes this with current opportunities for engagement with GBL for research skills.	<ul style="list-style-type: none"> <li>• Survey</li> </ul>	<ul style="list-style-type: none"> <li>• Strong appetite for games and gamified approaches in research training.</li> <li>• Key themes are: institutional and attitudinal barriers to the use of GBL; the need for balancing flexibility and structure; and diverse learner cohorts.</li> <li>• Priority topics within researcher development for GBL approaches are ethics, AI, and literature review.</li> </ul>
	<b>Word count of all submitted publications (excluding references)</b>		<b>75,200</b>			

Appendix Table 2 - supporting works with SW identifiers

ID	Supporting Work (SW)	Brief description	Type	Main findings/contribution
1	<i>How to Fail Your Research Degree</i> (Abbott, 2017)	<p>"How to Fail Your Research Degree" is a game designed to teach research skills to postgraduate students. It encourages a light-hearted engagement with the various academic skills and activities necessary to undertake postgraduate research and the risks and pitfalls that can affect a research degree. The learning outcomes are:</p> <ol style="list-style-type: none"> <li>1. Understand the various risks affecting research and their impact on projects</li> <li>2. Recognise dependencies between tasks at different stages of research</li> <li>3. Understand the interrelations of different risks with the activities to negate or mitigate them</li> <li>4. Be aware of the time-critical nature of short research projects</li> </ol>	Tabletop game	<p>There are no other games that have the same learning outcomes. The game uses GBL literature to rigorously match Intended Learning Outcomes (ILOs) to appropriate game mechanics and this mapping is clearly articulated using the LM-GM framework. It has been distributed to over 200 HE staff involved in research support/learning development, in over 45 countries. It won the Best Serious Game award at Joint Conference on Serious Games, 2015. The rationale and design process is outlined in <a href="#">PW1</a> and its high success at achieving learning outcomes is evidenced in <a href="#">PW4</a>. It is free online at <a href="http://howtofailyourresearchdegree.com/">http://howtofailyourresearchdegree.com/</a></p>
2	<i>On the Shoulders of Giants</i> (Abbott, 2018)	<p>This game is modified from a commercial board game: Meeple Circus. It focusses on increasing students' knowledge and confidence of literature search and literature review techniques through dialogic learning. It is free online at <a href="https://gamebasedlearninginhe.wordpress.com/my-games/">https://gamebasedlearninginhe.wordpress.com/my-games/</a></p>	Tabletop game (modded)	<p>This game provided the main inspiration for, and contributed to, the theoretical analysis of game mechanics for dialogic learning (see <a href="#">PW5</a>) which is a highly original contribution to an under-researched area in GBL.</p>
3	<i>Protection</i> (Chatzifoti et al., 2021)	<p>A "provocative" game designed to increase dialogue and knowledge exchange with the context of a co-design serious slow game jam. This game focusses on the metaphor of code security. Play it here: <a href="https://secrious-research-project.itch.io/protection">https://secrious-research-project.itch.io/protection</a></p>	Digital game	<p>Very rigorous interdisciplinary collaboration is crucial for good game design and was well structured and implemented here. There was also an innovative use of extremely limited guidance and metaphor as game mechanics to 'provoke' constructivist reflection. This output forms the basis of the analysis in <a href="#">PW8</a>. It was shortlisted for the ECGBL 2022 Best Serious Game award.</p>
4	<i>Creative Thinking Quest</i> (Abbott, 2021)	<p>A long format learning tool delivered using Twine (a hypertext interactive narrative software) in the form of a Choose Your Own Adventure. It scaffolds the entire process of designing a research or creative project, from ideation through to writing the bid/brief in detail, and choices made by the user present the most useful development activities for each stage. Development activities are largely based on the (CC-BY-NC) <a href="#">Creative Thinking Cards</a> by School of Thought, supplemented with a range of other tools. The Quest is free online at <a href="https://daisyabbottitchio.itch.io/creative-thinking-quest">https://daisyabbottitchio.itch.io/creative-thinking-quest</a></p>	Gamified learning tool	<p>The Quest has had significant reach. A detailed evaluation of how this tool was used is in <a href="#">PW11</a>. Main contributions are around the need to personalise content for diverse cohorts due to their different learning needs and goals, and the subsequent empirical data on gamification within a particular application context. The technical method was also delivered as two online workshops to share skills with the Playful Learning community.</p>



5	Agents of Change Toolkit (Pantić <i>et al.</i> , 2022)	The Agents of Change Toolkit (ACT) helps teachers and schools to achieve the UN Sustainable Development Goals (SDGs) through game-based approaches and examples. It was produced via collaboration between researchers, practitioners, and leadership. Main website: <a href="https://www.agentsofchangetoolkit.org/">https://www.agentsofchangetoolkit.org/</a> SGROC template: <a href="https://miro.com/app/board/o9J_lxh17Bo=/">https://miro.com/app/board/o9J_lxh17Bo=/</a>	Toolkit	The ACToolkit won “Outstanding Flagship Project” from 2022 RCE Awards for Innovative Projects on Education for Sustainable Development. The rapid game prototyping method used, and results, is described in <a href="#">PW7</a> and this method was instrumental in the development of the Serious Slow Game Jam method which built on and adapted it, see <a href="#">SW8</a> and <a href="#">PW9</a> .
6	<i>Collaboration</i> (Chatzifoti <i>et al.</i> , 2022)	A “provocative” game designed to increase dialogue and knowledge exchange with the context of a co-design serious slow game jam. This game focusses on the Secure Software Development Lifecycle and highlights the human interactions aspect of cybersecurity. Play it here: <a href="https://secrious-research-project.itch.io/collaboration">https://secrious-research-project.itch.io/collaboration</a>	Digital game	Very rigorous interdisciplinary collaboration is crucial for good game design and was well structured and implemented here. There was also an innovative use of metaphor and exploration as game mechanics to ‘provoke’ constructivist reflection This output forms the basis of the analysis in <a href="#">PW8</a> . It was shortlisted for the ECGBL 2022 Best Serious Game award.
7	Playful Learning Online (Abbott, 2022)	Summarises large and small playful teaching interventions from 2017 – 2022 with a focus on the pivot to online implementations necessitated by the pandemic lockdowns.	Keynote	The keynote gives a brief overview and my personal reflections on what was successful and what was not. A video recording of the interactive session is online at: <a href="https://www.youtube.com/watch?v=s_1l6zcEJR4">https://www.youtube.com/watch?v=s_1l6zcEJR4</a>
8	SECRIOUS Slow Game Jam Toolkit ( <i>SECRIOUS Slow Game Jam Toolkit</i> , 2023)	A range of resources to support ‘slow’ game jams for cybersecurity education. The SSGJ toolkit includes: adaptable structure; Cybersecurity card deck (subject specific); Learning Mechanics, and Game Mechanics Card Decks (subject agnostic); structured activity worksheets and digital whiteboards; code snippets to speed up implementation of common game mechanics; small provoking games; documentation to assist in creating toolkits for other subject domains. All of these tools are freely available from the project website: <a href="https://secrious.github.io/">https://secrious.github.io/</a>	Toolkit	Tangible toolkits, especially for abstract concepts, have been noted as useful for: increasing design speed and focus; articulation of reasoning and justification for decisions; and resolving disagreements.  This is the only freely available, comprehensive toolkit for running a multi-day game jam/design sprint for serious games. Resources and rationale are discussed in more detail in <a href="#">PW9</a> and the evaluation is discussed in <a href="#">PW12</a> .
9	Serious Game Rapid Co-Design Workflow (Abbott, 2024)	Drawing heavily on <a href="#">SW5</a> and <a href="#">SW8</a> , these are the final versions of the rigorous serious game design workflows I have iteratively developed over years of research. It structures Triadic Game Design in an understandable and accessible way, aimed at co-design for interdisciplinary collaboration. They incorporate other useful techniques such as gameplay loops and the LM-GM model. There are two versions, one lengthier and more rigorous and one which is faster and/or suitable for use with schoolchildren or absolute novices.	Workflow/workshops	These structured workflows make serious game design much more accessible to multi-disciplinary teams. They bring together the best aspects of <a href="#">SW5</a> and <a href="#">SW8</a> and include additional scaffolding for workshop facilitators.  Both workshops are freely available online in digital and pdf format at <a href="https://miro.com/app/board/uXjVK0ePzaU=/">https://miro.com/app/board/uXjVK0ePzaU=/</a>

## Appendix 2: Table of co-authored papers

The following published works involved co-authors. This table describes my contributions.

ID	Published work	Description of Daisy Abbott's contribution
<b>PW2</b>	Abbott D., Jeffrey S., Gouseti A., Burden K., Maxwell M. (2017) "Development of Cross-Curricular Key Skills Using a 3D Immersive Learning Environment in Schools" In: Beck D. et al. (eds) Immersive Learning Research Network. ILRN 2017. Communications in Computer and Information Science, vol 725. Springer, Cham, pp. 60-74.	This paper was entirely written by Daisy but benefitted from the insight of all named co-authors from their work on the research project. All co-authors approved the paper's content before publication and may have provided minor edits or feedback.
<b>PW7</b>	Abbott, D., Chatzifoti, O., & Craven, J., (2021) "Serious Game Rapid Online Co-design to Facilitate Change Within Education." In: Proceedings of Games and Learning Alliance, 10th International Conference, GaLA 2021. Springer.	This paper was entirely written by Daisy but benefitted from the expertise of both co-authors from their work on the research project, in particular Olga. Joanne Craven contributed insights from her previous work to the discussion section, in particular the reference to rapid prototyping. Discussions with Olga also informed the overall insights. All co-authors approved the paper's content before publication.
<b>PW8</b>	Abbott, D., Chatzifoti, O., & Louchart, S., (2022) "Provoking Games to Encourage Critical Reflection." In: Proceedings of the 16th European Conference on Game Based Learning.	Daisy is the primary author of this paper, which draws on the collaborative design of two games, with significant contributions from all co-authors. Daisy led on the research context, mapping of serious game mechanics, and discussion section. Olga led on the detail of game implementation and metaphor mapping. Sandy was instrumental in the core concept and provided feedback on the paper.
<b>PW9</b>	Abbott, D., Chatzifoti, O., Ferguson, J., Louchart, S., & Stals, S. (2023) "Serious 'Slow' Game Jam - A Game Jam Model for Serious Game Design" In: Proceedings of International Conference on Game Jams, Hackathons and Game Creation Events 2023 (ICGJ '23). ACM, New York, NY, USA.	Daisy is the primary author on this paper after having substantially rewritten an original draft by Olga Chatzifoti. The paper arises from the SECRIOUS research project. Olga's work on the literature review of game jams is an invaluable part of the research context and her analysis of game jam structure formed the foundation of the corresponding section of the paper. The original concept for the 'slow' game jam came from Sandy Louchart, and the bulk of the design and implementation of the method was by Daisy and Olga, overseen by Sandy. Jamie Ferguson and Sandy provided feedback and minor contributions and the paragraph on evaluation uses data from Shenando Stals from his role in the project.
<b>PW10</b>	Ferguson, J., Abbott, D., & Louchart, S. (2023) "A Model for Mapping Serious Game Mechanics to Pedagogical Patterns." In: Proceedings of the Joint Conference on Serious Games (JCSG). Springer.	Daisy wrote the research context section of this paper and performed the primary data analysis, including writing up the main results. The discussion section was jointly written. Jamie Ferguson wrote the remaining sections and prepared the paper for publication.
<b>PW13</b>	Stals <i>et al.</i> , (2025) 'Evaluating Serious Slow Game Jams as a Mechanism for Co-Designing Serious Games to Improve Understanding of Cybersecurity'. ACM Games: Research and Practice	Shenando Stals is the main author of this paper with guidance from Lynne Baillie. Daisy made substantial contributions to the research context section, method description, and wording throughout, as well as supporting during the game jam and data collection portion of the research, alongside other co-authors. Other co-authors contributed in line with their particular expertise.

### Co-author confirmations

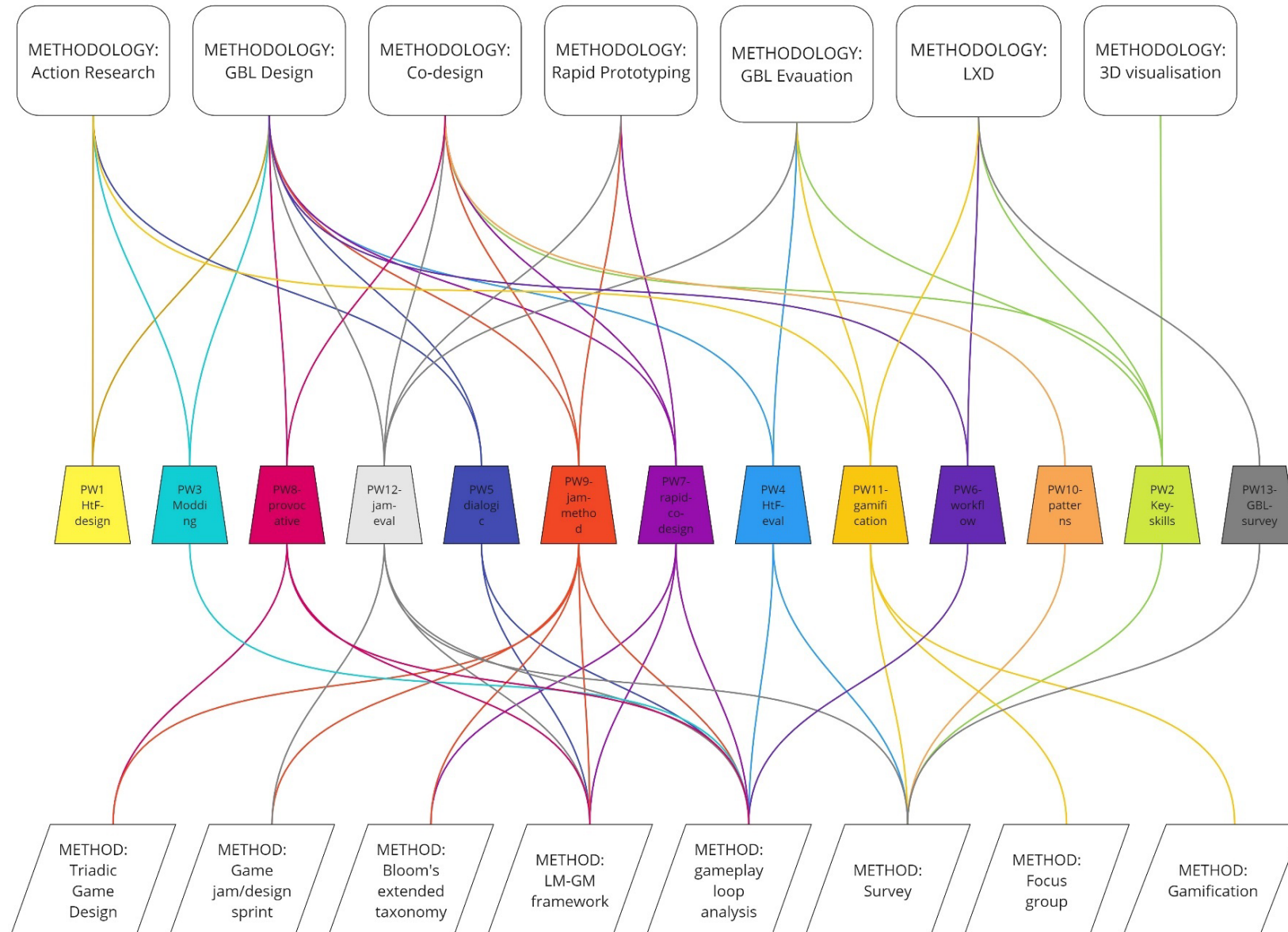
As advised by my Research Office co-authors were emailed with the above description of my contribution to each paper and asked to reply with their confirmation and/or any edits required. Original emails can be provided on request.

<b>Name of co-author</b>	<b>Date email received</b>	<b>Any edits to my description?</b>	<b>Confirmed</b>
<b>Lynne Baillie</b>	22/01/2025	No	Yes
<b>Kevin Burden</b>	22/01/2025	No	Yes
<b>Olga Chatzifoti</b>	21/01/2025	No	Yes
<b>Joanne Craven</b>	21/01/2025	No	Yes
<b>Jamie Ferguson</b>	22/01/2025	No	Yes
<b>Anastasia Gouseti</b>	22/01/2025	No	Yes
<b>Stuart Jeffrey</b>		No	
<b>Sandy Louchart</b>	22/01/2025	No	Yes
<b>Shenando Stals</b>	22/01/2025	Suggest to include my significant contribution to the Scare-City game and that section of the paper. However, this game focusses on cybersecurity so is not particularly relevant to this PhD submission.	Yes

## Appendix 3: large scale figures

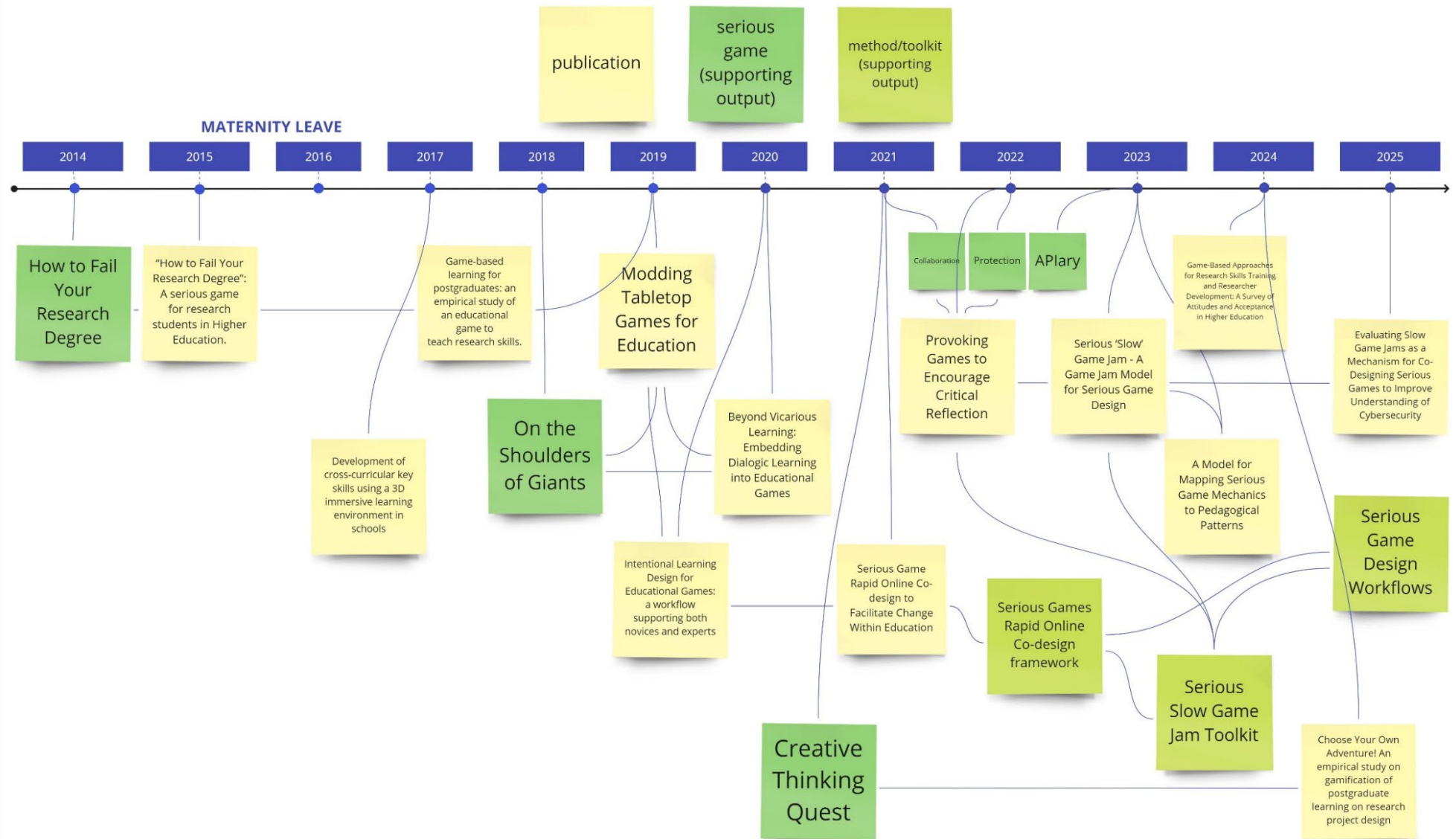


# Thematic analysis: methodologies and methods

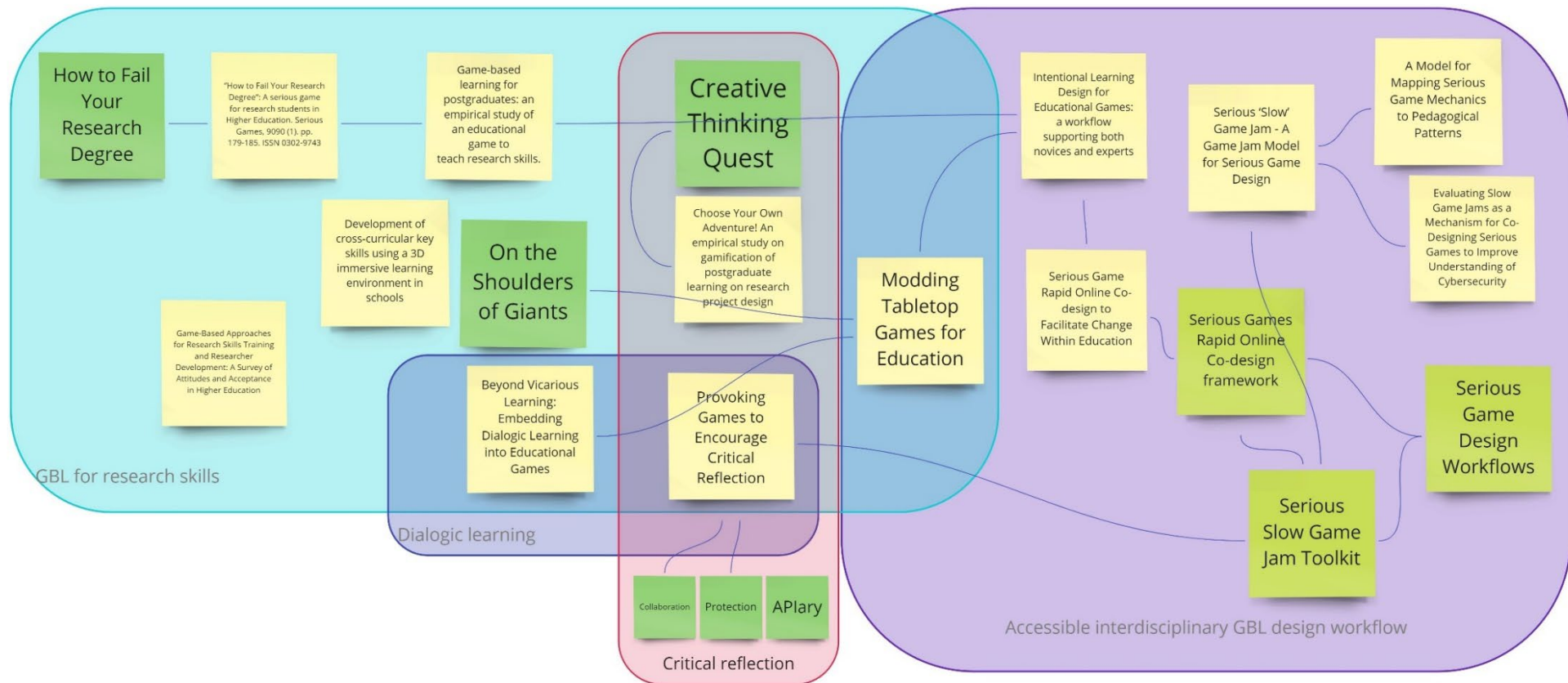
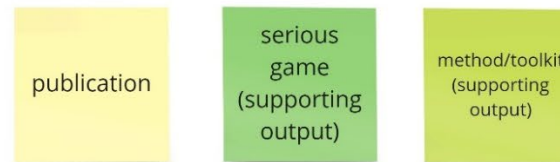




## Publications for examination (chronological)



## Publications for examination (by topic area)





## Appendix 4: Use of assistive/AI Tech in preparing this work

### Overview

As noted in Footnote 19, recent literature on AI tools demonstrates that they are yet to be sophisticated enough to provide meaningful conceptual analysis of scholarly literature and that a tool tested in 2024, which claimed to be able to “overview... any discourse, reveal the blind spots, enhance a scholar’s perspective” (<https://infranodus.com/>) was in fact “severely limited in its ability not only to identify and represent conceptual networks across a large number of texts, but as well to do so even within a single text, leaving us with serious reservations about the kind of knowledge-representation any such GPT-enabled ‘big data’ analysis of academic research and scholarship would, or could, produce” (Tursunkulova, de Castell and Jenson, 2024). This matches my own experimentation with AI as an assistive technology and therefore I have only used AI in very specific and limited ways in my practice and specifically, this submission.

### AI to assist in literature search

Whilst preparing a paper submitted after July 2024 (PW13), I used some AI tools to complement my literature search process (for example, <https://inciteful.xyz/>, <https://typeset.io/>, and <https://www.researchrabbit.ai/>) however, source articles were (of course) selected using human judgement so this use was about efficiency, not content. I also used <https://typeset.io/> as part of my literature search strategy to update the research context presented within this critical reflection. I have not used any AI summarising tools in any of my work.

### Generative AI

My main use of generative AI in the preparation of this document was to check ChatGPT’s output against my own understanding of concepts. It was generally correct, albeit at a more high/vague level than I can articulate the concepts (unsurprisingly.) Therefore, GAI was not generally helpful in reflecting on my work or producing this thesis. However, in some few cases (especially when exploring the fringes of the interdisciplinary topic area) GAI helped to refine my thought process or was used to produce suggested definitions that do not have my own positionality or biases. These instances have been comprehensively referenced in the table below, with an indication of impact on the relevant sentences in this thesis.

**No GAI text appears in this document or any of my published outputs.** All GAI outputs have been critically analysed and, where useful, integrated with my own thoughts and words, then expressed in an original form.

Prompt	Tool	Timestamp	Output	Use in this thesis
is there a difference between game-based and game-enhanced learning?	ChatGPT3.5	2023/11/18 15:51	Yes, there is a distinction between game-based learning and game-enhanced learning. While both approaches incorporate gaming elements into the educational process, they differ in their level of integration and the role that games play in the overall learning experience.	Confirmed my own interpretation. Impact 10%

			<p><b>Game-Based Learning:</b>  Definition: Game-based learning involves the use of games as the primary instructional method. The games are designed with educational objectives in mind, and they serve as the central component of the learning experience.  Role of Games: In game-based learning, games are not just supplementary; they are the core mechanism for delivering content and facilitating learning. These games are often specifically created or adapted to align with educational goals.  Example: Using a simulation game to teach historical events, where students actively make decisions and experience consequences based on their choices.</p> <p><b>Game-Enhanced Learning:</b>  Definition: Game-enhanced learning refers to the incorporation of gaming elements or mechanics to enhance traditional learning methods. In this approach, games complement other instructional strategies rather than being the primary focus.  Role of Games: Games in game-enhanced learning serve as supplementary tools or activities to reinforce concepts, increase engagement, or provide additional practice. They are integrated into a broader educational context.  Example: Using a quiz-style game as a review activity after a lesson to reinforce key concepts learned in the classroom.</p> <p>In essence, the main difference lies in the centrality of games to the learning experience. Game-based learning places games at the forefront, making them the primary vehicle for delivering educational content. On the other hand, game-enhanced learning incorporates games as supportive elements within a broader educational framework.</p>	
could you now define gameful learning, and highlight any differences from the previous terms used	ChatGPT3.5	2023/11/18 15:54	N/A	Discarded as this seems to be aligning it with gamification which is not my understanding of the term. Impact 0%
are game mechanics the same as affordances?	Gemini	2024/04/16 12.58	<p>No, game mechanics and affordances are related but distinct concepts in game design. Here's the breakdown:</p> <p><b>Affordances</b> are the potential actions that an element in the game world suggests or allows the player to do. They're about the perceived possibilities of interaction. Imagine a ladder in a game - it affords climbing. A key affords unlocking something. Affordances are intuitive and don't require extensive instructions.</p> <p><b>Game mechanics</b> are the underlying rules and systems that govern how the game works. They define how the actions (afforded by the game elements) play out and influence the game state. Thinking about the ladder again, the game mechanics would determine the player's climbing speed, if they can fall off, and how stamina is affected.</p> <p>Here's an analogy: Affordances are like the signs on a restaurant menu, telling you what dishes you can order. Game mechanics are the recipe in the kitchen, dictating how those dishes are actually prepared.</p> <p>In short, affordances provide clues about what the player can do, while mechanics determine how those actions function within the game's system. They work together to create a clear and engaging gameplay experience.</p>	Helped me to clarify the language I had used to describe game mechanics in section 2. Impact 30%.

what's the difference between types of learning outcome (cognitive, affective, behavioural) and Bloom's taxonomy?	SciSpace	2024/10/28 14:16	<p>The distinction between types of learning outcomes—cognitive, affective, and behavioral—and Bloom's taxonomy lies in their focus and application in educational settings. Learning outcomes describe what students should achieve, while Bloom's taxonomy provides a framework for categorizing these outcomes based on cognitive complexity.</p> <p>Types of Learning Outcomes</p> <p>Cognitive Outcomes: These involve mental skills and knowledge acquisition. For instance, Bolat's study found that most learning outcomes in educational programs were cognitive, focusing on lower-order skills like remembering and understanding(Bolat, 2023).</p> <p>Affective Outcomes: These pertain to emotions and attitudes. The same study indicated that only a few outcomes addressed affective skills, primarily at the receiving and responding levels(Bolat, 2023).</p> <p>Behavioral Outcomes: These relate to observable actions and skills. While not explicitly detailed in the provided papers, behavioral outcomes typically encompass psychomotor skills, which are essential for practical applications in fields like software engineering(Thant et al., 2023).</p> <p>Bloom's Taxonomy</p> <p>Cognitive Domain: This domain includes levels from basic knowledge to higher-order thinking skills like analyzing and creating. The emphasis on lower-order skills in educational programs suggests a need for more focus on higher-order outcomes(Bolat, 2023)(Thant et al., 2023).</p> <p>Affective Domain: Bloom's taxonomy also includes affective outcomes, which are crucial for assessing students' emotional responses and engagement in learning processes(Casey, 2024).</p> <p>Application in Curriculum: Bloom's taxonomy serves as a guide for educators to design curricula that foster comprehensive learning outcomes across all domains, enhancing student engagement and understanding(Engin et al., 2024)(Gavrilović-Obradović &amp; Zdravković, 2022).</p> <p>While Bloom's taxonomy provides a structured approach to categorizing learning outcomes, some argue that it may not fully capture the complexities of modern educational practices, particularly in assessing learning processes rather than just outcomes(Casey, 2024).</p>	Helped to clarify the language and source additional citations for research context. Impact 10%
Who is credited with the distinction between cognitive, affective, and behavioral learning outcomes in educational settings?	SciSpace	2024/10/28 14:51	<p>The distinction between cognitive, affective, and behavioral learning outcomes in educational settings is primarily attributed to the foundational work of educational theorists such as Bloom and Krathwohl. Their frameworks have significantly influenced how these domains are understood and applied in educational contexts. This tripartite model emphasizes the importance of integrating cognitive knowledge, emotional engagement, and behavioral skills in learning processes. [...]</p>	Used to confirm an uncertainty. Impact 5%
What is the difference between learning mechanics and learning behaviours?	ChatGPT	2024/12/09 15:09	<p>Learning Mechanics are about the design and execution of the learning process itself.</p> <p>Learning Behaviors are about the learner's participation and approach within that process.</p> <p>Both are critical for effective education: learning mechanics provide the structure, while learning behaviors determine how well a student engages with that structure.</p>	Used to confirm if my own phrasing captured it adequately or there was a simpler way. Impact 5%.
You are a professor in a UK university who is expert as assessing PhD submissions. Could you critique this abstract? present results as suggestions with a rationale for each. Game-Based Learning (GBL) is the intentional integration of gaming elements into learning experiences to deliver learning outcomes. GBL, and playful learning in general, are rapidly growing disciplines, however, there are still research gaps in GBL within adult	ChatGPT	2025/02/27 11:20	<p>Here are some suggestions for improving the abstract, along with a rationale for each:</p> <p>1. Clarify the Research Gap</p> <p>Suggestion: Clearly state why the gap in GBL for higher-order learning outcomes in Higher Education (HE) is significant and what specific challenges exist.</p> <p>Rationale: The abstract mentions a gap but does not articulate why it is important. Explicitly stating the consequences of this gap would strengthen the argument for the research's relevance.</p> <p>Example revision:</p> <p>"Despite the growing adoption of GBL, its application in adult learning—particularly for fostering critical thinking and research skills in HE—remains underexplored, leading to a lack of structured, evidence-based approaches for its implementation."</p>	Suggestions considered to improve the clarity of the abstract. Abstract manually edited. Abstract then considerably further edited down to 250 words. Impact 10%

<p>learning contexts, in particular for higher order learning outcomes within Higher Education. This PhD by Published Works comprises 13 published works, 9 supporting research outputs, and a critical reflection which, together, contribute to answering the core research question: "How can game-based approaches improve the teaching and learning of critical thinking and research skills in Higher Education?" The published works focus on learning outcomes such as critical thinking, research skills, creative idea generation, and behavioural change (rather than knowledge acquisition), in particular in a Higher Education postgraduate context where GBL is less well-researched. The submission synthesises and critically analyses the 13 published works as a holistic corpus of Research through Design, contextualised with up-to-date research on both GBL and learning theories appropriate to developing research skills and critical thinking. The submission uses a range of appropriate methods, with an overall focus on constructivist learning theories and supporting feasible improvements in GBL practice. Based on theoretical innovation and empirical evidence, results demonstrate significant potential for GBL to be used within research skills and critical thinking training in HE. In particular, the creativity, freedom to fail, community building, and personalisation of learning pathways are considered to be valuable outcomes of GBL in this context. Barriers to adoption and effective use are also analysed. A range of practical outputs scaffold GBL design processes, in particular for interdisciplinary teams developing GBL approaches. All games and tools produced are freely available online and already being used within research development, teaching, and</p>			<p>2. Strengthen the Research Question Framing Suggestion: Reformulate the research question to avoid redundancy with the sentence preceding it and to make it more precise. Rationale: The abstract already introduces GBL as a method to improve critical thinking and research skills. Restating this verbatim in the research question could be streamlined. Example revision: "This submission examines the role of GBL in enhancing critical thinking and research skills in HE, addressing the central research question: What pedagogical and design principles make GBL effective for higher-order learning in postgraduate education?"</p> <p>3. Highlight the Novelty of the Research Design Suggestion: Emphasise what makes the methodological approach particularly novel or rigorous compared to existing studies. Rationale: The phrase "a range of appropriate methods" is vague. Specifying the unique aspects of the methodology strengthens its credibility. Example revision: "Through a synthesis of 13 published works and 9 supporting outputs, this submission employs Research through Design within a constructivist paradigm, integrating empirical and theoretical insights to propose evidence-based frameworks for GBL implementation."</p> <p>4. Clarify the Practical Impact of Findings Suggestion: Explicitly state how the research impacts educational practice beyond the theoretical contributions. Rationale: While the contributions are clear, the abstract could better highlight how this research translates into tangible improvements in pedagogy or policy. Example revision: "The findings offer practical design principles for educators and interdisciplinary teams, ensuring that GBL is not only conceptually robust but also readily implementable in postgraduate curricula."</p> <p>5. Strengthen the Statement of Significance Suggestion: Add a concluding sentence that reinforces the importance of these contributions in the broader educational landscape. Rationale: The abstract concludes with a strong emphasis on past impact but could better highlight the research's future implications. Example revision: "By providing an evidence-based, scalable approach to GBL in HE, this research lays the groundwork for broader adoption, shaping the future of experiential learning for postgraduate education and beyond."</p>	
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game design communities. Published and supporting works result in three key contributions to knowledge and practice for GBL for higher order learning outcomes: 1. Evidence-based GBL practice for research skills and critical thinking training in HE. 2. Championing practical, authentic, analogue GBL. 3. Balancing rigour and usability in GBL co-design workflows. These contributions are evidenced in the submission itself and also the way in which the research has enabled research by others throughout the last decade.				
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### Other AI use

Whilst there is no other generative AI use within this written submission, I have used AI to assist in sharing the knowledge from these publications via conferences or public engagement (for example, GAI writing a first draft of a blog post summarising a newly published paper, or experimenting with AI video abstracts.) Therefore, some of the scripts for videos linked from Chapter 5 (which are provided for convenience and do not themselves form part of the submission) have been created using help from generative AI in producing first drafts, which are typically heavily edited. I have also used AI in more playful ways to assist with teaching, learning and knowledge transfer.

# PW1

## How to Fail Your Research Degree: A Serious Game for Research Students in Higher Education

Abbott, D. (2015) “How to Fail Your Research Degree”, in S. Göbel et al. (eds) *Serious Games*. Cham: Springer International Publishing (Lecture Notes in Computer Science), pp. 179–185. Available at: [https://doi.org/10.1007/978-3-319-19126-3\\_16](https://doi.org/10.1007/978-3-319-19126-3_16).

# **“How to Fail Your Research Degree”**

## **A Serious Game for Research Students in Higher Education**

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**Abstract.** This work in progress game was created to deliver knowledge and understanding of research processes and techniques, within the context of a postgraduate training programme at Glasgow School of Art. Development was in relation to the concepts of encouraging creativity and risk-taking within a safe game environment and of learning by (potentially) failing. Game characteristics and intended learning outcomes were defined, leading to game mechanics and text that emphasise player agency, working within a time limit, and humour. Initial small-scale evaluation shows that the game is highly successful at delivering the intended learning outcomes and is a memorable and enjoyable complement to the existing course curriculum.

**Keywords:** Serious games · Games for learning · Research skills · Higher education

## **1 Introduction**

Like many institutions, the Glasgow School of Art (GSA) provides a programme of core research skills; training aimed at postgraduate and PhD students with a specific focus on developing the knowledge and techniques required to do a research degree. The programme encompasses (amongst other things) good academic writing, best practice in research, and processes for managing a research project and incorporates the expertise of the academic researchers who teach on these courses, the direct value of which is emphasised by the Teaching and Learning Research Programme [1] (pp.14-15) and is equally applicable more generally at all levels of education [2]. Whilst developing and improving an existing course within this programme (delivered by GSA’s Digital Design Studio, which also offers a Master’s degree in Serious Games) consideration was given to how this widely applicable training could be delivered in a more interactive way (and to a larger cohort of students) in the form of a serious game.

## **2 Academic Context**

The value of play to learning has been recognised and interrogated for centuries [3]. Furthermore, various commentators on higher educational policy have noted the



movement of pedagogical rhetoric away from inspiration and enjoyment of learning towards a growing obsession with metrics (especially those that can be directly tied to economic activity) [4]. The purpose of teaching research skills is to enable students to critically and rigorously discover, analyse and interpret, but to also encourage the motivation to do so (hence the importance of emotional effects such as inspiration and enjoyment), leading to both deep understanding and robust lifelong learners. Within this local and wider context, therefore, the creation of a serious game for teaching research skills was highly appropriate.

A common concept in niche play activities such as live roleplaying, and latterly in the registers of critical debate and leadership/self-help [5,6], is that of “winning by losing”. That is, that the outcome of the game is centred around enjoying the process of the game rather than focussing on the result, and that a “loss” can actually be more enjoyable and/or useful than a “win”. With just a little terminological tweaking, the same concept underpins the educational philosophy and pedagogical discipline of “learning by failing”, particularly noticeable in early years learning and training artificial intelligence [7, for useful applications to wider pedagogy]. Again, these concepts focus on engagement with the activity itself, not measuring the outcomes. It is also particularly pertinent in the context of training research students to not only acknowledge but embrace the notion that an element of risk-taking is required to produce original and innovative work [8] (p. 303). The concept of the serious game was to fully embrace the motivating factors (of which enjoyment is just one) that embed these critical skills into the students’ ongoing practice, to include the ideas of risk-taking and learning by failing, as well as encouraging creativity, imagination, and problem solving – and to do this in a sufficiently structured and ‘safe’ playful environment [8] by reinstating fun play as a means to establish knowing [3] (p.18). Therefore, a primary driver for the serious game *How to Fail Your Research Degree* was to embed this learning strategy directly into the course to complement the existing more traditional and didactic methods currently used (primarily lecture-based with some discussion and tutorial sessions). This builds on the much more well-established educational practice of learning by doing, i.e. being directly involved and invested in the outcomes of the educational activity.

### **3 Game Design**

#### **3.1 Supporting Learning**

Game design began by defining the general game characteristics needed (based on the general academic context outlined above as well as the local context of the research skills programme at GSA). This was followed by clearly delineating learning outcomes for the game based on the existing curriculum for a single course within the overall programme.

#### **3.2 Game Characteristics**

The game characteristics were defined so that the game would:

- Be based on the curriculum for the Research Methodology and Scientific Writing taught module in Core Research Skills at the Glasgow School of Art.
- Be deliberately abstracted, simplified, and made light-hearted. It is not intended to be a simulation of doing research!
- Be simple in terms of game rules, focussing on the learning outcomes, not the skill of gameplay itself.
- Be playable in groups but also support individual play. The game will not be (directly) competitive or co-operative, however playing together with other people will reinforce the learning outcomes and the fun social aspect.
- Be playable within a fairly short time (e.g. under 30 minutes) to allow for play and discussion within a lesson/tutorial context.
- Enable and provide references for discussion and analysis after a play session.
- Include the principles of student-centred learning by being: fun and light-hearted; memorable; directly relevant to students’ situations; and of practical use in reinforcing the learning outcomes of the course.

### 3.3 Intended Learning Outcomes for the Game

To support learning outcomes of the research methods training course, the game should:

- Highlight various risks of research projects and suggest their impact on projects
- Reinforce dependencies between tasks at different stages of research
- Directly reinforce the interrelations of different risks with the activities taken to negate or ameliorate them
- Replicate the time-critical nature of short research projects

### 3.4 Review of Existing Games

A review reveals only one serious game that exists for broadly similar goals. The Continuing/Higher Education in Research Methods Using Games project “aims to develop a game to support students as they develop an understanding of research methods and statistics” [9] and has produced digital mini-games focussed on a particular topic (diet) and aimed primarily at social science and nursing students. The intention of *How to Fail Your Research Degree* was to be non-subject specific (i.e. research methods is the subject) and playable in a group tutorial context, therefore the solo, digital mode of play was not appropriate. Several games exist in the field of project management, none of which featured the game mechanics that would support the learning outcomes defined. Several were luck-based and use a snakes-and-ladders model<sup>1</sup> which is not a good fit for the non-linear, iterative, and thoughtful process of doing research. The circular model of a serious board game like CURATE<sup>2</sup> is

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<sup>1</sup> Project Risk <http://www.purplepaw.com/2009/08/project-management-training-board-games/>; Virgin Blue <http://www.torstenkoerting.com/2010/01/13/how-to-celebrate-project-closure-with-a-unique-board-game/>

<sup>2</sup> <http://www.digcur-education.org/eng/Resources/CURATE-Game>

somewhat more appropriate, however did not support the idea of active, self-determined building of a research framework which supports the production of results. Other games focussed on the research process were either fictional(!) and/or discipline-specific<sup>3</sup> or little more than infographics aimed at a much lower educational level.<sup>4</sup>

### 3.5 Game Mechanics

In response to the defined characteristics and intended learning outcomes for the game, mechanics were designed to emphasise the player's control and agency over building up their research framework, whilst including elements of luck in drawing cards representing different risks and events.

Players use Activity cards to construct a research framework in four stages: PLAN; RESEARCH CONTEXT; RESEARCH & ANALYSIS; and WRITEUP. The PLAN stage acts as a setup and practice phase where exactly 8 cards are laid out side-by-side. The three remaining stages each have two phases. First, there is a timed phase (the Activity phase) where players frantically build up their activity for that phase by turning over face-down Activity cards and fitting them into their project framework. It is important to work fast to get enough research done so that players can build on it in subsequent rounds. This is followed by an Events phase where players draw Events cards at random and resolve the impact of the event on their research.

With the exception of the PLAN stage, Activity cards are played within a 2 minute time limit, drawing and placing cards as many cards as the player can. This timed element is intended to be frenetic, demonstrating the passing of real time in which to perform research and also adding an emotional/adrenalin element to the game. To represent the thoughtful research process and enable player agency, each Activity card has arrows (or blank edges) that must match the cards around it. Players must play all cards from each stage in one horizontal layer, but is otherwise free to place a card wherever it is legal to be played. An example framework showing valid and invalid plays is shown in Fig. 1.

After each timed Activity phase, players take turns to draw three Events cards from the Events deck, read each out to the other players and then apply them to the research framework. Events can have disastrous (or occasionally helpful) effects on the research. Effects typically take the form of removing existing Activity cards (representing for example, data that cannot be used because it was not collected in an ethical manner) or 'blocking out' spaces in future Activity layers, making them unplayable and therefore making future rounds more difficult (representing for example, not doing enough reading for a literature review). Events can typically be negated or ameliorated by activities the player has successfully completed. For instance, a computer failure is entirely negated if the player has played the 'Research data management (RDM) Strategy' card in her PLAN activity framework and a

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<sup>3</sup> Research Lab: [http://bigbangtheory.wikia.com/wiki/Research\\_Lab](http://bigbangtheory.wikia.com/wiki/Research_Lab); Sharkworld <https://store.itpreneurs.com/en/sharkworld-a-project-management-game>

<sup>4</sup> E.g. How to Do research: <http://classroom-aid.com/2013/04/05/how-to-do-research-game/>

‘Procrastinate’ event can be ameliorated by having played a ‘Milestones’ Activity card. The tone of the cards and rules is lighthearted, making it clear that the research is an abstraction and exaggeration of real research, whilst having activities and events that are directly relevant to students.

The purpose of the game is to join as many Thesis cards (Activity cards with a solid black line at the top) as possible together in the WRITEUP phase (and to have the longest line of conjoined cards survive the final events phase). Fig. 1 shows an example framework with three conjoined Thesis cards, marked in red. The length of the longest line of joined Thesis cards demonstrates the success and robustness of the research project.

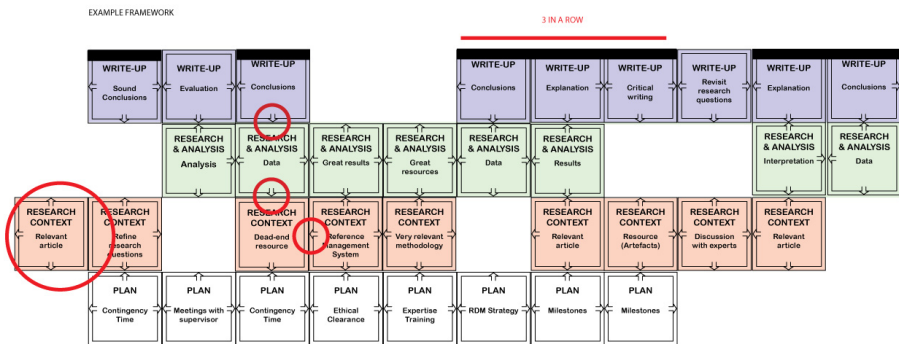


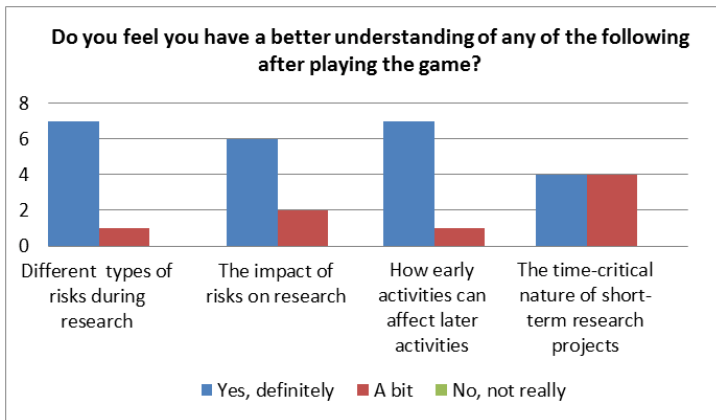
Fig. 1. Example gameplay showing illegally placed cards (circled) and conjoined Thesis cards

## 4 Preliminary Evaluation

*How to Fail Your Research Degree* is a work in progress. The game was tested informally and an initial set of improvements were made, largely to make the card layout more visually understandable and to tweak explanations within the rules document. Some feedback suggested making placing Activity cards more difficult (by reducing the numbers of joining arrows). This suggestion was rejected due to the context of a game that is likely to be played only once or twice by a general cohort of students, the majority of which will not be experienced board gamers. Whilst placing the cards will quickly be recognised as too easy by experienced gamers, the worst potential outcome of the game is if a student does not manage to place enough cards in a single phase and is therefore knocked out before the end. This outcome would be neither emotionally nor educationally rewarding and it was decided to reduce the chances of this as much as possible, without compromising the need to actively think about where each card is placed. After initial refinement, the game was played in the final tutorial of the research methods course (2014 cohort). A short questionnaire tested the Intended Learning Outcomes (defined in 3.3 above) and gathered freetext responses about lessons learned and the experience of playing the game.

As Fig. 2 shows, the game was extremely successful in communicating the types and impacts of risks during research, as well as the interdependencies between early

and later activities. It was also moderately successful at emulating the time-critical nature of short-term research projects. Freetext comments highlighted the major lessons learned or reinforced from the game, all of which align with the intended learning outcomes of the course. The game satisfies all learning outcomes specified and both formal and informal feedback shows that it was a funny, memorable experience for the students and relevant to their lives. Measured against the design criteria (specified in 3.2) the only area in which the game fails is in the length of time needed to play (it takes about 45 minutes to explain and then play the game with 4 players) and arguably, the clarity of the rules document itself – although the students found the rules easy to understand once explained verbally. Further refinements to improve rules clarity (e.g. the addition of a game board and further pictorial examples) have now been included.



**Fig. 2.** Chart showing responses to game learning outcomes

## 5 Conclusions and Next Steps

*How to Fail Your Research Degree* has produced largely positive initial results in terms of both learning about research methods and player experience. The major next step is to continue incremental improvements based on ongoing feedback and to corroborate initial results with a larger scale evaluation. The game is still a little too reliant on luck in the initial PLAN stage (which deliberately strongly influences how well the fictional research project stands up to the disasters that befall it). Therefore, optional rules are being considered which allow students to ‘purchase’ a limited number of missing elements (e.g. a data management strategy card). This would give players more control in creating a strong research framework. Through future use, the game will also allow a semi-structured longitudinal comparison of the understanding students have of the course material. Played once at the beginning of the course and once at the end, the abstractions provided by the game will allow students to recognise and reflect upon the techniques and processes they have learned before they put them into practice in their research degrees. Additionally, a structured game

environment lends itself easily to adaptations that could allow tutors to explore issues such as equality and diversity. Games allow the explicit foregrounding of “unfair rules” in a safe and uncomplicated environment which functions as a useful abstraction to discussing these issues as they play out in real life [10]. The game could be used in this way in any research-centred training.

Not least, this game brings back the fun into what risks being a rather dry subject if delivered in a didactic format. Games can, and do, have a place in making our learning environments effective and inspirational places.

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## PW4

# Game-based learning for postgraduates: an empirical study of an educational game to teach research skills

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ARTICLE



## Game-based learning for postgraduates: an empirical study of an educational game to teach research skills

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### ABSTRACT

Research skills are challenging to teach in a way that is meaningful to students and has ongoing impact in research practice. This paper investigates constructivist and experiential strategies for effective learning and deep understanding of postgraduate research skills and proposes a game-based learning (GBL) solution. A (non-digital) game called *How to Fail Your Research Degree* was designed and iteratively developed. Gameplay loop analysis identifies various learning and game mechanics and contextualises them in relation to GBL theory. Evaluation of gameplay ( $n = 127$ ) demonstrates effective transmission of intended learning outcomes and positive game experience based on Keller's Attention-Relevance-Confidence-Satisfaction (ARCS) model. Discussion proposes that the game has high cognitive authenticity, relies heavily on tutor facilitation, can create tension between knowledge and confidence, and is applicable to multiple domains and learning situations. GBL is proposed to be an original and effective approach to teaching high-level, functional learning outcomes such as academic research skills.

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### KEYWORDS

Game-based learning; GBL; serious games; research skills; postgraduate; gameplay loop

## Introduction

Educational games (also known as ‘serious games’) are widely acknowledged as fruitful tools for learning and skills development across multiple domains, specifically educational enhancement (Bellotti, Kapralos, Lee, Moreno-Ger, & Berta, 2013). The literature on game-based learning (GBL) has moved on from questioning *whether* educational games can successfully enable learning and now concentrates on *how* learning occurs: the particular ways in which games and their associated teaching practices can be best exploited to meet learning outcomes (Hanghøj & Hautopp, 2016). The emergence of, and need for, empirical studies which examine different game mechanics and their effects within courses is noted by Aguilar, Holman, and Fishman (2015). Higher Education has lagged behind school-based implementations of GBL, due to the barriers to adoption particular to this context (Moylan, Burgess, Figley, & Bernstein, 2015; Whitton & Moseley, 2012) and the difficulties of evaluating high-level cognitive outcomes (Whitton, 2012) resulting in little research addressing high-level, functional learning outcomes and less still specific to a postgraduate context.

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This paper analyses the development and evaluation of *How to Fail Your Research Degree*, an educational game for teaching postgraduate research skills. The design was in relation to both pedagogical and practical considerations<sup>1</sup> and gameplay loops have been analysed in detail to demonstrate the links between various game mechanics and their associated learning mechanisms. Literature on the evaluation of serious games informed the collection and analysis of quantitative and qualitative data from an extensive survey (n = 127) of the learning outcomes and experiential factors of playing the game. Results are then discussed in relation to GBL theory and this informs reflections on the game's implementation.

Development, contextualisation, and evaluation sought to investigate two specific concepts within GBL in a postgraduate context. Firstly, whilst there is significant evidence that games can effectively communicate knowledge, how can high-level, functional learning outcomes (such as research skills) be effectively taught through a game-based intervention? This addresses the research gap in close, empirical studies on GBL interventions within postgraduate learning. Secondly, what are the most fruitful facets of student engagement with this intervention, and does it encourage students to embed these skills into their practice? This, alongside the interdisciplinary analysis of game and learning mechanics offers insight into how GBL can be effectively deployed and its likely impacts.

### Rationale for game-based learning of research skills

Equipping postgraduate students with research skills and critical aptitudes is widely acknowledged as being crucial for their future problem-solving and employment opportunities. Yet, alongside this need, the literature identifies a widespread lack of satisfaction and engagement in research skills courses. '[T]he common finding among scholars is that students find methods classes "dry" and "irrelevant", leading them to not engage with the material as much as they would with a topic-based course.' (Ryan, Saunders, Rainsford, & Thompson, 2013, p. 88). Studies identify both the difficulty of teaching research skills in a way that is meaningful to students, and also the need to relate skills to real-world problems in order to increase relevance and motivation to learn (Waite & Davis, 2006, p.406; Ryan et al., 2013, p.88; Hamnett & Korb, 2017, p.449; Kirton, Campbell, & Hardwick, 2013). Furthermore, transitions from undergraduate to postgraduate study are recognised as posing particular challenges and, until recently, have presented a research gap (O'Donnell, Tobbell, Lawthom, & Zammit, 2009; Burgess, Smith, & Wood, 2013, p.4; QAA, 2017). Graduates from diverse backgrounds need to improve their critical reading, thinking, and writing skills in the context of a taught master's or research degree, often in a very different learning mode than the student has previously experienced (O'Donnell, 2009, p. 35–37). This context requires both deep understanding and the active application of research skills; quite different to learning outcomes related to simply retaining knowledge.

Precisely because of these challenges, recent course redesign and interventions in research skills tuition have emphasised constructivism, with educators introducing much more active and experiential teaching and learning methods. Examples include scaffolded real-life academic (Hammett & Korb, 2017) and extra-academic (Kirton et al., 2013) research activities; exposure to and critique of real-world examples (Ryan

et al., 2013); mind maps (Kernan, Basch, & Cadorett, 2017); and metacognitive strategies such as active reflection (Saemah et al., 2014; Kirton et al., 2013) and peer assessment (Burgess et al., 2013). Positive results were reported for learning outcomes, engagement, and practical application of knowledge and skills. These results, specific to teaching research skills, reflect the wider literature on experiential and active learning strategies, and authors note the need for further innovation and a ‘culture shift’ within research skills course delivery (Ryan et al., 2013, p. 88).

### **An original intervention: game-based learning of research skills**

The characteristics of learning and playing games are closely correlated: curiosity, persistence, risk-taking, reward, attention to detail, problem-solving, and interpretation (cf. Klopfer, Osterweil, & Salen, 2009). The research presented here sought to enhance a lecture-based research skills course and improve knowledge retention, deep understanding, and students’ research practice, reflecting previous moves towards active, constructivist approaches. There is no evidence of similar GBL strategies being used within postgraduate research skills teaching, making this approach a novel intervention. The overall goal was to enhance the comprehension and implementation of high-level, functional learning outcomes related to academic research, which is typically taught through lecture or seminar-based interactions. Pedagogy has for years acknowledged the tension between *telling* (e.g. via a lecture) and immersion in contexts of practice. Clearly, both are needed, however ‘Educators tend to polarize the debate by stressing one thing (telling or immersion) over the other and not discussing effective ways to integrate the two.’ (Gee, 2014, p. 114). GBL is well established as one way in which to complement the ‘overt telling’ limitations of lectures and other instructional approaches (cf. Boydell, 1976, p.32; Games & Squire, 2011; Kirkley, Duffy, Kirkley, & Kremer, 2011). Beard & Wilson firmly establish play as an experiential method – ‘play serves to *rehearse and exercise skills* in a safer environment’ (2002, p. 70) – and the vast majority of games are inherently active and constructivist. Research itself is also fundamentally active, experiential, and constructivist, and postgraduate assessments (e.g. dissertation or thesis) encourages learning activities which are highly goal-driven.

[W]hat is learned is goal-driven, and it is the learners’ goals and their ownership of those goals that shape the learning and problem solving process. [...] This epistemological commitment of sense making forms the basis for our design and use of games for learning. (Kirkley et al., 2011, p. 375)

Goal-driven learning, encouraging active participation, and rehearsing a relevant problem were core to the development of this intervention: a non-digital educational game called *How to Fail Your Research Degree*.

### **Game design and gameplay loop analysis**

Research into serious games shows that it is crucial to understand and integrate the serious game mechanics which are the relationship between pedagogy and game design; i.e. how mechanisms for learning are mapped to pedagogic goals. (Arnab et al., 2015). Arnab *et al.* reviewed the literature extensively to produce a descriptive and non-

exhaustive model to improve mapping of learning mechanics (LMs) to game mechanics (GMs): the LM-GM model (Arnab et al., 2015; Lim et al., 2013). This model, when combined with gameplay loop analysis (Guardiola, 2016), allows insight into the contextualised, dynamic relationships between player actions, pedagogic goals, and GMs.<sup>2</sup> The overall design parameters for *How to Fail Your Research Degree* have been previously published (Abbott, 2015) and full rules are available online (Abbott, 2017); therefore, this paper focusses on detailed mapping of LMs and GMs, incorporating in-game and out-game actions (Guardiola, 2016) in order to analyse purposeful learning within this context.

### Overall design

*How to Fail Your Research Degree* (henceforth *How to Fail*) is described as ‘undertaking a master’s degree at an unusually busy and calamitous stage of your life’ (Abbott, 2017). Figure 1 shows the high-level gameplay loop. Within the fictional context of a research dissertation, players draw and arrange tiles representing research activities (Activity Phase, see Figure 2) which are then affected by randomly drawn academic and real-life

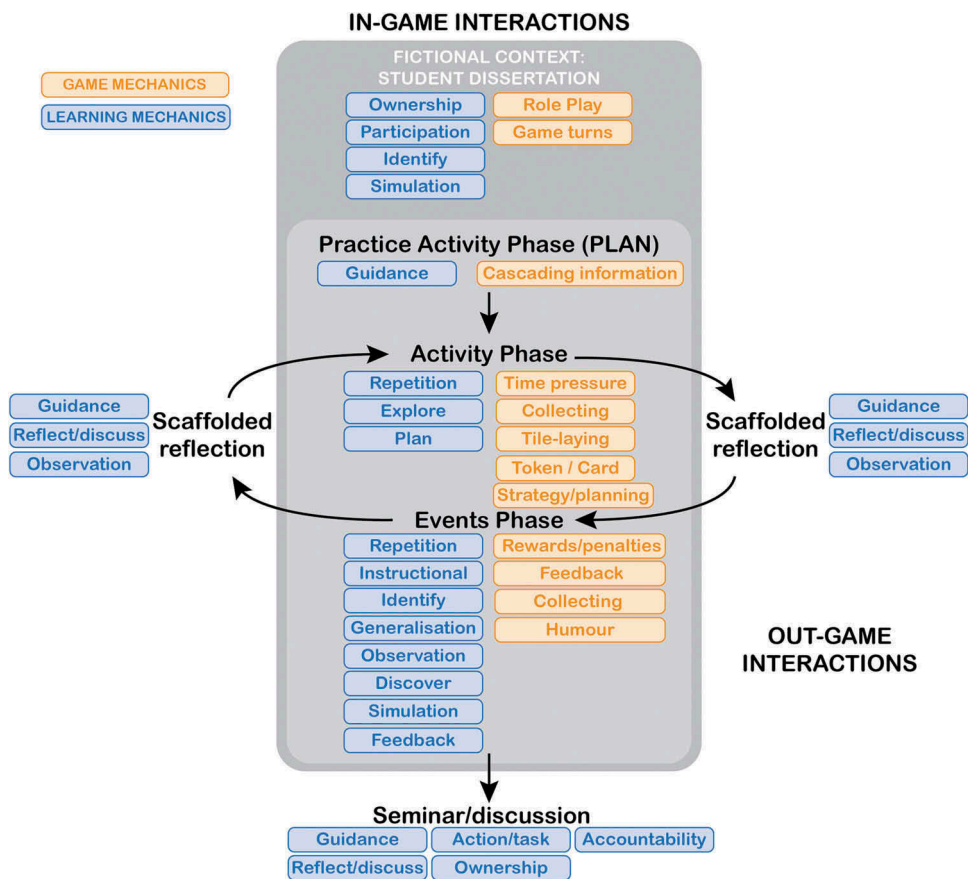
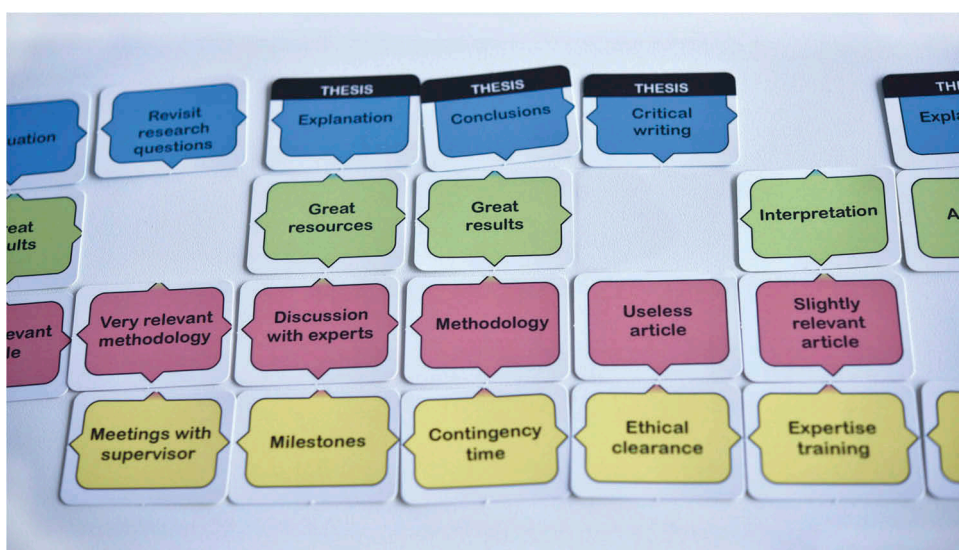


Figure 1. high-level gameplay loop analysis, identifying GMs and LMs.



**Figure 2.** example of a completed framework made up of Activity tiles from the four sequential rounds (Plan, Context, Implementation, Write-Up). The relative usefulness of each activity can be inferred from the connections shown on the cards, as well as whether or not it contributes directly to a good dissertation.



**Figure 3.** examples of Event cards.

events (Events Phase, see [Figure 3](#)). There are four rounds, a ‘practice’ Activity round (Plan), then three subsequent rounds: Context, Implementation, and Write-Up. The purpose of the game is to connect as many Thesis tiles as possible in the Write-Up round, representing a well-written dissertation. Within and between each round, players are supported in active reflection to enhance learning. Gameplay is followed

by a seminar/discussion in order to reinforce the lessons learned, propose future actions, and increase accountability.

The crucial role of reflection within GBL activities is well established: '[L]earners must have opportunities to analyse, reflect upon, and abstract what has been learned in the game' (Kirkley et al., 2011, p. 389). This is supported by Beard and Wilson (2002, p. 17) and Boydell who notes that this deeper understanding is core to the process in which an experience becomes conceptual guidance for new experiences (1976, p. 17). Sandford & Williamson note that space for reflection is rarely included in games for learning (2005, p.15), making its close integration into gameplay here significant.

The intention was to minimise learning *about* the game in order to maximise learning *through* the game (*cf.* Sandford & Williamson, 2005, p. 17), therefore rules are as simple as possible, whilst still supporting intended learning mechanisms. As Figure 1 shows, gameplay incorporates social and vicarious learning, out-game reflection, and repeating cycles of constructivist exploration, discovery, and instruction (discussed in more detail below). The overall gameplay loop takes place within an immediately recognisable and relevant fictional context (a simplified simulation of a student research project.) Creating a game environment which is fictional (and therefore safe) yet realistic provides students with a 'whole-task context' thought to be more easily mapped to real situations (Easterday, Aleven, Scheines, & Carver, 2011, p. 69) whilst also encouraging an element of risk-taking; required to produce original and innovative research (Fry, Ketteridge, & Marshall, 2003, p. 303). This approach is supported by the principle of constructive alignment between learning activities, assessments, and intended learning outcomes (ILOs). Biggs' extensive work on constructive alignment emphasises that aligned course design encourages active construction of meaning and the ability to abstract and reflect on learning in order to apply it to future situations (Biggs & Tang, 2011). In the GBL context, enhancing cognitive objectives requires close integration of game learning activities into the curriculum (Tobias, Fletcher, Dai, & Wind, 2011, pp.177, 198) and, when aiming to embed critical capabilities into students' ongoing practice, it is particularly important to align games (subject, gameplay, or both) with the core competency seeking to be taught, in other words reinstating *play* as a means to establish *knowing* (Games & Squire, 2011, p. 18). Therefore, the instructional goals of *How to Fail* are based directly on elements of the curriculum for the research skills course where the game was initially implemented, focussing on the successful management of a dissertation project. The game's ILOs enable students to:

- (1) Understand the various risks affecting research and their impact on projects;
- (2) Recognise dependencies between tasks at different stages of research;
- (3) Understand the interrelations of different risks with the activities to negate or mitigate them;
- (4) Be aware of the time-critical nature of short research projects. (Abbott, 2015)

As discussed above, research skills courses have particular challenges in motivating students to learn and practice these skills. Beard and Wilson state that 'for learning to occur and an opportunity for learning not to be rejected, there has to be an attitudinal disposition towards the event' (2002, p. 119). Although it is common to encounter the



(incorrect) assumption that *all* games are inherently motivating, simply because they are often fun, the need for connectivity in games which aim to increase motivation for learning is widely acknowledged. Keller states that:

To be effective, motivational tactics have to support instructional goals. Sometimes the motivational features can be fun or even entertaining, but unless they engage the learner in the instructional purpose and content, they will not promote learning. (2010, p. 25)

Keller also notes the negative effects of non-aligned game experience (p.222) and states that motivation ‘includes all goal-directed behaviour’ (Keller, 2010, p. 4) noting its complexity as both affective and cognitive (p.12), extrinsic and intrinsic (p.18). A wider discussion of the motivation for learning is outside the scope of this paper; however, it is notable that games are specifically mentioned by Keller as a technique to improve motive stimulation (2010, pp.130, 190), and he describes educational games as having elements of person-centred and interaction-centred motivational design models. Increasing motivation for a subject often seen by students as somewhat dry was a core design goal of *How to Fail*. Design was student-centric focussing on interactions that are light-hearted, memorable, and highly relevant to the course and programme outcomes as well as wider research capabilities. The game falls into a category of motivational design defined by Keller as *omnibus models* which ‘have more pragmatic or pedagogical origins and incorporate both motivational design and instructional design strategies without distinguishing between the two’ (p.27) and includes a constructivist approach designed ‘to help learners develop meaningful, contextualized bodies of knowledge’ (p.34). Put more simply, *How to Fail* explicitly connects the pedagogic method to the goals of learners to influence their attitudes towards core course content based on goal success (or failure) (cf. Keller, 2010, p. 22).

### **Specific game mechanics for learning**

Within the overall gameplay loop, the detailed mechanics were iteratively developed. One set of attributes define GBL as being at its most effective when it includes: active participation; immediate feedback; dynamic interaction; competition; novelty, and goal direction (Tobias et al., 2011, p. 177). Mechanics therefore encompass these attributes (with the arguable exception of competition) and emphasise the thoughtful nature of a research project, the player’s control and agency, and the pressures of time (Activity phase, Figure 4), alongside luck in encountering different risks and events and active reflection on how to avoid or ameliorate them (Events phase, Figure 5).

The Activity phase is largely preparatory, players collect different types of research activity, with elements of strategy and resource management within the metaphorical project. For example, during the Context round, a player draws a ‘Relevant Article’ tile which must be matched using the arrows to existing tiles played (Figure 2). LMs during this stage are limited to recognising and building the required activities (Plan) and a constructivist, exploratory approach to the relationships between tiles (Explore), proposed to be ‘most appropriate for teaching generalised thinking and problem-solving skills’ (Lim et al., 2013, p. 181).

During the Events phase, on the other hand, GMs are simply drawing and following instructions on Event cards and instead the LMs are firmly foregrounded. The risk or

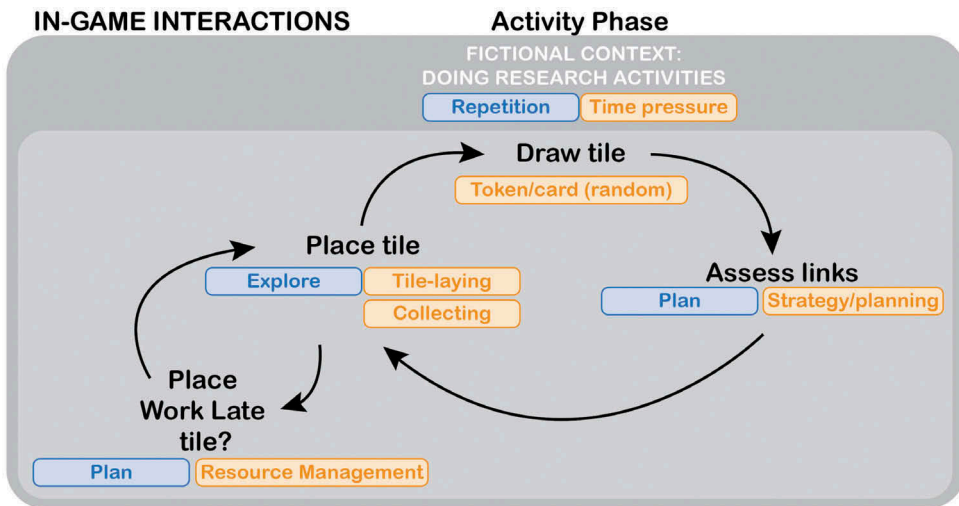


Figure 4. gameplay loop analysis of the Activity Phase.

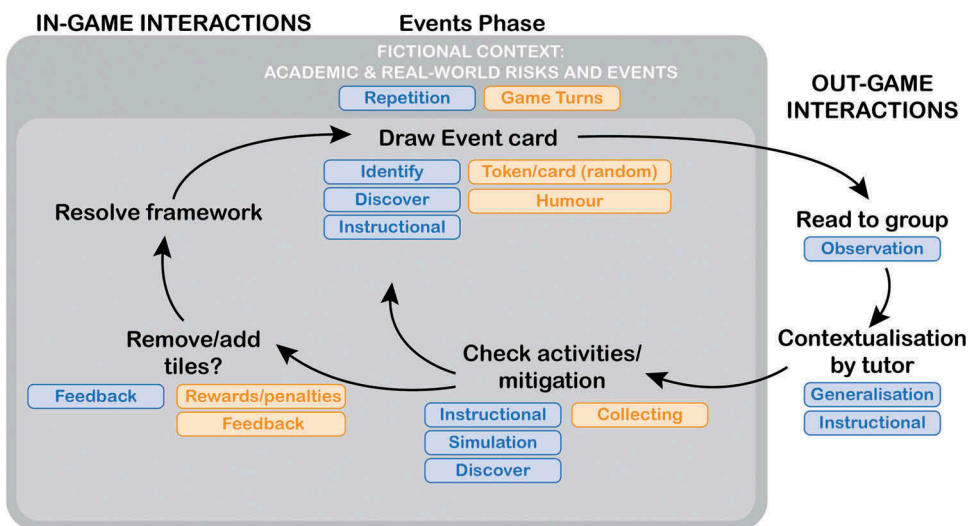


Figure 5. gameplay loop analysis of the Events Phase.

event on each card is recognised or learned by the player (Identify/Discover, Instructional) and shared with the rest of the group by reading out the card (Observation). Tutor contextualisation aids direct or inductive learning, relevant to both the Event and the Activities collected by the player which may prevent the card penalty. Checking the Event card against existing Activities creates active learning of the conceptual connections (Discover, Simulation) and the penalties/rewards on the card provide instant Feedback about possible consequences. For example, a player draws a 'Bluescreen' event (Figure 3), reads it out and checks her framework to see if she has collected a 'Research Data Management Plan' tile. The tutor defines 'research data management' and provides real-world examples of both the event and methods to

avoid it happening. The team does not have a ‘Research Data Management Plan’ tile and must, therefore, choose three other tiles to remove, representing work that was lost when the computer crashed.

Penalties and points of failure within educational games increase the challenge, excitement, and pressure, all of which work to provide meaningful agency over gameplay (Easterday et al., 2011, p. 70). Most games present losing as something to be overcome by strategy or mastering gameplay (*cf.* Juul, 2013, p. 9), whereas the Penalty/Feedback interplay is central to *How to Fail* as it highlights academic risks in a meaningful yet safe environment and, combined with luck, moves the focus of the game to *process*, i.e. engagement with the activity itself rather than results. Crucially, learning opportunities occur *during* gameplay, therefore, it is participation itself which is educational, not whether or not players ‘win’.

Habgood and Ainsworth (2011) discuss *intrinsic integration*, that is, an intrinsic link between GMs and learning content, and note that directing flow experiences (i.e. gameplay) towards educational goals could increase learning and motivation when core mechanics are intrinsically integrated with ILOs. They also state that learning in the intrinsic condition is more emotionally charged, which is thought to have benefits for long-term retrieval (p.198). As can be seen from the LM-GM analysis above, gameplay is intrinsically integrated with LMs, especially in the Events phase, and reflects the game’s overall metaphor.

To complement the theoretical analysis above, empirical data on learning and gameplay experience will now be presented.

## Evaluation

Serious games (SGs) evaluation literature demonstrates positive outcomes within formal education for knowledge acquisition and content understanding, knowledge retention, and in particular, motivation (Bellotti et al., 2013, p.2; Tobias et al., 2011, pp.160–161, 188) whilst simultaneously noting the shortage of rigorous studies and the need for robust frameworks for SG evaluation (Bellotti et al., 2013, p. 2) as well as the highly fragmented community in this discipline (Mayer et al., 2014, pp.502–504). Recent research attempts to address the lack of universal evaluation and validation procedures for SGs and to bring together fragmented research on this topic (GaLA, 2014). Bellotti *et al.* state that ‘assessment of a serious game must consider both aspects of fun/enjoyment and educational impact’ (2013, p. 1). The notion of ‘fun’ is broadly accepted as an SG characteristic however research has questioned whether emotional engagement need necessarily be a positive experience and analysed the value of less pleasurable facets to the ‘entertainment’ aspects of SGs (*cf.* ‘pleasantly frustrating’ experiences (Gee, 2007, p. 36) and Beard & Wilson’s description of ‘painful learning’ and learning from mistakes (2002, p. 22–26)). The balance between engagement and pedagogy is also acknowledged as being of critical importance to the success of any SG (Boughzala, Bououd, & Michel, 2013, p.845; Bellotti et al., 2013, p.3; Kirkley et al., 2011, p. 389).

Evaluation methods suitable for non-digital games include post-game questionnaires as well as teacher assessment based on observation during gameplay (Bellotti et al., 2013, p.3; Moreno-Ger, Torrente, Serrano, Manero, & Fernández-Manjón, 2014, p. 10). The importance of triangulated methods is also specifically noted by Mayer et al. (2014,

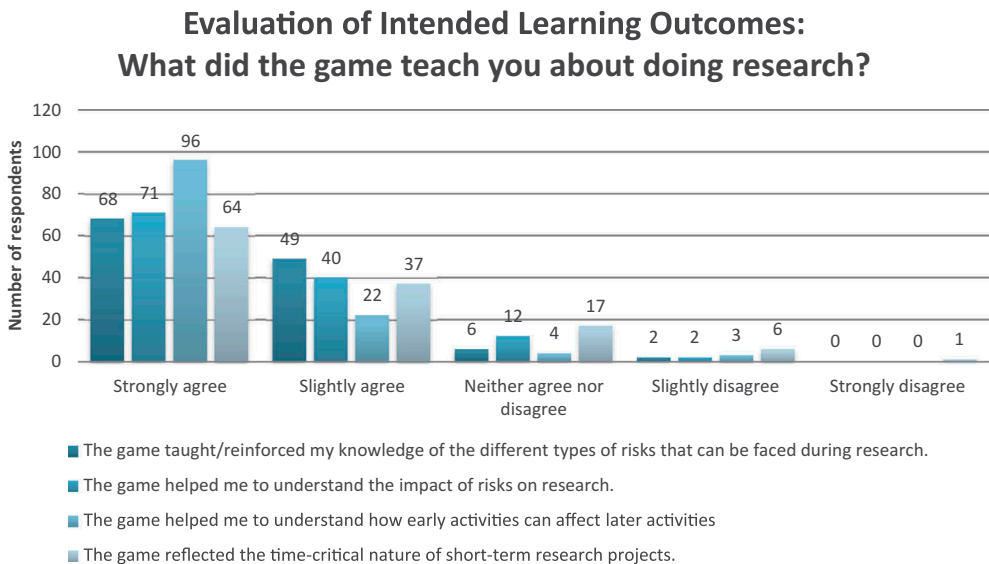


p. 509) and qualitative evaluation of serious games within Higher Education is identified as a research gap by Boughzala et al. (2013, p. 846).

## Methodology

The evaluation methodology for *How to Fail* draws on the above research context and therefore focusses on testing two aspects: the effectiveness of the game in achieving its intended learning outcomes (ILOs), and the experience of gameplay itself. Dede proposes that a valuable assumption for a research agenda is to focus on individual learning rather than attempting to demonstrate generic effectiveness in a universal way (2011, pp.236--237); therefore, the target group for evaluation was taught master's and early-stage PhD students (the intended primary users) whilst also including a small number of final-year undergraduates and postgraduate tutors, where appropriate. After the study gained ethical clearance from the institutional Ethics Committee, 21 voluntary game sessions were run with over 130 players attending. Games had a varying number of players (from 2 to (typically) 8–12, but in one extreme example 28). Where participants exceeded four per game, players were grouped into teams and the facilitator encouraged equal participation by all team members. Game rules were briefly explained before gameplay and reinforced throughout. Gameplay was followed by a short reflection, distribution of the surveys, and then (where possible) a tutorial discussion focussing on reinforcing the learning outcomes. Participation in the survey was voluntary and anonymous and took place after gameplay and reflection, but before further discussion. 127 surveys were returned.

Quantitative data on the perception of cognitive outcomes were collected on a 5-point Likert scale measuring player agreement with four statements based on the game's ILOs (see Figure 6). Qualitative data were sought via free-text response which appeared before the more guided quantitative questions to avoid biasing responses.



**Figure 6.** Number of Likert scale responses to each ILO evaluation statement.

Evaluation of game experience used a widely applicable theoretical framework focussed on emotional engagement as the conduit to increased motivation: the (extensively validated) Attention Relevance Confidence Satisfaction (ARCS) model, which uses an extensive review of motivational literature to cluster motivational concepts into four categories, shown in the first three columns of [Table 1](#) (Keller & Suzuki, 2004; Keller, 2010, p. 44–45).

As noted in Roodt & Joubert, motivation in higher education is multifaceted; therefore, the ARCS model is a robust method of evaluating whether the major motivational facets defined by Keller exist within an SG (2009, p. 337). This model encapsulates ‘fun’ within the Satisfaction and Attention facets, and also provides a nuanced framework through which to examine other motivation-related game experiences. As with the evaluation of ILOs, free-text responses were sought before data on attention, relevance, confidence, and satisfaction were collected using a 5-point Likert scale.

Personal data collection was solely a self-assessment of research experience. Respondents could also write additional free-text feedback.

Quantitative data were collated and analysed with nonparametric statistical methods appropriate to ordinal, not normally distributed, data. Outliers were retained to show full range of responses. Qualitative data were hand-coded to triangulate quantitative results and identify any other major themes emerging by identifying synonyms and grouping statements by intent for a macro-analysis. All results were interpreted with the informal knowledge gained by the researcher having participated in the out-game elements of the GBL intervention (see [Figures 4–5](#)), observing players’ experiences of gameplay and examples of deep learning in discussions inspired or contextualised by the game. The participation of the game designer as facilitator was invaluable in informing analysis and interpretation of the way the game plays out in different groups and the major lessons learned. However, it is acknowledged that action research of this kind is also a methodological limitation. Rules explanations, gameplay, and reflection were not delivered in exactly the same way as the game is designed to be a responsive teaching tool. Furthermore, the presence of the game designer as facilitator may have influenced survey results, despite best practice being followed to ensure anonymity and encourage honest responses.

**Table 1.** ARCS Model (Keller, 2010, p. 45), final column added by author.

Major Categories	Definitions	Process Questions	<i>How to Fail LMs/GMs</i>
Attention	Capturing the interest of learners; stimulating the curiosity to learn	How can I make this learning experience stimulating and interesting?	Time pressure, humour, penalties/reward, explore, discover
Relevance	Meeting the personal needs/goals of the learner to effect a positive attitude	In what ways will this learning experience be valuable for my students?	Simulation, identify, plan, ownership, feedback, generalisation
Confidence	Helping the learners believe/feel that they will succeed and control their success	How can I via instruction help the students succeed and allow them to control their success?	Guidance, instruction, reflect/discuss, repetition
Satisfaction	Reinforcing accomplishment with rewards (internal and external)	What can I do to help the students feel good about their experience and desire to continue learning?	Penalties/reward, action/task, accountability, feedback, humour

### Longitudinal study

To complement immediate outcomes, reflection on the second-order learning outcomes over time was facilitated via a longitudinal evaluation ( $n = 13$ ) (*cf.* Mayer et al., 2014, p. 511). This sought to establish which lessons had been retained approximately 6 months after playing using free-text responses: what the player remembered learning, feeling, and other comments. The open-ended strategy avoids prompting the respondents' memories, to gain the most accurate results.

## Results and analysis

### Intended learning outcomes

A large majority of players agreed with the statements testing each ILO, indicating high levels of success in the knowledge acquisition/reinforcement defined (see Figure 6). Table 2 shows overall agreement (i.e. slightly agree plus strongly agree) with each ILO, all of which are over 80%. The game appears to be particularly successful at identifying risks and their impacts (94% and 89% agreement, respectively) and enabling the active discovery of interrelations and dependencies between early activities and activities and risks that come later, with 94% overall agreement (77% who agreed strongly).

### Specific lessons learned

A number of specific outcomes were identified by players in free-text responses; the most common are presented below, evidenced by selected quotes from players.<sup>3</sup>

- (1) Interconnectedness/dependencies in research activities. This outcome is directly aligned with the game's ILOs and triangulates the results of the third evaluation statement in Table 2.

'It demonstrated cause & effect issues in research and emphasised thinking ahead.' (Participant ID (PID) 22)/'The dependencies inherent in the structure of almost any research project e.g. if you haven't set milestones at the planning stage, you are vulnerable to distractions later etc.' (PID23)/'Everything is connected.' (PID123)

- (2) The importance of planning. This lesson arises from many of the Event cards being directly negated or ameliorated by activities in the Plan phase (e.g. Contingency Time ameliorates the penalties of getting ill) and is aligned with the ILO of demonstrating how early activities can affect research later on.

**Table 2.** percentage of responses agreeing with each ILO evaluation statement.

	% agreement
The game taught/reinforced my knowledge of the different types of risks that can be faced during research	94% (117/125 responses)
The game helped me to understand the impact of risks on research	89% (111/125 responses)
The game helped me to understand how early activities can affect later activities	94% (118/125 responses)
The game reflected the time-critical nature of short-term research projects	81% (101/125 responses)

‘Reinforced the importance of planning and strategy at the early stages of research.’ (PID14)/‘The need for careful planning.’ (PID24)/‘Remember to factor in contingency time – didn’t do this as a student and should recommend to others.’ (PID19)/‘The better I plan, the more likely I will succeed.’ (PID17)’

(3) The impact of both academic and real-world events/risks.

‘Reinforced the idea that research is very much managed on the individual level and is therefore caught up in a person’s life and circumstances.’ (PID14)/‘the importance of support structures (supervisors, friends and family etc) and potential need for training.’ (PID23)/‘bad stuff happens and you have to make tough decisions about what has to go.’ (PID24)

(4) That the game would be most useful played *early* in the research process.

‘I wish we could have done this or had it required at the beginning of our proposals.’/‘I wish I could have considered these outside factors sooner.’ (PID17)/‘Great game, possibly something that can be introduced at an earlier stage of the final project to know how to deal with blocks or certain obstacles’ (PID125)/‘The game was enjoyable and definitely worth using during induction day/week of embarking on a research project.’ (PID95)

It is notable that the game designer’s plan for most fruitful integration into the research skills course was independently confirmed by players. Delaying direct instruction to allow students to first engage in problem-solving activities has been shown to promote learning and re-learning at university level (Westermann & Rummel, 2012), which supports this position. Several players also noted that the game was a good ice-breaker.

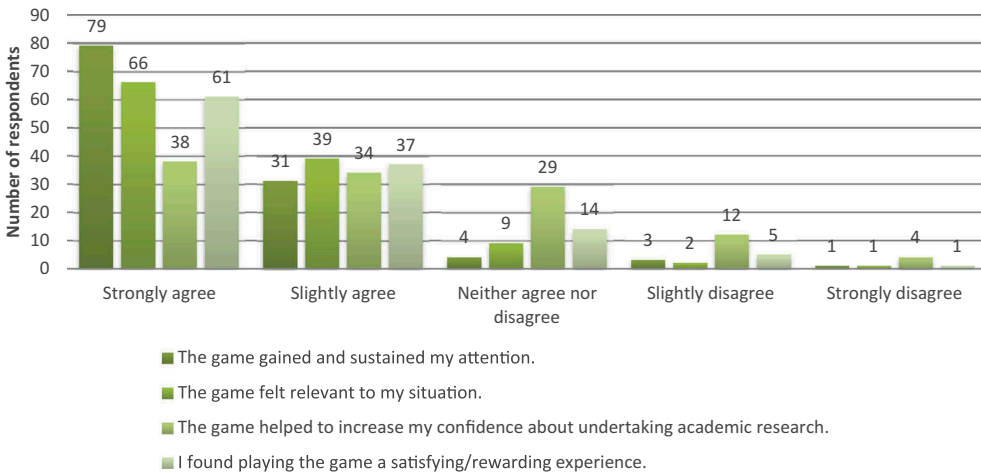
(5) Familiarisation with research terminology, particular for novice researchers and those with English as an additional language.

‘It was useful in demonstrating & repeating the terminology of research’ (PID19)/‘This would be useful for students needing reassurance in the use of English language terminology.’ (PID22)

Other specific lessons included the importance of considering the ethical implications of research, changing the player’s approach to research data management, and the specifics of planning the project (e.g. setting milestones, getting training where needed, and arranging appropriate meetings with supervisors).

With reference back to the gameplay loop analyses above, it can be seen that, as expected, the bulk of the learning/understanding occurs in the Events phase (Figure 5) with a mixture of Instructional, Discovery, Simulation, and Feedback learning mechanics (evaluation statements 1–3 and specific lessons learned 1–4). However, the Explore, Plan, Collecting, and Time-pressure mechanics during the Activity phase (Figure 4) are also crucial to support evaluation statement 4 and specific lessons 4 and 5.

## Evaluation against Keller's ARCS model: How did you feel while playing the game?



**Figure 7.** Likert scale responses to each of Keller's motivational factors.

**Table 3.** percentage of responses agreeing with each motivation evaluation statement.

	% agreement
The game gained and sustained my attention.	93% (110/118 responses)
The game felt relevant to my situation.	90% (105/117 responses)
The game helped to increase my confidence about undertaking academic research.	62% (72/117 responses)
I found playing the game a satisfying/rewarding experience.	83% (98/118 responses)

### Analysis of experience of gameplay

Evaluation of gameplay experience used Keller's framework to measure opinion on attention, relevance, confidence, and satisfaction (see [Figure 7](#) and [Table 3](#)).

#### Attention and engagement

92% agreed that the game gained and sustained their attention (67% strongly). This is the highest result from all four ARCS categories and indicates that the game is both novel and likely to be memorable. The framework indicates that a strong success in this factor indicates high perceptual and inquiry arousal, which will stimulate a curiosity to learn and apply understanding (Keller, 2010). Clearly, these causal links were not measured as part of this study; however, the extremely high positive result in this category is notable. Qualitative responses specific to attention and engagement included:

'It was neat to see a fast-forwarded process of how to write a thesis.' (PID17)/'The game taught various elements of research in a fun and interactive manner.' (PID13)/'Excited, nervous about the Event cards and engaged with the narration of the game' (PID91)/'it definitely sustained my attention and interest throughout ... Thoroughly enjoyed playing.' (PID21)/'Lots of fun and very instructive!' (PID106)

## Relevance

90% agreed that the game felt relevant to their situation (56% strongly). This strong result in terms of goal-orientation and motive matching also applies to Keller's third subcategory for relevance: familiarity (*ibid.*) (especially, as noted above, in terms of embedding appropriate research terminology). Situational relevance is also strongly reflected in the qualitative responses, with many students relating the game directly to their own research projects and processes:

'I think this was very accurate to myself/'Some of the planning cards gave me more ideas for my research.' (PID17)/'Timed nature of rounds feels like master's year.' (PID24)/'I also felt I could relate to my own research process throughout the game.' (PID15)

Perhaps surprisingly, high levels of relevance also applied to more and less experienced players (e.g. supervisors and undergraduates) who were easily able to generalise the fictional context and relate it to their own situations. A number of participants suggested ways in which the game could be made specifically relevant to them by adapting the final round:

Really good tool to brainstorm process of research, could blue deck be altered for researchers i.e. research paper/exhibition be a goal not a thesis? (PID19)

## Confidence

63% agreed that the game increased their confidence in undertaking academic research (33% strongly). Overall this category is not as emphatically positive as the other motivational concepts measured. Given the game's focus on penalties as a memorable learning strategy, this is perhaps not surprising. Keller's subcategories within Confidence focus on learning requirements, success opportunities, and personal control (2010) and whilst the first two are clear within the game, several players noted a frustration with the lack of personal control over cards drawn and luck-based elements of the game:

'so happy I could test my understanding of research but slightly frustrated that luck played such a high impact on my performance.' (PID20)/'Might be interesting to plan first round (PLAN) by choice and not luck. Felt a bit harsh to be peer-reviewed on what was drawn from pack.' (PID66)/'Under pressure – not very happy. It is a great idea and very clever – just not sure about how it might be made more reassuring.' (PID11)

Responses also revealed that some players felt less confident about research due to having gained an insight into the breadth and depth of procedures required of them.

'I didn't realise that ethical clearance was so important and could destroy the validity of your research.' (PID17)/'for those well-versed [research processes are] fine, for less experienced [they are] daunting to take into account.' (PID19)/'Added worry about how much there is to do.' (PID36)

This result suggests that increased knowledge can actually come into direct opposition with student confidence about the research they will undertake. Therefore, whilst realising how much you do not yet know is undeniably a useful outcome, it may have a negative impact on motivation.

### Satisfaction/reward

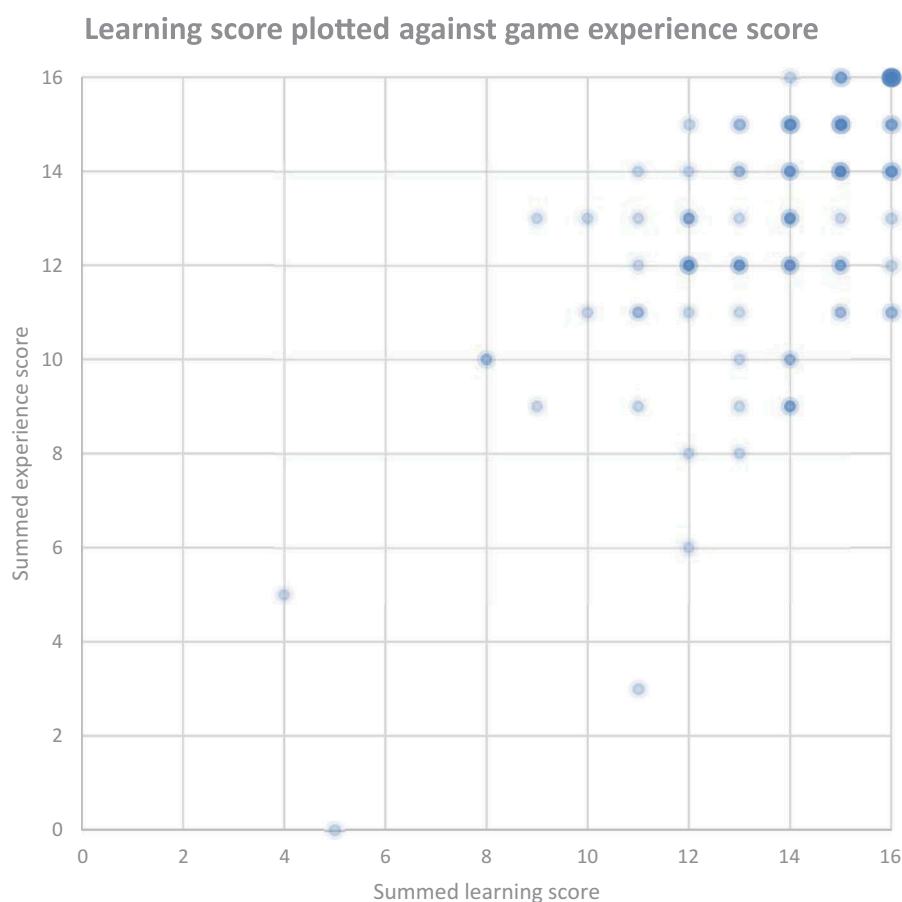
83% agreed that the game was satisfying or rewarding (52% strongly). This indicates not only a strong intrinsic reward within the game but also a link that was obvious to players between the game and their extrinsic goals (*cf.* Keller, 2010). Free-text responses emphasised this finding, identifying enjoyment of the experience (whilst acknowledging stress alongside fun as a useful emotional response) and desire to both use and share the game's learning outcomes:

'Slightly stressed! Enlightened.' (PID18)/'I found it fun and a bit playful' (PID16)/'Entertained and invested' (PID122)/'Relaxed at the start and a bit stressed by the time it came to write-up! Very positive experience as it is very well organised and didactic and presents a clear framework for approaching research.' (PID14)/'Excited and stressed. Great game, the events especially shows how one thing can mess it up. Would love to play again!' (PID115)/'Really excellent way into thinking through the mechanics of research!' (PID21)/'Good opportunity for discussion.' (PID24)/'**I hope my classmates do this**' [author's emphasis] (PID17)

### Player-level analysis

In order to gain further insight into individual player experiences, Figure 8 shows responses converted to numerical data (0 = Strongly Disagree, 4 = Strongly Agree) and summed to provide an overall Learning Score and Experience Score for each player where 16 represents strong agreement with every ILO or experience statement and 8 represents neutral overall (e.g. four Neither Agree Nor Disagree responses). Null value pairs were removed and transparency applied to show the frequency of responses. Acknowledging the limitations of converting Likert scales to numeric data (assuming linearity), it is notable that only outliers had Learning or Experience scores below 8 (Neutral) (see Figure 9), furthermore that the maximum value (16, 16) is the most common response. There is a (statistically significant) strong positive correlation between Learning and Experience scores ( $r_s(114) = 0.65$ ,  $p = 0$ ), suggesting that learning and 'fun' is well balanced.

Three-quarters of players reported very positive learning outcomes and gameplay experience (i.e. averaged 12 or more) with a median value of 14 for both. Results showed no significant differences between players with differing research experience,<sup>4</sup> indicating that the game remains useful at a number of different levels of research expertise. In terms of group size, there were no significant differences between reported learning between individual players, those playing in small groups, and those playing in large groups. However, the very large group ( $n = 28$ ) demonstrated a statistically significant drop in enjoyment of approximately 2 points ( $p = 0.01539$ ) compared with groups of up to 12 players and three of the four outliers who did not enjoy the game were from this large group. It is speculated that this is due to the lack of personalised scaffolding and opportunities for engagement with such a large group. The facilitator's informal reflections on this game also indicate that scalability is an issue, which is reflected in the literature on educational games (Baalsrud-Hauge et al., 2015). There were no significant differences in enjoyment scores between individual players and those playing in small teams; however, observation indicated that team play was more discursive which is felt to be a benefit.



**Figure 8.** Quantified, summed individual responses on learning and gameplay experience.

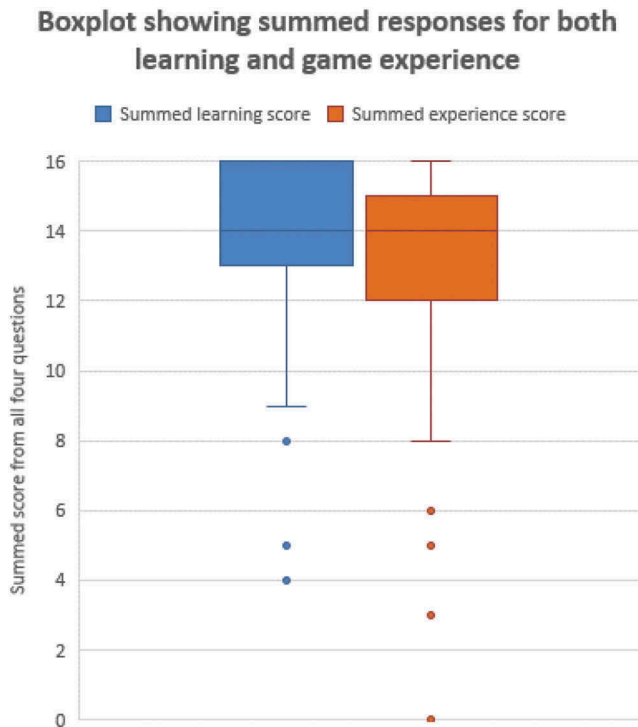
### **Longitudinal evaluation results**

Longitudinal evaluation reinforces the results above, albeit with the limitation of a much smaller sample ( $n = 13$ ). The most common lessons mentioned were the importance of planning (85%,  $n = 11$ ), having learned about the research process in general (69%,  $n = 9$ ), issues surrounding time management (e.g. setting milestones) (62%,  $n = 8$ ), and being made aware of the number and diversity of risks (54%,  $n = 7$ ).

‘It was a fun and engaging way to understand what the steps for a research project are.’ (Longitudinal PID7)/‘It made me more aware of everything that could potentially go wrong, so reinforced the fact you need to plan well’ (LPID2)/‘Great fun, and a good way of taking a step back and seeing what can go wrong.’ (LPID11)

Responses indicate that the major lessons learned from the game are retained in the medium term and have a role in contextualising research skills and approaches learned subsequent to playing the game. 77% ( $n = 10$ ) of responses specifically mentioned the impact that the game (and the student’s subsequent reflections on it) had on planning research projects, in fact, 54% ( $n = 7$ ) reported that they felt the value of having played the game increased over time.





**Figure 9.** Boxplot showing summed responses, quartiles, median, and outliers.

'I remember at the time the game made me think about how carefully I had planned my research and prompted me to re-think the timescales required for things like ethical clearance. It also encouraged me to rethink my approach to backing up my work. I think overall the game had a positive impact on my approach to planning my research project, as I took a lot of it into consideration when planning the next stages of my project.' (LPID1)/'when I had played this game in the beginning of my course, I wasn't really understand it fully [sic] but now I can relate it to my research.' (LPID4)/'**It was a good laugh at the time but now, more than half way through the dissertation project, I can appreciate the take home message from the game more.**' [author's emphasis] (LPID2)

Furthermore, 31% (n = 4) expressed a desire to play the game again.

I think it would be a good idea to play the game again, now that the project proposal is approaching. It could be a good reminder of how we should plan our research.(LPID7)

Despite the small sample, the qualitative longitudinal evaluation appears to support the hypothesis that the game is both memorable and successful in embedding the knowledge acquired into research practice.

## Discussion

Overall, *How to Fail* appears to overcome some of the challenges of teaching post-graduate research skills in a meaningful and memorable way. Players reported high achievement for all four ILOs and qualitative data demonstrates deep understanding of

the issues explored, with players actively relating their game experience to their real-life challenges in undertaking postgraduate research. Furthermore, a large majority of players found the game enjoyable and rewarding. The most significant findings and limitations of this research will now be discussed in detail.

### **Integrating multiple interaction modes with educational content**

*How to Fail* includes both positive and negative emotional states of engagement (humour and failure) and aims to encourage creativity, imagination, and problem-solving within a sufficiently structured and ‘safe’ playful environment (cf. Fry et al., 2003). It makes use of emotional ‘waves’ with periods of high-concentration, high-flow activities (Activity phase) followed by periods of calm which include guided reflection on each phase of the game and the overall result (cf. Beard & Wilson, 2002, pp.124–130, 147–154). This is particularly important as Habgood and Ainsworth note the competing demands of ‘intrinsically integrating learning content within frantic action-based games’, noting that without the chance for reflection this mechanic could inhibit learning (2011, p.175–176). This combination of constructively aligned content and interaction behaviours shows *How to Fail* to be a *content system* which delivers understanding of a subject area – however as a one-off tutorial intervention, it also functions as a *trigger system* which creates an experimental context for understanding a subject, built on by the tutor in subsequent discussion (Klopper et al., 2009, p. 23).

### **Cognitive authenticity**

As indicated by the high levels of reported relevance, above, *How to Fail* focusses on usable knowledge, rather than being designed as ‘a solution looking for a problem’ (Dede, 2011, p. 235) and conforms to the guidelines suggested by Kirkley *et al.* for problem-centred game design:

The problems or challenges provided via game play should reflect the types of real-world problems, situations, and scenarios faced by people in the field and also meet the curricular needs and requirements of the course or educational program. (2011, p. 388)

In this way, the game functions as a ‘metaphoric intervention’ (Beard & Wilson, 2002, pp.158–160) within the course it was designed for. The aim in game content, form, and function, was to have *cognitive authenticity* to both the learning domain and the course content (Kirkley et al., 2011, p.376, 388) and to improve *connectionism* – i.e. cognitive reasoning rooted in specific areas of embodied experience (Gee, 2014, p. 8). It is widely acknowledged that assessment forms have a strong influence on the learning process and approach taken by students (cf. Norton, 2007, pp.93–95; Ramsden, 2003, p. 67–72). *How to Fail* mimics and exploits assessment forms, explicitly linking the research skills course with the student’s future dissertation requirements. The game functions as a ‘practice-run’ for an independent master’s project and bridges the gap between a simulated problem and a real-world problem, highly relevant to the student.

### ***Tension between penalties and confidence***

Whilst this game has an overall positive result for increasing confidence about research, this motivational factor was less successful than the others due to two characteristics: first, the lack of control over cards drawn and second, the emphasis on losing tiles as a penalty, which contributed to anxiety about success.

Since initial testing, game rules have been tweaked to increase player agency and optional rules also have an impact on personal control (*cf.* Abbott, 2017). These additions allow players to actively address research weaknesses, increase the overall chance of success, and also allow tutors to adapt the game to the predicted resilience of their students. The game is designed to also function as a workshop tool with the cards being used as triggers for group discussion (without gameplay). For example, allowing players to rebuild their projects using face-up tiles as part of the post-game tutorial could increase confidence whilst also reinforcing learning outcomes.

Although the majority of player reactions to the penalties were positive, 15% (n = 13/89) of free-text responses used synonyms for feeling nervous/anxious and 11% (n = 10/89) reported a feeling of stress/pressure. Responses also demonstrate a very high level of personal identification with, and commitment to, the fictional project (triangulated by the relevance results, above) which may contribute to negative emotions. However, the majority of these responses contextualise these feelings as positive or fruitful, as a realistic representation of the challenge of completing a dissertation, or a useful way to focus.

‘Generally enjoyed [the game]. I got a heart attack (almost) when I was picking the “fail” card.’ (PID77)/‘A bit unsure – a wee bit unprepared/overwhelmed – which seems totally appropriate!’ (PID9)/‘Stressed about how little time we have to complete the research project – 3 months and no plan!’ (PID36)/‘Excited but nervous’ (PID43)/‘Excited, nervous about the Event cards and engaged with the narration of the game.’ (PID91)”

As mentioned above, game mechanics with negative outcomes can have very strong learning potential. Several players acknowledged that the points of loss were where lessons were learned most powerfully, some even expressing disappointment at their lack of penalties within the fantasy context:

Our experience provided us with a relatively pain-free route to the thesis – it was only seeing how other teams ran into difficulties that underlined risks. (PID81)

It is also notable that Event cards resulting in catastrophe caused typically high levels of hilarity across groups, with good-natured acceptance from the affected player(s) and *schadenfreude* from other teams. These emotional peaks were almost always positive and often the heightened affect led to unprompted reflection and analysis about why the Event had the effect it did. Similarly, where disasters were narrowly averted by the player(s) having previously played Activity tiles that negated an Event, there was usually a sense of delighted relief from the team in question.

Therefore, it is felt that the significant advantages of the emphasis on penalties far outweigh the tiny minority of cases where the penalty was not seen to be productive. It is also hypothesised that the increased player agency created by the rules amendment above will further increase player confidence in research skills and, by implication, motivation for research.

### **Reliance on the tutor-facilitator**

One unexpected result is the extent to which gameplay itself relies on the performance of the tutor/facilitator. Tutor participation is inherent to the game's design (namely their role in interpreting and contextualising ILOs during the reflective phases of the game), however the tutor's role in clearly explaining the rules to allow players to quickly start the learning activity is also critical. The tutor also levels the playing field for players who take longer to grasp the rules, actively helping those teams who are obviously lagging behind in placing their Activity tiles, with verbal reminders of rules and strategy guidance. Furthermore, the tone of the game being actively performed to players by the facilitator helps to maintain a humorous atmosphere. Support structures in productive failure scenarios are important to reduce the risk of unproductive experiences whilst still allowing students to participate in unstructured generation and invention activities (Kapur & Rummel, 2012). In addition to supporting students' own reflection, techniques used to guide the emotional response of the players included exaggerated dismay at penalties, exaggerated relief at narrow escapes, or 'playing the villain' by reversing these reactions to increase humour. This performative role was not anticipated whilst designing the game but developed instinctively during early playtesting. Whilst it appears to increase engagement and emotional peaks during gameplay – a definite advantage – it also requires high familiarity and commitment from the tutor-facilitator, which could impede wider take-up of the game. This reliance has been ameliorated by production of a tutor guide with notes on how to run the game successfully and a short, funny, introductory video (Abbott, 2017).

### **Wider applicability**

The game's educational context and design principles focus on skill *improvement* rather than establishing a baseline of knowledge, perhaps explaining why the game appears to be equally successful for players with more or less experience of research (within the evaluation inclusion criteria). Essentially, gameplay appears to function independently of the research expertise of the player, enabling useful self-reflection even in highly experienced researchers, both in terms of their own research and when considering how to best support students.

'I thought I might feel distant or unreal. But v quickly I applied my own experience as a research student. I was engaged and actively thinking about each task.' (PID83)/'Fun but thoughtful! Reinforced good practices I have so felt good. [...] I imagine it would be very helpful for new researchers.' (PID68)/'I think it would work well with our students.' (PID110)

The game appears to have wider applicability beyond taught Master's programmes and first-year doctoral training. Players indicated a strong appetite for use of the game (or a trivially adapted version) within other areas of Higher Education, in particular for early career researchers, students and staff with English as an additional language, and equality and diversity training. Several tutors also expressed a desire to create a version for undergraduate and/or Further Education contexts.

In order to enable wide access and adaptation, *How to Fail* has been released under a Creative Commons NC-BY-SA licence. It is suitable for adaptation to any fictional

context which has a broadly linear activity model with a final outcome measurable in terms of quality (examples suggested so far include arranging a fashion show, managing a group project, or creating an exhibition). It would be a fruitful further study to consider further developments in terms of the five-dimensional framework of scalability (Dede, 2011, p. 239) in order to maximise the benefit from the game.

## Conclusion

*How to Fail Your Research Degree* uses a pedagogically robust framework to align game mechanics with learning mechanics and is perceived by players as strongly educational with strongly positive gameplay experience in three of Keller's four motivational categories (attention, relevance, and satisfaction); fairly positive for confidence. Qualitative and quantitative evaluation results imply an increased motivation for learning and embedding research skills. Learning outcomes appear to be retained over the medium term, although this finding was based on a small sample. The game also demonstrates the potential for adaptation to different learning contexts and wide dissemination. Limitations include scalability, learning mechanisms being relatively minimal in the Activity phase, and the action research methodology of this study which may have skewed results. Despite this, the game has clear potential for benefit to students via successful integration with teaching and learning activities in a number of contexts and provides a useful case study for the serious games research community in terms of integrating learning and game mechanisms.

This research focusses on game-based learning as a complement to postgraduate research skills courses. A fruitful further study would be to perform a comparative analysis between game-based learning and other existing methods for teaching research skills, taking into account prior knowledge and testing short- and long-term skills improvement for a range of learning situations.

In conclusion, *How to Fail Your Research Degree* has been shown to be an effective step towards an innovative way to teach, embed, and help retain knowledge and skills for undertaking academic research.

## Notes

1. High-level design goals and practical considerations have been previously discussed in Abbott (2015).
2. Although much of the literature analysing serious games and their mechanics are focussed on digital games, these concepts are equally applicable to tabletop games as interactions are defined as between the player and the game, not as human-computer interactions.
3. Themes were widely represented in responses, however for brevity, only a few illustrative examples for each are included here.
4. Acknowledging the small sample size for less and more experienced researchers (n = 9 and 12, respectively).

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No potential conflict of interest was reported by the author.

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## PW3

# Modding Tabletop Games for Education

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# Modding Tabletop Games for Education

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**Abstract.** This paper describes a learning-objective-centric workflow for modifying (‘modding’) existing tabletop games for educational purposes. The workflow combines existing research for serious games design with novel systematic analysis techniques for learning and game mechanics and gameplay loops to improve the understanding and rigour of the process. A detailed worked example applies the workflow to the development of a serious tabletop game with the educational goal of increasing knowledge and confidence of performing postgraduate literature reviews. Systematic application of the workflow to a real example supports the value of this approach and provides a useful template for educators to follow for increasing the quality and feasibility of self-designed serious games.

**Keywords:** Serious Games, Board Games, Modding, Game-Based Learning

## 1 Introduction

It is now well evidenced that games can be engaging and effective tools for education but that the design of an intervention has as large an effect on success as the medium [1] and that designing effective game-based learning solutions requires significant expertise in both game-design and pedagogy [2]. Educational games which do not successfully combine game design with learning design are ineffective in terms of engagement, learning, or both (often known as a ‘spinach sundae’: a product which is neither appealing nor good for you [3]). Furthermore, research into game-enhanced learning demonstrates that the different characteristics of different games have discernible effects on the learning behaviours of players [4] and consequently on how well the game achieves its educational purpose [1, 5]. In short, educational game design is complex, resource intensive, and requires multiple interdisciplinary skillsets. Games designed for digital platforms also need significant technical expertise and the resources to support them. Despite these barriers, the well-documented advantages of game-based learning (GBL) drive demand for games for learning, training, or behavioural change (henceforth referred to as ‘serious games’) across a wide range of contexts [6–8]. However, as evidence of the efficacy of GBL grows, the discipline gains new advocates from a variety of backgrounds which increases the risk of GBL solutions being designed and implemented in isolation of the expertise and resource contexts necessary to make them effective. This paper presents a practical solution to the tension between the growing desire for serious games amongst students and educators and the barriers to effectively implementing them [9]. It is proposed that serious game design can be streamlined and

made cost-effective, without the loss of either learning objectives or game engagement and enjoyment, by developing educators' skill in modifying existing tabletop games.

### 1.1 Why tabletop games?

Tabletop games (e.g. board, card, and dice games) are under-represented in serious games literature; in fact, many definitions inexplicably restrict the concept to digital games. For clarity, this paper defines 'games' according to Juul's six game features (games have rules; variable, measurable outcomes with different values; players invest effort and are attached to outcomes; and consequences are negotiable) [10] and 'serious games' as games which have at least one characterizing goal as well as entertainment, *regardless of platform*.

Clearly, delivery platform (like game mechanics) affects interaction and therefore learning behaviours. Major advantages of digital games are their infinite reproducibility, scalability, and remote digital accessibility. However, if this is not needed – as is the case in some classroom delivery – the interaction behaviours of tabletop games can make them much more appropriate to a wide range of teaching situations. Tabletop interaction is kinaesthetic as well as mental, often involving players literally constructing maps, hands of cards, structures, or patterns on the game board where options are explored and solutions reinforced by physical movement and positioning. Unlike the typically isolated, human-computer-interaction gameplay of educational video games, tabletop games are usually social experiences where players analyse, learn from, and react to the strategies and actions of others. Furthermore, the educator is not only present but an active facilitator when students play educational tabletop games – allowing a more scaffolded learning experience that can be adapted on-the-fly to players' needs and also encourages further learning activities to take place in and around the game context. Enhanced scaffolding has been shown to have a significant improvement on acquisition of intended learning outcomes (ILOs) [1] and instructional support during gameplay is recommended [11]. These characteristics of tabletop games can increase the well-documented educational advantages of digital serious games, particularly for understanding complex systems [12] and collaborative group approaches [1] in tutorials or closely guided classroom contexts.

Furthermore, a common misconception that digital games are inherently engaging and motivating for learners is not supported by evidence. Even well-designed digital serious games can be disengaging, even intimidating, for some learners [7, 13] (particularly in Higher Education [14]) and there is evidence of lack of confidence for teachers using digital serious games, as learning to facilitate the game requires non-trivial additional expertise [13, 15]. This barrier is reduced (albeit not eliminated) for tabletop games, partly due to their lack of technological interface but also because rules and components are explicit and transparent [12]. Technical barriers to engagement should not be underestimated in educational settings. Not only do computer games require hardware, software, power, and often network connections to run at all (infrastructure that is often assumed but rarely smooth for educators to implement [13]), many digital serious games struggle to satisfy the user expectations created by the commercial game industry [13].

Finally, tabletop games require no programming skill and can be relatively quick and cheap to develop. This makes them considerably more achievable for educators who have games experience but limited time and money to devote to designing GBL activities. Nevertheless, for tabletop GBL to be successful, it still requires considerable pedagogical and game design expertise. This is the challenge this paper addresses.

## 1.2 Why mod?

Flexibility and customisability are key features of tabletop games that can increase enjoyment [16] and potentially learning. The conceptual approach here assumes that pedagogy experts have familiarity with games, the desire to create GBL activities for their students, but not necessarily any applied game design expertise. It is concentrated on three principles:

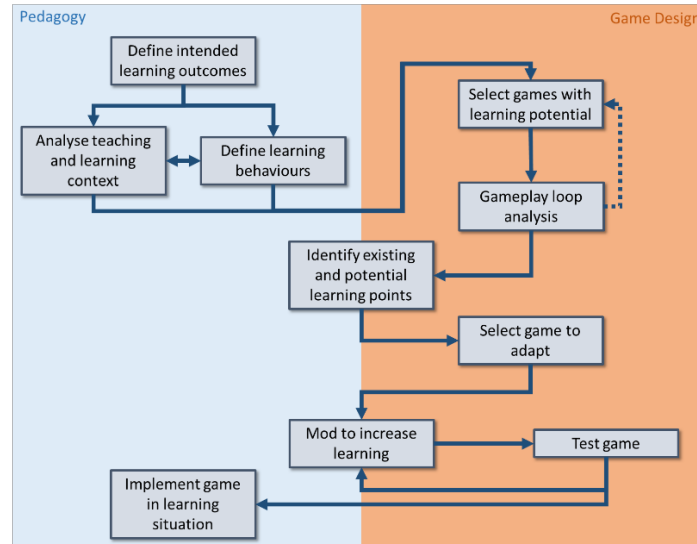
1. Educators could focus on adapting ('modding') existing tabletop games, instead of creating a game from scratch. This approach reduces the game design expertise required (modding skill relies on recognizing/adapting rather than conceiving/designing appropriate game mechanics) and eliminates the need for lengthy testing, as the game being adapted is already commercially successful. Of course, adaptations for learning will still require evaluation and it is important to acknowledge that game literacy is important as misrecognition of game mechanics may impair learning. However, modding markedly reduces the expertise and resources required to produce an effective serious game.
2. Serious game design is made more manageable by adapting previous processes and workflows, concentrating on modding. This provides robust design principles that are easy to understand and follow, whilst also giving educators the framework for the baseline skills required for serious game design and a context for improvement.
3. The incorporation of analysis techniques that can be relatively easily understood and applied allows pedagogy experts to swiftly gain the minimum expertise necessary to produce and implement a serious game without too onerous a demand on their time.

The remainder of this paper presents a workflow for serious game modding, aimed at educators with some experience of GBL, which is critically applied via a worked example (identified as important for understanding [9, 15]). The game developed elucidates the process for a particular, real-world educational setting; increasing knowledge and confidence for Higher Education students about to undertake a literature review.

## 2 Workflow for serious game modding

**Fig. 1** shows a workflow for effectively modding tabletop games for educational contexts. This workflow synthesises previous serious game development models [4, 5, 17–19], incorporating guidelines aimed at educators [13, 20], with a particular focus on tabletop GBL [6] and modding [12]. It further enhances previous research by categorising the steps by pedagogic and/or game design expertise and including gameplay

loop analysis [21] as a method to map learning mechanics to game mechanics [22] in order to inform both choice and adaptation of games. Each step is described below.



**Fig. 1.** - Workflow for modding existing games for educational purposes

#### *Define learning outcomes*

The first (and most important) step is to define the overall purpose of the activity in terms of its intended learning outcomes (ILOs): i.e. what knowledge or understanding should be improved after playing? This may seem obvious but is worth making explicit that ILOs should be clearly defined and kept in mind throughout the design process. If this step is taken for granted, or subsumed into game design, it is likely that the game will either not be effective, or will teach something other than the lessons intended. This primary and central position of ILOs reflects previous research cited above.

#### *Analyse context and define learning behaviours*

The next, concurrent, steps are to consider the learning and teaching context and to define the intended learning behaviours [4, 17, 23]. Too often games are developed in isolation of their context and not enough thought is given to how they will be effectively integrated into teaching and learning practice [13, 17]. Is the game intended for quiet, independent study or will it be deployed in a classroom of 30 children? Will it be played once or repeated? Will players compete or co-operate? Who will lead the game and support the learning? A common mistake in designing serious games is to default to a 'question and answer' model, familiar to educators from quizzes and simple trivia games. This is perfect for demonstrating existing knowledge but ineffective for learning new information [5]. Therefore, if ILOs are centred around memorisation, the learning mode is behaviourist 'drill and practice', and the context is independent home study, a digital game with strong extrinsic rewards, high interest and replayability, or both,

could be an effective solution [11, 24]. Conversely, if ILOs rely on collaborative, constructivist learning behaviours and the context is a one-hour tutorial for postgraduates, this will require very different gameplay to achieve best results [23]. Understanding *how* as well as *what* the students are expected to learn is crucial to informing all the game design steps that follow. A useful guide for GBL novices can be found at [20].

#### *Select potential games*

Next, create a shortlist of games that have potential for delivering the ILOs defined, in the way that fits the learning situation. For educators with limited experience of games, this can be daunting, however it arises directly from the analysis of the learning behaviours and situation and becomes easier as modders increase their game literacy [12]. Broadly speaking, modders should consider the overall metaphor for the game as indicated by the learning behaviours, for example, collaborative problem-solving, competitive race, resource management, creative interpretation, or map-building. To then shortlist suitable games it is useful to use published classification systems such as the Gameplay / Purpose / Scope model [25], fan-produced tabletop game taxonomies<sup>1</sup> and (not to be overlooked) one's own experience and recommendations. It is also recommended for educators to involve their students in the design stage, as much as is possible, not only for acceptance but students themselves may have valuable insights. Importantly, the overall game format should arise from learning behaviours and context, not the subject matter. Whilst it may be tempting to search for games with similar content to the ILOs, it is the underlying game mechanics that support learning and there arises a risk that the game 'skin' (i.e. theme/narrative) will distract from the actual pedagogic goals.

#### *Gameplay loop analysis, identification of learning points, game selection*

Gameplay refers to players interacting with the game and here explicitly includes cognition as well as physical actions influencing the game world. The gameplay loop follows Guardiola's definition [21] and builds on his pedagogic method: the loops represent gameplay as linked actions. This process breaks down and describes every game interaction, allowing educators to consider the types of behaviours involved and map them to learning behaviours. This stage is more easily understood using the worked example (**Fig. 2**), however the basic steps for analysis are as follows. Firstly, *play the game*. Whilst aspects of gameplay loops can be discerned from reading the rules, it is necessary to gain a more holistic understanding through play as this includes social and emotional elements of gameplay. Next, map the gameplay loops as a flowchart at a macro level, identifying In Game and Out Game actions [21] i.e. actions that have an immediate, measurable effect in the game such as moving a piece, and those that do not such as chatting to other players. As much as is productive, expand each sub-loop and categorise the types of interactions using an established concept map such as the Game Mechanic – Learning Mechanic framework [22]. This allows the identification of learning mechanics that happen in and between each interaction (not forgetting Out Game

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<sup>1</sup> E.g. <https://boardgamegeek.com/thread/581158/alternative-classification-board-games-long>;  
<https://www.boardgamegeek.com/image/3613899/rouie-a>

actions, where important scaffolding and metacognition takes place). Finally, highlight points that would easily support additional learning mechanics, even when not currently present in gameplay. Based on these analyses, it is possible to see which games have the mechanics that best support the learning behaviours desired (or, to demonstrate that games do not support the overall purpose, in which case it may be necessary to return to the shortlisting stage or elect instead to create the game from scratch).

#### *Modification for learning*

If analysis shows that all learning mechanics are already present and the game's theme can be mapped directly to the stated ILOs, modifying a game could be as simple as changing the theme content ('reskinning'). However, it is more likely that game mechanics will need to be added to or altered to enable or reinforce the desired learning mechanics and players' exposure to learning material (content) during gameplay. A simple example is creating a trivia game by adding 'question and answer' interaction which acts as a gateway to progression. Whilst this 'quiz' approach can be very effective for certain ILOs, it has limitations [5] whereas gameplay with intrinsically integrated learning content can be more effective for learning and motivation [26]. Therefore care should be taken to, where fruitful, embed learning mechanics into the core of gameplay without disrupting the overall game. In general, once gameplay satisfies the ILOs, context and behaviours defined, game mechanics should be altered as little as possible as every change affects the game system and balance and could lead to unwanted emergent behaviours or even risk undermining the ILOs.

#### *Testing and implementation*

The modded game should be iteratively tested and improved to ensure firstly that the modifications have not 'broken' the game and, crucially, that the game does impart the ILOs stated. Then the game can be implemented in context.

### **3 Worked example: a game to teach literature review skills**

The serious game in this example arose directly from a practical problem: students on a postgraduate Research Skills course are required to learn how to perform a literature review but many lacked confidence and knowledge of how to begin and felt overwhelmed by the scale of this complex process, which impaired their learning. This pedagogic 'vertigo' can be very fruitfully mirrored and addressed by tabletop games. Whilst it is usually recommended to minimise learning *about* the game in order to maximise learning *through* the game [27], games systems can model larger complex systems and "when the sim dissolves the player's game vertigo, it also dissolves his system vertigo about the large and complex system that the sim is modelling." [12] Therefore, a GBL approach was chosen to reflect the process of undertaking a literature review and to diffuse students' trepidation about starting this large and complex task.

#### *Intended learning outcomes*

Intended learning (and attitudinal) outcomes were defined as follows. After playing the game, students should: Understand the basic principles of searching, evaluating, and assimilating research sources; Be able to identify different types of source and understand when they are most useful; Be able to describe techniques for choosing sources and deciding what to read; Recognise that evaluation of sources has a time cost, but saves time and improves quality overall; Understand that literature search and review requires iterative refocussing and describe techniques for refining searches, and; Feel more relaxed and confident about the literature search and review process.

#### *Teaching and learning context*

Implementation is within a postgraduate tutorial context, therefore a face-to-face, instructor-supported tabletop game is suitable. Student numbers exceed 30 therefore the game should either be simple enough to not require direct supervision or engaging enough to maintain interest and learning as a spectator. An alternative is to implement the game with smaller groups in turn whilst the rest of the class are engaged in a different activity, requiring the game to be relatively short duration. Supporting smaller groups of players is an acknowledged limitation of non-digital tabletop games with implications for educators that must be considered.

#### *Learning behaviours*

Learning behaviours were defined to mirror the real-life task of performing a literature review: exploratory, discovering, constructivist, independent, selective, refining/refocussing, consolidating, and non-linear. Overall comprehension of the process is more important than learning specific facts, therefore repetition is focussed on refining understanding, not memorisation. Due to students feeling overwhelmed, it is also important to 'drip feed' content, using a Cascading Information learning mechanic [22].

#### *Shortlist games*

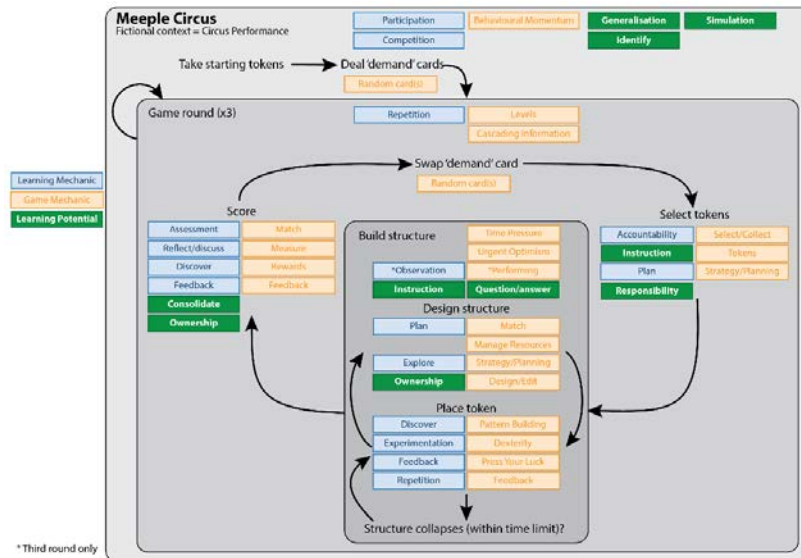
Games were shortlisted based on a strategic construction overall mechanic (as a metaphor for exploring and constructing an understanding of a research topic through a literature review), including elements of selection and matching (representing selection of sources to match research topic), and repetition for both consolidation of knowledge/understanding and refining. Five games were shortlisted using BoardGameGeek's taxonomy and personal recommendations: *Blueprints*, *Meeple Circus*, *Best Treehouse Ever*, *Junk Art*, and *Rhino Hero*.<sup>2</sup> All five games involve literally constructing something and for four games, Dexterity is a core mechanic meaning game tokens are played thoughtfully and carefully. All are competitive (with the exception of one of the minigames within *Junk Art*), however in all cases except *Rhino Hero*, competition

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<sup>2</sup> <https://www.zmangames.com/en/products/blueprints/>; <http://www.matagot.com/en/catalog/details/family-games/3/meeple-circus/894>; <http://www.greencouchgames.com/besttreehouseever/>; <http://www.pretzelgames.com/en/home/21-junk-art.html>; <http://www.habausa.com/rhino-hero/>



is via scoring each player's own structure rather than directly interfering with opponents' structures. All games except *Rhino Hero* explicitly involve repetition and Cascading Information is core to *Meeple Circus* and *Best Treehouse Ever*.



**Fig. 2.** - gameplay loop analysis of Meeple Circus, using an extension of the LM-GM model

#### Gameplay loop analysis and selection

Guided by the literature, gameplay loops were produced for each shortlisted game (including every minigame within *Junk Art*) and points of learning (and potential learning) were identified. This allowed a rigorous parity of comparison between each game.

*Rhino Hero* was rejected first as the lose condition is binary – when the tower collapses, the game ends for everybody – this halts learning. Analysis showed that this game relies heavily on Dexterity and Press Your Luck mechanics which were difficult to imagine being intrinsically integrated with the ILOs, and learning mechanics are restricted to planning which cards to use against your opponents. However, its simplicity, linearity, and quick repeatability would be highly appropriate for lower-order ILOs related to literature review, especially as the folded cards are reminiscent of books.

*Junk Art* was also rejected. Whilst several of the minigames were highly appropriate for the fictional context of performing a literature review, token design made balancing pieces more difficult which, considered alongside the core role of fallen pieces in most of the minigames' exit conditions and scoring, was felt to not contribute to the learning behaviours effectively. A further reason was that scoring rewards and penalties are explicitly comparative (e.g. who has the tallest sculpture and/or most fallen tokens), whereas the scoring of the remaining three games focusses more on how well each individual construction matches external scoring conditions. The latter situation was judged to be more appropriate to the literature review metaphor.

*Blueprints*, *Meeple Circus*, and *Best Treehouse Ever* were all suitable for modding for the ILOs and context defined. All three use repetition, strategic selection and management of resources, strategic placement of tokens/tiles in the overall construction, followed by a scoring phase which allows assessment, feedback, and reflection for players. Furthermore, all three involve design for pattern matching with strategic elements. *Meeple Circus* uses an elegant Cascading Information mechanic via game Levels to gently introduce complexity, thereby reducing game vertigo whilst also acting as a highly appropriate metaphor for the iterative refining process of exploring a research topic. Furthermore, overall its rules were felt to be simpler than the other two games, therefore *Meeple Circus* (**Fig. 2**) was selected as the game to be modded.

#### *Mod game to increase learning*

The first step was to change the theme to match the learning situation. Instead of creating a circus performance, players are building their knowledge of a research area by finding, reading, and synthesising literature and other research sources. Strategic selection of game tokens becomes searching and evaluating sources, placing tokens in the structure represents understanding and synthesising knowledge, matching acrobatic feats becomes closeness of fit to the research question being investigated, and scoring indicates the quality of the literature review. In this way, the game functions as a simulation, allowing players to both identify with the content and generalise it to their individual situations (**Fig. 2**).

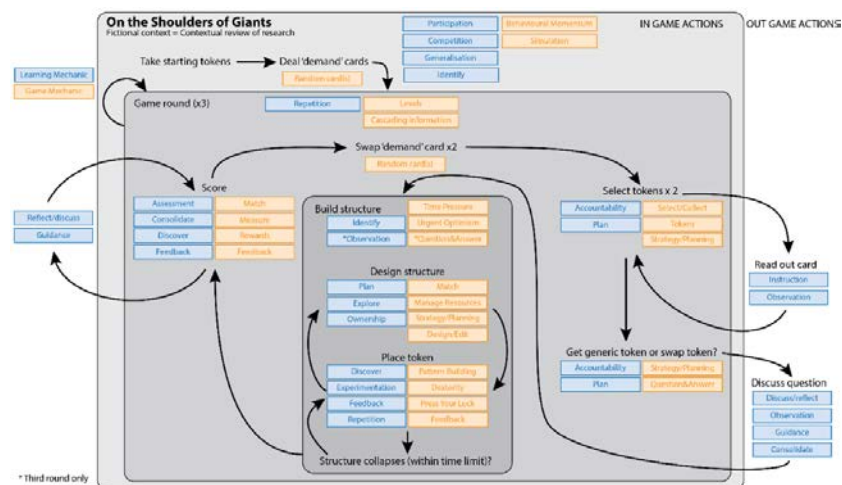
Care was taken when conceptually ‘reskinning’ the game to map components to ILOs which are supported by the game rules, particularly the scoring system. For example, a blue acrobat represents baseline knowledge sources used when starting a literature search – because it scores points for touching the ground it is much more useful in the first round than a red acrobat, which represents innovation and originality and scores highly in later rounds. ‘Audience demand’ cards score when a player matches their pattern – this represents the student’s current use of sources to understand their research area – and changes between rounds, making it an excellent metaphor for iteratively developing an understanding of a specific topic. The change in game theme requires explanation to students, therefore an Instruction learning mechanic is required in the Select and Build phases.

The next step was to evaluate how well the reskinned game matches the ILOs. Each ILO was mapped to existing game mechanics to assess whether it was delivered. Where not effectively achieved, additional learning and/or game mechanics were devised using the points of potential learning already identified in the gameplay loop analysis. Additional game mechanics were required to deliver the Instruction, Question/Answer and Consolidate learning mechanic potential. To ensure all ILOs were satisfied, the following rules were added:

1. When taking any component, players must first draw the appropriate card for that component from the new deck of Instruction cards and read out the fact/tip to the group. Cards contain ideas for sources of this particular type, and techniques for evaluating sources and deciding what (and what not) to read. This builds knowledge

which can be later demonstrated or discussed in ‘out game’ learning activities with direct relevance to the student’s particular subject domain.

2. After component selection, players have the option of receiving a generic extra component (such as a 6-sided die) or of swapping one of their existing components for one of their choice (after considering a question from a new deck of Evaluate cards). This mechanic creates active engagement with the techniques of rigorous evaluation of sources. However, this mechanic in particular needed to be tested to ensure that swapping leads to higher scores than accepting the generic component.
3. During the ‘swap demand card’ phase, the two (as opposed to one) players with the lowest score can swap an ‘audience demand’ card. To do this each must read out a card from the new deck of Refine and Focus cards. This increases emphasis on techniques for refining and focussing research questions.
4. The final round contains performative ‘challenge’ cards. These cards were altered to allow players to demonstrate knowledge about specific aspects of the literature review process, as well as learning from each other. They move cognitive processes explicitly into the active mode by prompting recall, analysis, or interpretation of game content.
5. Finally, the name of the game was changed to *On the Shoulders of Giants*.



**Fig. 3.** Gameplay loop analysis of *On the Shoulders of Giants*: educational mod of Meeple Circus

*On the Shoulders of Giants* was then informally tested with small numbers of students and staff who teach research skills and feedback on gameplay and the content and phrasing of learning cards was incorporated. No major changes were required.

## 4 Conclusion and next steps

This worked example of the development of a tabletop serious game shows the value of using a robust design workflow to modify an existing tabletop game. Reflection on

the process demonstrates that close analysis using the LM-GM model, combined with gameplay loops, allows the identification of particular points within gameplay where educational content can be integrated to match the game's content to defined ILOs. This makes the process of game design significantly easier and more rigorous, especially for modders who do not necessarily already have a high level of game literacy.

Further steps are to formally evaluate this game with a larger cohort of students in order to demonstrate whether or not it is effective at delivering the ILOs and attitude change defined. Another avenue for future research would be to test this workflow with educators who have limited experience of game design, to establish if their experience supports the hypothesis that serious game design can be achievable (albeit still challenging) by analysing and modding tabletop games in a systematic and rigorous way.

Finally, incorporating feedback from the serious games research community has the potential to further improve and potentially streamline this workflow to increase its efficacy and ease of use.

Game rules and further information about this research is available at <http://blog.gsofasimvis.com/index.php/research/games/>

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## PW5

# Beyond Vicarious Learning: Embedding Dialogic Learning into Educational Games

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## Beyond Vicarious Learning: Embedding Dialogic Learning into Educational Games

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**Abstract:** Dialogic learning has a substantial overlap with the characteristics of multi-player game-based learning (GBL). Both dialogic and game-based learning are proposed to be beneficial methods for postgraduate learning contexts with higher order cognitive and skill-based outcomes. Research skills and critical thinking are widely shown to be crucially important but very challenging to deliver effectively. This paper uses three case studies of existing tabletop games to consider how modification to include dialogic learning can improve learning outcomes in a postgraduate context. Games were analysed using gameplay loops and characteristics of dialogic games are identified with recommendations of specific Learning Mechanic – Game Mechanic mappings. Learning Mechanics proposed to encourage dialogue were identified as: Plan, Analyse, Reflect, and Consolidate, typically associated with the following Game Mechanics: Strategy/Planning, Design/Edit, Match, Measure, and Feedback. Game Mechanics which may inhibit dialogic learning are Time Pressure, Competition, and Dexterity. An interaction model is presented with recommendations for dialogic game design which is proposed to increase dialogic learning which can increase student ownership, confidence, and consolidation of knowledge. This contributes to the current research gap for dialogical interactions within GBL.

**Keywords:** Dialogic learning; game-based learning; pedagogy; serious games; educational games; dialogue

### 1. Introduction

Dialogic learning arises from exposure to (and participation in) multiple, equal perspectives within learning environments and the process of learners actively co-constructing knowledge and meaning (Alexander, 2008). Dialogic learning has been shown to be beneficial across a wide range of learning contexts, however, dialogue and construction of meaning are, naturally, affected by the characteristics of the learning environment (Wells, 1999). Multiplayer games and game-based learning (GBL) typically provide characteristics which map directly to those identified as fruitful for dialogic learning. Games are: active; collective (co-operative, collaborative, competitive, or a mixture of these); provide reciprocal, dynamic interactions; purposeful/goal directed; and use feedback to cumulatively build towards a goal (see Alexander, 2008, p. 28; Tobias, Fletcher and Wind, 2014, p. 177 for good definitions of the characteristics of dialogic learning and game-based learning respectively). Due to their inherently social and structured nature, non-digital tabletop games in particular provide a range of opportunities for creating dialogue supporting learning. Despite this potential, dialogical interactions within GBL has been identified as a research gap (Arnseth, Silseth and Hanghøj, 2018). GBL dialogue tends to take place in an unstructured, informal way, or outside the context of the game itself for example in a debrief activity. Whilst this is certainly valuable, ‘out game’ dialogue requires further facilitation and the focus on the facilitator may undermine a truly egalitarian dialogue. If dialogic learning is embedded into game rules however, it is proposed that it is approached more collectively as part of the active and experiential participation in the game by players.

One of the learning contexts that seems to particularly benefit from dialogic relationships between teachers and students is postgraduate study, in particular, the teaching and learning of high-level functional outcomes such as research skills which combine knowledge with skills to produce the overall competencies required at postgraduate level. This paper uses three tabletop game case studies to reflect on how an existing serious game designed to teach a particular research skill might be improved by the explicit inclusion of dialogic interactions to foreground multiple perspectives and complementary knowledge and to further increase player confidence and ownership over the topic. These theoretical reflections lead to a preliminary proposal for mappings between Game Mechanics and Learning Mechanics (Arnab, Lim, Carvalho, Bellotti, Freitas, *et al.*, 2015) which are likely to lead to fruitful dialogue, and how this dialogue might be managed in terms of both ‘in game’ and ‘out game’ interactions (Guardiola, 2016).

## 2. Research context

Postgraduate research skills combine knowledge, competencies, and aptitudes and therefore require an approach that incorporates both constructivist and experiential pedagogies where knowledge is both embedded and applied to a context relevant to the student. Serious games are widely recognised to have the capability to both train skills and impart knowledge, due to the provision of a 'safe' but relevant environment where the student engages directly with an experience allowing affective arousal and implicit delivery of information through play mechanisms (McGregor and Bartle, 2019), leading to goal-directed learning behaviours. Huo analyses game mechanics in relation to behaviourism, cognitivism, and constructivism, showing variation across subjects and for differing knowledge structures and intended knowledge and competency outcomes (Huo, 2019) showing how games can enhance both knowledge and competencies. It has been shown that dialogue helps to improve this tacit knowledge arising from serious games as students are encouraged to review and exchange knowledge with one another (e.g. Camilleri and Camilleri, 2019) and of course is a core element games which encourage co-construction of knowledge and teamwork for collaborative problem-solving (Kang *et al.*, 2019; Sun *et al.*, 2020). This combination of pedagogic approaches to combine knowledge and skills can be seen in various games for specific educational purposes (particularly where skill training is very resource intensive e.g. clinical applications) but as is seen below, has not yet been applied in dialogic academic research skills training.

### 2.1 The challenges of teaching research skills

It is widely accepted across the literature that critical thinking and research skills are essential capabilities for students to master in order to progress both in their studies and in the workplace. This is borne out by the prevalence of courses within programmes of study, devoted solely to developing students' higher order thinking. However, the effectiveness of these courses and motivation of students undertaking them has been shown to be commonly problematic (Earley, 2014). According to one study focussing on research methods teaching, "Students consistently underperform and give low ratings in [research methods] module evaluations" (Ryan *et al.*, 2014, p. 88) and students struggle to link academic research skills with their need and desire to undertake practical problem-solving in a real world context (*ibid.*) Another study bluntly presents the research methods course as "one that instructors hate to teach and students hate to take" (Kollars and Rosen, 2017, p. 333). Other studies also note the difficulty of linking research skills courses to workplace contexts and a student perception of irrelevance, leading to a lack of motivation and engagement with learning content (for example: Waite and Davis, 2006, p. 406; Kirton, Campbell and Hardwick, 2013; Hamnett and Korb, 2017, p. 449). This issue is particularly relevant to the postgraduate context where students are increasingly expected to swiftly develop and practise higher order thinking skills and undertake independent research as part of their programme of study. The transition from undergraduate to postgraduate academic contexts has been noted to present particular challenges (O'Donnell *et al.*, 2009, pp. 35–37; Burgess, Smith and Wood, 2013, p. 4). Across various disciplines, a range of responses by teachers can be seen which aim to increase active learning and constructivist pedagogies with overall positive results for both increased cognition and engagement in students (Burgess, Smith and Wood, 2013; Kirton, Campbell and Hardwick, 2013; Rahman *et al.*, 2014; Ryan *et al.*, 2014; Hamnett and Korb, 2017; Kollars and Rosen, 2017; Kernan, Basch and Cadorett, 2018). This is in line with the main recommendation from a 2014 synthesis of the literature on research methods education that "teachers need to use active learning approaches to teaching the course in a way that provides hands-on exposure to research methods" (Earley, 2014).

Increasingly, teachers in Higher Education are considering the potential of game-based learning (GBL) to deliver constructivist approaches in the teaching and learning of research skills. A strong case for "the potential of games to alleviate the anxiety and lack of motivation methods students report" is made by Kollars & Rosen who draw on a wide range of literature to suggest "that games can help mitigate some of the problems of the standard research method course" (Kollars and Rosen, 2017, p. 335). Despite the barriers for Higher Education implementations of this method noted by Whitton & Moseley (2012), a variety of research is emerging which uses GBL to contribute to the learning and teaching of critical thinking, research skills, and graduate attributes (e.g. Cicchino, 2015; Hannan and Neame, 2017; Kollars and Rosen, 2017; Abbott, 2019a; Barr, 2019; Limniou and Mansfield, 2019) along with a range of playable 'research games'. However, studies and games focussed on postgraduate research skills are still rare, and, as noted above and in O'Donnell *et al.* (2009), these higher order learning outcomes and expectations of student independence in research activities create particular difficulties for teaching and learning in this context.



## 2.2 Dialogue as fruitful method for learning research skills

In order to address these particular challenges, a dialogic approach may be fruitful. Dialogue to build critical thinking is a widely accepted tactic and several scholars have acknowledged the value of dialogue specifically in postgraduate teaching and learning, typically focussing on the student-supervisor relationship (e.g. Morton, Storch and Thompson, 2014; Benade, 2015). It is difficult to find studies that focus specifically on dialogic learning within postgraduate research training; for example, Pipere and Salite focus on research skills but within teacher training (Pipere and Salite, 2006). Nevertheless, it is proposed that encouraging dialogue is likely to be productive in improving student engagement with research skills courses and their confidence and ownership of their learning journeys.

## 2.3 Existing GBL for research skills that include dialogue

Games have been noted as useful tools to prompt discussion within research skills training (Limniou and Mansfield, 2019) and several recent examples of (face-to-face) games for critical thinking or academic skills result in discussion (Abbott, 2015; Hannan and Neame, 2017; Pun, 2017; Lane, 2018). However, a review of GBL for research topics or critical thinking failed to find any games that *explicitly* include dialogic learning within their gameplay and none yet encountered by the author convincingly embody all five of Alexander's defined characteristics of a dialogic learning environment: collective, reciprocal, supportive, cumulative, and purposeful (Alexander, 2008, p.28). This reflects the overall position of games within dialogic learning contexts; namely, despite the clear potential of games as a fruitful method "there is a lack of knowledge of how teachers and students can utilize games and features of games as relevant tools for talk and learning" (Arnseth, Silseth and Hanghøj, 2018, p. 1). Therefore, the inclusion of game mechanics that require or encourage dialogue as part of GBL approaches in teaching research skills addresses a gap in the existing research and is a promising avenue for further investigation.

## 3. Design and development of game prototype

In response to observed barriers in students learning how to undertake a literature review research task as part of a postgraduate course in academic research skills, a prototype serious game called On the Shoulders of Giants was previously developed by modifying a commercially available tabletop game. As described in detail in Abbott (2019b), students' lack of familiarity with literature search and critical writing skills, coupled with the scale of the task, led to many of them feeling overwhelmed. This lack of confidence at the overall complexity of synthesising information into a literature review format acted as a barrier to learning, exacerbating student anxiety and impairing cognition. The overall strategy for On the Shoulders of Giants was to break down the overall learning and behavioural outcomes into manageable sub-tasks and to focus on the playful elements of the game format to dissipate unease about engaging with the learning content. Iterative development led to game mechanics being added specifically to maximise vicarious learning by requiring players to read out their own game cards to the group (Abbott, 2019b, pp. 9–10) and demonstrate their knowledge in an active, performative, final round (Abbott, 2019b, p. 10). Dialogic learning, however, was not explicitly included in the game itself as more than a suggestion, and is proposed more as a debrief and/or 'out game' activity. Full rules are available (Abbott, 2018).

Further analysis of the prototype indicated that there could be a potential benefit to including dialogic learning as explicit interactions within the game, and adapting the game mechanics to require or encourage egalitarian dialogue where possible (as opposed to the current model of tutor-as-expert presenting complementary information to students during gameplay). Furthermore, as part of the development of On the Shoulders of Giants, two other commercially available tabletop games were analysed in detail for their potential to contribute to GBL approaches in research skills teaching and learning. These existing analyses provide a baseline for focussed case studies on the possibilities of dialogic gameplay in existing games, which may have fruitful lessons for future dialogic game design.

## 4. Game analysis for dialogic learning

### 4.1 Theoretical framework

GBL takes place within a broadly constructivist instructional framework and is almost always situated within a wider instructional context, playing its part within a larger system. The wider instructional context is of course socioculturally mediated, a fact too often overlooked in GBL theory and of relevance when considering how to explicitly integrate dialogue into games. Despite advances in GBL research, recent critiques of serious game design methodologies claim that there is still a lack of “proper consideration of the relationship between learning mechanics and game mechanics” (Czuderna and Guardiola, 2019, p. 208; see also Huo, 2019) and advise an approach which more explicitly links learning design with game mechanics, recognising that play and learning are not so far separated as has been previously proposed (Arnab, Lim, Carvalho, Bellotti, De Freitas, *et al.*, 2015; Czuderna and Guardiola, 2019, p. 209; Westera, 2019). In order to attempt a design process which genuinely unifies gameplay with dialogic learning, this paper adopts the gameplay loop methodology as described in Guardiola (2016) combined with the Learning Mechanic – Game Mechanic (LM-GM) framework (Lim *et al.*, 2013). This approach allows for a formal description of how learning happens through gameplay interactions at a micro level, and enables the identification of specific interactions where dialogic learning can be prompted within (as opposed to alongside) GBL.

### 4.2 Gameplay loop analysis

All three case study tabletop games analysed (*Meeple Circus*, *Blueprints*, and *Best Treehouse Ever*) are based on the overall mechanic of constructing structures or arrangements from game components (cards or pieces) with varying amounts of physical dexterity required. This was seen as a suitable overall metaphor for the process of learning how to ‘build up’ a literature review (Abbott, 2019b). Furthermore, all three are ostensibly competitive games with one winner. These characteristics make identifying points for dialogue an interesting design challenge as it could be considered that competition and concentration on physical dexterity inhibit dialogic learning. Nevertheless, these games make interesting case studies as fully-fledged game systems (as opposed to much less-structured games, which function more as discussion tools (e.g. Fairness Toolkit (Lane, 2018)) or are structured primarily around the Role Play game mechanic. It should be noted that highly structured, turn-taking games fit the definition of “logical dialogue games” in formal dialogue theory (Pilkington, 2015). As such, an analysis of existing tabletop games offers the potential to identify precisely which game mechanics could be exploited for dialogic learning (and which may not).

Figures 1 – 3 show each game represented as a gameplay loop, annotated with both Learning and Game Mechanics at each point in the gameplay, and with darker background annotations showing places where game modifications for educational purposes could lead to further Learning Mechanics (LMs) being added. Gameplay elements considered particularly suited to dialogic learning have been marked with a circled letter D.

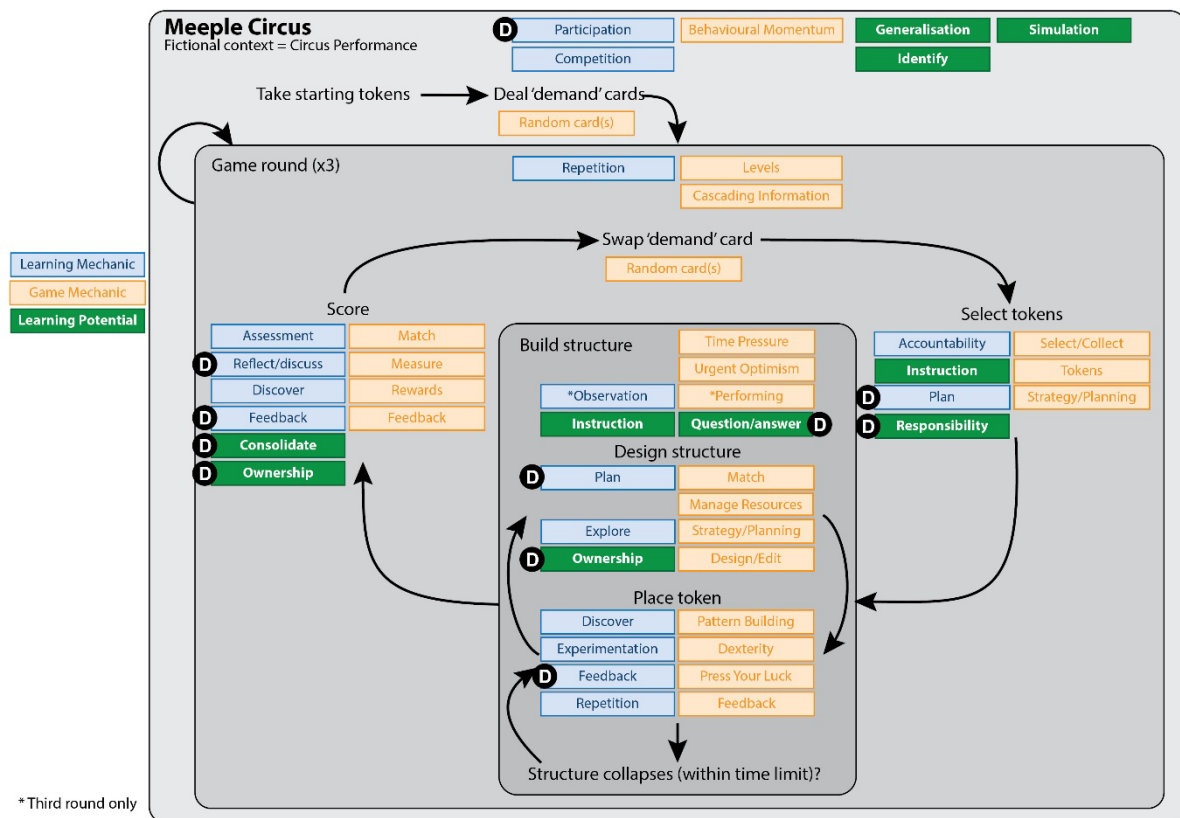


Figure 1 - Meeple Circus: annotated gameplay loop showing Learning Mechanics, Game Mechanics, and potential for dialogue

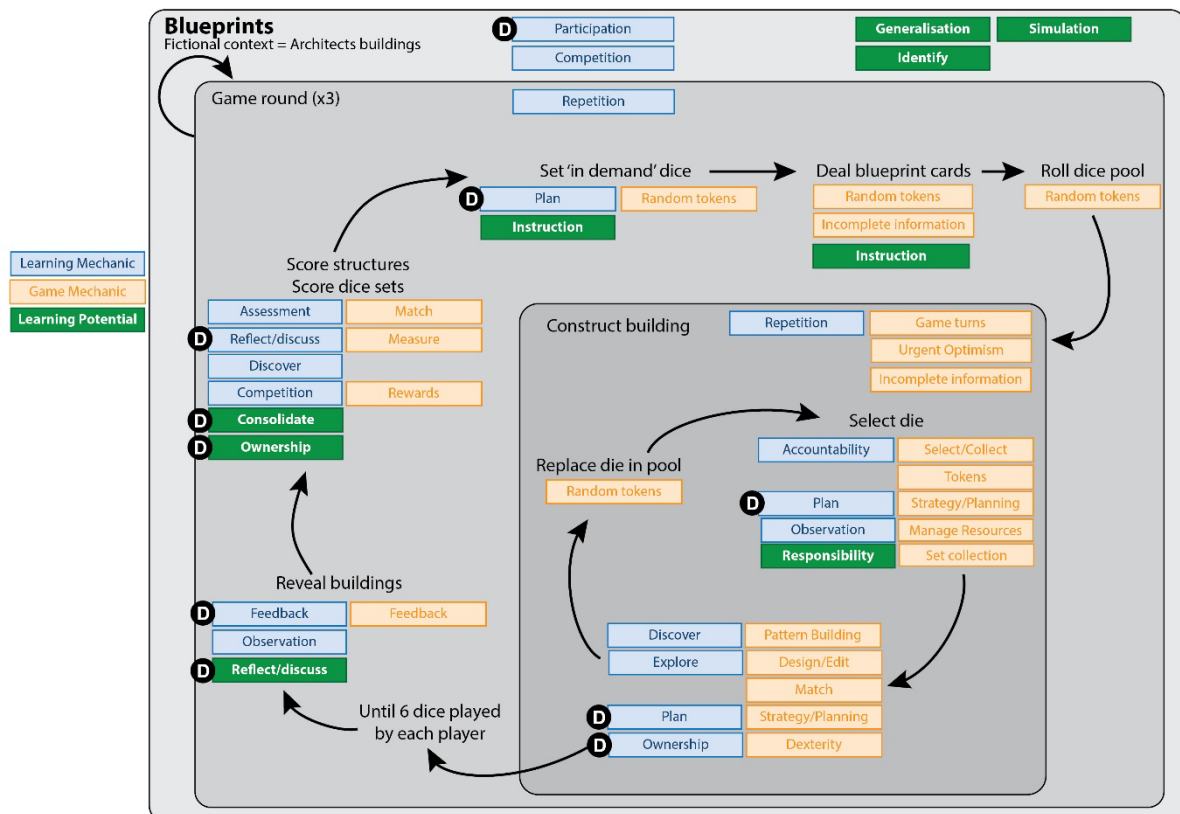


Figure 2 - Blueprints: annotated gameplay loop showing Learning Mechanics, Game Mechanics, and potential for dialogue



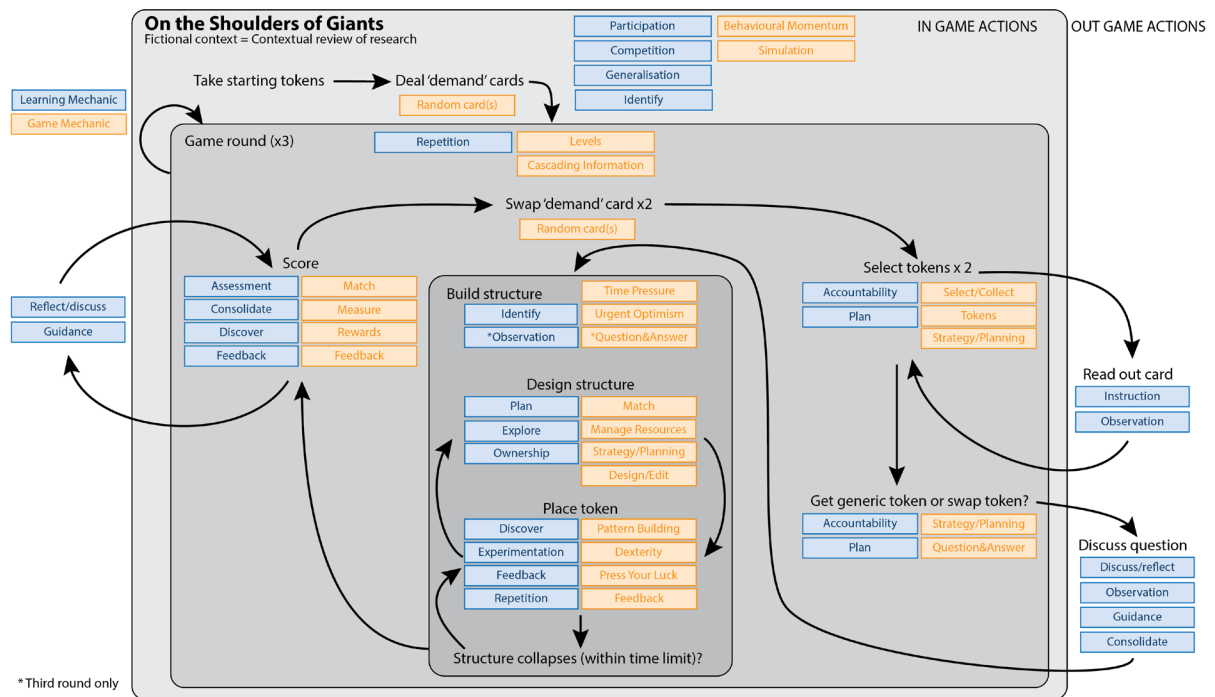


Figure 4 - gameplay loop for On the Shoulders of Giants, an educational mod of Meeple Circus

### 4.3 Analysis of dialogic learning within the LM-GM framework

Within the limitations of this narrow genre of construction-themed tabletop games, it can be seen that there is no simple one-to-one interaction between GMs, LMs, and dialogic learning. A preliminary proposition of three categories is suggested: GMs which either prompt or inhibit a number of initial dialogic LMs, which then themselves can prompt subsequent LMs (which may or may not also include dialogue). For the purposes of this model, shown in Figure 5, the LM Reflect/Discuss has been separated into Reflect and Dialogue, acknowledging that Dialogue could take place across all of the identified LMs, if the circumstances encourage it.

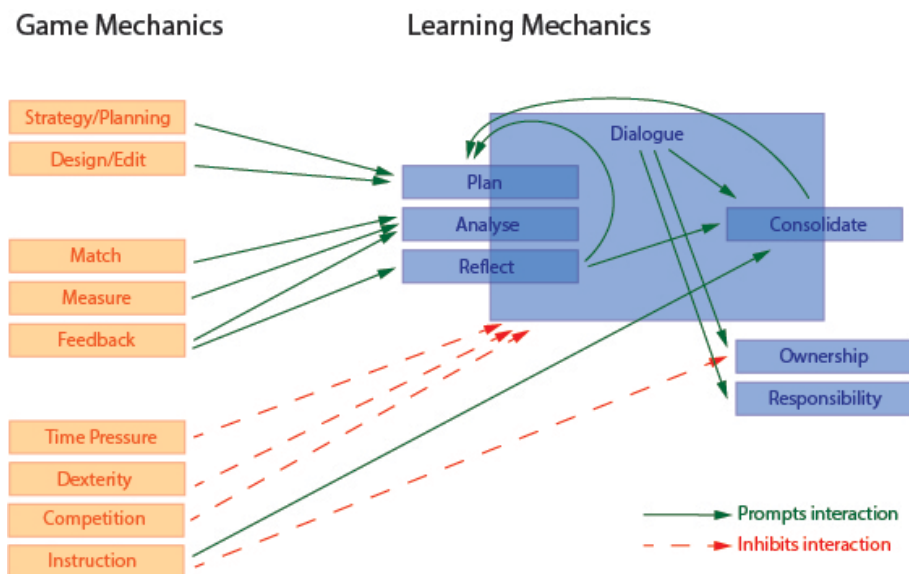


Figure 5 - interaction mapping between GMs, initial LMs, and subsequent LMs derived from three construction-themed tabletop games.

The first major feature to note with this model is that whilst many LMs *can* include an element of dialogue, this tends not to arise from the GM itself – as can be seen, no GM present here directly prompts Dialogue, rather the GMs prompt cognitive interactions such as Plan, Analyse, Reflect, and Consolidate which *may* include Dialogue but do not have to. Some of these LMs then prompt further LMs. Some GMs however do inhibit Dialogue, typically due to competing cognitive loads, it is difficult to engage in dialogic learning whilst under time pressure, for instance.

What then, prompts dialogic learning as an ‘in game’ interaction? As hinted at above, fruitful dialogue between learners requires communal goal-directed behaviours which are absent in most games where players compete in teams of one. Collaborative discussion tends to take place only as ‘out game’, reflective interactions, borne out by the analysis of *On the Shoulders of Giants* in Figure 4. Whilst Tobias *et al.* include Competition as a core characteristic of an effective educational game (2014), in this case, Competition as a GM is actively detrimental to this type of learning, considered suitable for postgraduate research skills. Instead, to encourage dialogue alternative GMs such as Collaborate, Cooperate, Communal Discovery, and Role Play could be the focus. Does this mean, then, that highly structured, competitive games should not be considered as GBL tools within this context? This author proposes that the advantages for student engagement and motivation – excitement, novelty, desire to win, turn-taking ensuring that all learners get a chance to participate – not to mention a clearly structured rules set for the teacher to use, maintain competitive games as a worthwhile approach for higher order learning outcomes, provided that Dialogue-prompting GMs can also be effectively included. The following overall principles are suggested for modifying game rules to increase dialogic learning.

1. Where Competition is a core game mechanic, group students so that they compete as a team. Depending on the exact game rules, teams of 2-4 are recommended to ensure every learner participates. (This has the added advantage of increasing the number of players the game supports, a noted limitation when using tabletop games for GBL).
2. Ensure that Plan, Analyse, and Reflect LMs are dialogic as much as possible. For example, Plan dialogue could take place within teams whereas Reflect could involve dialogue across all teams. If possible and appropriate, GMs not typically seen in this genre of game could be included, for example, players could be asked to Role Play during the scoring phase to critique their own or others’ strategies in order to deepen understanding.
3. The tutor/game facilitator’s input should be minimised. Where possible, Instruction and Guidance should be restricted to how to play the game, or to prompt dialogue where needed. This encourages egalitarian dialogue between all participants which increases focus on the Ownership and Responsibility LMs. Instruction can then further consolidate learning during the ‘out game’ debrief, if necessary.
4. If the game includes GMs that inhibit dialogue, split the cognitive load between team members, where possible. For example, each round one team member could focus on Dexterity interactions whilst the others engage in dialogue that formally complements the actions involving physical game pieces. Alternatively, a Turn Taking GM could be added to ensure all team members engage in the different types of interactions. Time Pressure can inhibit dialogue, however it can also increase excitement and focus. Time Pressure should be carefully balanced with other GMs to maximise the learning.

#### 4.4 Dialogic modifications for *On the Shoulders of Giants*

In line with the analysis above, modifications for dialogic learning will now be presented for the primary case study: *On the Shoulders of Giants*. These modifications should be read alongside the full game rules (Abbott, 2018).

Rule change	Justification
Require players to play in teams of 2 or 3. All actions which refer to a player now involve the whole team.	Introduces new GMs: Collaborate and Communal Discovery whilst maintaining Competition. Team limited to 3 to ensure Participation is maintained.
Formalise Turn Taking within teams when drawing game components.	Ensures all individuals maintain Participation.

When game cards are read out to the group, the team to the left of the active team has a very brief dialogue and then responds with a question, comment, or real-life example.	Replace the 'out game' Instruction and Observation (see Figure 4) with an 'in game' formal Analyse and Dialogue LM.
In the Using Sources phases, one team member builds whilst remaining team members discuss ideas, real-world examples (or if stuck, ask questions) about the type of component being placed.	Requires Communal Discovery GM. Introduces Discuss and Analyse LMs to the build phase. Separates cognitive load.
When choosing a 'star' resource in the second round, each team discusses and contextualises their resource for the other teams. The tutor should only provide Guidance where absolutely necessary but can provide dialogic prompts if needed.	Moves the focus from Guidance and Instruction to Dialogue.
The final round should be performed as previous Using Sources phases with one team member building whilst the other(s) perform the Question/Answer interactions. Observing teams make notes. After each team has performed a short formal dialogue (using Turn Taking) consolidates the learning for all teams.	Splits cognitive load and provides further Consolidate interactions through Dialogue between teams. Turn Taking ensures brevity and participation.

## 5. Conclusion

This research has provided theoretical reflections on a particular genre of tabletop games and their suitability for modification to include dialogic learning. Within the LM-GM framework, three games were analysed using gameplay loops and particular interactions were identified as having potential for increasing dialogue. Useful Learning Mechanics for dialogue were identified as Plan, Analyse, Reflect, and Consolidate, which, when combined with Dialogue (which was separated from the Reflect/Discuss mechanics identified by Arnab *et al.* (2015) for the purposes of this analysis) have subsequent benefits for Ownership, Responsibility, and Consolidate. The gameplay loops indicated that the Game Mechanics which lead to these LMs are likely to be Strategy/Planning, Design/Edit, Match, Measure, and Feedback. Therefore, when designing or modding games to encourage dialogic learning, these GMs could be made central to gameplay to achieve the learning behaviours desired. The analysis also identified some GMs that can be detrimental to dialogic learning, namely Time Pressure, Competition, and Dexterity and suggested some ways in which their counterproductive effects for dialogue may be reduced. It is proposed that games which already encourage informal dialogue can be adapted to move away from Observation (i.e. vicarious learning) and Guidance towards full participation in the 'Dialogue' Learning Mechanic.

Limitations are that these propositions are based only on a particular type of tabletop game, those that were initially shortlisted for modding for a specific educational purpose; building knowledge and confidence for postgraduates undertaking a literature review. Therefore these games include game mechanics that might inhibit dialogic learning and the modifications proposed may not be as effective as designing a dialogic learning game from scratch. Nevertheless, game modding can be a fruitful approach as it greatly reduces the time and expertise needed to design an educational game and is particularly suitable for educators who are not also experienced game designers. The GMs and LMs identified as productive or counterproductive for dialogic learning are limited to the scope of the game genre being analysed here and should not be considered to be a comprehensive list. Wider recommendations beyond these case studies could be achieved by analyses that cover a range of different game genres.

A further limitation is that this analysis is untested. The research methods initially included testing and co-design with students; this was made impossible due to COVID19 restrictions, therefore this paper concentrated instead on theoretical analysis. Empirical testing is needed to establish if dialogue is actually encouraged in the ways suggested and furthermore if that dialogue does in fact lead to the outcomes proposed. Therefore these results should be taken as preliminary until further validation has occurred.

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## PW11

# Choose Your Own Adventure! An empirical study on gamification of postgraduate learning on research project design

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## **Choose Your Own Adventure! An empirical study on gamification of postgraduate learning on research project design**

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### KEYWORDS

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Academic Development  
Learning Development  
Higher Education  
Postgraduate  
Personalized learning

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### ABSTRACT

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It is difficult to teach complex topics such as academic research to student cohorts who are widely heterogeneous in prior knowledge, learning goals, and learning preferences. Exploratory, quest-like approaches show promise for increasing engagement, personalisation, and autonomy, however, there is a lack of empirical data on which, if any, aspects of gamification can benefit learning. This paper presents analytics and qualitative responses to a Choose Your Own Adventure for postgraduate design of research projects. It focusses on non-linear navigation for self-directed personalisation, digital badges, and the role of narrative within a gamified learning tool. Results highlight high user attrition, effective personalisation of learning, high acceptance of gamification approaches, and much lower interest in some gamification elements, contributing value to the pedagogy of learning and teaching research skills.

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## **Introduction**

This article discusses the creation and evaluation of the Creative Thinking Quest, a gamified tool for scaffolding the various skills and activities required for conceptualizing and designing research and creative projects. The motivation for gamification came from a pragmatic epistemological stance in response to my critical reflections on one particular assessment within a 12-week, postgraduate course on research skills: a proposal for an academic research project in the creative disciplines. The assessment evidenced challenges for many students in high-level concepts (e.g. appropriately scoping their project so it is achievable), nuanced understanding of research methods, and detailed project planning (for example, writing concrete objectives that help to answer the research question.) Personal reflection and scholarly enquiry on submissions over a four-year period identified the need to more closely personalize learning content for the unusually diverse cohort of students on the course. The main challenges identified were the large number and diversity of the intended users and the widely acknowledged difficulties of teaching higher-order learning outcomes related to

research skills in Higher Education (cf. Hamnett & Korb, 2017; Ryan et al., 2014). Recent meta-analyses of gamification in formal education conclude that gamification has the potential to enhance aspects of all three learning domains: cognitive, affective, and behavioural outcomes (Huang et al., 2020; Ritzhaupt et al., 2021; Sailer & Homner, 2020), although the latter notes a greater effect in schools (as compared to HE) for cognitive outcomes (Sailer & Homner, 2020, p. 105), reiterating the challenges of meaningfully teaching research skills at postgraduate level.

Therefore, action research was undertaken to improve cognitive, affective, and behavioural outcomes related to the knowledge and practice of research design, using gamification to attempt to address key challenges of meaningful personalisation and scaffolding at large scale, and motivation towards learning a “dry” topic (Ryan et al., 2014). Action research as a reflective, collaborative methodology can provide a systematic approach to developing evidence-based teaching practices. It is particularly useful for allowing exploration and cyclical evaluation of innovative instructional practices as it provides a much-needed evidence-base, encouraging teachers to critically examine their own assumptions about teaching and learning and create transformative practice (Weller, 2019, pp. 292–3). This paper presents empirical evidence of a gamified approach, along with critical reflections on ways to use findings in enhancement of practice for research skills teaching.

For the avoidance of doubt, this article uses the definition of gamification proposed by Deterding et al. (2011), “the use of game design elements in non-game contexts” (Deterding et al., 2011, p. 9), which distinguishes it from both ‘playful learning’ and ‘game-based learning.’ Playful learning is defined by Whitton & Moseley (2019) as an intrinsically motivated, player-led activity and, along with others (e.g. James & Nerantzi, 2019), they note the advantages of play in adult education as it includes constructivist educational strategies, self-supported learning, strategies for engagement, and signifiers of experimentation and exploration. Within the Creative Thinking Quest tool that arose from this action research, learning content is not delivered as an integrated game but rather a quest containing game elements of choices, puzzles, and badges (for personalisation, consolidation, and motivation respectively), and activities to perform, directly relevant to a real research project design. In other words, the play elements are typically separated from the learning elements. Nevertheless, this gamification strategy shares many of the advantages of both playful and game-based learning in this context. The self-scaffolded nature of a quest format allows for high degrees of relevance and preference for students learning research design and reflects the inherent uncertainty of postgraduate research (McCulloch, 2013). Furthermore, exploratory learning formats such as quests create high learner agency, encouraging autonomy, self-direction, and meta-cognition (Blaschke, 2021) – all crucial skills for postgraduate research.

### ***Study aims and objectives***

This study's main aim was to determine if and how a gamified learning tool for research design is effective.

Sub-questions focussed on whether the tool could deliver usefully personalised learning content, the impact of narrative and achievement badges, and overall acceptance of gamified approaches for this topic.

This paper provides useful empirical data and insights that contribute to the developing pedagogy of research methods, focussing on active learning strategies (for more context see Nind & Katramadou, 2023; Saeed & Al Qunayeer, 2021), in particular, gamification.

### **Research Context**

It is important to begin by noting that gamification as a concept has existed for centuries, and has taken on new meanings since becoming popularised as a term in the 2000s. Gamification is continually evolving and now includes a wider range of mechanics, including sophisticated digital tracking. Nevertheless, despite a wider range of gamification strategies now being used, it is still broadly understood as a layer of game mechanics and/or aesthetics being applied to a "normal activity" to encourage (or discourage) certain behaviours (Hon, 2022, p. 10). A recent meta-analysis of gamification in education (Ritzhaupt et al., 2021) states that much of the focus has been on 'pointification', i.e. points, leaderboards, badges, or a combination of all three. They note the potential for the integration of more gamification elements, mentioning specifically the key gamification elements of: quests, personalisation, non-linear navigation, and narrative (2021, pp. 2497–2499) and suggest that future empirical gamification studies and practices should explicitly consider game elements "beyond mere pointification" (2021, p. 2516). Importantly, this meta-analysis also identifies that the latter three elements are rarely seen in previous studies on gamification in education (2021, p. 2507) making this paper a valuable contribution.

The rationale for using game-like approaches for teaching research skills is clearly outlined by previous research (e.g. Kollars & Rosen, 2017 and Abbott, 2019), identifying games' advantages for motivation, reduction of anxiety, applied approaches for obvious relevance to students, and metacognition. Learning outcomes specific to research skills and research methods training need to span cognitive, affective, and behavioural domains, and are widely acknowledged as presenting challenges for pedagogical practice (Nind & Katramadou, 2023) that game-like strategies, which foreground student-centred, active and experiential learning, can fruitfully address. An online list of Research Support Games (Bray & McCutcheon, 2021) gives a good indication of existing game-like approaches to teaching research skills. Of the games listed, most address a topic related to research (e.g. copyright, Open Access, publishing) rather than the design of research projects. Three games cover the research process, either directly or tangentially, and one is focussed on research

methods. None directly address project design. My own further review identified a wide range of other examples, including games for library research (Tekluve et al., 2015), critical thinking (Gusmanson & University of Cambridge, n.d.) evaluation of sources (Walsh, 2018), and PhD induction (Watson et al., n.d.) amongst many others. Only one example identified covered the research design process in detail, where, using inspiration from previous work (Kollars & Rosen, 2017), the research design process is mapped onto a “creative and collaborative”, scaffolded murder mystery framework (McCarty, 2021, p. 624). This study had a similar goal in that developing a realistic independent research project was a core learning outcome. Both of these studies note clear advantages for student confidence and motivation.

In terms of gamification, no examples covering research design were found that went beyond superficial pointification (e.g. snakes and ladders with quiz questions). However, three examples relevant to academic skills development used non-linear narratives to present information based on user choices: Research Data Management Adventure (*Research Data Management Adventure*, n.d.); Open Axis (Brennan, 2021); and DLTE Quest (Illingworth & Abbott, 2022). Analysis of this approach notes that “Gamification can be a useful tool to explain concepts with lots of “it depends” answers. Crucially, games acknowledge that there are many different paths to success, much like scholarship” (Brennan, 2021) and that “fun”, interactive exploration of a topic is “a refreshing alternative to trawling through pages of intranet materials” (Illingworth & Abbott, 2023). Non-linear navigation is also identified by Ritzhaupt et al. (2021) as the only gamification element that has a statistically significant positive effect on behavioural outcomes, and they identify “a lack of empirical studies that explore the potential of these gamification elements in educational practice” (2021, p. 2516). This quest-like approach therefore shows promise for the development of new learning tools.

### Design and Implementation of the Learning Tool

To address the challenges of teaching research project design to a very diverse cohort of students, an intervention entitled Creative Thinking Quest was developed. Figure 1 shows the development workflow. The first stage was to review existing useful materials for the intended audience, which here explicitly included people conceiving and designing a creative project as well as

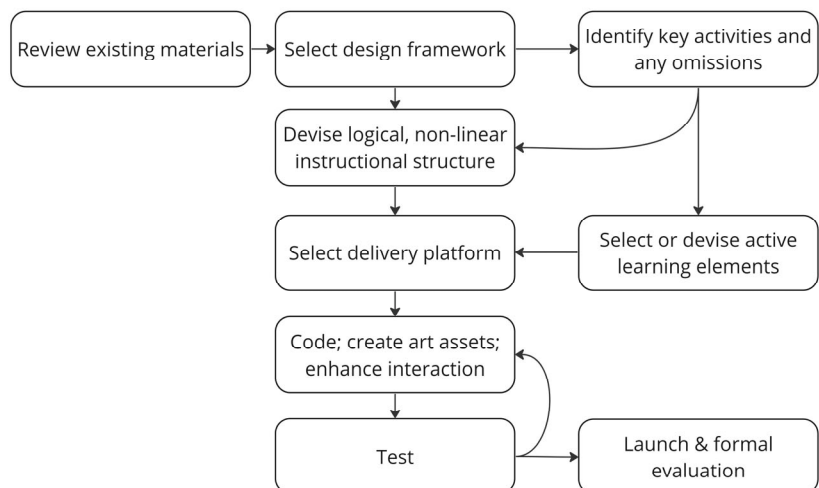


Figure 1 - Design workflow for Creative Thinking Quest

those doing more formal research project design (with a non-exclusive focus on academic settings).

Considering the full range of necessary activities from idea generation through to formal brief-writing, various tools were consulted. Due to its wide applicability across the research design process, alignment with the critical thinking learning outcomes, and availability under a Creative Commons BY-NC licence, the Creative Thinking Card Deck by School of Thought (*Creative Thinking Cards Deck*, n.d.) was selected as the main resource, with other useful tools or games also informing the design process and/or being later incorporated as 'prizes' (e.g. *Smudge Skittle*, n.d.)

The next steps were to selectively choose the key activities from the Creative Thinking Deck, undertake analytical structuring for well-scaffolded instructional design, and identify learning outcomes that were important for the context of this tool but missing from the Creative Thinking Cards (e.g. consideration of ethics, writing project objectives, data management). A logical structure was then devised that allowed for personalisation by offering choices between digging deeply into a particular set of activities or skipping them, and offering alternative formats for activities (for example, visual vs. textual brainstorming). Based on these requirements, the instructional design coalesced into a non-linear Choose Your Own Adventure (CYOA) format, including elements from classical quests such as a mentor, a series of trials, enemies to fight, and periodic recapitulation/revision of the project idea. CYOAs are just one example of interactive, or personalised pathways through material, where the user takes on the role of the protagonist in a story whose choices (to a greater or lesser extent) determine the plot and outcomes. Therefore, they usefully share characteristics with the concept of learner journeys in education (Abbott, 2020). Non-linear content, including CYOAs, tend to fall into a set of recurring patterns that affect how users engage with them. For example, a binary choice at each node will branch out into many completely divergent but relatively short paths, suitable for multiple playthroughs, whereas a largely linear path with quickly rejoining side branches leads to a relatively consistent experience where users will see most of the content. As can be discerned from Figure 2, the Creative Thinking Quest combines elements of the 'branch and bottleneck' and 'quest' structures (as defined by Ashwell, 2015), which allow a high degree of personalisation and deep exploration within conceptually clustered nodes, whilst simultaneously directing learners towards the most important and universally useful learning content.

The following simultaneous stages were to consider when and how activities could be made more active with the inclusion of short playful interventions (as opposed to text instructions), including some gated content that requires users to demonstrate knowledge to access; and to consider a platform that could deliver the functionality required. A range of interactive web tools (e.g. *Flippity*, n.d.; *Scratch*, n.d.; *ThingLink*, n.d.) were used to aim to increase engagement and active learning, and the open-source, interactive narrative platform Twine (*Twine*, n.d.) was selected for its relative ease of use and ability to export to a single html file into which

the other web-based tools could be embedded.

Next followed a series of short, iterative prototyping and testing phases where the 'chunked' learning content was encoded into a non-linear quest format, all active learning enhancements were designed and embedded, and the quest was given a simple 'skin' inspired by retro digital text-based adventures. Images were created where appropriate (typically by original creation or sourcing and restyling existing Creative Commons images) and a simple narrative based on a fantasy-themed journey was written. Feedback from initial testing phases with small groups led to additional content being added for users developing projects in groups (presented as a 'side quest'), additional games, achievement badges, and a change in art style. The Creative Thinking Quest was launched and disseminated to the general public in October 2021 through the Itch.io game hosting website (*Itch.io*, n.d.). Figure 2 shows all 82 linked nodes of the final quest within the Twine software and has been annotated with overlaid shapes and text to show conceptual stages, formulated as chapters within the overall narrative.

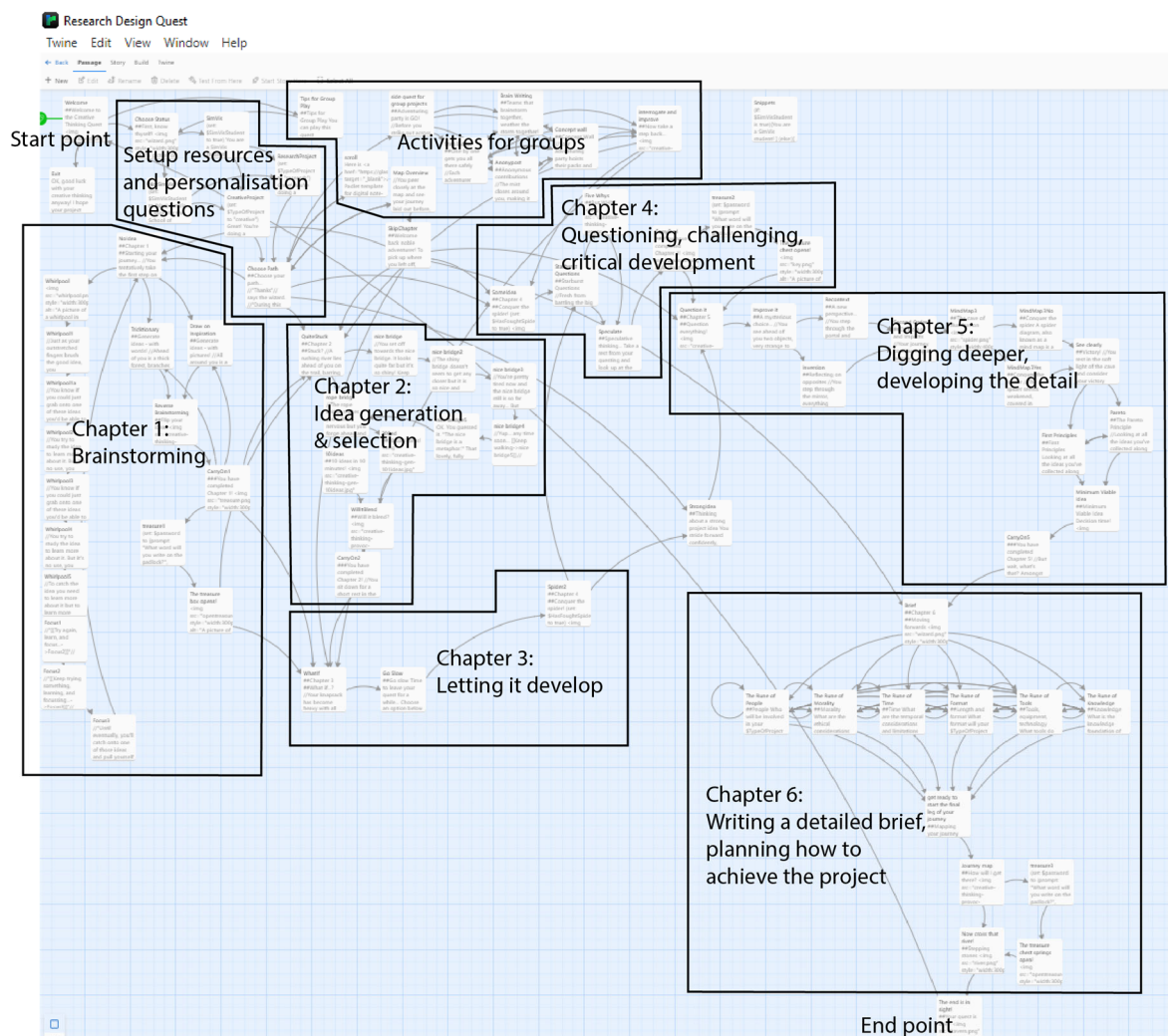


Figure 2 - Structure of the Creative Thinking Quest in Twine with annotations to show conceptual themes of each chapter



## Evaluation Methods

Empirical data was gathered using three complementary methods in order to capture a mixture of large-scale quantitative data on the use of the tool, and qualitative data to inform interpretation of the quantitative data and provide deeper insight into users' attitudes towards different aspects of the content and delivery.

Triangulation of evaluation methods for game-based approaches is noted as important (Mayer et al., 2014) and qualitative data are specifically mentioned as both crucial to achieve a complete evaluation of a game-based approach, and as a research gap for games in Higher Education (Boughzala et al., 2013). Therefore, this mixed-method approach combines simple automated game analytics, a post-play survey, and a focus group with expert practitioners to gain further insights. All data collection was completely anonymous and voluntary. Where the evaluation was made available to students it was emphasised that participation in both the quest itself and the evaluation was entirely optional and had no way of being linked to individuals and no bearing on assessments. Ethical clearance was granted by The Glasgow School of Art.

### *Automated game analytics*

Web analytics can provide large-scale, systematic, but high-level use data. Itch.io provides overall use statistics as views (of the game landing page) and plays (clicking Run in the game window.) It also provides referring URLs. In order to collect more detailed analytics from within the game itself to enable interpretation of game use, javascript snippets\* were embedded within the quest pages which, when visited, capture simple anonymous data including choices made by the player such as type of project (research or creative), the path(s) selected through the quest learning content, and time spent between individual pages. Automated game analytics such as these are particularly suitable for capturing behavioural measures of learning (e.g. time on task, access to particular content) (cf. Ritzhaupt et al., 2021) and the non-personal demographic data gathered allows for greater insight into who is using the tool. The variables captured were written to a Google spreadsheet using Google Extension Apps Script† and later optimized to identify individual game sessions. As all users are completely anonymous, analysis was at the level of individual play sessions (rather than unique

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\* Javascript is an object-oriented computer programming language commonly used to create interactive effects within web browsers.

† Apps Scripts integrate with and automate tasks to extend the functionality of Google products, in this case automating the writing of variables into a new row in a Google Sheet to collect data about user sessions.

users.) Data was captured periodically at key points during the quest (for example, at the end of chapters) so is not a perfect map of user activity, nor does it distinguish between time a user is actively on task vs. simply having the page open in a browser window. Nevertheless, despite its limitations, this session-level data is very useful to establish overall use patterns for the tool. Consent for data gathering is acquired at the start of the game. For the purposes of this paper, data from 18 January 2022 – 31 October 2023 is used.

### ***Survey***

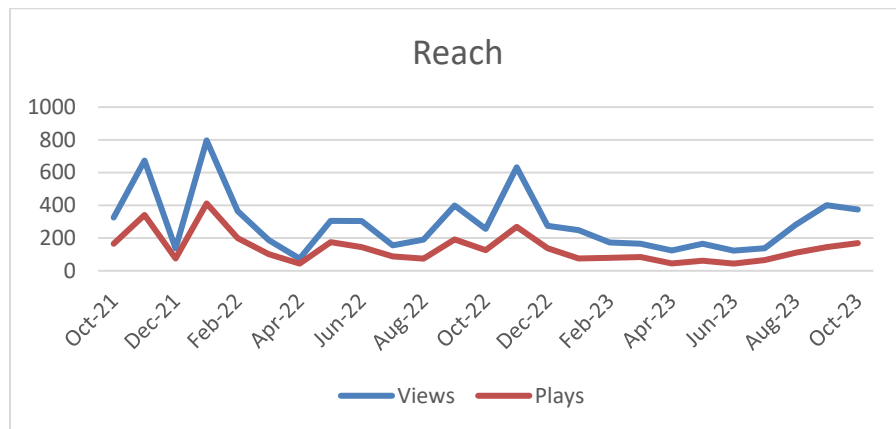
This method aimed to capture data on users' roles (e.g. undergraduate or postgraduate student, staff, creative practitioner), prior development of a particular project idea, and affective outcomes (motivation, perceptions of learning, and attitudes on digital badges, narrative, and personalized learning.) A link within the quest itself takes users to a detailed participant information sheet and consent form, followed by a short survey combining fixed options with free text responses to elaborate. This non-automated method allows direct, structured qualitative and quantitative data from users to be collected to enhance interpretation. Over the evaluation period, 26 valid responses were collected.

### ***Focus group***

In order to gather expert views, a focus group with around 20 participants took place at a conference focused on playful learning. Participants were shown the Creative Thinking Quest and preliminary evaluation data, and asked to respond to a series of provocations (aligned with the particular educational issues explored in the survey) through discussion and making anonymous notes. These notes have been used to inform the analysis.

## **Results & Discussion**

In the two years after the quest was launched (October 2021-2023) the game page on Itch.io had 7,365 views, of which 3,446 (48%) translated into clicking into and playing the game. Referring URLs identify that, as well as a range of referrals from the UK Higher Education learning and teaching and research development communities, the quest has been linked from virtual learning environments (VLEs) at 13 universities, with seven of these (two from outside the UK) showing evidence of sustained and meaningful use (i.e. more than 20 referrals).



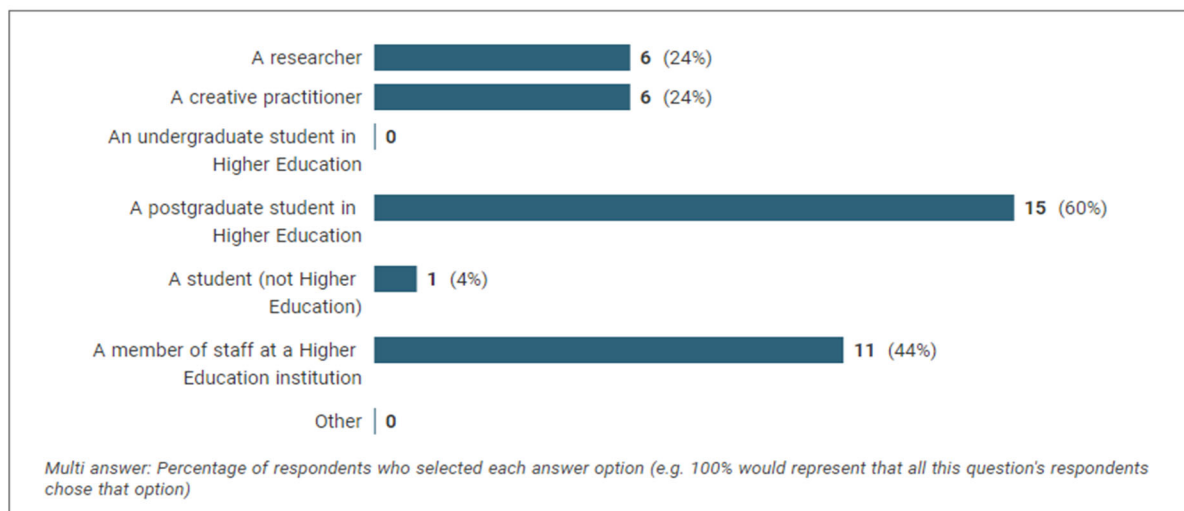
**Figure 3: Page views and plays of the Creative Thinking Quest:**

The following results data uses view, plays, and analytics from the slightly shorter period the detailed game analytics were implemented, i.e. 18 Jan 2022 - 31 Oct 2023.

### *User information and overall impressions*

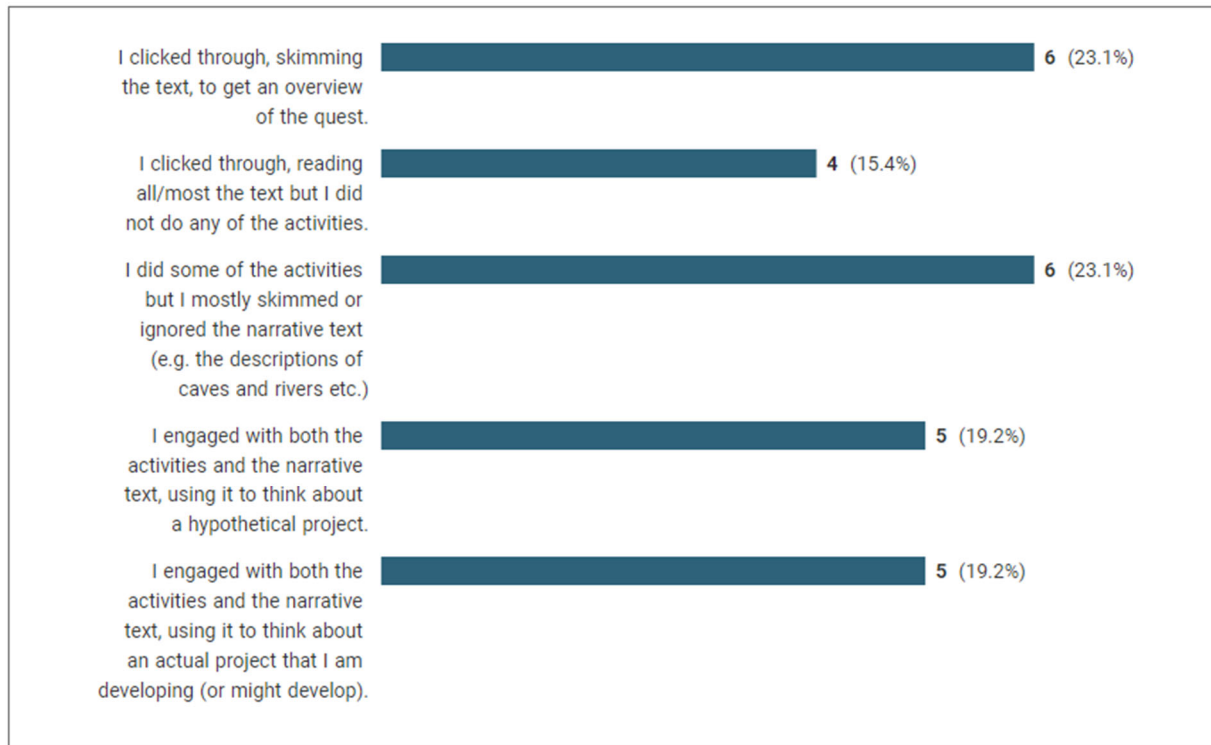
The evaluation survey (n=26) that was released alongside the quest aimed to find out more detail about users, their roles, and preferences. Figure 4 shows user roles with most being the target group of postgraduates in HE, with a high proportion too of HE staff members. These non-mutually exclusive categories also show an even split between those who identify as researchers and creative practitioners. Of the total number of play sessions, 13.4% came from my own students for whom the quest had initially been designed.

#### **1** Are you (tick all that apply)



**Figure 4: Survey Question 1 - User roles**

**5** Which of the following best describes your use of the quest?

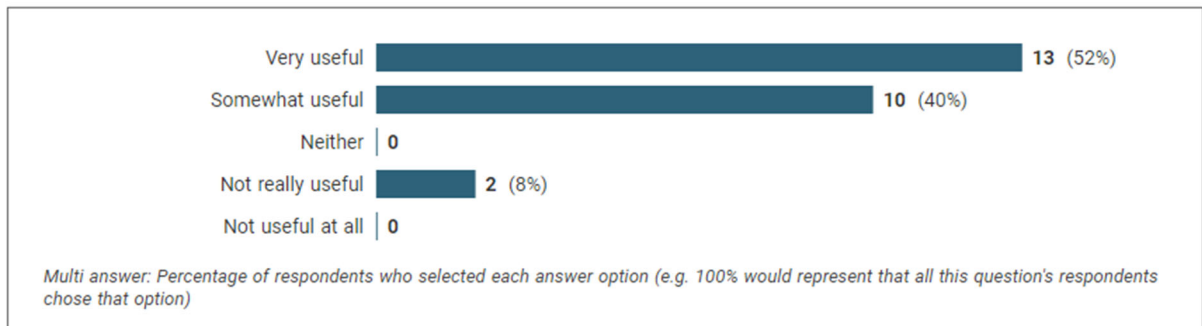


**Figure 5 Survey Question 5 - Ways of using the quest**

As can be seen from Figure 5, uses varied from those who just wanted to have a quick look at the quest (qualitative responses show that HE staff wanted to check if it was suitable for their own students) to those who engaged with parts, or all, of the content, to varying levels of depth. The difference between these use cases is analysed in detail in the Using or Perusing section, below.

**13** How useful did you find the Creative Thinking Quest overall?

**13.1** Overall, I found the quest:



**Figure 6: Survey Question 13 - Overall usefulness of the quest**

Overall satisfaction with the quest was high. Figure 6 shows that all but two of the respondents found the quest useful and Figure 7 shows that 14 out of 24 (58%) would probably or definitely use the quest again. Qualitative responses highlighted that the quest was “engaging”, “memorable” and, in particular, that the way the content was chunked and structured was excellent. Comments included: “I liked that it made each stage equally as important, breaking it into bite-size pieces and forcing you to work through it methodically and not miss anything out. Some tasks resulted in unexpectedly helpful answers. I liked that I could stop and return later”, and “A far more engaging tool than written websites or info a tutor could describe to a student”. 10 academics also emailed directly with extremely positive feedback. When talking about if/how the quest would be re-used, respondents identified that they would come back to it at dissertation time, or use it with their own students.

#### 17 Do you think you will use this Quest again in the future?

##### 17.1 I will vs use this quest again.

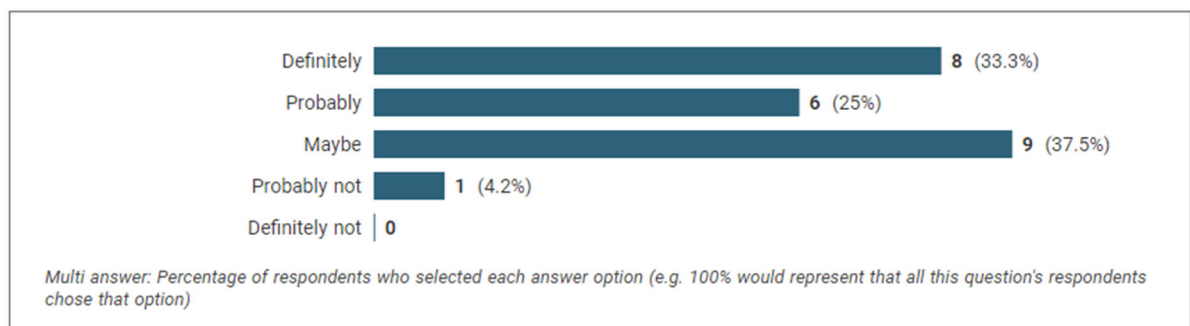


Figure 7: Survey Question 17 - Reuse of the Quest

### *Personalisation of learning*

In its initial stage, the Creative Thinking Quest asks users to choose from a series of options designed to both ease them into the material, and personalise the learning content which is then delivered. A binary choice between Creative Project or Research Project does not affect the quest path itself but is instead written to a state-tracking variable which is used to tailor content more specifically at some points, especially for more procedural learning content. For example, ethical approval from your university is emphasised for ‘research project’ but ethical considerations for arts is presented more generally if the user chose ‘creative’. The main personalisation comes from question and response choice between four options based on how well-developed the user’s project idea already is. The paths through the quest are summarised in Table 1 and Figure 9. There is also a side quest for users who will be working on projects in groups.

Table 1: initial responses to the question "Tell me, how much of an idea for a project do you already have?" and how content is personalized.

Initial path choice text	Jumps to	Types of learning activities in this chapter
Absolutely no idea whatsoever!	Chapter 1	Idea generation, brainstorming, scoping
I'm quite stuck for an idea.	Chapter 2	Brainstorming, scoping, and decision-making
-	Chapter 3	(Advocating leaving the tool and taking time to reflect.)
I have some ideas...	Chapter 4	Investigating ideas in more depth, refining, and improving
I already have a clear idea of my research project (path 1)	Chapter 5	Refining and improving ideas through specific questioning, selecting an (in scope) final idea
I already have a clear idea of my research project (path 2)	Chapter 6	Working on the fine detail of project design and writing a project brief

Figure 8 shows the frequency of project type from everyone who started using the tool. 59% chose research project with 41% choosing creative project. This is an expected split given the context that the Creative Thinking Quest was designed for and disseminated into. Analytics closely match the data from the user survey (where the research-creative split was 58% and 46%, respectively.)

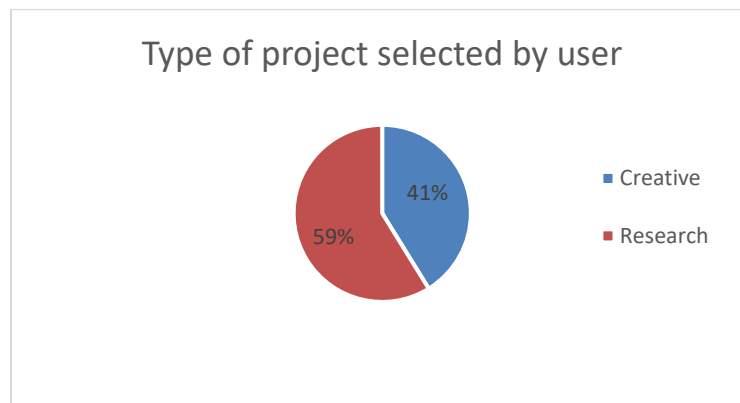
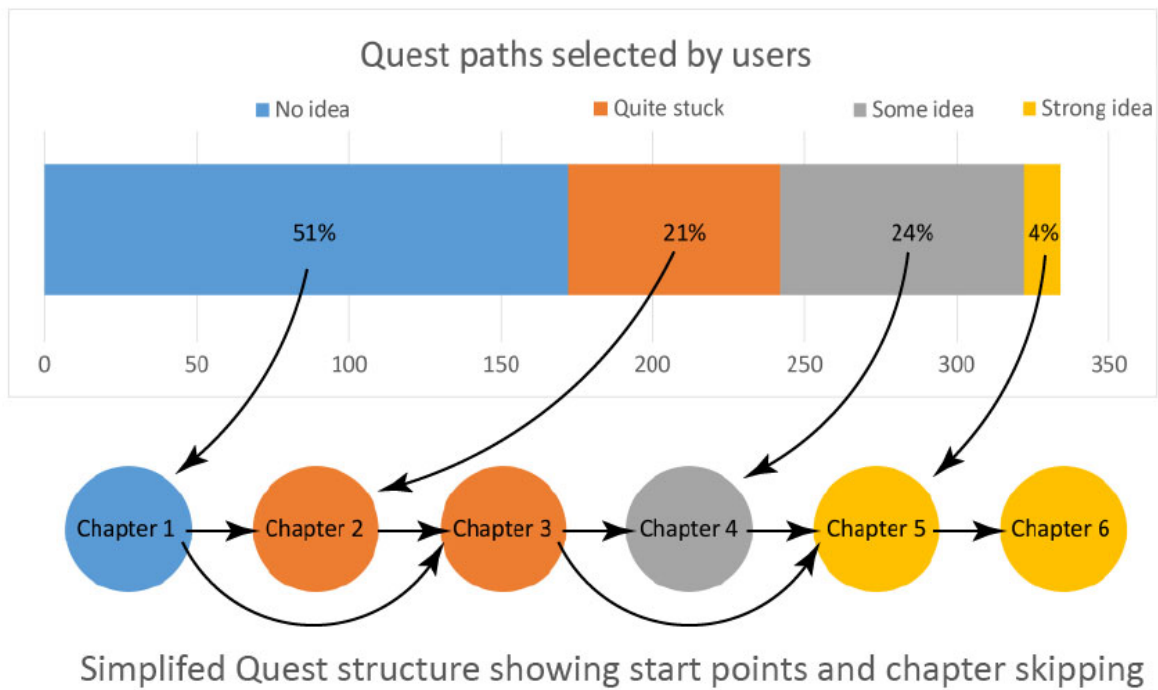


Figure 8: Project type chosen at start of quest

Figure 9 shows the pathways taken by users through the quest. Just over half chose No Idea (51%), Quite Stuck or Some Ideas were 21% and 24%, respectively, and only 4% stated they have a Strong Idea (therefore being taken to Chapter 5 or 6.) It should be reiterated that Figure 9 tracks play sessions, not unique users. Therefore, it is highly likely that some users chose No Idea at first, before returning to the quest for one or more play sessions where they subsequently chose a more advanced pathway. As can be seen from Figure 2 and Figure 9, there are also nodes that allow users to move within and between chapters based on their choices, and these nodes summarise more briefly the learning content of chapters that are skipped.

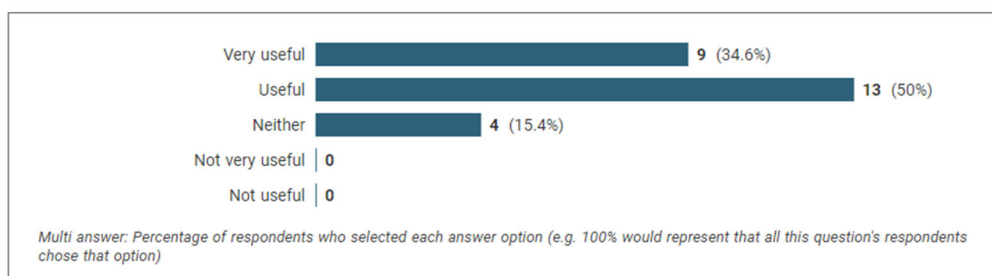


**Figure 9: Users' estimation of how well-developed their project idea was when starting the quest**

The evaluation survey gleaned more detail about use and attitudes towards personalised content. 84.6% of users found these activities useful or very useful (Figure 10). One response stated: "Loved the choose-your-own-adventure element of the activities. Thought they were well described, with just enough information to ensure you could do the critical thinking properly". Users were also asked if they preferred text-based prompts for learning activities (36% preferred) or using embedded apps with more interactivity (64% preferred). This non-decisive split also highlights the advantages of offering different pathways through material so that learners can select their preferred approach.

**7** If you worked through some of the idea development activities, please answer Question 7 below. How useful did you find the idea development activities overall?

**7.1** I found the activities:

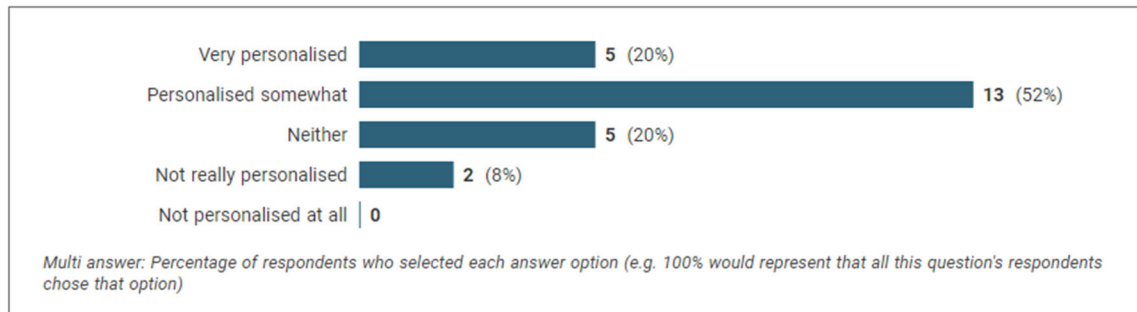


**Figure 10: Survey Question 7.1 - Usefulness of learning activities**

72% of users felt that the quest was somewhat or very personalised to their individual needs (Figure 11). However, qualitative responses highlighted that with such a broad scope it is important to ensure that some content is seen by everyone (“The personalization makes it engaging, but since there are specific tips that everyone needs, personalization is less important”) and that “It clearly worked for my needs but with such a broad scope to address, it's understandable that not every part meets needs like the last and so on”.

**9** Did you feel that the quest was personalised to your needs?

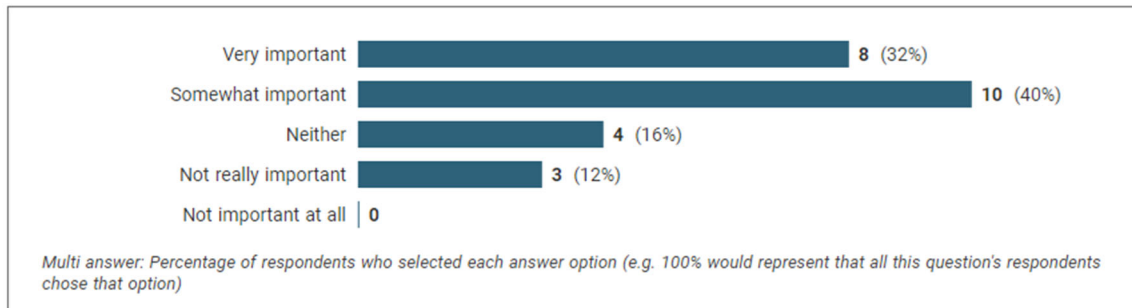
**9.1** The quest was: vs for my needs.



**Figure 11: Survey Question 9.1 - How personalized did the quest feel**

**10** How important do you think that personalisation is for people engaging with this sort of learning content?

**10.1** Personalisation is:



**Figure 12: Attitudes towards importance of personalisation of learning content**

Figure 12 shows that 72% of respondents felt that personalisation (in general) is somewhat or very important, but that “It depends on the openness of the user or the learning situation” and their emotional connection to the material and/or narrative. Interestingly, 12% of respondents felt that personalisation was Not really important. Ritzhaupt et al. found a small negative effect from adaptivity/personalisation on outcomes (2021, p. 2510). They are however keen to emphasise the very small sample size and question this finding, stating that “non-linear navigation displayed higher effect sizes [on affective outcomes] when present, and



quests/missions/modules had very similar effect sizes with and without it" (2021, p. 2516).

Experts from the focus group speculated on the nature of exploratory learning and how it would suit some students (very self-directed learners) more than others, so clear guidance toward core topics is needed. They also reflected on the relationship of personalisation to the somewhat "transactional" nature of postgraduate HE and how playful and exploratory approaches can change the relationships between student and teacher. Play is described as "the *process* that smooths out the reductive, transactional striations of [...] formal education" making "research methods teaching ripe for gamification" (James & Nerantzi, 2019, pp. 25, 285) and play explicitly supports constructivist learning (crucial for postgraduates.) Furthermore, creative or game-like approaches by their very nature move students into the role of creator, reinforcing their autonomy and agency over their own learning, and reconstructing relationships with both the learning material and their teachers (cf. James & Nerantzi, 2019, pp. 285, 322).

Therefore, although its impact on outcomes is currently unclear, personalisation is acknowledged as particularly important in the postgraduate context where learners are characteristically more self-directed and have a wider range of learner goals. The quest was broadly successful at providing this through both non-linear pathways and choices between activities. Nevertheless, careful scaffolding is still required when designing structures for quest-like content.

### ***Using or Perusing?***

The total overall views of the quest were compared to the number of unique play sessions, and data from in-game analytics were used to distinguish between users who were simply having a quick look at the quest ("perusers", with a total view time under five minutes), and those who engaged more meaningfully ("meaningful users" whose play sessions either lasted 5+ minutes or included correctly answering one of the in-game quizzes). It should be noted that in-game analytics are only captured when a player reaches the end of a chapter, therefore if a play session resulted in meaningful engagement but for whatever reason the user did not progress to the end of the chapter, this data is omitted from these results. The definitions used for different use cases is summarised in Table 2, which also indicates the proportion of each use case for the evaluation period.

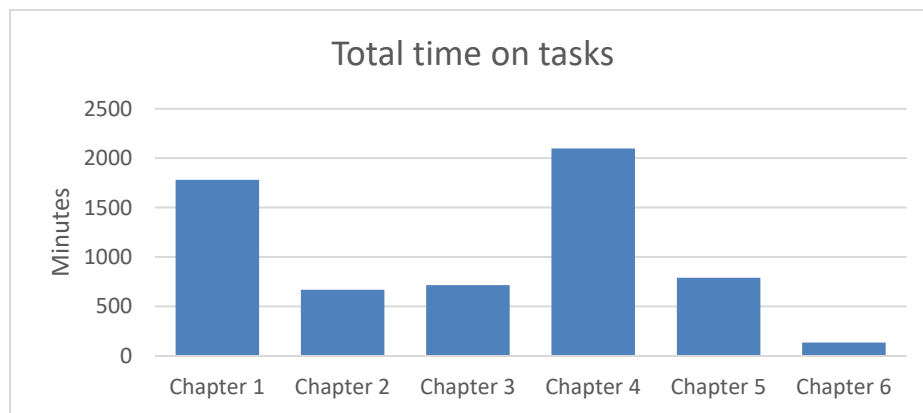
Table 2: Definition of use types for the Creative Thinking Quest

Use case	Use type	Proportion
Visited the game page but did not start the game	Viewed	100%
Visited the game page, started the game, but never arrived at the final page of any chapter	Started	48.0%
Played the game and finished a chapter but with a play time of <5 minutes	Perused	5.0%
Played the game for 5+ minutes, or completed >0 in-game quizzes	Meaningful Use	2.4%

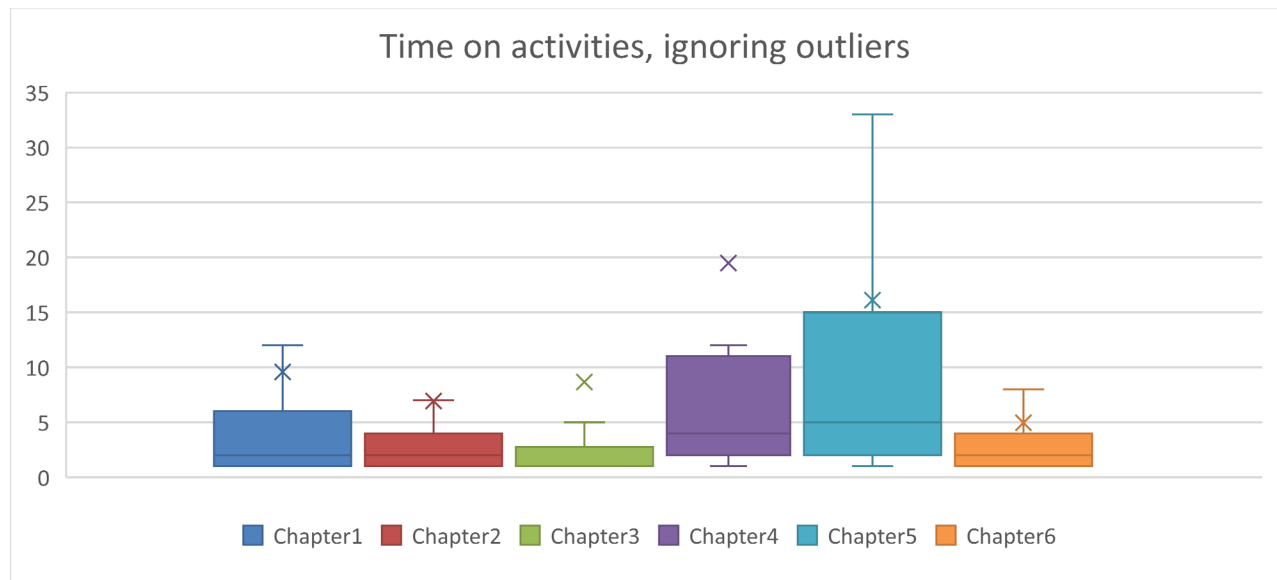
Acknowledging the limitations on data collection, it can be seen that just under half of page viewers started the

quest, only around 1/10 of those perused enough to reach the end of a chapter, and only half of those (2.4% overall) engaged meaningfully with the learning content.

The quest is largely composed of learning content that prompts players to undertake thinking or analogue activity alongside the quest itself (for example, making notes on a piece of paper) so it is impossible to ascertain whether an activity was actually completed. Instead this information is inferred from time spent on each section. The 'time on task' was captured by comparing the time difference between visiting the first page of each chapter and the last page of each chapter. In several cases, this time spanned more than one day, indicating that a browser tab had remained open, but it is very unlikely that this is true 'time on task'! Therefore, during analysis, a cap of 120 minutes was applied as an attempt to balance capturing longer-term working sessions without introducing extensive confounding data, as it is unlikely that time over 120 minutes represents true engagement. Every chapter except Chapter 6 had session time outliers. These have been excluded from Figure 14 in order to show the more relevant median session times more clearly.



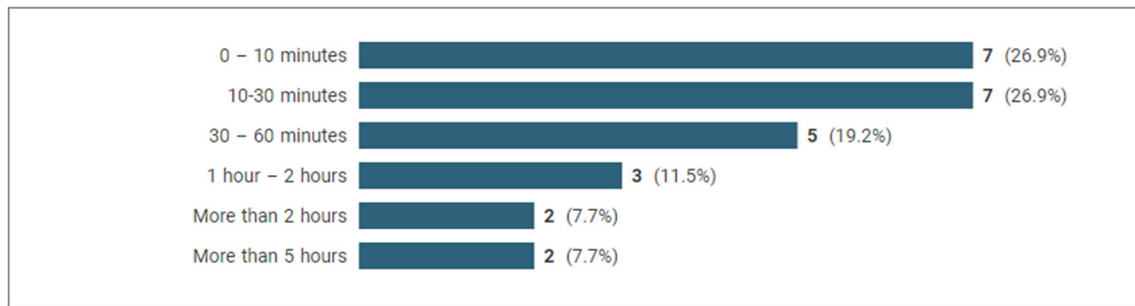
**Figure 13: Cumulative time on task for each chapter in the quest**



**Figure 14: Detailed time on task data showing quartiles, mean, and median**

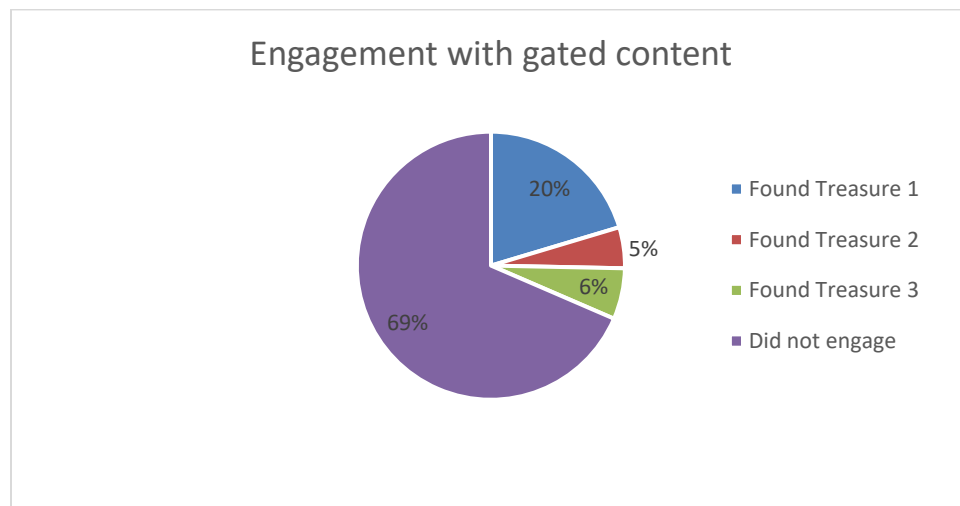
It can be seen from Figure 14 that Chapters 1 and 4 have the longest cumulative session times, at around 1,750 minutes and over 2,000 minutes, respectively. These chapters are the two main entry points for players choosing the “I have no idea” and “I have some idea” quest paths. However, the way in which the learning content was used appears to differ. Examining Figure 14 and the session-level data shows that Chapter 1 of the quest had a much higher proportion of perusers (as might be expected, people having a quick look before deciding if the quest is suitable for their/their students’ needs), whereas engagement with later chapters shows fewer sessions but higher average ‘time on task’ (both mean and median.) Chapter 1 data shows that 75% of sessions lasted around six minutes or less, whereas the variation is much higher for Chapters 4 and 5 with the 75<sup>th</sup> centile at around 11 and 15 minutes respectively. Triangulating these analytics with the self-reported time spent using the tool from the survey (see Figure 15) shows a clear pattern of lots of short gameplay sessions, with a long tail of people engaging very deeply with the quest over a longer period. The expert focus group suggested, during discussion of this issue, that it is quite typical for any one intervention to have low use rates and that similar patterns are seen in videogame culture and other online learning tools. However, they noted that this is not necessarily a bad thing: “It might be about choice and that the users can choose their own time and level of participation, and if they want this or another thing to address their learning needs”. Certainly, whilst there are very few other similar gamified tools on this topic, there are hundreds of books, course materials, and blogs helping students to develop advanced research skills. Again, the heterogeneity of students was emphasised, with the success (or not) of gamified approaches being dependent on both the goals of the course and on individuals’ identities.

**4** Roughly how long did you spend interacting with the quest, altogether?



**Figure 15: Survey Question 4 - Time spent using the tool**

In three cases, the quest prompted users to engage in active learning to unlock “treasures” – a small quiz designed to consolidate understanding led to content that was locked behind a password. These were possible to track using in-game analytics. Engagement with the (explicitly optional) treasure chests is summarised in Figure 16 and shows that the proportion of Meaningful Use game sessions that resulted in finding at least one ‘treasure’ is around a third of the total.



**Figure 16: Percentage of engaged users who unlocked each treasure**

This analysis of personalisation and use of the quest emphasises the need for explicit learning experience design (LXD), which foregrounds learners as individuals with differing preferences and desired outcomes. This can be challenging for novice designers (Chang & Kuwata, 2020), however, despite the challenges in designing them, gamified and game-based approaches suit LXD and personalized learning very well (Abbott, 2020). It is clear from the high proportion of superficial users that this particular topic, presented in this particular way, did not result in extended, deep learning for most. Nevertheless, the extremely positive feedback from those

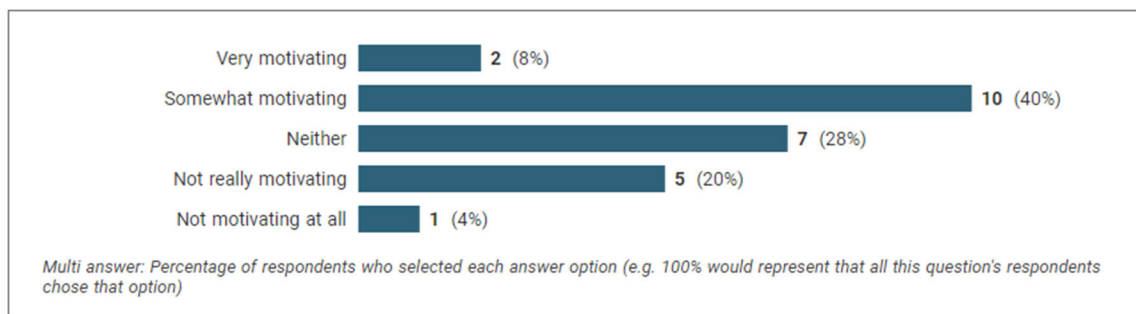
who did engage deeply shows significant impact on those it suited (e.g. “It made me think in different ways”, “a really nice combination of content, depth and fun in this!”) and the potential for new use cases (e.g. “I know I won't 'really' use it myself, even if I think it is a good idea, but I might use it collaboratively”).

### ***Digital Achievement Badges***

Throughout the quest, players can earn ‘badges’ in the form of digital images, which they are encouraged to save alongside their research development notes. Much of the literature analysing badges and their impact notes that they are amongst the most commonly used gamification elements, but have mixed or no differences on both outcomes and motivation (Huang et al., 2020; Kyewski & Krämer, 2018; Ritzhaupt et al., 2021). This is borne out in this study with only five (22%) respondents stating they had saved their badges, and 48% reporting that they found badges somewhat or very motivating. My own students were also offered the chance to display their badges on a class leaderboard – an opportunity with a 0% take-up! This finding contributes further evidence that ‘badgification’ is not necessarily a productive approach; or at least public display of badges is not generally desirable. The expert focus group discussed the differences between digital and physical badges, suggesting that physical badges could be more motivating, and that “badges for the sake of badges” was likely to be a less effective gamification element than achievements with a function (e.g. those that open up a new section of a map, or give the player a new ability). Reflecting the literature, they also noted that badges may even have a negative effect on intrinsic motivation (cf. Kyewski & Krämer, 2018). Nevertheless, the badges were enjoyed by several respondents: “While I didn't save the badges, they made me smile when I got one!”.

#### **12** How motivating did you find the digital badges (achievements)?

##### **12.1** I found the digital badges:



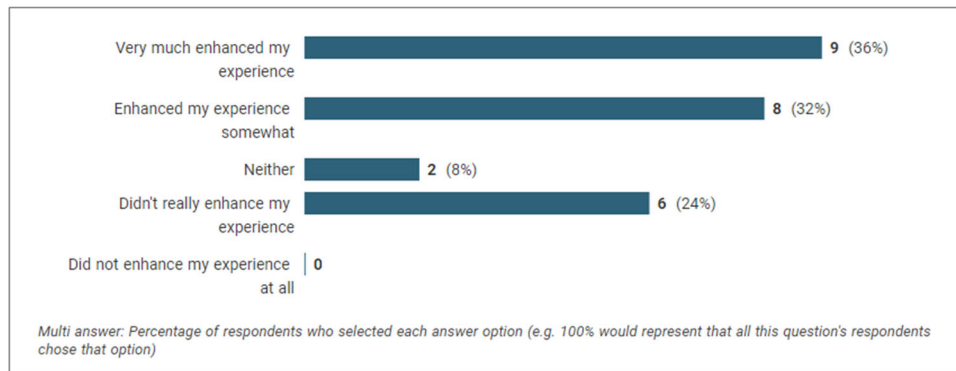
**Figure 17: Survey Question 12 - Are badges motivating?**

## Narrative

The Creative Thinking Quest had a deliberately light-touch narrative which acted more as a fantasy ‘flavouring’ for the player’s journey than a story in itself. The survey indicated a generally positive response to narrative elements, with 68% stating that it had enhanced their experience to some extent (Figure 18). However, it did not enhance the experience for around one-third of respondents, and as Figure 5 also shows, more than 20% who were engaged in learning content ignored the narrative elements.

**8** Did the narrative content (e.g. the pixelated images and the descriptions of caves and rivers etc.) enhance your experience of using this tool?

**8.1** The narrative content:



**Figure 18: Survey Question 8 - Narrative enhancement of the experience**

One meta-analysis shows that game narratives can have significant positive effects for behavioural outcomes, and analyses reasons why the effect for cognitive and motivational outcomes was non-significant (Sailer & Homner, 2020, pp. 102–103). A notable point raised is that quality can be a confounding factor, highlighting specifically the relevance of narrative at key points in the learning journey, whether it meaningfully develops, and the authorial skill of the creator. “Most learning designers who apply and investigate gamification in the context of learning are not trained as writers and are probably, on average, not successful at applying game fiction effectively” (2020, p. 102). This is certainly true for me! The expert focus group also reinforced this point, emphasising that, in order to be useful, narratives need to be deep, authentic, and (again) approached thoughtfully with due consideration given to LXD. Therefore, whilst a well-designed narrative can certainly contribute to effective gamified learning, a shallow ‘skin’ is more likely to be ineffective or even distracting. (For a great example of simple learning content elevated by a compelling narrative, see *Lost at the forever mine*, Field Day Learning Games, n.d.). Therefore narratives that simply seek to add ‘flavour’ to an experience may be enjoyable but are not recommended.

**Conclusion**

The webpage analytics provided crucial usage data but had clear limitations, in that some users (who did not reach the final page of each chapter) will have been omitted from the dataset and that a browser tab remaining open in the background could create confounding time data. The analytics give a good overview of parts of the quest, but were far from perfect due to the time and technical burden of implementing them comprehensively across all 82 nodes. They also could not capture qualitative user data, and so were complemented by the user survey and the focus group with playful learning experts. This triangulation demonstrated consistency in general, although unsurprisingly, there is a bias towards 'deep' users in the respondents to the questionnaire. Consequently, the questionnaire results skew towards positive engagement compared to the 7,000+ users curious enough to visit the quest's landing page.

The main finding from this empirical research is that the Creative Thinking Quest was meaningfully used by a tiny proportion of the people who visited it. Few people finished the quest, or undertook the (optional) treasure chest quizzes. Nevertheless, this still resulted in hundreds of meaningful uses, its incorporation into university VLEs across the world, and feedback from the long tail of 'deep' users was extremely positive.

Personalisation was generally successful and users commented on the effective structuring and high quality of the content. Several respondents noted the need for 'core' content and its associated scaffolding.

Personalisation through non-linear navigation was thought to be particularly valuable for self-directed learners and the postgraduate context.

Badges and narrative were gamification elements that were less successfully applied in this study, with badges being of little interest other than a novelty, and the narrative providing some flavour but not reaching the quality or depth to create real emotional or behavioural impact.

Overall the Creative Thinking Quest was very well received and provides an alternative approach to learning about academic research design. The main ideas for improvements were an interactive map to navigate the content, and a progress bar to help players' expectations and sense of achievement. Both of these would be helpful but would also need careful consideration before implementation to retain the sense of a learner constructing their own personal journey through the material.

This tool was created as a direct intervention for a problem identified through critical reflection on teaching practice. Further reflection-in-action is useful to best inform future practice. My main consideration is the apparent contradiction between the exceptionally positive reception to the Creative Thinking Quest and the (relatively) low numbers of meaningful uses, especially within my own cohort for who the tool was specifically designed. In fact, this reinforces Learner Experience Design literature (and indeed the different lenses of critical reflection (Brookfield, 2017)) in demonstrating that, even if teachers think quest-based approaches work well,

students are highly heterogenous. Whilst some will be delighted by, and highly engaged with, gamified learning, others will be indifferent at best. That said, for those whom this approach worked at all, evidence supports it seeming to work very well. Acknowledging that there is no “one size fits all” solution to pedagogical challenges is the first step in creating truly personalised learner journeys.

### ***Recommendations for other creators***

- Do not underestimate the time necessary to create a well-structured and visually engaging learning quest. A design that is robust enough to provide most users with interactive yet relevant learner journeys takes substantial time to develop and test.
- Capturing usage analytics is technically demanding, and either extremely labour-intensive in the analysis stage or likely to miss some information. Rather than take the self-coded approach used for this study, it is instead recommended that those who need gameplay analytics for research purposes collaborate with existing organisations such as Open Game Data (*Open Game Data*, n.d.).
- Narrative should be relevant, meaningful, and well-designed. If the learning designer using gamification does not themselves have strong creative writing skills, collaborate with a writer who does.
- Before committing to ‘pointification’, perform scoping research to establish if this type of gamification will motivate your users or increase learning outcomes.

Many aspects of gamification have inconclusive results about their impact and efficacy for a range of learning outcomes and learning behaviours. This study provides additional evidence for a non-linear, quest-based approach focussed on delivering personalised learner journeys. It also provides insights that could encourage further investigations into which gamification techniques are most likely to be well-received and effective for different learners, or how classroom teaching might be informed by similar (complementary, optional, deliberately non-universal) gamified interventions.

The Creative Thinking Quest is available free online at <https://daisyabbottitchio.itch.io/creative-thinking-quest>.

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PW8

# Provocative Games to Encourage Critical Reflection

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# Provocative Games to Encourage Critical Reflection

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**Abstract:** The SECRIOUS project takes a game-based approach to improving knowledge and attitudes in cybersecurity practices. Our methodology includes interdisciplinary Serious Game co-design with coders and aims to produce critical reflection on participants' own coding practice. To encourage this we created a series of Small Provoking Games (SPGs) about the project's three overarching topics (Code Security; API Security; Security Lifecycle) and five co-produced themes (Coder Practices; Code Motivation; Morality; Resources; Communication). Games and play are well-suited for creating both reflection-in-action and reflection-on-action. Provoking a lasting change in attitudes towards secure coding practice requires dialogic or inquiry-based reflection leading to transformative reflection. We define a 'provoking game' as one that uses the techniques of reflective game design to produce cognitive and affective challenge – a eudaimonic appreciation of the player experience. This emphasises a player's sense of purpose and aims to create exo-transformation (change in attitudes and/or practice outside the game.) SPG design foregrounded Khaled's principles of reflective game design and was led by serious game experts, a cybersecurity expert, and a playwright, and included input from the entire SECRIOUS team to define each game's specific focus. Two SPGs were produced: Protection (which challenges the assumption of 'absolute' cybersecurity protection) and Collaboration (which highlights communication in cybersecurity developer teams.) A third game is in development. SPGs feature highly exploratory gameplay, expected failure, and focus on metaphor (of both game objects and player actions) to create doubt, contradicting existing mental models and encouraging the players to question the game rules and underlying concepts. The games were used within game-jams to provoke critical discussion, a creative mindset, and group reflection. This paper analyses the design process of these two SPGs and reflects on our contribution to reflective game design.

**Keywords:** Serious Games, reflective game design, critical thinking, cybersecurity, reflection

## 1. Introduction

The overall goal of the SECRIOUS project is to engage coders in cybersecurity issues as both players and designers of serious games. The main problem was defined not as a lack of knowledge resources but as a need to shift attitudes towards attaining and effectively using knowledge about cybersecurity. To achieve this, our methods needed to 1) encourage critical reflection leading to attitudinal and behavioural change and 2) elicit the nature of cybersecurity practice. Provoking a lasting change in attitudes towards secure coding practice requires dialogic or inquiry-based reflection leading to transformative reflection (Baumer, 2015; Mekler, Iacovides and Bopp, 2018). Small, provoking games (SPGs) are proposed as an effective method for interventions that aim to challenge learners' (false) preconceptions and create revised understandings. We define a 'provoking game' as one that uses the techniques of reflective game design to produce cognitive and affective challenge and aims to create exo-transformation (change in attitudes and/or practice outside the game) (Mekler, Iacovides and Bopp, 2018). In this sense, SPGs are about players' self-awareness and attitude shift with regards to their subject matter.

As well as functioning as standalone games, our SPGs were specifically designed to enmesh with our cybersecurity game jams to provoke reflection and contribute to the co-design process of new serious games arising out of the game jam. As such, the SPGs play a part in wider methodological development for the co-design of serious games. This paper covers the context of using serious games to provoke critical reflection, our methodology and methods, an analysis of the games themselves (both available at SECRIOUS, 2022), and our reflections on this process.

## 2. Research background

The concept of 'reflection' has been defined in numerous ways and there is no single, widely-accepted definition. However, literature reviews (Atkins and Murphy, 2018; Reflection Toolkit, 2020) note that despite the range, complexity, and abstraction of scholarly writing on reflection, differences are typically around terminology and the structure of the metacognitive process. Definitions tend to share three main elements which can be summarised simply as: reflection is a *conscious exploration* of the *self* to *construct new insights*. Furthermore, the literature tends to agree on three key stages of reflection: Breakdown (also called discomfort, surprise, conflict, or dissonance); followed by Inquiry (analysis); which may lead to Transformation (new perspective, affective and/or cognitive change) (Schön, 1992; Baumer, 2015; Atkins and Murphy, 2018).

The depth of reflection is defined in different ways and using different terminology. Depth is typically structured as a hierarchy from superficial observations, through intentional inquiry and/or dialogic reflection which constructs links to one's own experiences and/or wider social and ethical constructs, to truly transformative and/or critical reflection that results in a meaningful shift in beliefs, approach, or behaviour and that extends into the future. Critical reflection specifically includes "bringing unconscious aspects of experience to conscious awareness" (Sengers *et al.*, 2005, p. 50).

Existing literature on reflection within serious games notes that many games' purposes go beyond knowledge acquisition and aim for attitudinal or behavioural change, for which reflection at least at the level of constructing relationships between a game and real life is required (Khaled, 2018; Mekler, Iacovides and Bopp, 2018; Whitby, Deterding and Iacovides, 2019). Khaled notes that simulations of real life processes afford reflection as they "explicitly represent systems of beliefs, propositions and processes [...] enabling interrogations of validity" (2018, p. 5), a characteristic shared by games. However, "Unlike simulations, games are inextricably linked with the notion of designed challenge and often also with difficulty. [...] Non-trivial challenge, analysis and problem solving, key parts of the reflective process, are already present in how we generally understand games." (pp.5-6). Mekler, Iacovides and Bopp also state that games are particularly suitable for supporting reflection as they "confront players with puzzling or surprising situations, which invite them to plan, experiment and look for new solutions" (2018, p. 315), matching the three key stages of reflection. Schön (1992) distinguishes reflection-in-action as synchronous with practice and reflection-on-action, which occurs after the activity has taken place. Reflection-on-action can (but does not necessarily) result in behavioural/attitudinal change and can also feed back into reflection-in-action. In the context of serious games, a combination of both types of reflection can result in-game reflective processes (e.g. developing your conceptualisation of the game or altering your play style) and out-of-game changes in, for example, self-image or behaviours (Whitby, Deterding and Iacovides, 2019). Games' potential clearly reaches beyond reflection-in-game as the fictionalised challenges both provoke curiosity and grant agency, which supports reflection in out-of-game contexts (cf. Khaled, 2018, p. 22), demonstrating again the real potential for games as a medium to support transformative reflection.

Various principles for reflective game design have been proposed, although there is no unified approach (Kitson *et al.*, 2019). It is important to begin by challenging the assumption of 'fun' that is still common in research on serious games. Serious games can, of course, be fun however, a more important concept is that of the 'serious experience' (Mekler, Iacovides and Bopp, 2018), where negative emotions can lead to positive experiences, producing eudamonic appreciation (i.e. contentment from having purpose in life). In other words, games can be *rewarding*, whether or not they are also *enjoyable*. This concept is particularly important when considering reflective game design and it is noted that greater cognitive and affective challenge tend to lead to greater appreciation (Whitby, Deterding and Iacovides, 2019 p.340). Kitson *et al.* note that "although we can use technology to design for transformative experiences, we do not design the experiences themselves but rather create the conditions to invite them" (2019, p. 2). Useful analyses of design qualities that inhibit or encourage reflection in game design (Sengers *et al.*, 2005; Khaled, 2018; Mekler, Iacovides and Bopp, 2018; Whitby, Deterding and Iacovides, 2019) have been synthesised into our recommendations for reflective game design:

- Provide for interpretive flexibility (Sengers *et al.*, 2005) to encourage the active construction of meaning crucial for reflection and meaningful 'questions over answers' (Khaled, 2018, p. 23).
- Expose unconscious aspects through challenging player expectations (of game systems, narrative, content, and external assumptions) (Sengers *et al.*, 2005; Khaled, 2018; Mekler, Iacovides and Bopp, 2018); explicitly designing to "engage, problematise, and potentially conflict with cultural and social

norms" (Whitby, Deterding and Iacovides, 2019, p. 339); and making learning clear and conscious (Khaled, 2018, p. 23).

- Create player actions/decisions that are emotionally or cognitively meaningful to increase eudaimonia and extended reflection (Whitby, Deterding and Iacovides, 2019, p. 345).
- Provoke the player. Khaled calls this "Disruption over comfort" and notes that "Games that are designed to disrupt can create opportunities for players to be thoughtful, creative and innovative"(2018, p. 23). It includes techniques of distancing, surprise, and failure to help trigger the critical analysis necessary to contradict an existing mental model. However, it is also crucial that provocation needs to be well-balanced for player engagement.

### 3. Provoking game design

Drawing on the recommendations for reflective game design above, our main emphasis (in both design process and SPG product) was on: *interpretive flexibility*; *disruption of/subverting* expectations; *expected failure/frustration* during construction of meaning; explicit *out-of-game reflection*; and *rigour*. Our aim was to focus players' attention on critically examining the game object's behaviours and the rules governing their interactions. Therefore, the majority of player responses should take place at the meta level - outside of the game. To maximise critical reflection, we defined overall principles for designing the SPGs.

- 1) Abstraction of the content entities to their essential properties and methods, and re-rendition in a fictional, unconventional metaphor.
- 2) Integration with out-of-game activity to re-contextualise game content and experience within the domain of cybersecurity.
- 3) Use of metaphor to "mask" familiar content and create the distance conducive to critical reflection.

#### 3.1 Interdisciplinary co-design

SPG design was in the context of a highly interdisciplinary research project and it was crucial to maximise the different types of expertise within this team. This paper's authors (all serious game specialists) worked closely with a cybersecurity expert and a playwright. This collaboration was particularly fruitful as it allowed thorough and nuanced investigations of the problem area, focussing on the most important intended outcomes. This laid rigorous groundwork for a well-scoped serious game intervention. The cybersecurity expert ensured the validity of the content and its modelling, whilst the playwright was crucial in producing a creative, unconventional metaphor, as well as designing an engaging overall narrative and story beats for the games. Furthermore, the entire SECRIOUS research team was involved in ideation for each game's subject, and contributed feedback, validation, and oversight throughout the design and development process. We consider this interdisciplinary approach to have been absolutely crucial for rigour.

#### 3.2 Design and implementation of two provoking games for cybersecurity

##### 3.2.1 Triadic Game Design

Triadic Game Design (TGD) is well-established as a rigorous serious game design method and can also be used for documentation and evaluation (Harteveld, 2011). TGD breaks serious game design into three aspects: Reality (where the investigation of the problem area and the associated subject matter takes place); Meaning (where the intervention strategy to generate change is designed) and Play (where the gameplay to best achieve this change is designed.)

The Reality aspect was analysed in interdisciplinary meetings with the support of data gathered in user-centred workshops that SECRIOUS held for this purpose, cross-referenced with related literature to clearly define each problem area and establish priorities. An ideation phase focussed on creating questions inspired by the project's three overarching topics (Code Security; API Security; Security Lifecycle) and five co-produced themes (Coder Practices; Code Motivation; Morality; Resources; Communication). These questions were used to identify an overall concept for three SPGs which together cover these topics and themes. (This paper considers the first two games; the third is currently in development.) Each SPG design process started with the preconceptions that we aimed to target in each game's audience. Led by cybersecurity experts, we composed a set of entities/concepts essential to the specific subject in question and defined key messages that the game should convey.



For the Meaning phase, we drew explicitly on the principles of design-for-reflection to produce an intervention strategy with a list of associated learning mechanics. Using guidance for serious game workflows (Abbott, 2020) we defined: 1) intended outcomes; 2) learning context; 3) learning behaviours (using Bloom's Taxonomy (Anderson and Krathwohl, 2001)); and 4) emotional design. We then used this information to select appropriate Learning Mechanics (LMs) from the Learning Mechanic Game Mechanic (LM-GM) Framework (Lim *et al.*, 2013). We also considered the LMs for the post-play activity as these 'out of game' reflections were core to our strategy.

For the Play phase, we worked with the playwright to devise a premise for a comprehensive metaphor and a loose narrative plot to cover the intended outcomes arising from the Reality and Meaning phases. Working with the cybersecurity expert, we translated subject matter entities into in-game objects and the subject matter principles into game rules. LMs were mapped directly to appropriate Game Mechanics (GMs). We shortlisted a set of genres and play-styles appropriate to the LM-GM mappings and content, formulated player actions, and designed the serious gameplay loops. We also specified in-game performance assessments, win/lose conditions and concluded with level design, which was directed to stage in-game events inspired by real-life conditions. These activities all drew directly from the LM-GM mapping that arose from the TGD process. It is important to note that this is not a fully linear process and iterative design cycles clarified and reinforced elements in all three phases. Lastly, game designers specified the content for the post-play activity. The specific design of each SPG is summarised below.

### 3.2.2 SPG#1: Protection

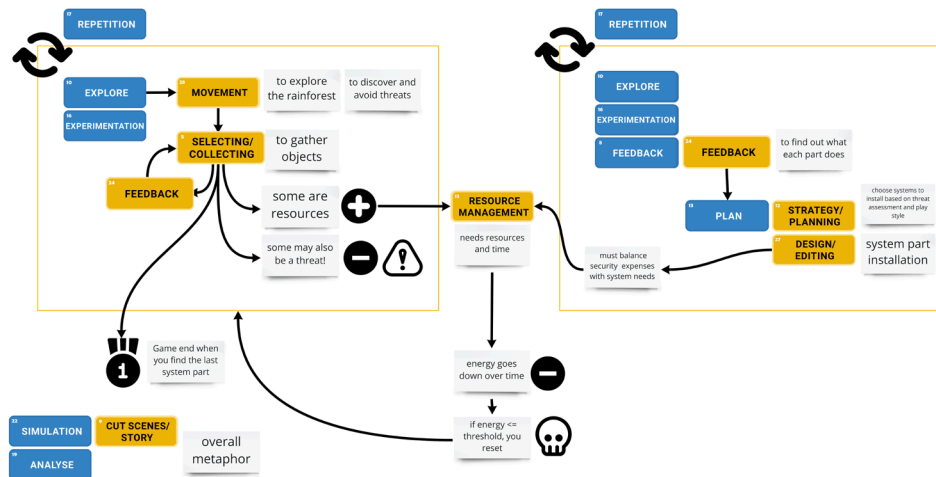
The first SPG, named Protection, was designed to address the following preconceptions:

- Coders think cybersecurity is an optional and obscure feature that is the domain of dedicated experts, rather than an essential aspect of any application.
- Coders think that cybersecurity is binary, instead of thinking in terms of a fluid and changing landscape of risk that is in constant need of re-assessment.
- Coders not appreciating the diverse range of mitigation strategies and their suitability towards certain threats, or compatibility to each other.
- Coders thinking of cybersecurity as an independent layer with a view of "the more the better", whereas it is an integral part that should be balanced with functionality.

This led to the definition of the following learning outcomes. After playing players should:

- Perceive cybersecurity as a crucial component of any system
- Reflect on their own coding practice.
- Understand that absolute security is not possible.
- Understand that risk assessment is contextual and can fluctuate over time.
- Grasp the concepts of risk, threat and countermeasures and figure out that threats and defences have multiple (1-many) relationships.
- Acknowledge that security features may have functionality trade-offs.

The most relevant Learning Mechanics were the *Simulation* of a fictional yet recognisable situation which allows players to *Explore* and use *Experimentation* with *Feedback* to reverse-engineer the rules of the game which in turn allows them to *Analyse* and *Plan* how to succeed. We explicitly excluded *Instruction* and *Guidance*, however, implicitly in the meta-game and explicitly in the post-play activity, the player is prompted to compare how these rules reflect or contradict their own mental model of their cybersecurity practices. To serve these LMs, we selected the core Game Mechanics of *Movement* (to explore and avoid threats), *Collection* (of defences/mitigations), *Design/Editing* (of a defence strategy), and *Strategy/Planning* (to adapt to changing contexts). Figure 1 shows the gameplay loop with associated Learning and Game Mechanics.



**Figure 1 - gameplay loop showing mapping of Learning and Game Mechanics for Protection**

We then designed the core metaphors for game objects and game rules. These are summarised in Table 1, Figure 2, and Figure 3.

**Table 1 - each game object with its justification for Protection**

Game object	Justification
Main character	A hybrid biological/electronic entity to convey the universality of the concept of security.
Digital rainforest	An ecosystem of software applications with a changing context (day-night cycle represents abundance vs scarcity).
Plants	Data suppliers.
Berries	Data that the character can process: beneficial orange berries give power (juice) to the main character; harmful purple berries (poison) have a delayed corruption effect (as from malware) and blue berries stick the main character's mouth shut, mimicking a distributed denial of service attack.
Malicious agents	Hackers. Each predator has a different movement pattern (patrol, hunt, spring-trap) and damage effects representing common attack methods, such as control hijacking, process shut down, asset theft, etc.
System parts	Cybersecurity defence strategies that negate or mitigate negative effects and increase main character's functionality and ability to avoid threats.

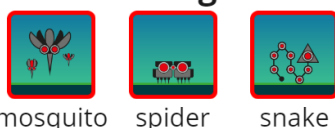
### Main character



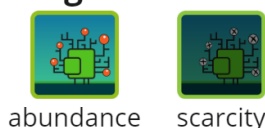
### System parts



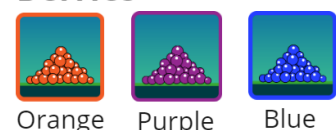
### Malicious agents



### Digital rainforest



### Berries



**Figure 2 - Protection game objects**

Game rules, reflecting the principles laid down during the Reality phase, are:

- A character starts unable to defend themselves and needs to collect and install system parts for defence. Installing defence modules takes time and resources.
- Some threats can be rendered obsolete by installing the proper defence modules, some can only be mitigated, while for others there are no defences and the player needs to avoid those threats.
- Some threats can become more or less dangerous based on other conditions. For example, blood sucking mosquitos become more dangerous if the player is paralyzed by a spider and cannot escape.
- Some defence modules render others useless, while some defence modules complement each other. E.g. a filter module at the I/O port (prevention mechanic) makes the database compartmentalization module (contingency mechanic) redundant.
- Installing the most impervious defence module significantly increases resource consumption and limits functionality.
- Installing too many defence modules causes system overload and triggers a non-responsive state until upgrades are uninstalled.

## Threat - Mitigation system

There are two mitigation methods:

- Play-style based mitigation, where the player must adapt their play style accordingly mainly by movement/avoidance.
- Security-upgrade based mitigation, where the player can install (at a cost) a defence module and use its active or passive effect.

















Threat	Play-style	Security upgrade	
 Starvation	Eat berries at day or using stored juice at night	 Wait till dawn	
 Sticky Berry	Avoid consumption / consume to intentionally close port	 Makes this threat obsolete	
 Poison Berry	Avoid consuming / consume with empty reserves	 Risks only 1/3 of total at each incident	 Makes this threat obsolete
 Spider	Avoid touching by waiting & timing your movement	 Can run, is able to pass through easier	 Form A: blocks scratch damage Form B: also blocks status fx
 Snake	Avoid touching by getting out of reach	 Rise higher to avoid triggering an attack	 Form A: blocks bite damage Form B: also blocks status fx
 Mosquito Swarm	Avoid touching by getting out of reach	 Can run, is able to avoid easier	 Wait till dawn

Figure 3 – Summary of Threat-Mitigation interactions in Protection

In terms of gameplay, Protection is a short, 2D, side-scrolling, real-time, single-player game with genre elements from action (move/avoid/collect), strategy (manage resources/select) and puzzle (choose/combine). The player must navigate a risky landscape, trying to survive against various threats using diverse defence systems. Our design avoided common tropes associated with these genres (e.g. score, time pressure, lifecount), allowing instead the exploratory approach conducive to critical thinking. Productive failure is a core concept and the player is expected to 'die' at least once as they gather information. The player must analyse feedback loops to discern the game's rules and create defence responses. Feedback is frequently counterintuitive or surprising, subverting players' expectations. The three main in-game actions are moving, collecting, and installing/uninstalling defence systems (the main educational player action, mirroring the process of risk assessment and defensive planning). This requires the player to first find the respective module (which represents gaining and updating knowledge in real life.) Protection is single-player to serve our goal of inquiry-based reflection on an individual's own practice.

The story takes the protagonist on a journey of natural evolution and intentional change, starting with the protagonist becoming aware of their own existence and expanding into developing movement and a metabolic cycle (input/output). Intentional change is ensuring survival by installing combinations of defence systems. The character has no explicit purpose other than surviving in its harsh, native environment. The story concludes with the protagonist symbolically mastering these conditions and flying away. In the post-play activity, players

were asked to interpret in cybersecurity terms what they thought the entities represented and what they deduced from the story.

### 3.2.3 SPG#2: Collaboration

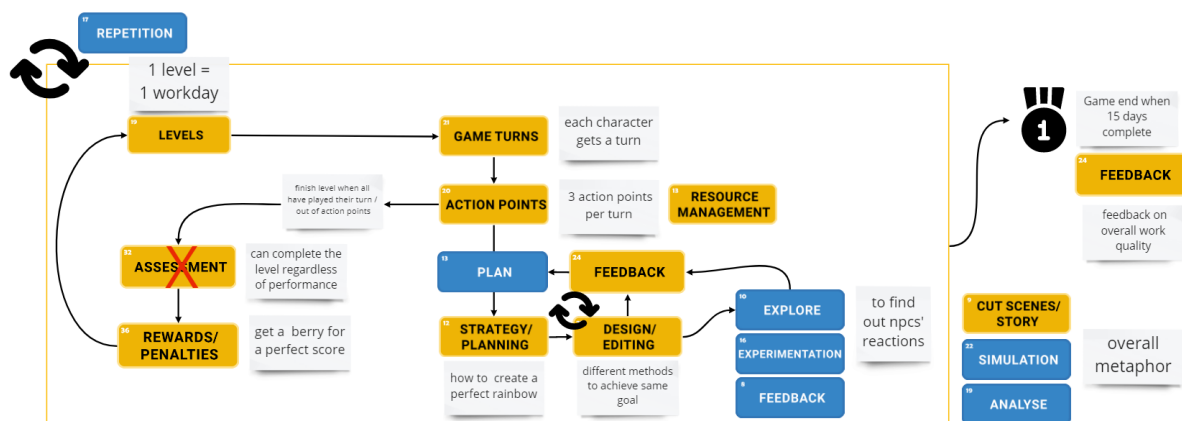
The second SPG, Collaboration, was designed to address these problem areas:

- Developers (or teams) working on different parts of the code tend to operate in an isolated way and cybersecurity issues can creep in due to a lack of overview and/or communication.
- Developers may not treat communication as an important part of their job and consequently may not be willing to devote time and energy to it.
- Human/“soft” skills are an undervalued and frequently untrained skill set in highly technical work environments but are crucial for successful project delivery and good work conditions.

This led to the following core learning outcomes. After playing players should:

- Understand that the security of the product is only as good as the security of the weakest link.
- Understand that the quality of communication across teams can affect the quality of the end-product.
- Appreciate that the human side of communication is as important, energy consuming and skilled as the technical content.
- Grasp that security needs to be implemented in multiple aspects and stages, therefore overview and communication throughout the development pipeline is necessary.
- Reflect on their own communication skills and cybersecurity contexts.

Learning Mechanics were identical to Protection, however, this time they were mapped to *Levels* and *Game Turns* (representing time in the Security Lifecycle), *Action Points* (representing worker time/resources), and the same *Planning, Design, Resource Management, Feedback* cycle as in Protection. See Figure 4.



**Figure 4 - gameplay loop showing mapping of Learning and Game Mechanics for Collaboration**

We then designed the core metaphors for game objects and game rules. Collaboration adopts the same fictional universe with its light-hearted tone and colourful iconography as Protection, but expands the list of in-game entities, summarised in Table 2 and Figure 5.

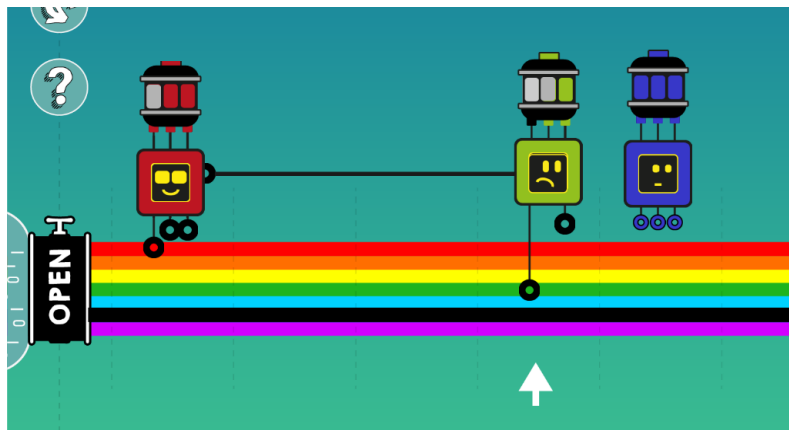
**Table 2 - each game object with its justification for Collaboration**

Game object	Justification
The Rainbow	An infrastructure that outputs ‘rain’ into the digital rainforest, representing a publicly-used software application with its seven coloured lanes representing the dimensions of the cybersecurity requirements.
Rain	Data flow that can become corrupted without secure infrastructure.
Trees	The user community that relies on the infrastructure to serve a vital need, and the variable health of the ecosystem.
Monsoon season	Represents the duration of the team project: 15 days (15 game levels.)
Main character	The same main character as Protection.
Other characters	Various colleagues, similar but distinct creatures with their own personalities (expressed

	by face) and expertises (expressed by colour).
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Collaboration game rules are:

- Each co-worker can construct lanes in their own colour/expertise. Some roles can combine their efforts to construct lanes in a composite colour. Some roles are unique and impossible to substitute.
- Each co-worker has their own personality and default mood/behaviour ranging from highly motivated through indifferent to opposed to the project's goal.
- Talking to NPC co-workers influences their mood and behaviour. Each personality responds differently to various communication styles.
- At the end of a work day, the Rainbow should have all 7 coloured lanes. Each missing or incorrect lane reduces the cybersecurity quality of the Rainbow and contributes to Rain acidification.
- Acid rain impacts the health of the ecosystem. Damage accumulates over the duration of the monsoon season.
- There is no personal reward or penalty for the team members for the quality of their work. The only feedback that exists is the observed health of the ecosystem.
- There is no fail threshold for each level, or for the game overall. A player is allowed to complete a level (commit code) no matter what cybersecurity quality the Rainbow has
- Damage done to the ecosystem can be ameliorated to a small degree using berries, which are generated if a level is completed with a perfect score.



**Figure 5 - cropped screenshot from Collaboration showing communication and different moods**

Collaboration is a turn-based, puzzle game, with each level representing a work day and a whole game run representing a software project. Collaboration is single-player with AI agents to model specific behaviours. The puzzle for each level is to find the appropriate actions to take in order to make the safest Rainbow possible. This requires players to learn/recall the order of colours in the Rainbow (an abstraction of technical skills), and also observe and understand their colleagues' personalities (the human aspect). The challenges are designed to be not always feasible or perfectible. Furthermore, the challenges frequently have more than one solution representing different approaches to problem-solving. In Collaboration, time was quantified in work shifts and had a sense of chronological order which led us to adopt the turn-based approach. Space was irrelevant as a concept which led to a single, static level design where all actions took place. Main variables for each level were the team composition and the Rainbow puzzle, allowing for levels to be procedurally generated. Action points were an essential mechanic to signify units of energy/time during a work shift. The player can choose to spend their action points constructing a rainbow lane (writing code) or communicating with their co-workers. This is a direct translation of the key message that communicating is as essential and time consuming as coding, but also equally an integral part of development work.

As in Protection, players were asked to undertake a post-game activity and describe in cybersecurity terms what (they thought) the entities reflected, but this time players were also asked to directly reflect on how they manage their real-life work relationships and compare that to in-game events.

## 4. Discussion

These two SPGs appear, on some level, to be quite different. In Collaboration, players have a clear premise, identity, and objective and the game rules are highly scaffolded with a tutorial and reference manual. On the contrary, in Protection, players have ambiguity and freedom with instructions limited to the game controls and absolutely everything else open to interpretation. However, both games were designed with the fundamental concept of provocation through both the subverting of player expectations and of withholding information about the game rules which forces players to experiment, explore, and actively construct their own meanings and mental models. Game differences are to focus the player's attention to best achieve each game's intended outcomes. An evaluation of the SPGs in terms of their effectiveness in achieving reflection is outside the scope of this paper (detailed evaluation is forthcoming). However, we can comment on preliminary results from using Protection and Collaboration within Serious Game Jams on the SECRIOUS project.

Firstly, the abstraction of technical detail and focus on visualising concepts and processes through a friendly metaphor made our SPGs an ideal medium for introducing cybersecurity to a novice audience. Cybersecurity is not often depicted in such a playful manner and this could help to promote engagement. Player feedback on the graphical style was very positive, whilst noting that the game setting was "difficult to interpret". The adoption of metaphor makes the post-play activity essential to a complete SPG experience as, whilst the games in isolation could create critical reflection, our overall purpose was reflection as part of co-design activities. Post-play reflection is an established technique in simulation-based training where an 'after-action review' helps players to receive extrinsic feedback, gain an overview, and analyse their performance (Meliza, Goldberg and Lampton, 2007). Our goal was rather to create dialogue as players compared and contrasted different interpretations of the metaphor and, by doing so, deepen their understanding of and relationship to cybersecurity concepts. Recontextualization during the post-play activity actively prompted players to compare their in-game experience with their real-life practices and note any new observations arising and their potential implications in real world terms. Post-play reflections demonstrated a variety of interpretations of character identity and which threat-defence combination was the most useful, implying different critical judgements (or at least different play styles). Furthermore, players effectively analysed and re-mapped the in-game content to SECRIOUS Cybersecurity Concept Cards (a forthcoming SECRIOUS output), with some very insightful responses. Therefore, we consider the ambiguity in asset design and gameplay to be successful.

Our SPGs excluded mechanics that promote 'gamified' engagement, such as competition and rewards. Protection also eschewed any instructions to orient the player. Furthermore, the games had a hybrid genre style, for example, Protection looked and felt like a platformer but control mastery was not the way to win, it was instead strategic thinking. It could be argued that this unfamiliar gameplay encourages reflection, however they may also have decreased engagement. In Protection players were initially confused (one asked "Are we supposed to know how to do this?"), however, continued experimentation allowed players to construct meaningful connections between game events and cybersecurity concepts. Players did express surprise (and sometimes frustration) during gameplay, especially at points that had been designed to challenge expectations or provoke 'out of the box' thinking, for example, the realisation in Collaboration that it was not possible to always get a perfect score, or the narrative twist in Protection that too many upgrades causes an overload.

Finally, it is important to note that our SPGs were designed as a single (or limited) user experience. Replayability was not a design goal and the focus was firmly on their place within a wider educational and creative methodology. This implies that SPGs for similar purposes could be made even shorter to improve completion whilst still providing the basis for critical reflection.

## 5. Conclusion

We have presented the rigorous design process of two Small Provoking Games which feature highly exploratory gameplay, expected failure, and focus on metaphor. We integrated gameplay experience with a range of post-game activities designed to create doubt, contradict existing mental models, and encourage players to reflect on underlying concepts and make links with real-world practice. Whilst evaluation is still in progress, it can be seen that these provoking games have been successful in creating ambiguity, meaningful connections, and an accessible introduction to cybersecurity concepts. A formal evaluation will follow to analyse if these characteristics have been successful in our core goals of 1) creating inquiry-based reflection, and 2) supporting players in the move from consumers of cybersecurity-themed games to co-designers.

## 5.1 Acknowledgements

The authors thank our collaborators at Civic Digits, a company that works at the intersection of games, performance and technology. Civic Digits' director, Dr Clare Duffy is a playwright and theatre director and Rupert Goodwins is a technical journalist with a specialism in cybersecurity.

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## PW2

# Development of Cross-Curricular Key Skills Using a 3D Immersive Learning Environment in Schools

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# Development of cross-curricular key skills using a 3D immersive learning environment in schools

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**Abstract.** Pedagogical opportunities offered by 3D immersive environments are not restricted to subject-based knowledge but also include non-disciplinary and cross-curricular key skills. This pilot study introduced a large 3D scene of a non-extant architectural exhibition into teaching and learning activities at three UK schools. From observation and qualitative data capture, a comparative case study identified a number of pedagogical opportunities and challenges. Despite diverse teacher and student approaches, a number of common factors were identified including constructionist teaching methods and the suitability of 3D environments for developing cross-curricular key skills and capabilities. In relation to the literature, this paper analyses how subject-aligned use of the 3D model met with differing levels of success, identifies four key skills that emerged from student use of the model across all three schools, and considers how challenges might be translated into further learning opportunities.

**Keywords:** Pedagogy, 3D visualization, Cross-curricular skills, Game-based learning, Collaboration, Creativity, Self-directed learning

## 1 Introduction

Whilst there is a growing body of research that focusses on pedagogical opportunities of 3D environments for the enhancement of particular, curriculum-based learning outcomes, few empirical studies consider their role in developing key cross-disciplinary skills and attributes such as collaboration, creativity, leadership, and emotional maturity. These capabilities are recognized across national curricula as intrinsic to the development of successful learners. Through a comparative case study of the use of a 3D environment in teaching activities in three schools, this paper investigates how 3D environments within the classroom can provide opportunities for developing key cross-disciplinary capabilities.

## 1.1 The REVISIT Pilot Study Methodology

Research Engagement through Virtual Immersive Tools for Learning (REVISIT) was a project with two primary aims: to develop innovative learning tools for schools using a dataset originally developed for higher education and research use; and to increase our understanding of the impact of immersive 3D environments for teachers and learners through a pilot study. The original dataset comprised a 2D digital collection and 3D model of the British Empire Exhibition which took place in Glasgow in 1938 [1]. The 3D scene re-creates over 100 individual building models (all but one of which are no longer standing) within the topology of Bellahouston Park, Glasgow, where the Exhibition took place. The digital collection includes photographs, architectural plans, ephemera, audio, and video.

For REVISIT, the 3D scene was delivered through VSim [2]. This (prototype) software was selected as it is specifically designed for pedagogical interrogation of 3D models; functionality includes real-time exploration alongside the ability to create narratives (linear ‘tours’ within the virtual space) and multimedia annotations, and the easy export of narratives and resources for classroom sharing and broader dissemination [ibid.]. Crucially when working with schools, VSim is free to use and standalone.

The existing 3D scene was optimized and converted to a COLLADA format, compatible with VSim. The archive of related cultural assets was organized into folders, targeting relevant curriculum areas as well as highlighting the most interesting items.

During the first phase of the project, teachers at three UK schools (one primary and two secondary) were introduced to the datasets and initial reactions and ideas for use were gathered through interviews. A firm aim of REVISIT was to avoid a ‘top down’ approach where university research data is simply delivered without being adapted to the new educational context, and is therefore of limited use. Therefore, the project sought to actively engage the teachers in the design of curriculum-aligned learning objects (i.e. VSim narratives) before delivery to the students. However, it was immediately apparent across all participating schools that there was a desire to use the Empire Exhibition 3D environment as a theme for cross-curricular learning, and for the pupils themselves to become co-creators of the narratives. Schools were therefore given autonomy in their use of the 3D scene and digital collection in lessons which reflects the constructionist approach recognized in other studies of teacher perceptions of 3D heritage data [3]. This resulted in three very different case studies, reflecting the different needs and approaches of the teachers and students who participated.

During the project’s second phase, teachers organized teaching and learning activities which used REVISIT data (see **Table 1**). Qualitative data were collected including observations, interviews with teachers and focus groups with students. A survey was also performed with students at one secondary school (n=33). Audio recordings were transcribed and coded in NVivo [4] to perform inductive thematic content analysis. Other data include the narratives and resources created by the pupils themselves.<sup>1</sup>

This paper focusses on a theme that emerged strongly from the content analysis, that is, the opportunities afforded by 3D environments for developing cross-curricular skills such as collaboration, leadership, creativity, and emotional intelligence.

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<sup>1</sup> Anonymized project outputs can be downloaded from <http://research.gsfasimvis.com/revisit/>

	<b>Young's Primary (YP)</b>	<b>Hall's Secondary (HS)</b>	<b>Barrow Secondary (BS)</b>
<b>Pupil age</b>	10-11	13-14	14-15
<b>Pupils participating</b>	26	106 participants (33 survey responses)	6
<b>Learning context</b>	Classroom, project-related activities	Classroom, 'creativity challenge'	Voluntary lunchtime club
<b>Time period</b>	Two months	3 days	Two 2-hour sessions
<b>Teachers participating and input</b>	2. High preparation, demonstration, and contextualization	8. Variable between teachers.	2. Low, some technical preparation, little pedagogical guidance

**Table 1.** Summary of teacher and student engagement in the pilot study. School and person names have been changed for anonymity.

## 2 3D Environments in Education

3D immersive environments are now accepted to have strong potential for creating engaging learning opportunities across a range of learner ages and situations. One review identifies pedagogical opportunities arising from these embodied experiences including increased motivation, the ability to contextualize learning objectives, and collaborative learning processes [5]. 3D models and environments have primarily been used in STEM subjects, however their growing use as surrogates for real-world environments is recognized, particularly where they model inaccessible historical or cultural spaces [6]. Although the majority of bespoke 3D educational environments still focus on particular disciplinary learning objectives, their value goes beyond increased cognition and also enhances motivation [7], and enables creative participation, digital/cultural production [8] and co-production [9].

In terms of immersive visuals, free exploration and interaction controlled by the user, and experimental, playful investigation, simulated 3D environments modelled on real places – defined by Dalgarno and Lee as “microworlds” [5, p.18-19] – share many of the characteristics of video games. Indeed, like good educational games, 3D learning environments can provide emotionally engaging, contextualized spaces for learning, even where there are no game mechanics present, as “the learner is able to construct a personal knowledge representation and iteratively refine this representation as he or she undertakes exploration and experimentation in a manner consistent with cognitive constructivist learning theories” [ibid]. The VSim ‘wasd’ navigational controls (similar to many gaming environments) and first-person viewpoint for exploration imbues the 3D scene with ‘game-like’ qualities; indeed, when introduced to classes of students, their assumption was clear:

*“It was all ‘aaahs’ and ‘wows’ and they asked “What game is this?” they believed it was a game, “What game is this?”, “Where can I get this?” ” (Daniel, YP, Year 6 teacher)*

Due to their overlapping characteristics, much of the literature on educational digital games is also highly relevant to 3D immersive environments. In fact, some studies' definition of educational games fully encompasses 3D environments, despite their lack of overt game mechanics [10]. Similarly, most research on both games and immersive environments has moved on from questioning *whether* they can be fruitful tools for learning and now concentrates on *how* particular games, environments, and teacher practices can be best harnessed to meet curricular aims [11].

The microworld based on the real British Empire Exhibition of 1938 is highly appropriate for learning goals related to this particular subject, similar to other recent examples of subject-specific game-like 3D immersive environments [12, 12]. However, the REVISIT pilot study identified that such environments are particularly suited to the development of not only subject-based knowledge, but general key skills for learners, a topic currently under-served in the literature.



**Fig. 1.** VSim screenshot showing 3D scene with overlaid interactive narrative including tour nodes and multimedia annotations. Participants created their own ‘tours’ and annotations.

### 3 Challenges for Curriculum-Aligned Learning

The challenges of aligning learning activities in 3D environments are well documented [3, 5, 6] and were reflected in the findings of the REVISIT study. These include organizational support and the time required for teachers to prepare appropriate and contextualized learning activities, as well as the possible emergence of technological behaviors or goals that are unaligned with intended learning outcomes [10].

#### 3.1 Curricular Flexibility

The varying success of the REVISIT pilot was highly correlated with the amount of institutional support and flexibility that teachers were (or were not) given. Particu-

lar challenges included several teachers feeling that using the 3D environment had been imposed upon them (by other members of staff) and/or simply did not have adequate time to plan for its effective use. At Hall's Secondary (henceforth HS), activities were planned as part of a three-day 'creativity challenge' towards the end of the school year, where it was seen to best complement the existing curriculum-based lesson plans. However this brought different challenges:

*"If this was starting in September [it would be easier, whereas] we are at this stage where kids are doing exams in 3-4 weeks so they are going to be pretty stressed out about that."* (Isaac, HS Learning and Teaching Director)

Conversely, at Young's Primary (henceforth YP), despite being extensively used in lessons over a two-month period at the same time of year, flexibility in curriculum planning resulted in greater levels of satisfaction from both teachers and students. This was explicitly acknowledged by the class teacher as well as the head teacher.

*"I know for a fact that had that flexibility not existed throughout the last six weeks there are certain members of the class who would not have achieved what they have achieved so whilst there's a rigidity that remains in education I feel the more this kind of thing happens it will become more flexible and children will become more rounded individuals."* (Daniel, YP Y6 teacher)

*"As a leader you've definitely got to be supportive and make sure that there's time available for the teacher to be prepared, to find out more about it, to explore other things themselves, to talk with yourselves. That's got to be a whole school, high level decision."* (Catherine, YP Head teacher)

At Barrow Secondary (henceforth BS), rigid timetables were surmounted by offering voluntary access to the learning activities via lunchtime workshops. Facilitated by one, highly-motivated but busy, teacher, this model of engagement limited the time available to engage with the 3D environment but ensured that students self-selected whether or not they participated. Describing the curricular challenges when working with innovative but computationally-demanding 3D environments, the teacher also identified other important resource limitations.

*"In my subject, in Geography, it would democratize possibly the ability for me to teach the curriculum. [...] I think 3D would enable me to do exactly what some of the richer schools do on a Saturday morning. [...] it might bring some of the processes to life in a way that I can't in a classroom in inner-city Glasgow [because of lack of resources]."* (Malcolm, BS Head of Humanities)

### **3.2 Constructive Alignment**

Constructive alignment of learning activities with their intended outcomes is core to much of the literature across education. Specifically, reviews of the field note the importance of close integration of learning tools such as games and game-like environments into the curriculum in order to enhance learning objectives [15, p.177,198] as well as making efforts to align teaching activities with the preferences of students [15, p.160-161, 188]. The Empire Exhibition 3D immersive environment clearly possessed what the YP teacher called "the wow factor", however "To be effective, motivational tactics have to support instructional goals. Sometimes the motivational fea-

tures can be fun or even entertaining, but unless they engage the learner in the instructional purpose and content, they will not promote learning” [16, p.25]. Furthermore, the creation of relevant and meaningful learning activities enabled by 3D environments requires both adequate time for preparation and particular pedagogical skills [3] – a challenge when so few teachers have experience using 3D environments – and design of activities using heritage visualizations is affected by both a teacher’s subject-specific confidence and their familiarity with cross-curricular themes [17].

Another challenge is the contextualization of both the learning activities themselves and the knowledge gained by students. “When using traditional computer-based learning tools, the teacher’s role is recognized to be paramount in securing a successful learning experience. The outcomes of any lesson-based computer activity will depend on the introduction of the task, the interventions made during the activity and the way that the activity is set in the context of students’ wider educational experience” [10, p.11]. Or, as more succinctly offered by Daniel at YP: “I think spinning a topic is crucial.” In terms of cognitive challenges when using 3D environments, not only is acquisition of subject-specific knowledge highly dependent on the time that teachers devote to familiarizing themselves with the learning tools [10], game-like learning tools have been criticized for only imparting superficial knowledge [14, p.64] which then needs to be contextualized by a teacher. Therefore, to glean subject-specific knowledge from 3D environments, the continuing challenge is the need for teachers to become expert at not only using this technology but also in how their subject is presented through it.

It is worth restating at this point that the REVISIT 3D environment was initially created as research data and is not specifically designed to fit with school curricula. (The re-use of legacy research data in classroom contexts was a core research question of the project and will be covered in a separate publication.) As such, it posed challenges for the all-important curricular alignment in some learning situations and met with widely differing levels of success, dependent on the approaches of individual teachers. Whilst in some cases, curricular alignment was obvious to teachers and was implemented successfully, other teachers voiced concerns about the relevance of the dataset in terms of their subject and the exact curriculum:

*“[Linking it to the curriculum was] a little bit artificial. I think things like when Sally was saying they took Tait Tower down because of the war beginning that was completely linked to the curriculum [but] history at school is punctuated by events like the First World War, the Second World War. [...] Where does the Empire Exhibition fit into that?”* (Malcolm, BS Head of Humanities)

Other staff described the 3D environment in terms similar to Dede’s “a solution looking for a problem” [18, p.235]. As a school technician put it:

*“Forcing the curriculum to fit with technology is never going to be the best way. Having a technology that is flexible enough for a teacher to customize it to their classroom, that’s when it becomes valuable.”* (Adam, HS Technician)

Teachers at HS also identified that their students were strategic learners, focused on their assessments. It is widely acknowledged that assessments strongly influence the approach taken by students in Higher Education [19, pp.93-95; 20, pp.67-72] and this was borne out by the responses of some students, particularly at HS.

*“I’ve learned a lot... I’ve enjoyed doing it as a one-off but I’m not quite sure if it helped particularly in the overall curriculum. It wouldn’t particularly help with an exam or something ‘cause it’s not subject specific.”* (Jenny, HS student)

Therefore, although the qualitative data collected demonstrates that children at all three schools learned and retained a considerable amount of subject-specific knowledge about the Empire Exhibition, it was not always clear to them how this knowledge was relevant in terms of their day-to-day curriculum.

The success of enabling learning through ‘customizing’ 3D immersive environments for classroom purposes is dependent on a number of factors including the characteristics of the 3D data itself; the delivery software; teacher attitudes, competencies, and preparation time; and student learning styles. Possibly in response to some teachers having difficulties creating learning activities that were closely aligned with specific curricular goals, many of the teachers involved in the REVISIT study intuitively identified cross-curricular competencies that complemented subject-specific knowledge. These were based much more on the core characteristics of the Empire Exhibition as a 3D immersive environment, rather than on the subject of the Exhibition itself. The remainder of this paper considers the primary cross-curricular key skills and characteristics that were identified from the REVISIT pilot study and considers the factors for their success (or failure) in a classroom context.

## **4 Key Findings: Cross-Disciplinary Key Skills**

### **4.1 Motivation to Learn**

Whilst motivation to learn is not itself a key skill, it is widely accepted as being crucial to successful learning behaviors [16]. Motivation and engagement are core perceived characteristics of 3D environments, predicted by teachers and borne out by students’ attitudes. Prior to developing learning activities, several teachers identified the value of the Empire Exhibition environment in motivating students:

*“I think that for me the biggest selling point is the historical and the geographical knowledge but I think for the children one of the selling points is ‘Hey this looks a bit like a game.’ ”* (Daniel, YP Y6 teacher)

*“The idea of having a virtual exhibition where kids could upload photos, videos, CAD models, that kind of thing is actually quite motivating for our children.”* (Lauren, HS Design teacher)

This enthusiasm for a novel learning style was echoed by students who displayed a high level of intrinsic motivation [21] when interacting with the 3D scene:

*“I was really pleased we were going to do a fun topic, I didn’t expect it to be this fun though, because you could engage with it really well and it was just, in a couple of clicks and you were on, so it was really fun, yeah.”* (Mohammed, YP student)

*“It was different because there’s not many games – it’s not a game but it’s like... there’s not many programs like that and it’s very easy to control, many things to explore and it’s very interesting cause [the Empire Exhibition] is not here anymore, it’s not existing so it’s good to find out what it was like in history and what they thought it was going to be like in the future.”* (Rowan, YP student)

In general, secondary school students were positive but less effusive and more focused on specific learning goals, although one boy from HS described using the 3D scene as “much better than school”. In all three schools some students were motivated to carry on learning outside formal educational contexts. Motivation was perceived to be derived directly from the form of the learning environment itself, encouraging students to dig deeper into the subject-specific learning outcomes being presented.

*“Some of them have asked if they can download it at home, some of them have asked if they can stay in at lunch times and play times and they have done. Some have created work in their own time. And again I don't think I would have got that if I had said ‘There's a book about the exhibition’ so it has been fantastic really [...] It was mind-blowing really because it's taken learning home and I think you can't underestimate the power of a good hook into a topic and for me that was the main benefit of the [3D scene].”* (Daniel, YP Y6 teacher)

Furthermore, several teachers recognized the deep learning that had taken place as a result of highly motivated learners combined with well-contextualized learning activities. The YP head teacher observed that “the children have been absolutely absorbed and engaged with it and at a quite high level I think of enquiry, of challenge.”

## 4.2 Theme Learning

Debates around cross-curricular teaching and learning in the context of 3D environments are usefully summarized by Lackovic *et al.* acknowledging that confusions can arise from an insufficiently-defined educational purpose (as discussed above) [17]. Reflecting Lackovic's findings, teachers at all three case study schools quickly identified the Empire Exhibition scene as a ‘hook’ for cross-curricular teaching activities and identified a wide range of ways in which to link activities back to curricula.

*“I was thinking Geography initially but then there's a historical side but also when you look at the different industries [represented in the Exhibition], you get a scientific slant in it as well. And also looking at the numbers and things, numbers of visitors and the cost and how long it lasted. I'd like to do some maths behind it...”* (Daniel, YP Y6 teacher)

This approach derived from the nature of the research data itself as well as individual school policies for enabling study through project work and/or multidisciplinary ‘themes’. One factor that became clear during the study was that, by providing immersive spaces for learning, 3D environments are particularly suited to integrating subjects together on a project with teachers identifying the benefit of wrapping up subjects perceived as ‘dry’ (such as maths, information technology, or the evaluation of sources in history) with activities seen by the children as being more fun.

*“Because you can weave all the topics together it's so much easier. The other day I did a lesson and they had no idea they were learning. They did two geography objectives and two maths lessons and they had no idea.”* (Daniel, YP Y6 teacher)

Where the integration of the 3D scene was most successfully implemented, teachers highlighted particular characteristics of 3D environments and recognized that this theme-based approach allowed a different mode of learning to take place, thereby reinforcing the cognitive processes of more traditional teaching methods.



*"I thought it's good for the kids as well to get away from the, what I call the tyranny of the words [...] having a different sort of medium to look at ideas I thought was really interesting. [...] It's good to get the kids just to think outside the box and it's interesting because [...] they're used to studying in a particular aspect, in particular subjects. When you can do something completely different kids go "I hadn't realized you can do this in history." Well of course you can." (Ralph, HS History teacher)*

Within the primary school, the theme was used extensively for a period spanning two months. Acknowledging the critical factor of his own preparation of learning activities, the class teacher (who had no prior experience with 3D models of any kind) described the Empire Exhibition theme as the most successful he'd ever seen and went on to describe not only the way in which the 3D scene had been used to deliver the curriculum but also its longevity as a teaching tool.

*"I just went through the national curriculum and looked at the expectations for the children and was able to plan a curriculum fully centered on the project and I think it's been highly successful. [...] If you choose the right stimulus you are able to maintain a topic for a prolonged period of time and I think this has been going for seven weeks now and they are still going and they are still enthusiastic." (Daniel, YP)*

However, 3D immersive environments are not only suited for theme learning but also encourage teaching and learning of non-disciplinary key skills, a fact which was recognized by teachers even where the integration of the 3D environment into their curricula was more problematic. Lackovic *et al.* identify three particular non-disciplinary benefits to the use of 3D models: relevance, scaffolded immersiveness, and encouraging constructivist learning experiences [17]. The REVISIT study resulted in significant evidence that use of the Empire Exhibition 3D environment had strong impact in developing the following four key skills.

### **4.3 Collaboration**

The potential for fruitful collaboration between learners was identified early on, particularly in subjects which incorporate group working into the curriculum.

*"It's got scope for teamwork because then they could create work as teams and then actually put an exhibition together. [...] It's the collaboration and the fact that they can upload different media. I do really like that." (Lauren, HS Design teacher)*

The three case study schools demonstrated different approaches to encouraging collaborative learning. At YP the theme learning approach led to a large number of teaching and learning activities including guided tours of the scene and related cultural archive by the teacher (using an interactive whiteboard), free exploration by groups of children, digital co-production, and grouped and individual creative or cognitive tasks that took place outside the 3D scene but were closely related (for example, calculations of visitor numbers and making models of pavilions). HS used a different approach where students were split into groups wherein only a few of the most engaged children worked directly with the 3D environment whilst others created digital material for the chosen narratives. BS students each worked individually on a single narrative within the virtual environment, collaborating informally between computers.

Collaboration appeared to be inherent in the student's use of the 3D environment, even where learning activities had not been explicitly designed to encourage it. A large factor was in learning how to use VSim itself. Although some had played computer games, the vast majority of students and teachers had never used a 3D model or environment within the classroom before. As noted with regard to digital games: "A period of learning **about** the game was required before learning **through** the game could become possible." [10, p.17] and strong collaboration between students learning how to use the software was evident across all three schools.

Hannah: *"I just learned the simple controls at first but then some people told me more about flying, how to go in fast mode – "*

Louie (interrupting): *"We were like interacting with each other and helping each other with stuff like that [...] we learn off each other."* (YP students)

Collaboration was not restricted to sharing technical expertise; students collaborated on navigating the scene to find certain buildings and shared their discoveries with one another, outside the parameters of the particular activity being worked on.

*"Somebody found something and he gets really excited and he tells everyone else and everyone else gets really excited"* (Rowan, YP student).

The focus groups and survey undertaken with HS students indicate that using the Empire Exhibition 3D scene in their lessons increased collaboration with other students (63% agreed) and also identified collaborative working as one of the most enjoyable aspects of their participation.

#### 4.4 Leadership and Self-Directed Learning

As noted above, a major challenge for using 3D environments in the classroom is the requirement for teachers to become expert users. Whilst this can certainly create problems, REVISIT data demonstrated that occasional frustrations from students regarding a teacher's lack of technical knowledge were far outweighed by opportunities for developing leadership skills in students. A case study of teaching with Minecraft identifies how such a challenge can be explicitly converted into a learning opportunity: "The teachers here position themselves as not-knowers of the game, which creates space for the students to position themselves as experts. By explicitly positioning themselves as 'learners' of the Minecraft game mechanics, the teachers provide authority to the students and open up for a multivoiced dialogue." [11, p.270]

Across all three schools, some students were allowed to flourish as experts when using the 3D scene, guiding others (and in many cases, their teachers as well).

*"Some of the children are better on computers than I am and they quickly figured out a way to do things and that allowed me to have some children who were leaders and so they could help others so they were playing teacher."* (Daniel, YP Y6 teacher)

As has been noted elsewhere [10, p.15] this allows certain students, who are perhaps not used to leading in academic situations, to become 'champions', acting as guides and tutors to others, developing confidence and authority, not only in terms of navigating the 3D environment but of discovering the content within.

Mohammed: *"Mr W. like he knew the most so he was teaching us but the more we got to do it like without him, like now we know more than him about it so – "*

Samir: *"We also got to know all the buildings without Mr W. starting to tell us. The first thing we did when we was learning, we went on and just messed about and 'cause we were messing about we knew what buildings there were."* (YP students)

Exploratory, immersive 3D environments also allow students to actively lead their own learning. In fact, even where guidance material had been prepared (for both technical and subject-based learning outcomes), the nature of the 3D environment appeared to encourage students to reject the worksheets and learn in their own ways, recognizing freedom and independence as both enjoyable and fruitful.

*"You can't really teach it to people, it's more effective if people teach it to themselves when it comes to technology and stuff."* (Mandy, BS student)

*"Personally for me it's more engaging, like, being able to explore yourself, at your own pace. [...] It's independent learning – that works for me."* (Jenny, HS student)

This key skill was also acknowledged by teachers at all three schools and self-directed, independent learning was encouraged in learning situations, allowing students to direct curricular goals as well as technology-centered goals.

*"I said 'What do you want to know?' and then they wanted to know facts about the exhibition and so the very first maths lesson was real facts and figures from the exhibition, attendance figures, the cost."* (Daniel, YP Y6 teacher)

*"The idea of being able to move around without the teacher guiding them is something that is very important and we've tried to that in our faculty for a few years."* (Malcolm, BS Head of Humanities)

Allowing students to lead their own learning not only increased self-determination in lessons but also the students' ownership and pride over the narratives produced as part of learning activities. Before planning his lessons, the YP teacher stated:

*"I'd like to think this is going to be very child-centered and that I more the facilitator walking round troubleshooting rather than standing at the front saying 'do this'. I want them to come up with something that they own and that they are proud of."* (Daniel, YP Y6 teacher)

The validity of this approach is confirmed by observational and qualitative data collected from students, with many demonstrating a high level of commitment to producing high-quality work for the virtual narratives ('tours'): *"I was like John and Dania, proud of the fact that we could make such a tour."* (Imran, YP student)

#### **4.5 Creativity**

Incorporating creativity into learning was also identified as a core benefit. HS students returning the survey conclusively agreed (80%) that the 3D scene made learning more interactive and creative engagement was seen as the second-most enjoyable characteristic (after collaboration). Students identified creative activity at a number of levels in the designed learning activities, from the very nature of free exploration leading to playful engagement, to the ability to create their own digital and non-digital products using the content and inspiration provided by the 3D learning environment.

*"Without the tour I think it would be a bit boring 'cause all you could do is just go around in the Scottish buildings and do nothing with them. But making your own tour you could feel proud of what you'd done, it's an achievement."* (Rowan, YP student)

The capacity and desire for playful engagement was recognized by teachers as a core element of self-directed discovery and experiential learning.

*“The fact that you could fly to the top of buildings it just made children feel like they were almost being naughty but in a constructive way. [...] One child discovered that he could walk up the slide and slide down in the little playground that’s hidden behind the building.”* (Daniel, YP Y6 teacher)

Creative engagement was seen as particularly relevant where creativity itself plays a role in developing the learners along curricular lines, for example, in design and computing at the secondary schools.

*“We always build creativity into the curriculum, it’s really, really important because otherwise if the kids don’t have that confidence then when they get to A-level they’ll just fall flat,”* (Lauren, HS Design teacher)

Students also independently linked their creative activity whilst producing narratives with learning outcomes, demonstrating, to a greater or lesser extent, their ownership and understanding of the value of the constructivist approach to learning.

#### **4.6 Emotional Intelligence**

The final key skill that was explicitly highlighted by teachers was the effect of using the 3D environment on their students’ maturity and emotional intelligence.

*“There is the academic side that they are learning the objectives fit for the national curriculum, fit for their age group, but also their emotional intelligence is growing, their artistic, cultural intelligence is developing so they are becoming more rounded by doing the project theme.”* (Catherine, YP Head teacher)

This perception held true, even when teachers were not fully convinced of the value of the 3D scene to their subjects. The HS Information and Communication Technology (ICT) teacher proposed that “They like the freedom and it builds their maturity and it builds their teamwork which is fantastic. [...] They will grow from this as people more than they will grow from this as computer scientists.”

Teachers noted that some children not only demonstrated leadership, as discussed above, but took on wider responsibilities in the context of lesson delivery, such as setting up the lab. Some also discussed the project outside school, bringing back further insights to share with other students. The widely-stated view that children were becoming more ‘well-rounded’ during the pilot is inherently tied in with the experiential learning delivered by 3D environments. Boydell’s assertion that experiential learning “involves the learner sorting things out for himself” [22, p.19] was almost directly repeated by one student when he said “We mainly try to sort it out ourselves.”

Another aspect of emotional intelligence, resilience, was raised in response to the VSim prototype crashing. Whilst this was certainly not ideal, several teachers noted positive side-effects (including the fact that the 3D immersive environment was intrinsically motivating [21] and increased resilience and persistence in pursuing learning tasks) alongside resilience in dealing with the frustrations of losing work.

*“The children differ in mental strength and also in resilience and some children were like “Oh I have to start again” where others they were a little bit upset because they’d put work into it and that disappeared. But then trying to turn everything into*

*positive, I used that as a teaching point how even when you are an adult you need to save your work after every small part that you do so that you don't lose any.*" (Daniel, YP Y6 teacher)

Linking back to curricular alignment, the 3D scene was seen to have high cognitive authenticity [23, p.376, 388] to the learning domains the children function in, even in those cases where subject alignment was more tenuous or problematic. Most teachers acknowledged that close engagement with digital learning environments is very useful for children as they develop into adults with many noting that the advantages (and problems) of such tools "readies the children for life outside of school which is far more important than passing tests" (Daniel, YP Y6 teacher).

Finally, there was evidence that the mode of engaging and interacting with the scene (alongside the 2D archive of related media) increased imagination, identification, and emotional engagement for both teachers and students.

*"I enjoyed the most about like you could just go anywhere, there was not boundaries, you could just explore everywhere, [...] you could just imagine how it would be if you was there and many other people were there."* (Rowan, YP student)

## 5 Conclusion

Technological innovation in classrooms is rich with opportunity but also accompanied by both pedagogical and technical risk. The REVISIT pilot study demonstrates the diverse approaches, successes, and difficulties of incorporating a 3D learning environment into lessons at three different schools. However, it also reveals that this game-like mode of learning is highly suited for the development of non-disciplinary key skills, in particular, collaboration, leadership, creativity, and emotional intelligence. The research identifies areas where the well-documented challenges of integrating 3D environments into school curricula can be converted into opportunities for enabling and encouraging these key skills. The results of this pilot study indicate that 3D environments can function as effective contexts for constructivist learning and co-creation activities, and may be more intrinsically motivating for some students. A fruitful further study would be to compare this model with other modes of learning known for developing cross-curricular key skills and to examine the specific affordances of 3D environments within this context.

## 6 Acknowledgements

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## PW13

# Game-based Approaches for Research Skills Training and Researcher Development: A Survey of Attitudes and Acceptance in Higher Education

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# GAME-BASED APPROACHES FOR RESEARCH SKILLS TRAINING AND RESEARCHER DEVELOPMENT: A SURVEY OF ATTITUDES AND ACCEPTANCE IN HIGHER EDUCATION

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## Abstract

Research skills training is both crucial and ubiquitous in Higher Education (HE), however there are a range of pedagogical challenges in effectively delivering research capabilities and learning outcomes. The move towards constructivism, including game-based learning (GBL) techniques, in research skills training has been shown to improve outcomes for students, yet GBL for research skills is under-researched compared to other application domains.

This paper analyses the results of a new survey of attitudes towards GBL specifically for improving research skills training in UK HE institutions. Responses came from 92 researcher developers, research leaders, librarians, and academic skills teachers. Results demonstrate a very strong appetite for games and gamified approaches in this topic area, with a large majority of respondents noting the potential for novel, interactive and experiential techniques for delivering high-level learning outcomes. Thematic analysis of qualitative responses identifies and analyses key themes such as: institutional and attitudinal barriers to the use of GBL; the need for balancing flexibility in learning approaches with a structured framework to scaffold learning; and for a choice of complementary methods to suit diverse learner cohorts. Other key findings are related to accessibility; platforms for engagement; cultural knowledge and perceptions; and the potential for cognitive overload. Results also identify those topics within researcher development that are thought to be most important for GBL approaches.

This paper gives a clear overview of the attitudes, opportunities, barriers, and concerns of HE staff when considering the use of GBL to complement existing research skills training provision in universities and contextualizes this with current opportunities for engagement with GBL for research skills.

Keywords: Game-based learning, serious games, researcher development, research skills, higher education, research.

## 1 INTRODUCTION

Research skills are crucial for students at all levels of Higher Education (HE), in particular postgraduates who rely on independent problem-solving and rigorous research design and methods. However, students often find research skills courses "dry" and "irrelevant," leading to disengagement [1]. To enhance relevance and motivation, which in turn leads to more capable and satisfied student researchers, those teaching research skills have increasingly begun to emphasize constructivism, using active and experiential methods [2], [3], [4], [5], [6]. These approaches have been shown to improve learning outcomes, engagement, and practical application of skills. However, the literature notes that further innovation and cultural shifts are needed [1].

Game-based learning (GBL) approaches can be effective for learning and skill development across a range of fields. However, HE has been slower to adopt GBL due to unique barriers such as the perception of games as frivolous and challenges in evaluating high-level cognitive outcomes, particularly at the postgraduate level [2]. Research skills training is an area of particular need in terms of both student satisfaction and equipping students with the skills they require to successfully transition to further study or work. Therefore, this paper focuses first on the existing context of GBL for enhancing teaching and learning of research skills in an HE context, and then on a detailed survey of the attitudes towards, and acceptance of, GBL in those delivering research skills training in UK institutions.

## 2 RESEARCH CONTEXT

My own previous work explores GBL for enhancing research skills training in depth, noting that learning outcomes in this topic can be cognitive, affective, and behavioral [7]. Furthermore research capabilities tend to sit towards the higher levels of Bloom's Revised Taxonomy [8] which can present challenges for



both learners and teachers [9]. Previous work (including my own) provides a convincing rationale for the use of GBL for high-level learning outcomes [2], [6], [7], [10], [11] as games and playful techniques reflect the active, experiential, creative, and student-centered pedagogies that are recommended in this domain. It has been noted that GBL offers opportunities for personalization of learning and can be particularly useful for the process of scholarship, as it reflects the variety of paths student researchers can take to achieve success, the uncertainty of outcomes, and possibility of failures which lead to subsequent successes [12], [13]. Furthermore, the novelty or enjoyment provided by (some) GBL techniques can revitalize learners' motivation and emotional affect, and, in conjunction with increased agency over learner journeys, can improve knowledge retention [14], [15]. The literature also clearly identifies a slower take-up of GBL in HE [16] and specifically in research skills training [2], [6]. Although a full contextual review of games for HE research is outside the scope of this paper, previous reviews show that, whilst there are a number of games which address a specific topic related to research (e.g. copyright, data management, Open Access), there are considerably fewer that aim to support general research processes [7], [17]. The complexity of research training provision (see Section 4.1) and tangled terminology within the domain makes identifying GBL complex as 'research' can mean anything from the design, implementation, and dissemination of a whole research project to a single information gathering task, e.g., a literature search.

## 2.1 Acceptance of game-based learning within Higher Education

In general, teachers in UK HE consider GBL to be a promising pedagogical approach that can improve engagement and outcomes, *provided that* it is well-designed and fits within the educational and practitioner context [18], [19], [20], [21], [22]. Studies cover both analogue and digital games, although are skewed towards digital GBL. Valencia *et al* [19] used the Technology Acceptance Model (cf. [23]) with a sample of over 100 HE teachers, demonstrating very high intention of use and perceived usefulness of serious games (80-90%), whilst also identifying significant barriers to use such as lack of both time and confidence (particularly with technology.) These results are reflected in Sandí-Delgado *et al* [20] where high acceptance is observed overall, with important factors related to the individual, perceived ease of use, and usefulness contributing to intention.

As noted in [20], there are no prior studies focusing on acceptance of serious games for the development of academic competencies, and that study focusses on technological competencies. [19] suggests that future work to assess acceptance within specific knowledge domains is needed. This paper builds on previous work by: focusing on a particular domain of knowledges and competencies (researcher development); including analogue game-based approaches; and contextualizing acceptance within the time/budgetary context of UK institutions. It therefore represents a valuable contribution to our understanding of attitudes towards GBL in HE.

## 3 METHODOLOGY

Research skills provision at UK HE institutions is extremely complicated and dispersed both across and within institutions, meaning that it is difficult to ascertain the appetite of game-based approaches in research training communities. Therefore, it was decided to perform a 'wide and shallow' survey of as many relevant communities as possible. Ethical clearance was granted by The Glasgow School of Art. Inclusion and exclusion criteria were:

- Respondents must be over 18 and fluent in English.
- Respondents must have a connection to academic development, learning development, researcher development, or research skills training in a UK institution at some level, for example, as their core role (e.g., a Researcher Developer, Head of Doctoral Training) or as an educator teaching research as part of a subject-based course.
- Respondents must provide informed consent.
- Respondents must NOT be game-based learning specialists in fields other than research skills training.

Participants were asked to confirm they met these criteria as part of informed consent.

The survey was developed in JISC Online Surveys platform. A link was shared to relevant JISCMAIL lists (the UK's national academic mailing list service [24]) targeting communities of research or academic skills developers (see Table 1.) The link was also shared on closed email lists of UK HE research skills developers through personal contacts. Data collection was undertaken in June – July 2024.

*Table 1 - Mailing lists targeted*

<i>List name</i>	<i>Subscribers (June2024)</i>
rdscholarship@jiscmail.ac.uk	194
ldhen@jiscmail.ac.uk	1628
research-staff-support@jiscmail.ac.uk	420
lis-researchsupport@jiscmail.ac.uk	749
gtadev@jiscmail.ac.uk	101
jisc-digi-research-community@jiscmail.ac.uk	478

It should be noted that there is likely to be substantial (unquantifiable) overlap in membership of these lists, so it is not possible to say how many people were invited to take part overall. Preliminary results were shared back with each of the above lists 1 – 2 weeks after the initial invitation. In order to keep the recruitment highly relevant to the inclusion criteria, the link was not shared on any other mailing lists. In particular, to avoid skewing the results, the link was *not* shared in game-based learning communities.

### 3.1 Data analysis

Quantitative results have been presented directly, with percentages showing the proportions from answers given (as almost all questions were optional.)

Qualitative results have been coded by keyword (descriptive codes tallied with manual adjustments to remove negative concepts of the same word and/or account for misspellings) and concept (author's analysis and classification), then thematically grouped. This process was data-driven in order to capture the full range and nuance of responses given.

Data was anonymous at point of data collection. Some respondents included data in free-text responses that could potentially make them identifiable which was redacted/anonymized by the researcher and not seen by anyone else.

## 4 RESULTS

There were 92 valid responses to the survey. The geographical spread of respondents was broadly representative across the UK's population.

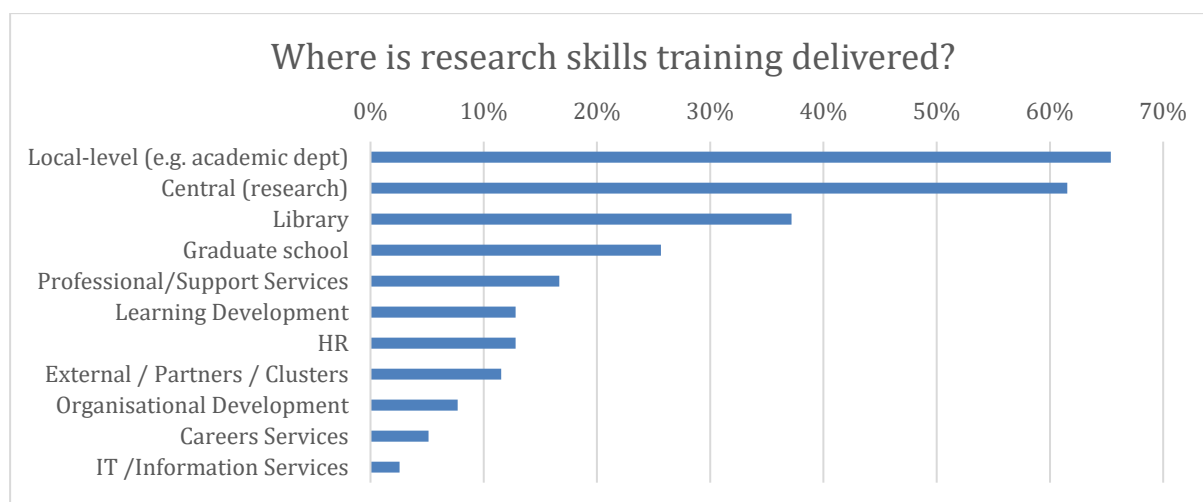
### 4.1 Institutional contexts

In order to understand better the institutional contexts of research skills training, the survey asked about participants' institutional contexts and individual roles within that context.

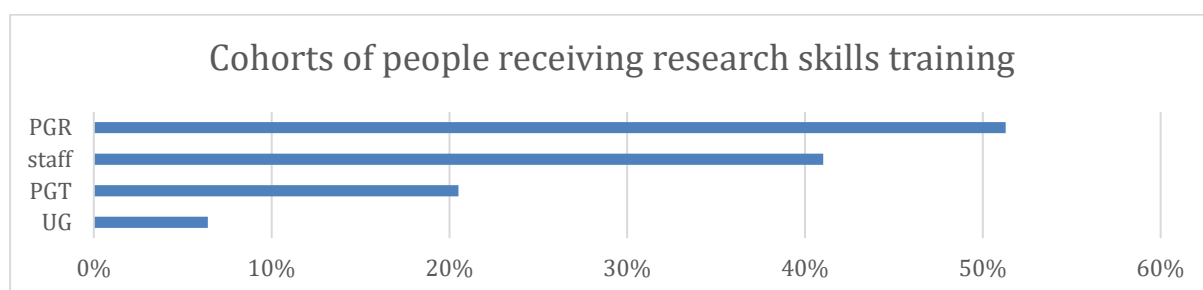
There were 78 free text responses to the question: *"Research skills development can sit within a Research Office, Learning and Teaching, a specialised department, or at school/departmental level – where does most research training come from at your institution? Does it come from a different place depending if it's aimed at staff, PGRs, or students on taught programmes?"*

Descriptive keyword codes (with synonyms) for these responses were counted and are shown in Figure 1 and Figure 2. The responses clearly confirm the very complicated nature of research skills provision at UK HE institutions. There are a large number of (overlapping) places where research skills are taught with the most mentioned being local-level (i.e. from within academic departments or on specific courses), followed by central delivery through various research services (both above 60%), then the institutional library (37%), and discrete graduate schools (26%). Four more places are mentioned by 10 – 20% of responses: professional services; learning development; HR; and, interestingly, external sources such as university partners or research clusters. The terminology used by respondents was also diverse, with a range of terms being used for most categories of provider.

In terms of audiences, postgraduate researchers (PGRs) appear to be the priority, followed by early career researchers (ECRs.) Only 21% mentioned postgraduate-taught cohorts (PGT) and just 6% mentioned undergraduates (UG.)



*Figure 1 - places within UK HE institutions where research skills training is delivered (based on descriptive keyword codes)*

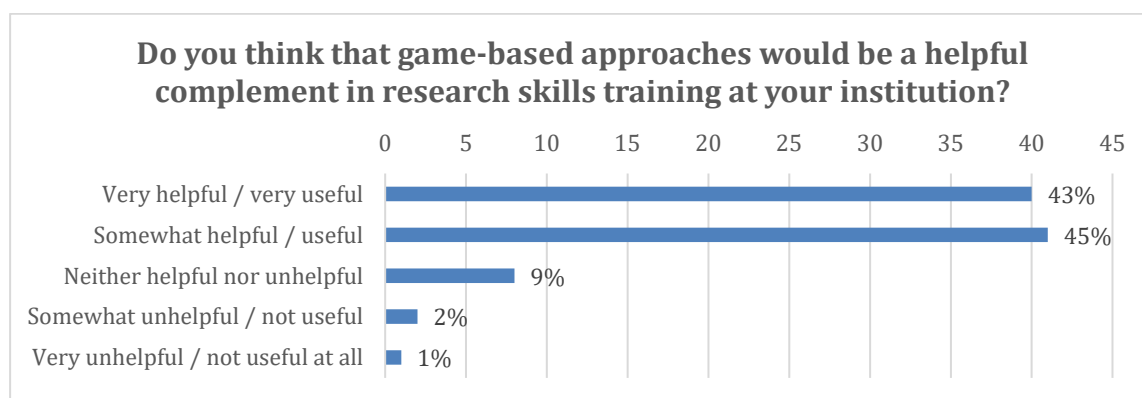


*Figure 2 – mentioned audiences for research skills training (based on descriptive keyword codes)*

A more robust analysis of the qualitative data was undertaken by manual coding and thematic analysis of concepts raised to ascertain key themes. This supports the conclusion that research training is dispersed across institutions and there is usually different training for different audiences (55%). 45% stated that research training comes from a mixture of centralized and local departments, whilst 38% said that all research training is centrally provided but from different departments (e.g. research offices, graduate schools, libraries.) Some mentioned that only PGRs get dedicated research skills training (8%) or that there is no training for taught students (4%). 12% said that taught students only get local training. 12% stated that some training is shared between PGRs and staff. Finally, 8% of responses noted that special research training for particular topics was provided.

## 4.2 Attitudes towards game-based approaches

The survey aimed to gain an overall impression of attitudes towards game-based approaches for research skills training within HE institutions.



*Figure 3 - overall attitude towards using game-based approaches as a complement to existing research skills training*

Figure 3 (above) shows a high acceptance of game-based approaches as a complement to research skills training, with 88% of responses being positive towards their use.

There were 71 free text responses to the prompt: “If you would like to, please explain your answer. E.g. What are the opportunities or pitfalls you envisage for game-based approaches in research skills training?” The most commonly used keywords were Engaging (19 responses, 27%), Novel (15, 21%), Fun (14, 20%), and Interesting (11, 15%). It can be seen from Figure 4 that free text descriptive keywords focused mostly on the emotional affect of game-based approaches, with other significant categories being ‘Impact on learning’ and ‘Innovation.’

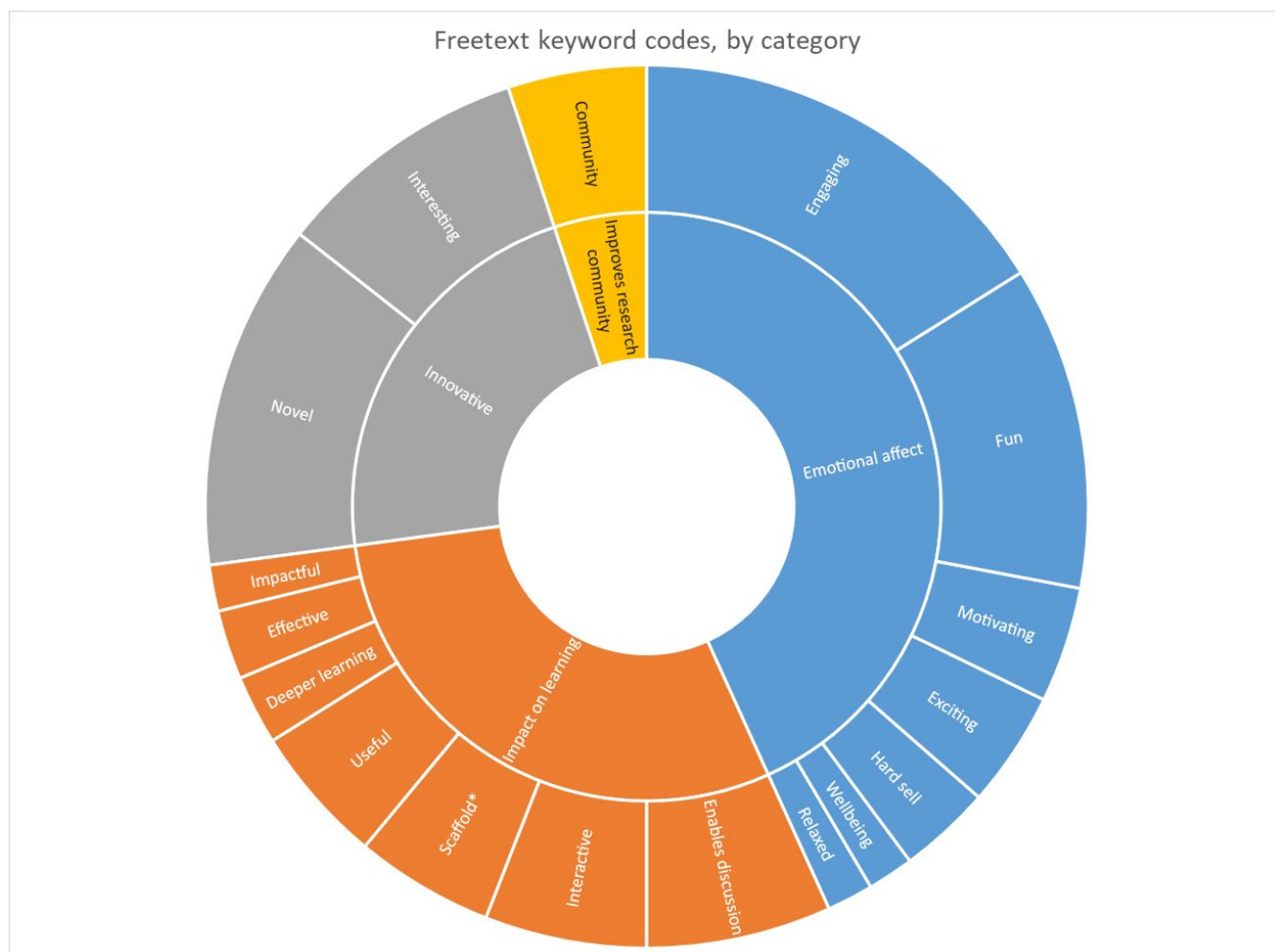


Figure 4 - sunburst diagram showing keywords and concept categories

A detailed thematic analysis of the qualitative data was undertaken by manual coding and categorization of concepts raised. This data is shown in Table 2 and Figure 5.

Table 2 - Hierarchical concept mapping of free text responses

Category	Overall theme	Sub theme	Sub theme	Count
Emotional affect	Positive	General positive comment		31
		Removes fear of failure		8
		Engagement beyond cognitive		4
		Positively affects wellbeing		3
		Enhances teambuilding /collaboration		7
	Negative	Hard sell	For staff/leadership	4

			For students	9
		Game 'failures' can demotivate		3
	Neutral	Not 'one-size fits all'		4
		Need to match tone with content		5
Impact on learning	Positive	Efficacy	Enhances relevance/relatedness	6
			Good for experiential learning	10
			Useful for "tricky" concepts	5
			Scaffolds learning	4
			Improves retention of ILOs	5
		More efficient		7
		Supports diverse learning styles		9
		Good feedback from students		6
	Negative	Less efficient		2
		Hard to fit into existing curriculum		4
		Increased cognitive load		4
		Efficacy risks	Distract learners	3
			Oversimplification	2
	Neutral	Needs skilled facilitation	Difficult to resource	9
			Needs debrief	2
			Success depends on game	6
		Integration	Recommend short games	7
			Communicating relevance is key	6
		Not 'one size fits all'		10
		Inclusion risks	Neurodiversity	2
			Cultural/social	4
Research community	Positive	Useful for dialogic/team learning		7
		Enhances collaboration		9
	Neutral	Staff confidence/training needed		2

As can be seen, the majority of concepts concerned the potential impact on learning, with positives highlighting expected efficacy benefits (e.g., experiential learning (14%), scaffolding, and retention) as well as benefits for alternative learning formats (13%) and previous experience of good feedback from students (8%). Interestingly in this context, five respondents specifically praised GBL for teaching "tricky"/complex concepts. Much smaller numbers of responses highlighted potential negative efficacy, e.g., the risk of distraction or oversimplification (3%), and increased cognitive load for learners (4%). In terms of efficiency of learning, 10% indicated GBL could be more efficient for delivery, conversely 3% suggested GBL could be less efficient. Respondents also noted a wide range of practical considerations, primarily the issue that games require skilled facilitation which can be difficult to resource, and that success is very dependent on the individual game. The concept that there is no "one size fits all" approach came across strongly in the responses (22%). Integration of GBL was also an important consideration: shorter games (to be combined with existing workshops) were suggested (10%); communicating relevance of the activity to students is key (8%); and fitting games into an already crowded curriculum is difficult (6%). Inclusion and accessibility were also mentioned as major considerations (10% proposing a positive impact and 6% proposing a negative impact.)

The second largest theme was that of emotional affect from games, with a majority of positive responses. 44% included a general positive comment such as “I like this idea” or “I find this works well with my students.” Major sub-themes are that games enhance teambuilding, collaboration, familiarization, and dialogic or team learning. 11% of responses also explicitly noted the ability of games to reduce the ‘fear of failure’ common in students. Other sub-themes were: positive effect on wellbeing; and usefulness of engagement beyond the cognitive (e.g., visual, tactile, or physical enhancements.) These findings overlap with the more detailed insight into the role games can play in supporting research communities, in particular, that games can enhance both disciplinary and interdisciplinary collaboration (13%) and collaborative learning. However, there is a relatively common opinion that game-based approaches are a “hard sell” for students (13%) as well as for staff and leadership (6%), and that staff need training and confidence to run games effectively. One respondent specifically noted that more peer-reviewed research would help to increase confidence in positive outcomes from GBL.

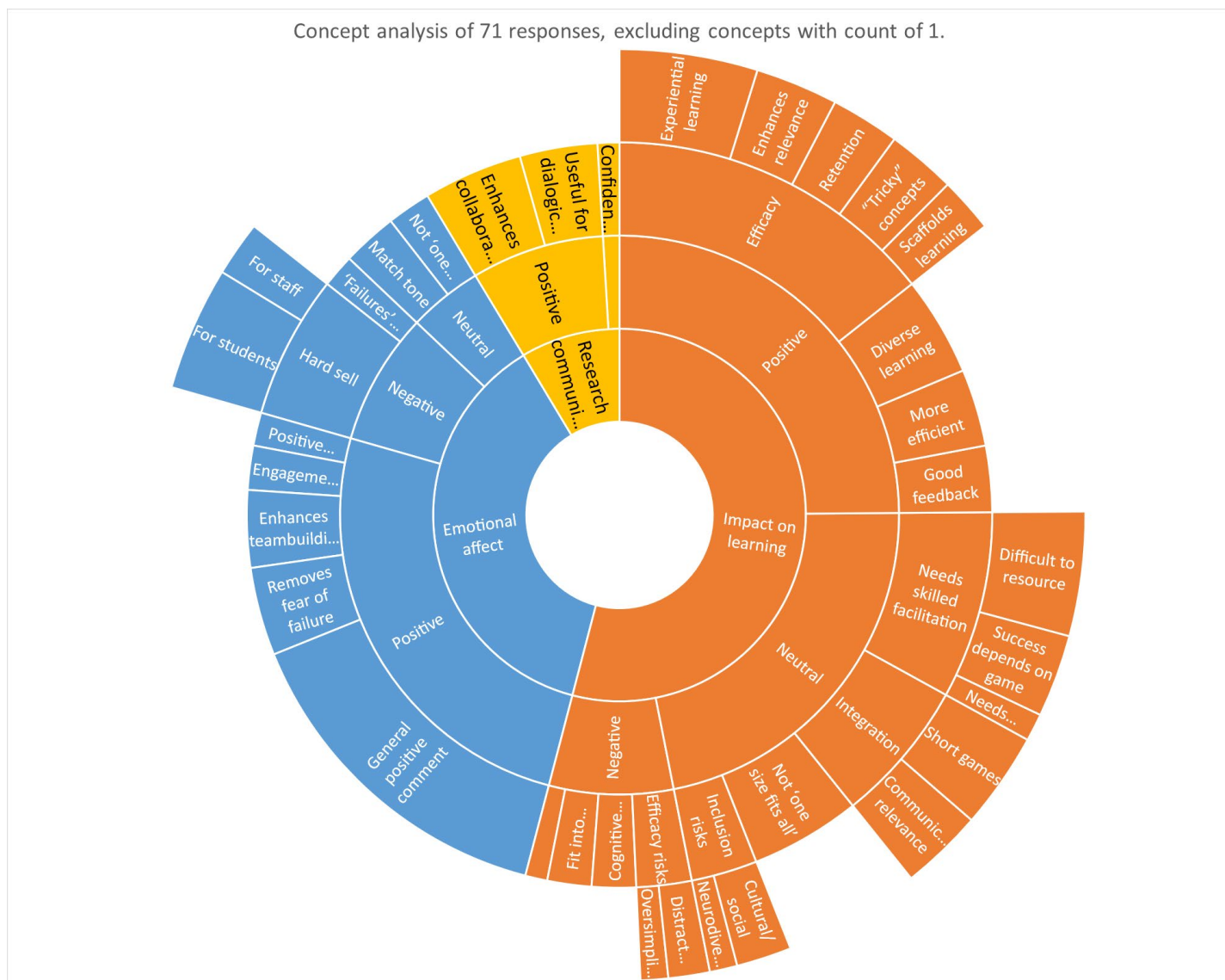


Figure 5 - sunburst diagram showing key themes in attitudes towards GBL for research skills

This analysis also revealed a small number of misconceptions about game-based approaches from participants: that games must be competitive (1 respondent); that games require high digital skills/need to be digital (2); and conversely that games need to be played in person (1).

### 4.3 Products and services needed to support GBL within research training

Supporting previous literature, there is evidence of a high level of criticality in the attitudes of research trainers with regards to game-based approaches. The results presented above identify a range of



accurate considerations about both the potential and the challenges of GBL to complement research training. The survey proposed a range of ways in which GBL might be delivered, and the support services that might be required for institutions to use this approach effectively. Participants were asked to rate their appetite for products and services related to game-based learning. As shown in Table 3, there is high appetite for games and services to complement research skills training, however the majority of respondents (82%) would be interested only if these are available without cost to their institution. Standalone games are clearly desired, if they are free, with only 13-17% of respondents saying their institutions might pay for these. Respondents indicated that their institutions would be more likely to pay for services than standalone games, with 29% saying they might pay for external game facilitation, 39% for external training to allow their staff to run games for themselves, and 26% for working with external GBL experts on bespoke game design. This final category, a service to partner with institutions to produce bespoke games, can be seen to be much less in demand, with 45% of responses being 'Not interested'.

*Table 3 – “Which of the following game-based products or services might you/your institution be interested in?” (92 responses)*

<i>Product or Service to support GBL</i>	<i>Not interested</i>	<i>Interested only if free</i>	<i>Interested and institution would pay</i>
Tabletop (physical, face-to-face) games about aspects of research skills	5%	82%	13%
Access to online digital games about aspects of research skills	6%	76%	17%
Game facilitation workshops (game-based training run entirely by an external facilitator)	19%	52%	29%
Game training workshops (external facilitator trains staff on how to run games for themselves)	8%	53%	39%
Paid service to help you develop your own bespoke games	45%	30%	26%

A clear finding is that resourcing (in terms of both time and money) is a major factor. Many respondents noted that tight budgets and spending freezes affects their capacity to both purchase the necessary resources, and devote the time to staff training that is required to effectively use GBL training, even if the service or product was highly desired.

#### 4.4 Desired GBL topics within research training

The survey asked respondents to identify any areas of particular need that they felt would benefit from a game-based approach. Of 62 responses, the most desired topics were: ethics/academic integrity (27%); Artificial Intelligence (in the context of research skills) (24%); and literature search and review (18%). Other topics mentioned by around 10% of respondents were: induction; student journey; career development; and data protection/research data management. Some of these responses also mentioned particular cohorts; the most common were PGR and ECRs (16%). Mid-career researchers were mentioned twice, and only one respondent mentioned PGTs as an audience.

#### 4.5 Survey limitations

The recruitment method (academic email lists) may have affected the sample by potentially skewing the type of practitioners who responded. The survey may also have suffered from self-selection bias. The survey was relatively short and, whilst it provides structured data for analysis, the results lack nuance. Future work could triangulate these results through interviews, focus groups, and testing prototype services with researcher development experts.

## 5 CONCLUSIONS

The main findings of this study are as follows.

As expected, research skills provision at UK HE institutions is shown to be extremely complicated and dispersed within (and sometimes across) institutions.

There is a high majority (88%) of positive attitudes towards GBL as a complement to research skills tuition and training. A range of benefits for learning were articulated, primarily focused on the positive emotional affect of GBL and its potential advantages for learning outcomes that are particularly relevant or challenging within the research domain. However, the overall strong acceptance needs to be interpreted in conjunction with the much smaller proportion of institutions who indicated that they can afford the time and/or cost to effectively implement GBL: 13% for analogue games; 17% for digital games; 29% for externally-provided GBL workshops; and 39% for staff training to implement GBL. Therefore, practical considerations impede take up of GBL for research skills. Furthermore, although considerably less than the positive attitudes, a range of conceptual barriers and/or weaknesses were also identified: that there is no “one size fits all” solution (22%); that the (all-important) curricular and contextual integration [21] can be a challenge, and that there are risks as well as advantages for social, cultural, and neurotype inclusion. One particular issue is that 13% of respondents (a minority but significant proportion) felt that GBL can be a “hard sell” for students. There is debate in the wider literature about student acceptance. Studies identify a wide range of different factors affecting student acceptance [25], [26], primarily the perception of whether GBL will enhance their performance and learning outcomes [25], along with effort expectancy and enjoyment [26]. As with HE staff, the literature supports there being a high level of criticality in GBL acceptance, and emphasizes the requirement for GBL to instill confidence in both teachers and learners.

Topics within research skills of particular interest for future GBL provision are ethics/academic integrity; Artificial Intelligence; and literature search and review, as well as topics related to more general student or staff development (e.g., learner/career journeys.)

Overall, the main findings of this study are 1) GBL has significant potential in this domain and 2) to confirm that it should be offered as a complement to (not a replacement for) non-GBL teaching methods.

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## PW6

# Intentional Learning Design for Educational Games: A Workflow Supporting Novices and Experts

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# Intentional Learning Design for Educational Games: A Workflow Supporting Novices and Experts

Daisy Abbott

This chapter proposes that learning experience design (LXD) and game-based learning (GBL) are mutually beneficial conceptual frameworks for increasing the effectiveness, appropriateness, and user experience of educational games. Drawing on a range of theories, five core LXD principles are defined. LXD is: human-focused, enjoyable and/or playful, goal-oriented, situated and relevant to learner's desires, and placed in supported environments and/or platforms. These principles are mapped to aspects of GBL, proposing considerable overlap between these disciplines, and supported by a wide range of literature. LXD principles are then suggested as solutions to some current challenges in GBL. A workflow is presented which synthesizes interdisciplinary GBL and LXD design processes and offers guidance suitable for GBL designers at a novice to expert level. The workflow categorizes GBL activities into related disciplines (Instructional Design, Empathy/Emotional Design, Interaction Design, and Game Design) to assist readers in analyzing where their own skills or skill gaps lie. A worked example illustrates every activity within the workflow, including practical methods of mapping learning mechanics to game mechanics and of performing gameplay loop analysis. The workflow aims to increase the rigour of GBL design and ensure it benefits from LXD principles, addressing a prevalent challenge in GBL design by focusing on the importance of both an appropriate pedagogical foundation and the needs and desires of learners.

## 1. Introduction

Learning experience design (LXD) is an approach that foregrounds learners and their desired outcomes in a goal-oriented way, acknowledging individual experience. This chapter proposes that game-based learning (GBL), with its focus on maintaining flow, increasing motivation, and embedding learning, can be a highly effective tool within LXD. Readers can increase their understanding of effective GBL processes using the guided workflow for intentional learning design for educational games, which draws on systematic analysis and matching of learning objectives, learning behaviors, and game mechanics, within an LXD framework. This step-by-step design process will also explicitly identify where GBL benefits from an LXD approach. The workflow is suitable for novices and experts alike; it identifies different disciplinary expertise at each stage and works through a simple example with additional references for GBL designers to follow up. Throughout the workflow, learner experience is at the centre of the process. Reflection on the workflow provides opportunities for readers to identify their own strengths and weaknesses as LX designers using GBL in their own practice.

## 2. Theoretical Context

### 2.1. Mapping LX Principles to GBL

LX research identifies various sets of guiding principles or opportunities for LX designers (Floor,

2018; Jagger, 2016; Raybourn, 2016; Rosencheck, 2015). Whilst there is some variation, core LXD principles are defined across the literature as:

- human-focused (encompassing personalisation, emotion, and experience),
- enjoyable and/or playful,
- goal-oriented,
- situated and relevant to learner's desires,
- taking place in supported environments and/or platforms.

Previous research on LXD applies these principles to online e-learning systems (Dinimaharawati, 2013; Jagger, 2016; Park & Lim, 2019); however, games are also closed interaction systems within a much wider instructional and human context and it is therefore useful to consider them as case studies alongside the general principles of their design. In mapping the different interdisciplinary elements of LXD, Floor (2018) places game design towards the goal (as opposed to the human) centred end of the spectrum. This chapter argues that existing limitations or weaknesses of GBL can be addressed by taking a more learner-centred approach. Each core LXD principle is analyzed below, showing commonalities with the characteristics of GBL and demonstrating that, as an educational approach, GBL can fit closely with LXD principles.

### **2.1.1. Human-Focused, Emotional, and Personal**

LXD is variously described as “learner-centred” (Rosencheck, 2015), “focuss[ed] on the learner” (Floor, 2018), and “put[ting] the human back at the centre” (Jagger, 2016); within LXD the learner's needs, experiences, desires, and emotions are crucial. Park and Lim (2019) state that “emotions directly and indirectly affect students' learning” (p. 53) and note that, despite limited representation in the literature, there is an increasing emphasis on emotional design across many fields, reflected in a range of studies on emotion and empathy in teaching and learning contexts (e.g., Kay & Loverock, 2008; Park & Lim, 2019; Tangney, 2014; Tracey & Hutchinson, 2019). Emotional design is also core to GBL, primarily in consideration of GBL increasing learner motivation and confidence as affective and motivational outcomes are evaluated alongside cognitive outcomes (Clark et al., 2016; Hailey et al., 2016). Both fields acknowledge and foreground *affordances* (i.e., properties of a system that lead to or trigger human action) as having an emotional as well as a functional role. Notably, standardised ways of evaluating emotion have been developed within GBL and, in wider terms, UX research (e.g., Bernhaupt, 2010, *passim*; Brockmyer et al., 2009).

LXD principles recommend high levels of personalisation and “humanity” in interactions (Jagger, 2016; Park & Lim, 2019) when creating personal learner journeys through games (driven by players' goals and enabled by their power over a choice of interactions) and have been a core concern of GBL research for well over a decade (Bellotti et al., 2013; Hauge et al., 2015; Lepe-Salazar, 2015). Player agency and control over game narratives and interactions is woven into both interaction design within GBL and the affordances of the game systems themselves (see Abbott, 2019a; Lim et al., 2013).

### **2.1.2. Playfulness, Fun, Enjoyment**

*Playfulness* is defined as a core design principle for increasing the emotional affordances of learning situations (Park & Lim, 2019; Weitze, 2016) and overlaps significantly with the “fun” or “enjoyment” outcomes described across the literature for both LXD and GBL. *Play* has been defined in a number of ways by different theorists; however, the widely accepted characteristics of play are that it constitutes a voluntary activity, lacks (or has negotiable) real-world consequences, and, crucially,

must be perceived as such by participants. For some, this perception of playfulness is all that is required for an activity to become play, and play cannot otherwise be defined as any one thing (Glenn & Knapp, 1987, p. 52). In his book *Play and the Human Condition*, Henricks (2015) defines this playful "disposition" as creating different motivations from those associated with other things we do and having the "distinctive quality of curiosity and enthusiasm" (pp. 28-29), which are both widely accepted as drivers for learning. Games harness the power of playful disposition but add the structure needed to guide players towards particular goals. Juul (2003) defines six features that characterise games:

1. Rule-based;
2. Variable, quantifiable outcome(s);
3. Different potential outcomes are assigned different values;
4. The player invests effort in order to influence the outcome;
5. Players care about the outcome;
6. Negotiable real-life consequences.

GBL uses the rules, outcomes, and values of games to structure learning content in a way that can be experienced by an invested, effortful learner with a playful disposition, in much the same way as learning environments structure their content.

### **2.1.3. Goal-Oriented, Manageable, and Progressive**

The goal-orientation of LXD can be easily mapped to games' "win conditions" or completion. Typically, a game's completion state is built on interim goals contributing to the overall learning outcome, a common structure directly reflected in multiple game levels, or missions building on previous expertise that progress to a final goal once mastery has been achieved. In the context of e-learning, Jagger (2016) calls this design structure *chunking* (i.e., learning content being broken into bite-sized pieces). In both LXD and GBL, chunking allows multiple individual interactions, which ideally provide immediate feedback, offers a chance for learner reflection, and builds on their overall understanding. These interactions provide individual pathways towards a coherent and understandable end point, resulting in personalised learning over which the learner has a considerable degree of agency.

The overlap between manageable, progressive goals and learner emotion is clear, and a learner's perception of success in achieving their goals is confirmed in literature across LXD, GBL, and pedagogy more generally as supporting the process of learning. The LXD principle of *Positivity* is related to the learner's confidence in being able to achieve learning completion (i.e., their final goal: Park & Lim, 2019). Again, these principles are reflected in GBL literature with multiple considerations of their relationship to players' experience of *flow* or intensified concentration (e.g., Hamari et al., 2016). Further examples are available which map this specific learning mechanic to related game mechanics of Behavioural Momentum and Cascading Information (Abbott, 2019a; Arnab et al., 2015). Feedback also contributes to emotional design (Park & Lim, 2019) and is highlighted as a priority in LX-informed GBL as critical for both learning and engagement (Dodero et al., 2015, p. 187).

### **2.1.4. Situated and Relevant**

LXD recommends that learning is well-situated within a relevant context (Jagger, 2016; Rosencheck, 2015) and emphasizes that learner experience is crucial to maintaining relevance (Huang et al., 2019, p. 92). GBL theorists also highlight that learning must be situated in terms of both

environment and interactions (Catalano et al., 2014) and propose specific mappings between learning mechanics (such as identify) with game mechanics (such as role-play; Abbott, 2019a; Lim et al., 2013). *Learning mechanics* (LMs) refers to the pedagogically constructed actions used to achieve the learning outcomes, distilled into specific interactions (Lim et al., 2013). GBL can develop this concept further by providing fictional contexts or simulations that serve as a *safe space* to practice skills or behaviors without fear of failure.<sup>[11]</sup> Significant overlap exists between designing for situated learning, reinforcing motivation for learning through human-centred, empathetic design, and creating learning outcomes that match learners' own goals.

### **2.1.5. Supported Environments/Platforms**

The sections above show that GBL can provide a structure that matches LXD principles by harnessing learners' motivations to guide them both emotionally and cognitively through a responsive learning environment towards their goals.

Therefore, GBL and LXD are congruently dedicated to foregrounding a human-centered, personal experience, which acknowledges players' emotional experiences alongside their intellectual goals. A well-designed, educational game can engage learners closely with its content and interactions, often resulting in a highly immersive and emotionally-engaging learning experience as learners pursue their own particular game-enabled learning goals. Furthermore, game interactions (and the user's control over them) can result in a strong sense of personal identification, agency/responsibility, and ownership over the learning journey.

## **2.2. GBL is Hard to Develop (Well)**

However, despite a growing demand for GBL (Westera, 2019, p. 59), the challenges around its development remain (Abbott, 2019b; Lamas et al., 2017; Ney et al., 2012). Systematic research has shown that simply because learning takes place in a game-based medium does not make GBL homogenous across different games (Clark et al., 2016). Further research links different game characteristics (e.g., such as mechanics, visuals, narrative) with different learning behaviors of players (Abbott, 2019a; Grey et al., 2017). The complexities of implementing GBL highlights that, despite games being able to empower learners to create personalised pathways through the material, these interactions are still defined by the affordances of the game system, platform, and overall learning environment. Furthermore, in order to be effective, GBL requires significant interdisciplinary expertise spanning game design, interaction design, and pedagogy (Bellotti et al., 2013), making it a complex and resource-intensive process.

Despite these well-researched linkages between learning behaviors and game mechanics, many GBL interventions fall short of their potential effectiveness and efficiency,<sup>[12]</sup> partly due to significant barriers in terms of resources and expertise and partly due to the emergent understanding of this interdisciplinary subject. Very little research to date provides a framework which pairs game elements and learning at either a theoretical or empirical level, and this results in educators being "overwhelmed by the plethora of design choices and level of complexity entailed in integrating, combining and balancing learning with game features" (Lamas et al., 2017, p. 990). This overlooked, explicit interdisciplinary link between pedagogy and game design reinforces LXD's potential role in advancing GBL towards a more human-centred approach by synthesizing player experience with instructional design. Games without a strong pedagogical and learner-focused foundation are likely to fail (Lepe-Salazar, 2015; Westera, 2019) and, without significant interdisciplinary expertise, presenting learning elements as games could create uncertainty and misalignments (Bellotti et al., 2013; Lamas et al., 2017). Furthermore, "The role of the teacher in

guiding learning via games seemed to be fuzzy and unclear and may lead to confusion during the design stage, game play and after the end of the game” (Lameras et al., 2017, p. 974). Games and curriculums are experiences designed to engage their respective audience; however, because experiences are unique to each individual, a potential for a disconnect still exists between the designer and the player and/or the educator and the learner (cf. Grey et al., 2017, pp. 64-65). These barriers could be ameliorated if GBL design activities were more explicitly informed by LXD.

## 2.3. GBL Benefits From an LXD Approach

By exploring experience-based pedagogical concepts for GBL, a 2019 article by Westera identifies several improvements that could be applied to GBL, which are of particular relevance within the LX conceptual framework. Games are highly constructivist and rely on an experience-based approach, and Westera (2019) aligns with LXD literature in stating that learning from experience is the dominant pedagogical paradigm (El Mawas et al., 2018; Floor, 2018; Tangney, 2014). He then critically evaluates available evidence to identify common potential weaknesses in GBL design (summarised and analysed in Table 1, which also suggests the most relevant LXD principles to address each). These issues can be tackled if GBL design takes place within the LXD framework, to which it so closely aligns as shown above. However, despite the shared characteristics of LXD and GBL, this approach is not yet widespread or at least not explicitly articulated as such.

**Table 1**

*Mapping Common Weaknesses in GBL Interventions to Potential Solutions From an LXD Framework*

<b>Potential GBL weaknesses (Westera, 2019)</b>	<b>LXD-informed improvements (synthesised from previously cited LXD and GBL literature)</b>
Emphasis on rote learning over deep understanding	Focus on learner, learner-defined goals, frequent feedback, space for reflection, reward playful exploration and experimentation, situated learning
Minimal guidance and scaffolding	Chunked learning, acknowledging surrounding teaching and learning context, interactions outside the game where appropriate, empathetic design, "safe" and relevant learning environments
Shallow pedagogical foundations	Explicit use of LXD framework to inform GBL design, embracing emotional design, mapping learning behaviors to game affordances
Imbalance between immersion and cognitive load	Situated learning in relevant and familiar contexts, focus on learner-defined goals over system goals, chunked learning content, learner reflection
Relationship of reward systems with extrinsic and intrinsic motivation	Empathetic design, emphasis on learner's intrinsic motivation(s), progressive sub-goals
Differences between player performance and learning progress	Close alignment of game mechanics with learner goals, positivity principle, space for reflection, interactions outside game context

The remainder of this chapter focuses on a guided workflow for developing effective and learner-centred educational games. The aim is not only to increase interdisciplinary expertise in this area

but also to mitigate some of the barriers faced by educators choosing to use a GBL approach.

### 3. Design Method: A Workflow for Both GBL Novices and Experts

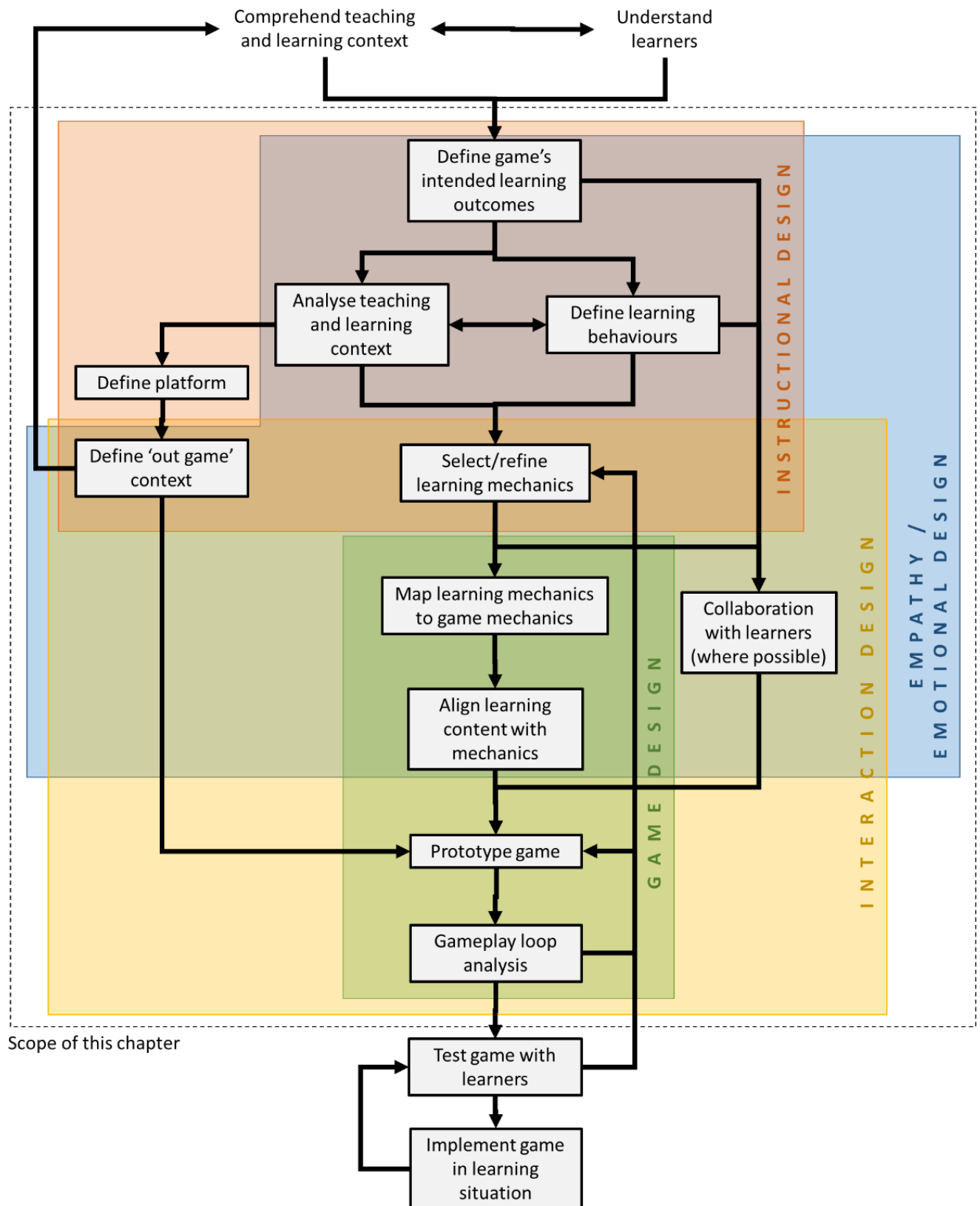


Figure 1



The workflow presented here (Figure 1) synthesizes elements from existing GBL design models (Catalano et al., 2014; Grey et al., 2017; Lui & Au, 2018; Marne et al., 2012; Nicholson, 2011) with a particular emphasis on those aspects most important to LXD by incorporating the design processes proposed by LXD experts (Floor, 2018; Rosencheck, 2015). It should be emphasised that the focus is LXD principles *specific to designing one particular intervention* – the workflow is situated within Plaut’s Interaction and Sensory planes, namely “What will learners actually be doing, hearing, and seeing during the learning experience?” (Plaut, 2014). Clearly, this question’s answer must arise from an overall comprehension of the learning context which can include curriculum requirements, organisational parameters, and, of course, early consultation with learners as advised in LXD; as Plaut (2014) states, “To use these methods effectively, you must have a strong grasp of your learners’ perspectives and experiences as they relate to the content” (Interaction plane section). However, these wider contexts can differ widely and are outside the scope of this chapter. Similarly, game testing, deployment, and evaluation are crucial steps in this process but these deserve a chapter of their own and will not be discussed in detail here. The dashed bounding box in Figure 1 demonstrates this chapter’s focus within the wider LXD context.

The workflow incorporates GBL guidelines specifically aimed at educators (Marklund, 2014; Torrente et al., 2011), recognising that GBL is highly interdisciplinary and requires strong pedagogical as well as game design foundations. Shaded boxes in Figure 1 attempt to show the different specific disciplines within LXD used at each stage and emphasize the need for learner-centred empathy.

The workflow begins by drawing on understandings from the higher planes of LXD: Strategy, Requirements, and Structure (Plaut, 2014). The initial phases of "Comprehend teaching and learning context" and "Understand learners" feed into Instructional Design activities such as definition and analysis of learning objectives, teaching and learning context, and appropriate learning behaviours and experiences. These activities overlap with Empathy/Emotional Design, progress into Interaction Design, and culminate in Game Design as learning content and mechanics are systematically matched with game mechanics (Lim et al., 2013). These activities are based on input from learners wherever possible, and linked back into the game’s LXD context by explicit consideration of out-game interactions. Finally the game is iteratively tested.

Each step in the workflow will now be considered in detail and illustrated with a practical, worked example for a non-digital game: a simple intervention in a primary school mathematics context.<sup>[3]</sup>

### **3.1. Define Intended Learning Outcomes**

Defining the intended learning outcomes (ILOs) for the specific GBL intervention is core to the workflow: “you start with formulating the desired learning outcome and every next step in the design process, including the choice of your medium or technology, is geared towards the desired learning outcome” (Floor, 2018). If this seems like an obvious statement, remember that, despite the recognition of ILOs as vital elements across the literature on LXD and GBL, recent reviews still identify significant challenges in linking learning content to game interventions (Lameras et al., 2017). Educators may already know what their learners want the game to achieve and will therefore be able to derive appropriate ILOs for the individual game. However, educators often expect too much from games (for example, a game to assist in teaching the content of an entire course); a position usually doomed to failure. For GBL to be effective, the ILOs must be manageable. ILOs can

cover knowledge, understanding, and attitudes; however, it is recommended to keep the ILOs: (a) few in number, (b) specific and focused, (c) well scoped, (d) achievable, and (e) measurable.

### **3.1.1. Simple Example: Curriculum-Derived ILOs**

Maria is a primary school teacher who has noticed that her pupils struggle with comprehending and verbally articulating the concept that the order of terms in a multiplication equation makes no difference to the result. Although her learners are too young to participate directly in game design, Maria has previously had good results and great feedback when delivering unusual and interactive teaching activities. She defines the following ILOs. Pupils should:

1. Understand that, when multiplying numbers, the order of numbers does not change the result;
2. Know the meaning of the term *commutative property*;
3. Feel more confident about multiplication and this terminology.

These ILOs are achievable and specific—for example, while knowing that  $4 \times 5$  and  $5 \times 4$  both  $= 20$  is useful, Maria is less interested in pupils knowing the answer than understanding the core concept. These ILOs will be foregrounded and referenced throughout the entire workflow, maintaining goal-orientation.

### **3.1.2. Extended Example: ILOs**

LXD principles recommend consulting with learners on the specifics of the design and, where possible, directly involving learners in the design process. Whilst for Maria the learner involvement may be limited to testing her prototype and iteratively improving it over time, many other learning contexts support a much higher level of learner involvement and co-design. Refer to the work of Marklund and Alklind Taylor (2016) for more on co-design. Additionally, Floor (2018) provides a useful template for analyzing the overall teaching and learning context in the LX Canvas tool.

## **3.2. Analyze Teaching and Learning Context**

The teaching and learning context specific to the intervention covers where and when the game will take place, how long it will take, how often it will be played, how many players it must support simultaneously, what materials or technology it needs, who (if anyone) will be supporting it, and so on. A common pitfall in GBL is for games to be developed in isolation of their context. Typically, the learning context is largely externally defined (e.g., a class has 30 children and lasts 50 minutes), but, even within strict parameters, some flexibility exists. Designers must consider questions such as, "Will the game be played together in class and supported by a teacher?" or "Is the game intended for independent study at home?" Therefore, designers must contemplate how GBL will be effectively integrated into teaching and learning practice in a way that is most effective and responsive to learner needs (Catalano et al., 2014; Marklund, 2014).

## **3.3. Define Platform**

Platform refers to what specific delivery mode the game will have (for example, an app, board game, physical game, PC game, virtual reality). The delivery mode is defined largely by what tools are accessible (for example, there is no point trying to design a collaborative app if the school has only

one tablet and a patchy wifi connection), but, again, flexibility exists and it is important that GBL design considers learner preferences rather than defaulting to the easy or most obvious platform. Whilst the example here is a physical game, the principles can also be applied to digital GBL.

### 3.4. Define Out-Game Context

Gameplay is affected by more than merely the features of the game itself. An *out-game* action is defined as an action which does not have an immediate and measurable effect within the game but nevertheless mobilizes perceptive and cognitive capacities and provokes *in-game* actions (Guardiola, 2016). Out-game actions are particularly important when using GBL within an LXD framework as this is where much of the learner reflection, support/guidance, emotional design, and authentic linking between game and wider context takes place. Some useful examples to consider are:

1. A tutor prompting or reinforcing learning from a game event,
2. A player vicariously learning from something another player does and adapting their own strategy in response,
3. Players collaborating to achieve a goal, or
4. An educator encouraging reflection on learning.

The context in which out-game actions take place could be externally imposed but still need to be considered critically to ensure the learner's needs and goals remain central to the process. One powerful example is that games provide a space for learners to behave differently, experiment, and fail safely, and evidence shows that being observed by non-players can break the "magic circle" of the game, embarrass players, and inhibit playful and/or learning behaviours (Huizinga, 1955).

#### 3.4.1. Simple Example: Learning Context, Platform, and Out-Game Context

Maria's learning context is within a primary school class of 30 children, with no teaching assistant, so the game must engage all learners at the same time with only one facilitator (Maria). She will be present at all times, leading and supporting the game and providing explicit assistance to learners who need additional support. The game platform must be immediately familiar to learners to prevent distraction from their learning goals; in addition, Maria has no budget for additional technology or tools. Maths lessons take one hour and (drawing on context external to the intervention) Maria wants the ILOs to be achieved in one lesson, with limited repetitions of the game.

### 3.5. Define Learning Behaviours

An absolutely crucial step in GBL design within an LXD conceptual framework is understanding "how" as well as "what" players are expected to learn. A common mistake is to default to a familiar *question and answer* model (e.g., Trivial Pursuit) where the learning behavior is in fact simply recalling knowledge the student already knows. This behavior is closer to a test than a game and is poor at enabling learners to embed new knowledge or understanding (Nicholson, 2011). Instead, top-level behaviors that support learning should be defined, such as:

1. Will players collaborate, co-operate, or compete?
2. What existing skills/knowledges are required and how will they be recalled/developed?
3. How might physical movement complement the emotional and cognitive outcomes?

4. Is repetition needed for reinforcement?
5. What are the learning behaviours that suit the learners best and will most effectively help them reach their goals?
6. What is the emotional as well as cognitive impact of particular learning behaviours and their results? and
7. What behaviours are likely to increase enjoyment and motivation?

It is quite clear that learning to play a scale on a piano requires different learning behaviours than learning to analyse a painting. A useful guide can be found in *Production of Creative Game-Based Learning Scenarios: A Handbook for Teachers* (Torrente et al., 2011).

### **3.5.1. Simple Example: Learning Behaviours**

Based on previous feedback from her learners, Maria identifies suitable learning behaviours compatible with her teaching context:

- The main learning behaviour must emphasise equivalence between sums (i.e., recognition, matching, grouping, or reordering);
- Cognitive processes must take place within interactions the pupils already know how to do;
- Learning must be active and collaborative;
- Repetition is required to reinforce learning and support pupils who are slower to grasp the concept;
- All children must be involved all of the way through (i.e., no-one is "knocked out");
- Learning behaviour should be novel (i.e., disrupting normal classroom behaviour);
- Physical actions must be aligned with cognitive concepts; and
- Pupils' learning should be self-directed.

Maria is foregrounding empathy in her design. She believes that, if the children have fun, feel ownership over the process, and disrupt usual classroom behavior, they will better learn and remember the ILOs.

Using both context and desired behaviors, Maria defines the platform as a physical game (i.e., the children will move around, matching and forming groups). She decides that the game itself should take no more than 30 minutes with out-game actions including explanations, scaffolding, and reinforcing the principle with applied examples in the lesson time remaining after the game ends.

### **3.5.2. Extended Example: Learning Behaviors**

Learners should ideally be closely involved in co-designing their own learning behaviors to ensure personalised learning pathways, goal-orientation, and appropriately supported environments. Defining learning behaviors with explicit learner input could be achieved by observation, consultation, or co-design. Where possible, GBL interventions should be designed flexibly to allow multiple learning behaviors (as learner groups are rarely homogenous). For example, players could be offered the choice of whether or not to play "against the clock."

### 3.6. Select/Refine Learning Mechanics

Once overall learning behaviors have been defined, more specific actions and interactions for achieving learning outcomes can be identified (learning mechanics). GBL novices could start by putting these mechanics into their own words; however, it would also be useful to use or take inspiration from any pedagogical framework with which the educator is already familiar (e.g., Bloom's revised taxonomy verbs; Anderson & Krathwohl, 2001). More experienced GBL designers could work from a framework specifically for GBL, such as the LM-GM model (2015) which provides "a non-exhaustive list of learning mechanics that have been extracted from literature and discussions with educational theorists on 21st century pedagogy" (Arnab et al., 2015, p. 396). What is important at this stage is not the exact taxonomy used but clarity of the precise actions that will lead to learner engagement with the ILOs.

#### 3.6.1. Simple Example: Learning Mechanics

Maria has used Bloom's verbs before and she identifies the following specific LMs which would help learners to acquire the ILOs.

- ILO 1: recognise (identical sums), identify (equivalent sums), compare and contrast (different and equivalent sums), connect/correlate (equivalent sums), transfer knowledge (to other equivalent sums)
- ILO 2: recite (the terminology)
- ILO 3: memorise (the terminology), relate/transfer (the property to other sums), collaborate (across groups with equivalent sums)

#### 3.6.2. Extended Example: Learning Mechanics

Using the LM-GM model, similar LMs can be defined:

- ILO 1: instruction, guidance, participation, action/task, identify, ownership, repetition, generalisation
- ILO 2: imitation, ownership, repetition
- ILO 3: imitation, ownership, responsibility, generalisation, feedback

### 3.7. Map Learning Mechanics to Game Mechanics

*Game mechanics* (GMs) refers to interactions with the game state, engaging players with the content. In other words, GMs exist to frame the game experience within the defined rules and to guide players in understanding the interactions required to participate (Lim et al., 2013). GMs affect game strategy and flow and require emotional as well as cognitive design. Explicit linking of pedagogically-founded LMs with GMs allows designers to ensure that an educational game focuses on the behaviors they want to encourage and that players can encounter learning content in the way that is most suitable. Arnab et al. (2015) call the resulting match a *Serious Game Mechanic* (SGM) and state that "SGMs reflect the complex relationships between pedagogy, learning and entertainment/fun, joining educational and gaming agendas. Therefore, SGMs are the game components that translate a pedagogical practice/pattern into concrete game mechanics directly perceivable by a player's actions" (Arnab et al., 2015, p. 395). By identifying SGMs, their LM-GM model enables further rigor in the analysis and evaluation of games in educational settings. In reality, this stage of the workflow is likely to overlap with the next one, creating a series of swift,

intuitive iterations of all steps within the Interaction Design category shown in Figure 1.

### **3.8. Align Learning Content with Designed Mechanics**

In this step, actual learning content (in our example, multiplication tables and math terminology) is aligned with each in-game and out-game action. These interactions then enable learners to construct the knowledge needed to achieve their goals. Whilst there may certainly be overlap here with earlier stages of the workflow, ensuring the core game mechanics create the right learning behaviors is crucial. Ensuring learner interactions are appropriate before the game is "skinned" with actual learning content emphasizes the learner-focused approach (i.e., a mode of engagement that is personal, supported, and goes beyond instructional design).

#### **3.8.1. Simple Example: Mapping LMs to GMs and Aligning Learning Content**

Using the LM-GM model, Maria maps her LMs as follows: To embrace collaboration, social learning, and enjoyment, the whole game will be based on communal discovery. Pupils will be allowed to discuss and help each other as they play. Game cards (randomly assigned) will contain learning content (some identical, some equivalent sums). Identifying/matching actions function as collecting all identical or equivalent sums together. Grouping will be through physical movement which reinforces the cognitive matching and quick feedback as grouping happens (as the learners realise that all sums in their group are either identical or equivalent) which reinforces the Identify and Connect LMs.

Maria's class tends to enjoy and learn more if they believe they can achieve the task. She knows their "growth mindset" can be mapped to the urgent optimism GM. Therefore, content cards will start very easy and progress in complexity/difficulty. Recitation/imitation of the terminology must be included in the game. Repetition of the game for memorisation and confidence is mapped to behavioral momentum.

### **3.8. Prototype Game**

The mechanics are now ready to be structured into gameplay. Prototyping is again likely to happen as a series of swift iterations, with early ideas being refined mentally before any material prototype is even attempted. It is certainly recommended to consider the next step (gameplay loop analysis) at least once and go through the recursive part of the workflow again before investing time in creating any game materials.

#### **3.8.1. Simple Example: Prototype Game**

For learners to achieve the ILOs, the collecting GM must be central to the process and the terminology must be included too. Maria's initial game idea is as follows:

- Pupils will be randomly assigned cards with multiplication sums written on them. Each pupil will get one card. Cards will be produced such that three equivalent groups can be formed (of 10 pupils each). Within each group, some sums will be identical and some sums will have the same terms but in a different order.
- Pupils will find their matches/equivalents and form physical groups based on their cards.
- Maria decides that shouting out the word "Commutative!" once a group has formed is a fun

way to cement the terminology and acts as a "finishing point." This will need an out-game action (the teacher speaking the word and asking pupils to imitate) in the early stages.

- As the pupils learn the concept, the game can be made harder (e.g., with more groups, sums, more than two terms).

### **3.8.2. Extended Example: Prototype Game**

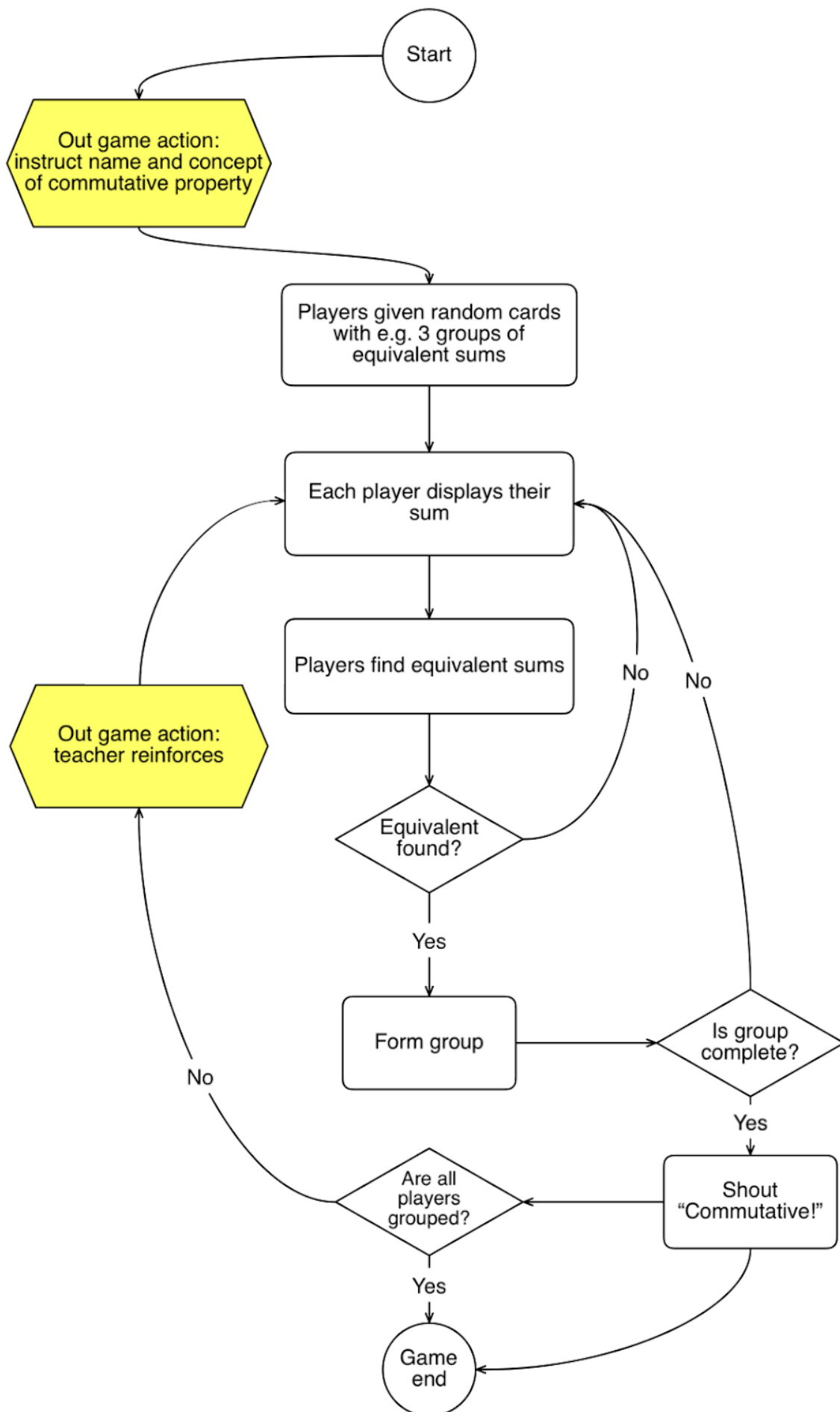
Game prototyping offers fruitful opportunities for learners to become directly involved in the co-design of their own learning activities. Whilst Maria's options may be limited due to the very young age of her pupils, she directly involves the pupils in creating the game cards by printing out word and sum templates for the children to colour in. This builds ownership over the process and excitement for the first playtest.

GBL designers working with adults or older children can improve their learner-focus by working much more closely with learners at all stages of the workflow. This is likely to be particularly useful in the Define learning behaviors, Align learning content, and Prototype stages. If working directly with learners is not possible, data about their goals, preferences, etc. could be gathered to inform the process.

## **3.9. Gameplay Loop Analysis**

Gameplay refers to any interaction with the game and, in the context of LXD-informed GBL, explicitly includes non-tangible emotional and cognitive actions/reactions as well as physical actions influencing the game world. A gameplay loop represents gameplay as linked actions, by breaking down and describing every interaction both inside and outside the game (e.g., teacher scaffolding; Guardiola, 2016). This process allows educators to work with learners during playtesting to confirm that the game reinforces their intended behaviors, appropriately integrates and exposes learners to content, and does not inadvertently create unwanted emergent behaviors (see Grey et al., 2017). Although seemingly daunting, this step can be achieved by creating a simple flowchart during playtesting.

In order to create accurate, learner-focused gameplay loops, actually playing the game is crucial, preferably with a group of people who were *not* involved in the design process. This development stage is the perfect opportunity to, as suggested by research, explicitly include students as co-designers (Marklund & Alklind Taylor, 2016). This gives much more insight into the social and emotional flow of gameplay that cannot necessarily be discerned simply from reading the rules. Gameplay should be mapped at an overall level, with any sub-loops expanded as far as is useful. The gameplay loop (see Figure 2) is likely to highlight omissions, improvements, or opportunities that can be achieved by refining the game through iterative playtesting with learners and also identify any unforeseen issues that might arise for individual players. Note that, whilst formal testing is crucial, it falls outside the scope of this chapter.





## Figure 2

*Gameplay Loop for Multiplication Game, Showing Out-Game Actions Which Link to the Wider LXD Context as Hexagons*

### 3.9.1. Simple Example: Gameplay Loop Analysis

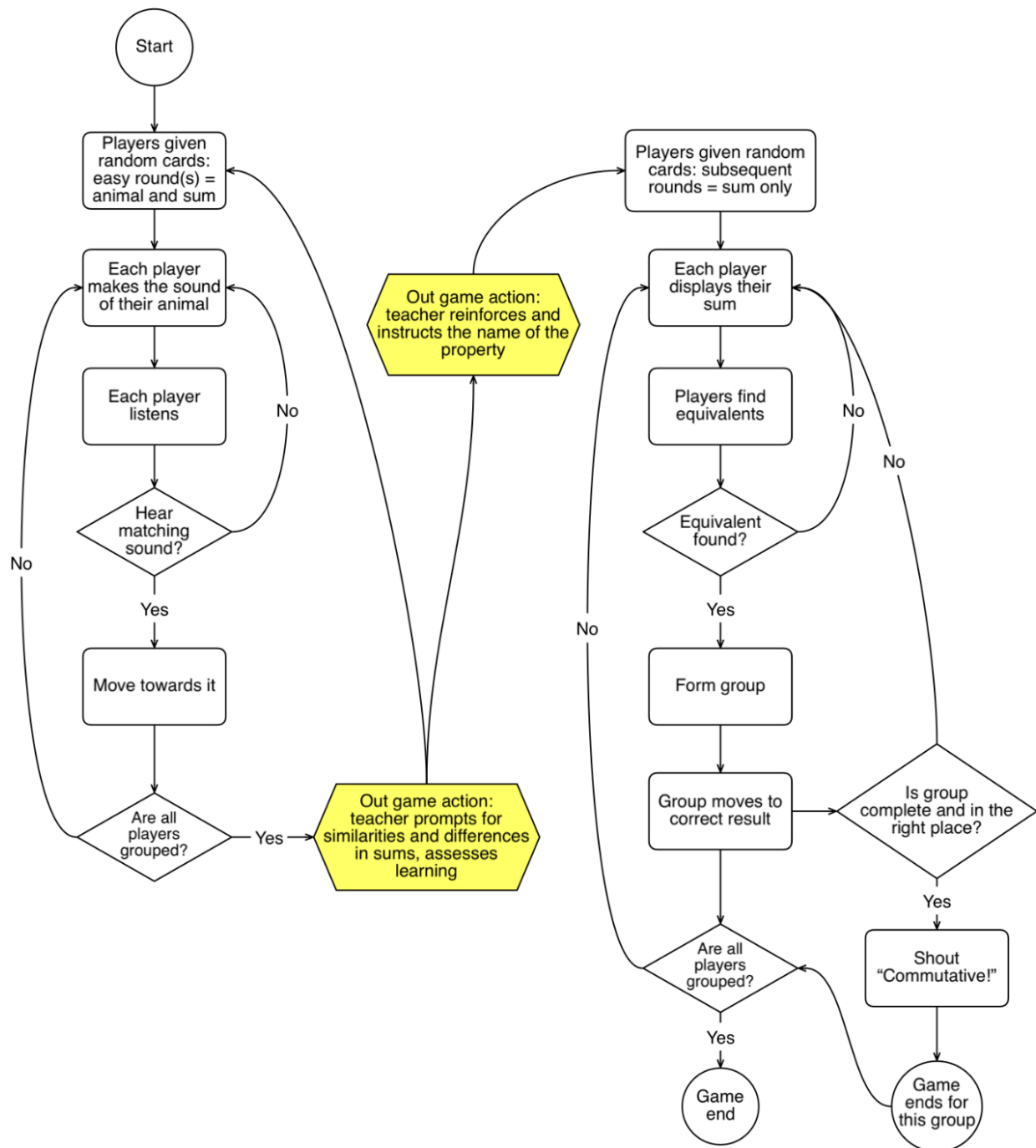
After a couple of playtests and her gameplay loop analysis (Figure 2), Maria realizes that she will still need to instruct the learners on what the commutative property actually is before they can engage in matching/grouping their sums. She wonders if this concept can be integrated into the game itself. Taking inspiration from another grouping game her class already likes (Animal Sounds), Maria creates a training round at the start of the game. In this game children are randomly assigned one of a few animals and they make the sound of their animal until all animals of the same type are grouped together. Maria realizes that, by combining this grouping behavior with the sum cards, she can encourage her pupils to actively make the connection themselves (e.g., all cats are equivalent to  $3 \times 5$ , all dogs are equivalent to  $2 \times 4$ ). Doing so will not only make the learning more constructive but will remove the need for explicit instruction, placing the emphasis back on the learners.

Maria also decides to take the game outside wherever possible and introduces a new element, a chalk circle on the ground for each group containing the correct answer to each groups' sums. This means that players can find their group in two ways, either by an equivalent sum or by knowing the answer. This gives pupils the flexibility of a different pathway to understanding.

After several iterations checking her LMs, GMs, and gameplay, Maria moves the second ILO to the main game (i.e., it does not happen in the training rounds) and is happy with her final game (see Figure 3).

### 3.9.2. Extended Example: Gameplay Loop Analysis

Gameplay loops can be made even more rigorous by including the LMs and GMs in the loop for further insight (Abbott, 2019b). This helps to show which behaviors/interactions players are spending most of their time doing (or which are side-lined) and can help GBL designers to centralize those learning behaviors defined as most useful.



**Figure 3**

*Final Gameplay Loop for Maria's Multiplication Game, Including the Training Round Based on Animal Sounds and Out-Game Actions*

## 4. Conclusion and Reflection on the Workflow

The workflow and simple example presented here aims to guide readers towards increasing the rigour of their GBL interventions and to ensure that they benefit from a more explicit LXD approach. Educational games can be powerful personal learning tools with a focus on emotional flow as well as learner goals. As is clear from the literature, GBL often fails at this core objective due to being too

much separated from both an appropriate pedagogical foundation and the needs and desires of the learners. LXD principles ensure this vital connection with learners can be maintained through the game design process.

By examining the interdisciplinary categories at each stage of the workflow, readers can identify where their own particular skills lie, establish any skill gaps that may need to be addressed in order to increase their overall expertise as GBL designers, and, for existing GBL practitioners, increase the focus on emotional design and the wider LXD context in which the workflow takes place. Admittedly, each stage may overlap with others as ideas are considered, and processes may be fuzzy rather than discrete. Whilst some may wish to follow the workflow step by step, others may already have an idea for learner-focussed GBL, in which case the workflow becomes a tool for validation of choices (and improving the rigour of the game design through subsequent iterations).

This chapter focuses on one small part of the overall LXD context (within the Interaction and Sensory planes) and has therefore not been able to discuss strategic, institutional, or practical considerations which impact game design within an LXD framework.

Finally, a widely experienced barrier for those integrating games into learning is resistance from colleagues or managers who may need to be convinced of the value of the GBL approach. In these cases, demonstrating the alignment of this GBL process with learner goals, desires, support-requirements, and enjoyment can help to elucidate the rigour and value of LX-centred GBL interventions.

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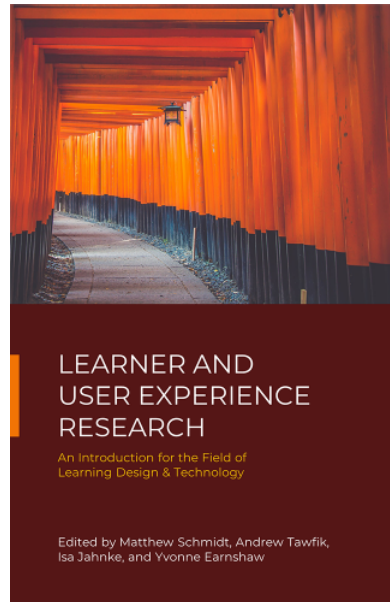
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[1] Much more detail on this can be found in (Abbott, 2019a; Raybourn, 2016; Whitton, 2011) amongst many others.

[2] For more on learning effectiveness, efficiency, and achievement see Huang et al., 2019.

[3] For those readers already familiar and confident with educational game design, an ambitious and complex example involving four high-level, functional outcomes at postgraduate level is presented in the work of Abbott (2019b).



Abbott, D. (2020). Intentional Learning Design for Educational Games: A Workflow Supporting Novices and Experts. In M. Schmidt, A. A. Tawfik, I. Jahnke, & Y. Earnshaw (Eds.), *Learner and User Experience Research: An Introduction for the Field of Learning Design & Technology*. EdTech Books. [https://edtechbooks.org/ux/11\\_intentional\\_learn](https://edtechbooks.org/ux/11_intentional_learn)



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## PW7

# Serious Game Rapid Online Co-design to Facilitate Change Within Education

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# Serious Game Rapid Online Co-design to Facilitate Change Within Education

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**Abstract.** Serious games have potential for facilitating change processes but require rigorous, interdisciplinary design to be effective. A novel, rapid online workflow was developed for co-design of games for change with school teachers. Major design challenges included: short timescale; appropriately scaffolding a complex process; remote online interactions; and interdisciplinary communication. The resulting workflow is highly visual, structured, and focused on swift knowledge exchange between pedagogy and game experts, drawing on relevant frameworks. Two workshops used the new method, producing eight co-designed serious games. Analysis suggests the workflow is effective for knowledge exchange for the rapid and rigorous co-design of serious games and has advantages for inclusivity and confidence in the co-design process.

**Keywords:** Serious Games, Education, Online Co-Design, Game Design

## 1 Introduction

Serious games are increasingly benefitting from co-design methods in their conception, design, and production. Co-design is a participatory method that involves all stakeholders and creates shared understanding between them as they participate in equally valuable yet diverse roles [1]. It is crucial to bridging disciplinary boundaries and improving the quality and effectiveness of serious games but there is little practical guidance on how exactly to achieve this goal. We present a new method for ‘Serious Game Rapid Online Co-design’ (SGROC) with school teachers, applied during the Agents of Change Toolkit (ACT) project [2] to produce eight serious games for change in schools. The workflow and serious games are freely available and represent a contribution to the field of serious games for educational contexts.

## 2 Background

Game-based learning has considerable potential for delivering both knowledge and behavioral outcomes, as is now widely recognized in the literature [3]. However, it is also acknowledged that there are still significant challenges in developing games that

are well situated in practice [4] and where game elements (mechanics, aesthetics, etc.) are appropriately linked with both learning behaviors and intended outcomes [5, 6], not least because of the highly interdisciplinary requirements of serious game design.

The Agents of Change Toolkit (ACT) facilitates teachers and schools to act as agents of change towards the UN Sustainable Development Goals (SDGs) [7] by leveraging serious games. Following recommendations from the literature, co-design with educators and school leaders was identified as the most fruitful approach [8, 9] and embedded throughout the project. Unfortunately, relatively little precise guidance exists to support the all-important linking of pedagogical foundations with game design in co-design methods, which risks ineffective serious games [10] and educators becoming overwhelmed by complexity [6]. Previous research by the authors explicitly addresses these challenges by marrying workflows suitable for game design novices [8, 11] with rigorous matching of learning and game mechanics [12]. However, in the context of COVID19 lockdowns, a need emerged for online co-design (OCD) activities. OCD is increasingly discussed in the literature with examples of general principles for OCD workshops [13, 14] but little related to educational game design. A rare exception presents a hybrid online/physical method for developing minigame prototypes over multiple sessions [15], noting the research gap in OCD for serious games.

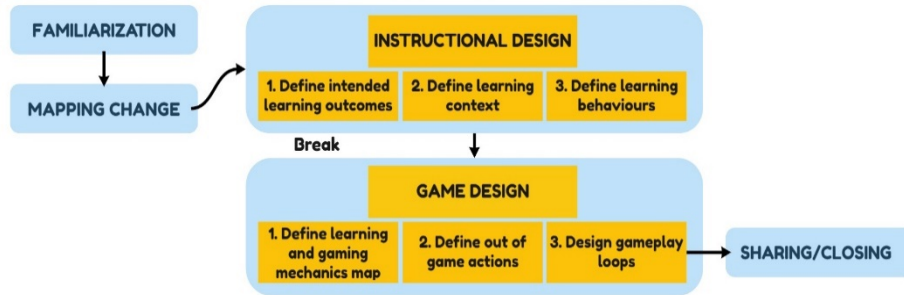
### 3 Serious Game Rapid Online Co-Design Method (SGROC)

In the context of the ACT project, the following needs were identified for co-design workshops with school teachers; online delivery; very low time commitment (2 hours); familiar technologies; small collaboration groups; and a strong link between pedagogical outcomes, learning behaviors, and game design. In order to meet these needs and the wider goals of ACT, we adopted a ‘lean’ methodological approach, i.e. collaborating closely with intended users to produce a minimum viable prototype which could then be further developed. It was necessary to devise a method which combined OCD with rapid prototyping of serious games, with heavily scaffolded game design processes that co-designers could grasp and productively use in a very short time. This was achieved by expanding recommendations in the literature specific to OCD [13–15] and co-design with teachers [e.g. 1] and significantly developing the visual and structural guidance required to achieve such rapid results. In particular, the game design workflow supporting both novices and experts [8] was applied in this context and combined with the robust Learning Mechanic Game Mechanic framework [16] and gameplay loops [17] to achieve rigorous yet feasible prototypes. The Serious Game Rapid Online Co-Design (SGROC) workflow is summarized in **Fig. 1**.

Miro (miro.com) was selected as the most suitable whiteboard interaction platform, used alongside Virtual Classroom and Zoom videoconferencing. To sufficiently scaffold the co-design process [cf. 1] and provide individual attention, workshops were offered to small groups of six educators with three serious game experts facilitating the design of two prototype games each, acknowledged as an ambitious target. Recruitment used the project team’s extensive network of educators, school leaders, and educational policymakers and events were shared publicly to increase access. Two

workshops were run, each with a full complement of 6 participants (12 overall). The workshops were also attended by 2 – 3 members of the ACT project team.

In advance of the workshops, participants were asked to define a specific change they wanted to achieve in their school, relevant to one of the SDGs. Prior to the event, desired changes were grouped into complementary pairs and assigned to each game designer to create the most fruitful collaborations.



**Fig. 1.** Workshop protocol overview

As with any platform it was important to ensure that participants could concentrate on the content of the workshop rather than struggling with the controls [cf. 13]. To maximize engagement, the familiarization activity was intrinsically integrated with the workshop content; participants constructed a ‘monster’ representing their previously-defined change and its challenges, and annotated it using virtual sticky notes. To further orient the participants and save time, the whiteboard was meticulously set up for each group, with sticky notes and working areas color-coded and tagged with participants’ names. All background and instructional elements were locked in place and clear labels provided for all icons and text that participants would be directly interacting with. This preparation was crucial in streamlining online interactions and keeping participants focused on content. All phases were illustrated with a worked example to provide inspiration, guidance, and continuity throughout the process.

The second short phase, Mapping Change, allowed the teachers to contextualize their own proposed change and align it with one or more of the SDGs.

The bulk of time was for rapid co-design, broken down into discrete tasks as shown in **Fig. 1**. The first phase, Instructional Design, built on the desired change and challenges from the familiarization phase to inform 1) the definition of brief Intended Learning Outcomes (ILOs); 2) clarify the learning context; and 3) experiment with a range of ‘learning qualities’ to allow the participants to get a sense of *how* the target audience would engage with the game or playful activity. Participants were offered a choice of learning verbs from Bloom’s extended taxonomy [18] (as teachers were likely to already be familiar with this) and/or a Learning Qualities Framework developed specifically for this workshop (drawing on [8]) which supported participants in systematizing learning behaviors using a simple verb + adjective format. The verbs and/or qualities were then used to define a primary intended learning behavior for the game. This rigorously-defined learning behavior formed the basis of Game Design.

With the help of the game designers, participants used their instructional designs to identify and pair learning mechanics (LMs) and game mechanics (GMs) to construct an LM-GM map, following the procedure defined in [12, 16]. LMs were selected and annotated to explain the choice. Appropriate GMs were then linked to relevant LMs and annotated with how the GM would be used within the serious game. LM-GM maps were then used to brainstorm ideas for game prototypes which foregrounded the LM-GM pairings. Where time allowed, LM-GM pairs were formulated into gameplay loops [17]. Game designers used examples of existing games to suggest and inspire. Finally, participants produced a one-sentence description of their prototype game. SGROC workshops closed by sharing the prototypes across the group and a recap.

### **3.1 Eight Games for Facilitating Change Within Education**

The ACT SGROC process produced eight finished games for facilitating change processes. After the workshops, games were briefly refined and finalized and content produced for game assets (e.g. question banks, cards, and boards). Where possible this was also via co-design with the educator (5 out of 8 games). Additional assets were produced where necessary (for example card sets, jigsaws, powerpoint) using original or Creative Commons art and crediting all creators. Each finished game document provides 1) a summary of the overall purpose; 2) any assets required; 3) how to play; 4) suggestions for different application areas which could also benefit from a similar LM-GM map and gameplay loop; 5) detail of the instructional design; and 6) gameplay loop annotated with LM-GM mappings [2]. The games are also contextualized in relation to the overall ACT project.

## **4 Discussion**

On balance, the SGROC method provided advantages over face-to-face methods. Not requiring travel reduced the time commitment (particularly important for school teachers) and expanded our geographical reach. One participant had to drop out due to poor connectivity – this may have been exacerbated by the ‘image heavy’ familiarization exercise (which was then streamlined for the next event). Despite connectivity barriers, OCD is considered to be more inclusive for those with caring responsibilities or neurodiversity [19]. The care and attention given scaffolding the workflow was crucial to success, as was the choice of technologies appropriate to use from (often restricted) school premises. Acute time pressure provided a way to kick-start the complex process of serious game design, forcing swift collaborative decisions to produce a ‘good enough’ prototype. (The rapid games design approach for complex systems in the context of sustainability is discussed in [11].) Most of the games were further developed and/or tweaked after the workshop (varying between 1 – 4 hours) to improve their gameplay and content. Furthermore, the highly scaffolded workflow was particularly useful when participants were working independently, increasing confidence and productivity. Participants provided very positive feedback at (and after) both workshops: e.g. “I just wanted to say a big thank you for a fascinating,

gruelling but very productive and optimistic event”. There was also evidence of considerable knowledge exchange within the interdisciplinary project team itself. Overall, the SGROC method achieved its design outcomes and contributes to OCD methods for serious games, as well as empowering educators as change agents. A formal evaluation of the SGROC workflow would provide deeper insights into user experience (across different roles) and goal attainment.

Unsurprisingly, as each arose from a specific desired change, the games are diverse: three highly structured games with associated assets, two loosely structured games, and three freeform playful and/or creative activities. Limited feedback on the games was gathered anonymously and thematically analyzed. Games were seen as useful, relevant, and understandable; suggested adaptations for (and adaptability of) games to individual contexts was considered very beneficial; games being contextualized within the change process was valuable; and the value of (and need for more) exemplification was noted. The Toolkit was launched in Sept 2021 and is being implemented within schools and teacher education degrees. A larger scale, systematic evaluation with users is needed to validate results and provide further insight (this is in progress).

## 5 Conclusion

The SGROC workflow provides a contribution with ongoing value to those undertaking rapid online games design with educators. Particular advantages of this method are: quick results; inclusivity; knowledge exchange; reduced demand on teacher time; genuine collaboration; and rigor. Main recommendations for successful use of the SGROC method are: use of blended spatiotemporal techniques to increase engagement, commitment, and rigor; meticulous preparation of online platforms; meaningful grouping of participants; meaningful familiarization activities; and a workflow structured to foreground each disciplinary expertise appropriately. This work was funded by the Scottish Universities Insight Institute. All of the games produced by the ACT project are freely available online [2] and the SGROC workshop template can be provided on request.

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## PW9

# Serious “Slow” Game Jam- A Game Jam Model for Serious Game Design

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# Serious ‘Slow’ Game Jam - A Game Jam Model for Serious Game Design

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## ABSTRACT

The Serious ‘Slow’ Game Jam (SSGJ) is a new model for use in serious game design and research. Game jams contribute to creative, innovative and collaborative design, however, game jams for serious purposes require an alternative model that integrates domain experts within the jammer community to ensure the validity of their designs and content. Furthermore, a rigorous yet accessible design methodology is required to balance pedagogic and game aspects to support jammers, as well as to assist researchers in subsequent analysis and evaluation. A standard entertainment game jam model does not afford support for these aspects. The SSGJ model addresses these needs through an inclusive, collaborative, and creative framework for multidisciplinary teams, which includes: encouraging reflection and knowledge exchange; improving content validity; and providing continuous support and mentoring to participants. Reflection on the model highlights the importance of framing serious game jams as explicitly educational activities and embedding them into existing training contexts. The SSGJ model contributes to a collaborative serious game design methodology for the wider research community, irrespective of application domains.

## CCS CONCEPTS

• Applied computing → Computer games; • Human-centered computing → Collaborative content creation.

## KEYWORDS

Serious Games, Serious Game Jams, Serious Game Jam Design, Interdisciplinary Game Design, Game Design Methodology

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## 1 INTRODUCTION

Serious games are “experiential gaming technologies for wider purposes” [40] or, “games that do not have entertainment, enjoyment or fun as their primary purpose” [27]. Game jams aim to rapidly produce a (prototype) game from scratch, usually with design and time constraints. Whilst it may first appear that game jams for serious purposes are simply a subset of game jams more generally, this paper explores some marked differences in the required processes, personnel, and outcomes, and challenges the notion that conventional game jam formats are (necessarily) the best fit for game jams for academic, educational, and/or research purposes. This paper investigates serious game jam design methods, and their associated benefits towards the serious games research domain. We present a freely available model for a Serious ‘Slow’ Game Jam (SSGJ) (building on current best practice) and its associated toolkit of resources, analyse its use within a specific subject domain, and reflect on its advantages and limitations as a complementary jam format.

### 1.1 Why are Serious Game Jams Different?

The creative, innovative and community-building potential of game jams, has been widely acknowledged [7, 11, 14, 15, 28]. Due to their purposefully short duration (average range of 24-48 hours [21]), game jams provide a design framework best suited to a rapid prototyping approach [28]. Key traits of rapid prototyping are promoting creativity through constraint, embracing failure as a source for learning, and encouraging experimentation and risk-taking due to lowered time and investment costs. This practice aims to promote innovation through the creation and evaluation of prototypes to filter out which ideas have merit for further development [11, 28, 30]. Game jams complement established game creation practices, which typically involve lengthy development times, multiple iteration cycles and considerable investment of time and money. From an educational perspective, game jams offer creative thinking, teamwork, and time/project management challenges to the participants, as well as an overview of the game production process in a condensed format, thus supplementing formal educational practices [14, 17]. In addition, they constitute important cultural and social events for



game developer communities.

Reflecting these benefits, game jams have emerged as a booming cultural phenomenon [42] and have received widespread attention from a multitude of research fields and perspectives. Researchers have investigated the qualities of games produced during game jams and the development practices that participants employ [10, 29], the educational value of game jam participation in terms of soft and hard skill development [14, 26, 33], the impact of game jams as a cultural practice on the game developer community [23, 33], and the use of game jams as production and training tools in formal educational frameworks [9].

Although most game jams are aimed at creating entertainment game prototypes (Global Game Jam (GGJ) and Ludum Dare being notable examples), it is not surprising that serious game jams have been recommended and implemented as a tool for serious game design and research [6, 35]. Academic game jams are one of the three categories recognized by Goddard, Byrne and Mueller [17], alongside independent and industry organized game jams. From a research perspective, game jams can be analyzed as a combination of crowd-sourcing [18] and research by design practices [6] with additional unique features, such as providing a social and playful work environment [17, 23, 33]. However, as noted by researchers with experience of serious game jams, the conventional entertainment-oriented game jam format (modelled after GGJ) has characteristics which may make it not best suited for serious game design [3].

A key trait in serious game design is multidisciplinary, since it involves the synthesis of domain-specific, pedagogical, and game design knowledge. This is reflected by the Triadic Game Design (TGD) methodology, which names these ‘worlds’ as Reality, Meaning, and Play respectively. [19]. TGD provides a very fruitful framework on which to develop game jams specifically for serious purposes. The mapping of these three distinct competencies refocuses a serious game jam from product to process - the emphasis is on the serious outcome after playing the game (and therefore the mapping process), rather than producing the most polished prototype. Furthermore, due to the essential nature of TGD’s interrelations, serious game design benefits from implementing a collaborative design framework which includes domain experts, educators, and game developers in order to facilitate knowledge exchange and improve rigour. It follows that the personnel involved in serious game jams are therefore likely to be quite different than those taking part in entertainment game jams. This presents a distinct need not met by conventional game jam formats and is a challenge to be incorporated in serious game jams, as noted by jams including: the Complexity Game Jam 2020 [20], noPILLS [35] and BrainJam [9]. Another characteristic that would be limited by conventional game jams are the time/skill barriers to inclusion for stakeholders from a wide range of professions [3].

## 1.2 Paper Structure and Position

This paper analyzes game jam design parameters before drawing insight from literature and practice towards the design of a

model better suited to the specific needs of the diverse serious game community including participants, domain experts, educators, and serious game researchers. We draw on, synthesise, and adapt, relevant game jam and design sprint principles, focusing on the key components of collaboration, creation without preparation, and improvisation – and challenging the need for intense time pressure, in line with an increasing acknowledgement for the need for ‘slow’ game jams as a complement to conventional models [24, 38]. We then propose the research-informed Serious ‘Slow’ Game Jam model (which distributes the short contact time of a typical jam over a much longer duration), building on good practices in the field focusing on inclusivity, flexibility, and knowledge exchange. In particular we propose: that the integration of domain experts is a crucial component to produce meaningful results; and that brief time-span game jam formats are not conducive to multidisciplinary collaboration, whereas introducing break time for reflection and paced, cascaded knowledge exchange is more fruitful and inclusive. Finally, we reflect on the opportunities and limitations offered by the SSGJ model, and discuss its wider contribution to serious games design and research.

## 2 RESEARCH CONTEXT

### 2.1 Overview of Game Jam Design Parameters

Game jams can have diverse formats according to their aims and context, while sharing a baseline of similarities [7, 13]. The following parameters have been synthesized from the literature, and provide insight into game jam design.

- (1) **Theme.** A theme (e.g. word, phrase, concept), announced in advance or at the start of the jam, provides a creative constraint which is open to interpretation by participants. In addition, optional prompts to guide creativity may also be provided (game genres, player modes, specific mechanics, etc.).
- (2) **Time.** Time constraints usually range from 8-72 hours, with 48 hours being the most prevalent choice, typically during a weekend. Although intense time pressure can be considered as conducive to jammers’ creative focus [18], it has been highlighted as a considerable challenge for participants [10] and can also be interpreted as a glorification of ‘crunch culture’. Furthermore, intense time pressure imposes accessibility barriers to a range of people who cannot (or choose not to) participate due to caring responsibilities, neurodiversity, and disability, amongst other reasons. It is increasingly being acknowledged that the removal of stress factors from game jams is an important step to improving participant diversity [16].
- (3) **Location.** Some game jams take place as gatherings in physical locations and others are hosted solely online. Since digital literacy is widespread in the game developer community, online game jams are popular due to their increased reach and flexibility, and the remote teamworking mode is aligned with established work practices [8]. Nonetheless, researchers comment favorably on the community-building and experiential potential of physically co-located game jams and advise them

where possible [17, 18].

- (4) **Participation & Teams.** Participation requirements vary depending on context. Independent game jams are usually open to anyone. Academic game jams may have participation requirements (relating to skill or expertise) or be invitation only [17]. Practices vary with respect to team formation. The GGJ model asks explicitly for single participant registration, since team formation is part of the event. In other cases, preformed teams are encouraged and in others, there are procedures for team matching during the event, which may involve curation by the organizers. Based on evaluation of user experience and outcomes, team formation curation is strongly encouraged [12]. There are various models for team formations, such as the one presented by Buttfield-Addison, Manning and Nugent [5], which is inspired by the Mechanics-Dynamics-Aesthetics (MDA) model, and the Massachusetts Institute of Technology (MIT) Innovation model [28].
- (5) **Technology.** Although most game jams are tech-agnostic, some jams are dedicated to the use of specific platforms for game production (e.g. Gamemaker, Godot), user interfaces and mechanics (e.g. Point and Click Game Jam, Text Jam), or algorithms (e.g. PROCJAM, AI Jam) [13].
- (6) **Support.** Participant support is a design parameter that allows a depth of approaches. Usually, support in entertainment game jams is minimal, as in the example of GGJ, which includes a keynote talk to orient players with the theme. In some cases, workshops and presentations are organized in advance to teach and train relevant skills, including fast prototyping methods, game design methods, or particular mechanics implementation [7]. Assigning mentors to support participants throughout is another practice, and jammers can also be encouraged to mentor each other, if appropriate [7, 37].
- (7) **Deliverables.** Typical deliverables are game prototypes and supporting media, such as a gameplay video and short text description. Furthermore, a prompt for active reflection can be included by inviting participants to do a ‘post mortem’-style presentation after the game jam, alongside their game demonstration [7]. Game jams are usually framed as non-competitive (GGJ), yet competitive elements may be present e.g. voting for top games in predetermined categories by participants or a panel of judges. Some game jams have prizes for winning teams.

## 2.2 Previous Recommendations for Serious Games Jam Design

Past serious game jams provide valuable insight into the challenges, practicalities, and good practices associated with organization and design that is more suitable for non-entertainment games. This informs our SSGJ design and provides a rationale for adapting or challenging the game jam design parameters presented above.

Theme plays a significant influencing role in a serious game jam as it is more than just inspiration for game design, it is an integral (and demanding) aspect of the activity, requiring appropriate and accurate content creation. Furthermore, to effectively design serious outcomes from the games, pedagogy emerges as an additional crucial parameter, as participants need to be able to understand how to: design, implement and convey learning through game mechanics. This additional need for pedagogy therefore necessitates the inclusion of materials such as the LM-GM cards [4] that can support participants in understanding the learning aspects of a serious game.

Therefore relevant skills needed by participants go well beyond technical knowledge and competencies related to game design and development. To address these major additional needs, the main recommendations from existing literature on serious game jam design refer to the Time and Support parameters, with jams being broken up into phases with breaks in between and explicitly including educational content. In [3] an initial study phase was followed by a week-long break, then the game development phase with temporal scaffolding in the form of task milestones. The organisers highlighted the need for longer time frames compared to entertainment game jams in order to appropriately address the challenges involved. Another jam [32] also included educational content a week in advance and split synchronous and asynchronous activities over a longer time frame: a 48 hour jam led to initial selection, then 2 weeks of development led to the selection of one game for further development and public release. This progressive filtering of design ideas from prototypes to product is aligned with a rapid prototyping approach. In some ways, a serious game jam benefits from a temporal structure similar to a design sprint however, recurring rest periods of a week or longer between activities is likely to be a fruitful approach.

In terms of Theme and Support, every study considered [25] recommends domain experts as mentors or full participants, by integrating lecture-like content at key points the jams [32], providing curated thematic guidance [32], pairing professionals with game design experts [1, 32] and other stakeholders [35] to ensure alignment with the goals of the activity, and providing a clearly structured journey through the whole activity [1, 3]. The necessary additional Support for serious game jams, crucial to ensure the validity of the ‘serious’ content of games in development, also has implications for Participation and Teams (as can be seen in the recommendations for mentors/participants) and implies a strong need for robust knowledge exchange activities.

## 3 SERIOUS SLOW GAME JAM MODEL

The SSGJ model falls under the wider category of ‘applied game jams’, which are defined as “game jams that explore a range of different topics, issues, and objectives through game development” [36]. For this reason, to aid in the design of our model we employed Reid *et al.*’s *Theoretical Framework for Game Jams in Applied Contexts*. With the goal of providing a framework for new applied game jam models, the theoretical model involves investigation of four

aspects: the problem space, the jam design, the jam delivery and its outcomes, and any follow-on opportunities.

### 3.1 Problem Space

In terms of the problem space, the objectives were to deepen participants' understanding of a particular domain (in our case, cybersecurity) and to identify and reflect on the serious game design patterns of jammers' designs. Therefore the methodology was to support both educational and research outcomes. Outcomes include participants who are more engaged in cybersecurity practices, serious games on particular cybersecurity topics, and a conceptual map of serious game intervention strategies. Our SSGJ methodology is intended to be flexible and generic so that it can be used irrespective of application domains.

### 3.2 Organisers & Participants

The SSGJ model is intended to be flexible in terms of participants and jam delivery can be adjusted to suit the participant group's levels of technical, pedagogical or domain knowledge - the examples discussed in this paper range from primary school to masters level students. Regarding organisers, to appropriately support jammers it is necessary to have representation of experts from: the application domain (here being cybersecurity) and serious game design. The experts for both categories were academics who are active researchers in: cybersecurity, software development, general game design and serious game design.

### 3.3 Jam Design

We defined guiding criteria as: 1) creating a multidisciplinary, collaborative framework for rigorous serious game design and 2) providing guidance and mentorship throughout the jam both to frame participation as a structured, educational and accessible experience, and to support the value and validity of the outputs. The following section presents the new SSGJ model, analyzed in line with the parameters described above.

- (1) **Theme.** Content is guided by domain expert mentors and structured educational materials including a bespoke card deck modelling cybersecurity concepts, information, and relationships. We provide theme inspiration with 'small provoking games' (SPGs), i.e. short serious games designed to provoke reflection on the problem at hand [2]. Our procedure includes prompting participants to play the SPG prior to the jam and hosting a group discussion facilitated by mentors at the onset, where the group attempts to contextualize the game experience within the application domain. This activity is intended to kick-start knowledge exchange through dialogue and thus draw out research questions and hypotheses for the serious game ideation stage. Whilst the Theme resources are cybersecurity-focused, the SSGJ structure is domain agnostic, and robust documentation supports the creation of new domain-specific card decks and/or SPGs.
- (2) **Time.** Multidisciplinary participants need time for knowledge exchange and reflection and to understand the SSGJ

model itself. However, there is a practical need to avoid deterring individuals with heavy workloads so the total active time of the jam should not increase. To reinforce accessibility and inclusivity, the SSGJ model is a 'no-crunch' working environment with non-exhausting session durations. This model re-evaluates time pressure based on serious game design needs. Drawing on practices in [3], we structured the game jam as three separate phases, each devoted to a stage in the game creation life-cycle (design, development and pre-release), with ample time in between for reflection (2 weeks) and a total duration of 4-5 weeks. Each phase is 2 work days, leading to an overall active engagement duration of 48h, matching typical game jams. The break time between phases is dedicated to tailored feedback to each team by the organizers and optional refinement work by the jammers, with flexible expectations defined by their availability (Table 1).

- (3) **Location.** As our target group is diverse, we offered different participation modes and embedded flexibility of engagement intensity in the model. To strike a balance between the acknowledged benefits of online and physical participation, we propose a hybrid format, where all engagement needs are served on an online basis to prioritize inclusivity and accessibility, while also catering for optional physical presence to accommodate direct socializing and local networking needs.
- (4) **Participation.** Following literature recommendations on team curation [12], teams are created by organizers using self-identified roles collected during registration, taking into account participant preferences and existing social connections. All participants remained in their assigned team throughout the jam, but they were not necessarily present for each and every activity, allowing flexibility around external commitments such as childcare or doctor appointments. Each core team also has an assigned domain expert mentor, recommended by [35], and a serious game design expert mentor. Where serious games research is an outcome we also recommend the placement of a research project member. The explicit inclusion of both domain experts and serious game designers as participant-mentors allows the delivery of high-quality support materials [3, 9, 31, 32], guidance in framing the SSGJ theme [32], supporting and contextualizing domain related material, and validating its modelling in the serious game. Assigning a domain expert as a core member of each team intensifies the contact and knowledge exchange between experts and jammers, as advocated in [3, 32].
- (5) **Technology.** Serving the hybrid modality, we propose using asynchronous and synchronous modes of communication on social platforms (e.g. Discord), online collaboration whiteboards (e.g. Miro), and remote teamwork tools featuring cloud storage (e.g. Dropbox). This technology supports ongoing documentation of design and development decisions. In terms of the game platform, we do not propose any limitations - this is especially important given the wider range of relevant skills represented in participants and therefore anticipating lower technical development skills, on average.

**Table 1: SSGJ Structure showing time, milestones, and support activities.**

	Week 1 (Phase #1)	Week 2-3 (Optional)	Week 3 (Phase #2)	Week 4-5 (Optional)	Week 5 (Phase #3)
Phase focus	Design		Development		Development and prototyping
Time	2 working days	2 weeks	2 working days	2 weeks	2 working days
Support	Domain Lecture Domain card activity SPG workshop TGD workshop	Reflection Mentor feedback Refine ideas	LMGM activity Game loops workshop	Reflection Mentor feedback Refine ideas	Peer review MDA framework Pedagogical patterns
Deliverables	Design document (draft)	Design document (final)	Greyboxed prototype	Early game prototype	Final game prototype, rules, documentation

Participants should be supported with instructions on any specific tool use at the beginning of the game jam.

- (6) **Support.** The SSGJ model includes guided, educational group activities supported with digital and physical materials. During Phase #1, jammers are introduced to key serious game concepts, terminology and the Triadic Game Design (TGD) methodology [19, 19, 41]. Support materials include three card decks: one domain-specific and two covering Learning Mechanics and Game Mechanics (LM-GM) [4] (to be used as design tools). Tangible toolkits, especially for abstract concepts, have been noted as useful for: increasing design speed and focus; articulation of reasoning and justification for decisions; and resolving disagreements [34]. In Phases #2 and #3, ready-made assets for common game functions and customizable Unity scripts that implement game mechanics introduced in the LM-GM framework are provided to speed up development. These activities, alongside the domain related activities (e.g. the cybersecurity lecture and SPG discussion), are spread across phases as shown in Table 1 and, we propose, will result in strong learning outcomes for participants as well as serious game prototypes that have high rigour and domain validity.
- (7) **Deliverables.** In addition to the usual deliverables (a game prototype and documentation), we include a serious game design document (SGDD) which lays out each serious game design according to a provided template, drawing from practices in [7], as a means to encourage an analytical approach during design from the jammers and to support the researchers in their consequent analysis. All educational activities during the SSGJ feed into the SGDD template. Because of the long overall duration of the jam, participants are provided with milestones to pace and monitor their progress, following practices in [3], as shown in Table 1.

### 3.4 Jam Delivery and Outcomes

SSGJ delivery is analyzed below. It is important to reiterate that the model is designed to function for participants as a significant learning opportunity as well as a creative and productive exercise.

Overall outcomes of each SSGJ include the serious game prototypes, SGDDs and documented analysis of each game, and the jammers’ learning experience. Outcomes of the SSGJ model as a whole include the potential re-use of the entire design and support toolkit provided during the jam, e.g. adaptable structure, the Cybersecurity, Learning Mechanics, and Game Mechanics Card Decks, structured activity worksheets and digital whiteboards, code snippets to speed up implementation of common game mechanics, small provoking games, and documentation to assist in creating toolkit resources for other subject domains. All of these elements are freely available for use.

### 3.5 Follow-on Opportunity

Through the embedded educational/analytical activities and the SGDD deliverable, the SSGJ model supports subsequent analysis and evaluation of the game jam outputs for research purposes. The research outcomes (for example, pedagogical patterns suited to the particular domain problem) are being analysed and will be shared in future. The published results can in turn support follow-up research both for serious game interventions on the specific domain, but also for serious game design methodology in general. Furthermore, the SSGJ provides a wealth of digital and physical resources to support serious slow game jams (e.g. the templates, card decks, and code snippets mentioned above) for adaptation by academics and researchers in other disciplines.

## 4 IMPLEMENTATION OF THE SSGJ MODEL

### 4.1 Participant Analysis

The SSGJ model was used to deliver three successful SSGJs between November 2021 and July 2022. Each event was supported by a minimum of three serious game design experts, a minimum of three cybersecurity experts, and a narrative designer, who acted as mentors throughout, plus additional support from members of the research project team. SSGJs #1 and #2 were in a hybrid format with the option to participate online or in-person, arranged as two contact days for each phase, with a two week break between each phase. Recruitment was open to anyone and advertised through social media and project networks. Due to the subject domain, the

**Table 2: Summary of SSGJ events**

	Format	Synchronous Contact Time	Overall Duration	Registered Participants	Actual Participants	Average Attendance	Age Range
SSGJ #1	Hybrid	48 hours	4 weeks + 2 days	12 (10m, 2f)	6 (4m, 2f)	75%	
SSGJ #2	Hybrid	48 hours	4 weeks + 2 days	14 (10m, 4f)	0	-	-
SSGJ #3	Hybrid	48 hours	5 weeks + 1 day	14 (11m, 3f)	13 (10m, 3f)	88%	22-35 (mean 26.3)
SSGJ #4	In-person	30 hours	5 days	27 (19m, 8f)	23 (16m, 7f)	97%	10-16 (mean 12.2)

target audience was anyone who codes (including professionals, students, and hobbyists), however registered participants were mostly students. Participant attrition had a significant impact, with a high (33%) rate for SSGJ #1 and SSGJ #2 had to be cancelled due to low attendance at the first event. The difficulties in open, public recruitment led us to consider the context of the SSGJ deployment and, as it was already designed as an educational creative experience, the remaining two SSGJ events were offered as complementary events within an existing framework. SSGJ #3 was integrated into a postgraduate programme (where students could optionally use the jam as a basis for coursework) and SSGJ #4 was adapted to use at a summer school with a younger participant pool and a shorter overall duration, whilst still preserving the SSGJ guiding criteria. Table 2 summarises the four jams (three successful, one cancelled) and shows much higher participation and attendance for the latter two events which we propose is due to the logistically smoother recruitment process. As part of registration we gathered data on participant demographics, motivation, and previous experience. This data is presented below, with participants who attended less than 60% of the SSGJ excluded. We analysed motivations for participation in the latter two SSGJs, with a list of possible reasons to participate graded on a 7 point Likert scale of how influential each was in deciding to attend. These questions were formed based on findings from Steinke *et al.* [39] and Lai *et al.*'s [22] observations from multiple decades of previous game jams.

The results (Fig. 1) indicate that the main reasons to participate in SSGJ #3 were to: acquire knowledge and skills in cybersecurity, to acquire knowledge in game design and game development, and to collaborate with experts, with 10/13 participants in each category rating this reason as “very influential” and mean scores of 6.5, 6.2, and 6.6 (out of the maximum of 7) respectively. The least influential reasons were to establish a business partnership (mean 3.8), and to acquire knowledge to start up a company (mean 4). For SSGJ #4 (see Fig. 2) influences on attendance were rated lower across all categories with the most influential categories being to acquire knowledge in game design and development (mean 5.8), to create a serious game (mean 5.6), and fun and enjoyment (mean 5.4). The least influential categories were related to starting a business, as in SSGJ #3. These results support our analysis of process (both educational and experiential) being (at least) as important as product for participants in serious game jams, and the recommendation for formal inclusion of domain experts. Participants were asked to rate their experience and skills related to the domain area, game design, and gaming in general prior to the start of the jam. Table

**Table 3: Participants’ self-reported experience, mean score of all participants on a Likert scale of 1 – 7.**

	Gaming	Game Jamming	Coding/ Programming	Secure Coding
SSGJ #3	3.4	1.9	N/A	2.1
SSGJ #4	5.3*	3.0	4.0	2.5

**Table 4: Participants’ self-reported skills, mean score of all participants on a Likert scale of 1 - 7**

	Game Designer	Game Dev	Game Art (Visual)	Game Art (Audio)	Secure Coder
SSGJ #3	1.5	1.4	1.3	1.4	1.8
SSGJ #4	3.3	2.9	3.0	2.6	2.0

3 and Table 4 show prior experience and self-reported skills, averaged for each game jam. It is notable that only one score (gaming experience for the schoolchildren participants of SSGJ #4, shown indicated with an asterisk\*) is above the mid-point of the scale, with participants in SSGJ #3 reporting low experience and skills in all categories. This supports our expectation that the participants in these jams do not necessarily already have strong game design or development skills and therefore underlines the requirement of enhanced support structures.

## 4.2 Initial Reflections on SSGJ Deployment

The first notable issue arising from the SSGJs is recruitment. In line with the project’s core audience of ‘anyone who codes’, we initially aimed to recruit a mixture of students, creatives, and software development professionals to each jam. However, we acknowledge the tensions between the accessibility aims of the SSGJ (takes places within working hours, not expecting ‘crunch culture’) and the recruitment of working populations, which led to a smaller and less varied group of participants than anticipated, even taking into account the planned ability to ‘drop into’ a team at the most useful phase of development. The challenges of recruiting mixed populations should not be underestimated due to the different barriers

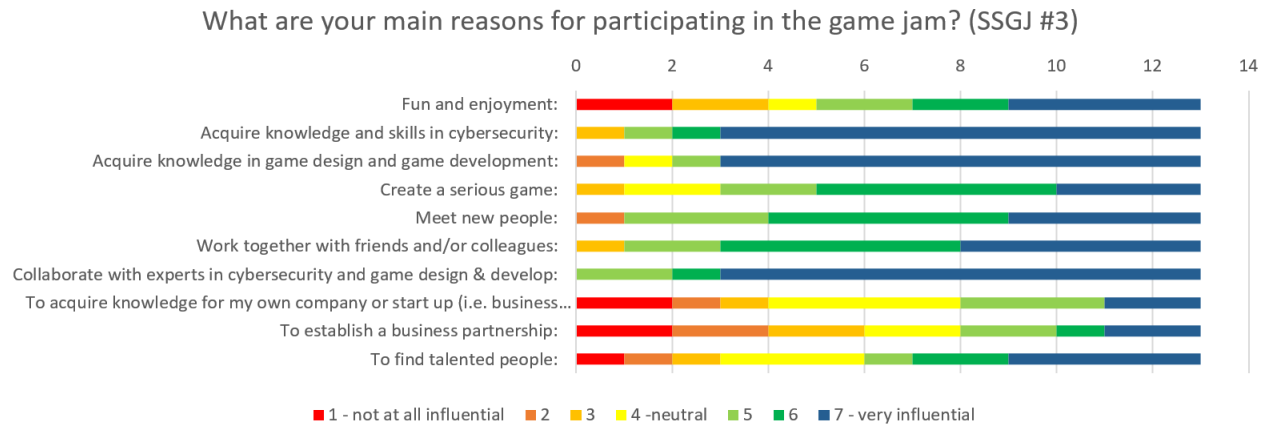


Figure 1: Motivation to participate for SSGJ #3

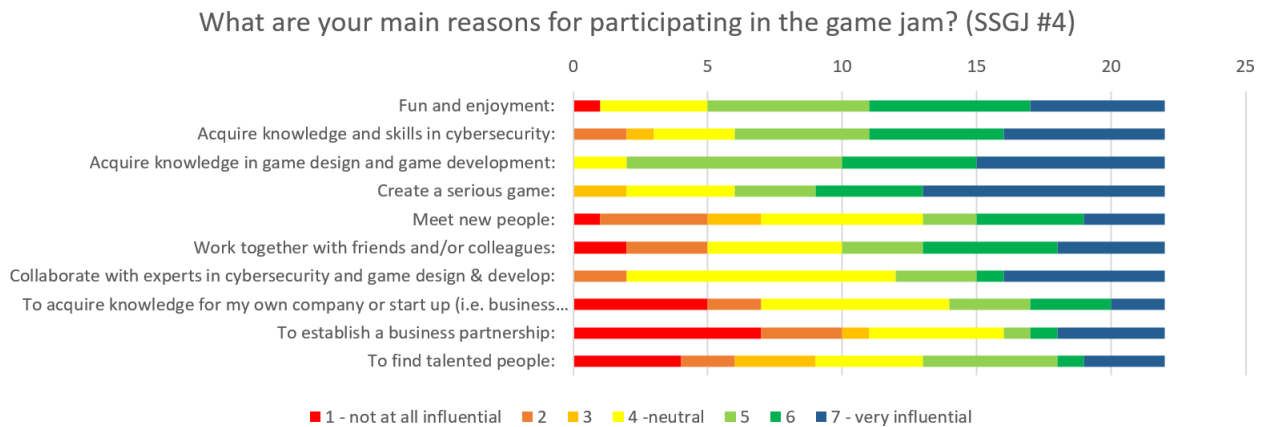


Figure 2: Motivation to participate for SSGJ #4

faced by different groups. For example, for working coders, engaging in continuing professional development (CPD) in the form of a jam on fixed dates proved very difficult, despite motivation. Student participants demonstrated less time pressure (except for one occasion where the jam dates clashed with a course deadline which affected attendance) but barriers included a lack of confidence in achieving jam outcomes for some. It should also be noted that three SSGJs took place during 2021-22 where COVID-19 restrictions were a relevant consideration and therefore the hybrid delivery was, for some events, a logistical rather than pedagogical requirement. We noted that online participation was especially useful but did sometimes negatively affect engagement. This period also saw an unusually high proliferation of online game jams which somewhat saturated the game jam community and may also have affected recruitment and participation. Due to the higher number of participants, lower attrition rate, and better attendance in SSGJ #3 and #4 (see Table 2) we propose that more targeted recruitment has a better chance of success than open, e.g. explicitly positioning the SSGJ as an option within an existing educational context such as a

degree programme or CPD offering. This leads to the second main reflection, how to frame the events. We observed a misconception in some participants that the jam was a course on game design, as opposed to a method to learn about another topic *through* serious game design. Correctly framing the SSGJ and effectively communicating it to target participants is crucial.

The third main theme regards participant capabilities and confidence. SSGJ participants were enthusiastic learners but generally rated themselves low in technical, design, and game literacy skills (Table 4), meaning aspects of the SSGJ toolkit designed to support digital game development (e.g. Unity code snippets implementing common game mechanics) were not used as they were not understood by the majority of participants. For this reason, the majority of serious games developed during the jams were tabletop rather than digital games (some of which were explicitly framed as a prototype for a digital game which could be developed later.) The lower-than-anticipated skills levels also affected interaction with experts, a key motivation for participants attending (see Figs. 1 and

2) and necessitated a redesign of much of the domain (and, to a lesser extent the serious game design) support material to become suitable for novice participants. Fortunately, this makes the SSGJ model in its current form more broadly accessible.

The final reflection is that the ‘slow’ aspect of the SSGJ appeared to be successful for most participants in terms of providing space for reflection and focus, despite time spent on asynchronous activities falling short of our prediction. There was a disparity between participants, some engaged a lot in the asynchronous activities and some did not engage at all. The ‘slow’ aspect was used by some teams for additional development of prototypes but for most it appears to have functioned as a period of intangible cognitive reflection or deepening understanding. It is notable that, even on SSGJ #4 where the overall duration was compressed to 5 days, several participants continued engaging outside of the contact hours, and even these short reflection periods were sufficient to allow the creation of concepts and prototypes. Several participants in SSGJ #3 also took advantage of the ‘slow’ aspect to attend flexibly despite other (medical, childcare, and academic) commitments demonstrating increased inclusion. Slow game jams run by others show similar success in inclusivity and reflection on the creative process [24, 38].

### 4.3 Recommendations

We propose the following recommendations for future implementations of the SSGJ model in other serious game design and research contexts:

- (1) The SSGJ should be targeted to, and integrated with, (formal or informal) educational or CPD programmes such that it dovetails with participants’ other time commitments and is highly appropriate for their needs.
- (2) Expectations and outcomes should be clearly communicated if the target audience is likely to have limited prior skills in game design and development. Importantly, the function of serious game design as an educational method rather than the sole purpose of the activity should be made clear.
- (3) Hybrid engagement is possible and fruitful, however, in person attendance should be encouraged for at least some of the contact time to build connections between participants and mentors.
- (4) Participants can vary widely in skill level in terms of domain-specific skills, game literacy, game design skills, pedagogic skills, and game development skills. Support materials should be tailored as closely as possible to the skill level of the intended participants and this should link to how the jams are targeted and framed. For domains other than cybersecurity, a card deck related to the learning objectives should be produced and organizers should also consider creating a small domain-specific ‘provoking’ game.
- (5) Registration data on confidence as well as skill level could be collected to facilitate good team curation.

- (6) Reflection time was crucial in allowing space for idea and asset generation. How the reflection time is structured and/or monitored is likely to be strongly affected by intended participants and may be instrumental to the success of a Serious Slow Game Jam.

## 5 FUTURE WORK

This paper focused on the design of SSGJ model, its motivations, reflections on the design and recommendations for future implementations. However, a detailed evaluation of the impact of the SSGJ model is forthcoming in a separate publication which uses quantitative results obtained from the aforementioned SSGJs to investigate: the impact on participants’ understanding of cybersecurity and serious game design; the use and value of the cybersecurity, learning mechanics, and gaming mechanics card decks; the motivation and work-load levels of participants; and the impact of the ‘slow’ format of the SSGJ. Furthermore, as these jams focused on cybersecurity, participants may have been generally more aware of gaming and game design. Future work investigating how successful the SSGJ model is when applied to non-computing contexts would provide a beneficial insight into how participants from different specialties engage with the jam.

## 6 CONCLUSIONS

The SSGJ model is a carefully structured framework which aims to improve the rigour, accessibility, and quality of multidisciplinary game jams for serious games research. Although implemented to date with educational goals related to a specific domain, the model itself is domain agnostic and applies to any research within which multidisciplinary and co-creation can be expressed through game development and/or design practice. The model builds on good practices in the field and the benefits associated with game jams, whilst being designed specifically for inclusivity, flexibility, and knowledge exchange. This results in a model that embraces a hybrid mode of engagement, a slower pace for conceptualization and production, and more emphasis on educational aspects to allow participants to develop a better understanding of key concepts and the nature and purpose of their serious game intervention. The SSGJ model was implemented at three events in 2021-2022 and reflections on their reception and efficacy imply that the ‘slow’ aspect of the jam model achieved its goals and that (mostly for logistical reasons) the model works best when offered as a complementary activity within an existing educational framework. A further, detailed evaluation of the impacts of the SSGJ model on participants and their serious game outputs is forthcoming.

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## PW13

# Evaluating Serious Slow Game Jams as a Mechanism for Co-Designing Serious Games to Improve Understanding of Cybersecurity

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# Evaluating Serious Slow Game Jams as a Mechanism for Co-Designing Serious Games to Improve Understanding of Cybersecurity

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We present a first evaluation of a Serious Slow Game Jam (SSGJ) methodology as a mechanism for co-designing serious games in the application domain of cybersecurity, to evaluate how the SSGJ contributed to improving the understanding of cybersecurity. To this end, we engaged 13 participants with no experience in cybersecurity, in a multidisciplinary SSGJ involving domain-specific, pedagogical, and game design knowledge, and encouraged engagement in-between scheduled days of the SSGJ. Findings show improved confidence of participants in their knowledge of cybersecurity (from 12.5% to 62.5%) after undertaking the SSGJ, with free-text answers specifically indicating an improved understanding in terms of vulnerabilities, attacks, and defences for three quarters of the participants. Also, confidence in knowledge of game design improved (12.5% to 75%), and the SSGJ successfully engaged participants in-between scheduled days. Finally, a serious game is presented that was co-designed with participants during our SSGJ, and produced as an output of the SSGJ methodology.

CCS Concepts: • **Human-centered computing** → **HCI design and evaluation methods**; • **Security and privacy** → *Usability in security and privacy; Human and societal aspects of security and privacy.*

Additional Key Words and Phrases: Serious Slow Game Jam, Serious Games, Evaluation, Workload, Motivation, Engagement, Cybersecurity, Secure Coding, Secure Code Citizens

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## 1 Introduction

With the democratisation of software development and deployment, the issues of code security and safety are widening. At the centre of this democratisation are the new code-citizens who are code-literate and able to build and run their own software code, by coding it themselves or by using code snippets from others [31]. They may have had no formal software engineering training and are often outside of the software industry which normally teaches, instils, and instructs best practices via house standards. Their understanding of the security implications of their coding is of fundamental importance to the security of software systems [31]. Research has shown that of the 1.3 million Android applications that contained security-related code snippets from Stack Overflow, 97.9% contained at least one insecure code snippet [24, 44]. We propose to put new code-citizens at the heart of secure code development, by using a Serious Slow Game Jam (SSGJ) methodology to engage them in the co-design of serious games. The SSGJ methodology implements an inclusive, collaborative, and creative framework for multidisciplinary teams. Compared to traditional, fast-paced game jams, it reduces the time pressure and inserts space for reflection on collaboration and play, the development of common-ground knowledge, and the exchange of knowledge. The SSGJ is spread across multiple weeks, allowing for reflection and refinement between scheduled days of the SSGJ. It provides support and mentorship from game design experts and cybersecurity experts throughout the SSGJ. At the same time, it retains the co-creation and supportive ethos of the traditional, fast-paced game jam. The SSGJ toolkit, comprised of a provocative game, Miro boards [66], Cybersecurity cards (for the application domain), Learning Mechanics cards, and Game Mechanics cards, is used to facilitate the SSGJ.

### 1.1 Research Questions

The overall aim of the research presented in this paper is to conduct a first evaluation of how our SSGJ methodology contributed to improving the understanding of cybersecurity. It investigates how different aspects of the Serious Slow Game Jam being evaluated may have contributed to this goal. To investigate this, we were guided by the following research questions:

- RQ1: How has the SSGJ affected participants' understanding of cybersecurity?
- RQ2: How can the cards for the application domain (in our case Cybersecurity cards), Learning Mechanics cards, and Game Mechanics cards that are part of the SSGJ toolkit, assist in serious game design?
- RQ3: What are the workload and motivation levels of participants during the SSGJ?
- RQ4: How has the "slow" format of the SSGJ affected participant engagement?

The remainder of this paper is organised as follows. Section 2 provides background knowledge regarding game jams, serious game design, the rationale for the proposed SSGJ methodology, and the potential evaluation methods for different aspects of the SSGJ. Section 3 presents the Serious Slow Game Jam methodology and the procedure for evaluating a Serious Slow Game Jam we conducted in the application domain of cybersecurity. The results of this evaluation are presented in Section 4. Section 5 discusses one of the serious games that was further developed by serious game design experts, from the co-designed (digital and non-digital) prototypes delivered through the SSGJ methodology. The findings are discussed in Section 6, and the conclusions and future work are presented in Section 7.

## 2 Background

### 2.1 Game Jams and Serious Games

Game jams have received attention from different research fields and perspectives [26]. Compared to game development in the entertainment industry, most game jams are typically aimed at creating rapid prototypes of entertainment games. According to Kultima [48], a game jam is an accelerated opportunistic game creation event

where a game is created in a relatively short timeframe, during which design constraints are imposed and explored to inspire creativity, and the resulting outputs are shared publicly. Due to their purposefully short duration with an average range of 24-48 hours [3, 48], game jams provide a framework best suited for a rapid prototyping approach [3, 68]. Research has focused on various aspects of game jams, including the qualities of games produced during game jams [26], the development practices that participants employ [70, 98], and the educational value of game jam participation in terms of the development of soft and hard skills [29, 63, 75]. The impact of game jams as a cultural practice on the game developer community has also been investigated [56, 75], as well as the use of game jams as production and training tools in formal educational frameworks [25]. Game jams can have different effects on learning. They have been shown to enhance game development skills, STEM skills, and personal and interpersonal skills [63]. They also have been shown to enhance teamwork, communication, and project-management skill sets [29], provide an (online or co-located) environment that encourages social, participatory or situational learning [29], as well as self-directed learning [22]. They also enable formal and informal learning through play and experimentation [33, 62, 82], and can provide more abstract learning experiences that increase motivation and self-efficacy [9].

### 2.1.1 *Serious Games.*

Serious games have been defined as “games that do not have entertainment, enjoyment, and fun as their primary purpose” [64]. Most definitions of the concept are vague, and what their primary purpose is can differ. However, it is argued that the addition of pedagogy, that is, activities that educate or instruct and thereby imparting knowledge and skill, is what makes a game serious [32, 99]. Serious games can allow learners to experience situations that are difficult to experience in the real world for reasons of safety, cost, time etc., and have an impact on the player’s development of different skills [32]. To this end, serious game design is multidisciplinary as it involves the synthesis of domain-specific knowledge, pedagogical knowledge, and game design knowledge, as reflected by the Triadic Game Design (TGD) methodology [40].

Game-based approaches have been applied for training, motivation and education in the domains of software engineering and cybersecurity [19, 59, 72]. One form of intervention is to simply ‘gamify’ existing tools or development methods, for example, using a Catch-The-Flag contest to train players to build, break, and fix software [71]. Investigations of gamification for software engineering [19, 72] outline the preliminary research and challenges, however it is advised to move beyond simple gamification approaches such as points and rewards [47, 72]. Therefore, bespoke serious games are considered to be promising opportunities for learning and training, and a range of games have been developed for both software engineering [59] and specifically for cybersecurity. Examples include competitive games where players attempt to find uncaught mutants or to write mutant-catching tests [83], a tabletop game on the drivers and biases within security decision-making [30], and a co-designed tower defence game focused on developer-centred security [4, 57, 58].

### 2.1.2 *Serious Game Jams.*

Serious game jams have been recommended and implemented as a tool for serious game design and research [18, 79]. Besides industry and independent/indie organized game jams, academic organized game jams are one of the three categories of game jams identified in the literature [33]. Academic game jams characteristically bring together academic researchers with the aim to produce research outputs. Compared to game jams focused on the creation of entertainment games, they replace abstract and arbitrary design themes with context-based research based on an application domain (e.g. health or cybersecurity). However, as has been previously noted, serious game jams have different needs in terms of their processes, personnel, and outcomes [3] and benefit from time and space for reflection and verification in addition to entertainment jams’ key characteristics of the rapid prototyping approach (e.g. creativity through constraint, risk-taking, lower time/investment costs, and the selection of the best ideas for further development). Also, academic game jams are typically run by academic institutions or as part of academic conferences or workshops, which often limits the accessibility for and diversity

of participants [33, 49]. For example, to participate in Quantum Game Jams, participants had to be either scientists who are experts in the application domain, or experienced game designers or game developers [50].

In addition, in serious game design, the gameplay design needs to be understood with regards to the application domain and pedagogical objectives, conceptualised in Triadic Game Design [41] as Reality (i.e. the application domain), Meaning (i.e. pedagogical value), and Play (i.e. gameplay). Therefore, serious games design places much more emphasis on mapping these three aspects for effective learning outcomes. However, the conventional entertainment-oriented game jam format is not best suited for the needs of serious game design and serious game design research [6]. Their generally fast and intensive pace can make them inaccessible [26, 35, 49, 52] and leaves little room for participants to refine or reflect on their work [3]. This need for refinement and reflection was also identified by Hecker and Blow [43] who argued that game jams are shallow and horizontal by design. They introduced more vertical Depth Jams, in which developers focused on improving and polishing one particular feature or mechanic in an already existing game, in an attempt to bridge the gap between game jam (prototypes of) games and fully developed games [43, 52]. To address the need for deep understanding and mapping of game mechanics to learning outcomes and the explicit representation of pedagogical experts in serious game jams (in addition to subject and game experts), we have proposed the design of a new Serious Slow Game Jam method [3]. We define the SSGJ method by the key concepts of collaboration, improvisation, rapid creativity common to rapid prototyping approaches and design sprints. The SSGJ method incorporates these characteristics alongside the time-limited, stand-alone nature of a jam, however, instead of being intensely concentrated, the limited time is meaningfully distributed over a longer period [3].

### 2.1.3 Game Jam Design Parameters.

Game jams can have diverse formats depending on their aims and contexts. However, an analysis of the literature on game jams identified several shared design parameters [21, 28, 51, 68]. These are the theme of the game jam, time constraints (i.e. typically ranging from 8-72 hours), the location (i.e. physical, online, or hybrid), participation and team requirements (i.e. prior experience and skills), technology use (i.e. technology-agnostic or dedicated platforms for games production), participant support (i.e. keynote talks, workshops, presentations, mentoring), and deliverables (e.g. game prototypes, supporting multimedia, and documentation) [3, 21, 28, 51, 68].

Past serious game jams have provided valuable recommendations regarding these design parameters, as well as insights into challenges, practicalities, and good practices regarding serious game jam design [1, 6, 76, 79]. Like academic-organized game jams, the theme for serious game jams does not just provide inspiration for game design, but also defines a research context and application domain. To achieve the research outputs requires accurate and appropriate content creation and thus expertise of the application domain. In addition, for the design of effective serious games, this requires significant expertise in pedagogy besides skills and expertise in game design and game development [3]. Recommendations from existing serious game jams advise to address these significant additional needs for participants via the Time and Support parameters [6, 76]. It is recommended to divide the game jam into phases with breaks in between [6], and explicitly provide (synchronous and/or asynchronous) educational content over a longer period of time [76]. It is also recommended to integrate domain experts (and other stakeholders) into the game jam as mentors or participants [1, 6, 76], and integrate lecture-like content at key points during the game jam. This is to ensure the alignment of goals of the activities, provide a structured journey for participants, and to ensure the validity of the content in the serious games produced [1, 76]. How this has informed the design of the Serious Slow Game Jam method [3] will be discussed in Section 3.1

## 2.2 Evaluating Game Jams

Evaluation of game jams has focused on various aspects of game jams, including the qualities of games produced during game jams [26], and the educational value of game jam participation in terms of the development of soft and hard skills [29, 63, 75]. More formal frameworks for evaluation of certain aspects of game jams have been

suggested, such as the Triadic Game Design Evaluation framework for a balanced evaluation of serious games design [40]. However, game jam evaluations tend to focus on a specific aspect of the game jam [40], rely mostly on qualitative evaluation [27], and often lack rigour and depend on the evaluation of experts (sometimes based upon predetermined criteria) [40]. There is a gap in establishing a universal method with which to evaluate game jams against their intended outcomes [40, 80]. It has been suggested that, in comparison to traditional, short-format game jams, more extensive, in-depth game jams have potential for a more comprehensive evaluation [82].

### 2.2.1 *Knowledge and Understanding.*

Assessing learning outcomes from game jams is difficult [9, 29]. The learning experience is a very private experience [29], while devising tests for participants to assess their knowledge and understanding or having participants write reports after the game jam, add to the participant's workload and can take away from the playful learning and learning through experimentation that game jams provide [33, 62, 82]. Therefore, reports of learning are typically self-assessed by game jam participants [8, 9]. In order to determine how the SSGJ has affected participants' understanding of the application domain (in this case cybersecurity), pre-/post-tests, self-assessment, and peer-assessment can be used. Pre-/post-tests are one of the most used experimental designs in educational research to assess the effect of new teaching methods [10, 20]. This can be a one-group pre-/post-test design, or a pre-/post-test design where the results of the pre-/post-tests for a new teaching method, like learning by game design, are compared to the pre-/post-test results of a control group using an existing teaching method [78]. They have also been used in the context of serious games to assess learning outcomes after playing a serious game, with the pre-test providing a baseline to compare the test scores of the post-test against [10, 12, 42, 73]. It is also straightforward to implement both in paper or digital form, meaning it may be suitable for a SSGJ that takes a hybrid format. It provides a direct way to assess the learning outcomes of the SSGJ relating to levels of knowledge and understanding in cybersecurity [10, 12], and confidence in key cybersecurity skills [13, 31]. Besides obtaining knowledge, learning meta skills (e.g. socialising) and experiences of learning in game jams is also important, in particular from the perspective of motivation. These learning experiences in game jams can drive future learning and have a positive impact on self-efficacy [9, 63]. Confidence in key skills is an important aspect of the learning experience [13]. The Student Instrument for measuring Confidence in Key Skills (SICKS) [13] can be used for a quantitative measurement of confidence regarding cybersecurity and game design knowledge and skills. The SICKS measurement assesses confidence levels of students across six variables corresponding with key skills in education. For the evaluation of the SSGJ, those key skills could be replaced by key cybersecurity skills identified by Georgiou et al. [31]: code practices, resources, communication, and morality.

A potential limitation of pre-/post-tests is that unlike in-process assessment, this evaluation does not depend on all of the information that can be collected during and within the different phases and activities of the Serious Slow Game Jam [90], but additional methods in the form of self- and peer assessment of serious games can be implemented to this end [61]. Peer assessment has been shown to be more effective on a team level, as opposed to on an individual level [23], and in the context of serious game research can result in participants assessing their team skills more accurately [12]. For the assessment of participants' understanding of cybersecurity during the SSGJ, feedback could be provided to the participants which would contribute to their learning experience. This has been shown to be particularly important for participants unfamiliar with game design or the domain in which it is applied [14]. This feedback could be provided by the cybersecurity experts [94] and/or by other participants through peer-review of other participants' games [40]. Troiano et al. [94] advise that for serious games, the emphasis should be on evaluating the Reality construct of TGD (in particular reality representation and contextualization), and that this evaluation should be done by domain experts. However, Hartevelde [40] stresses the importance of the player or learner being part of the evaluation. Advantages of peer assessment are that it helps participants understand their own work better, provides more immediate feedback, and improves attitudes towards the learning process [61, 87]. Therefore, peer assessment combined with feedback from experts would

be the preferred evaluation method, which has been used in computer science education and in the software development process and for code reviews (e.g. [61]).

### 2.2.2 Workload.

A review of game jams over the past twenty years [52] revealed that traditional, fast-paced game jams aim to create a game in between one and three consecutive days. Although participants are typically people with experience in programming and game design, the schedule and strict deadlines result in a high workload [26, 35, 52]. To reinforce accessibility and inclusivity, the SSGJ model aims to be a ‘no-crunch’ working environment by having session durations that are non-exhausting, and re-evaluating time pressure based on serious game design needs [3]. To evaluate this, the workload of each of the activities during the SSGJ needs to be assessed. In game jams, the workload is typically evaluated qualitatively based on observations of the game jam organizers, or interviews with game jam participants [62]. However, the NASA-TLX may be a suitable option, as it is a subjective, multidimensional assessment that rates perceived workload [38, 39] quantitatively making it more suitable for comparison, and has been widely used in complex socio-technological domains like aviation and healthcare [16] and in the domain of gaming [53, 55, 77, 97]. Alternatives to measure workload are the Subjective Workload Assessment Technique (SWAT) [81] and Workload Profile (WP) [95]. However, these are not as well established as the NASA-TLX, are less robust, and are more difficult to comprehend by participants (in particular the WP) [84].

### 2.2.3 Motivation and Engagement.

Motivation plays an important role in participating in game jams [17]. Due to the “slow” aspect of the SSGJ, participants are asked to commit over a longer overall duration than a traditional game jam [52], while the contact hours remain the same. Therefore, understanding what motivates participants to participate and return (or drop out), is important as (intrinsic) motivation is more likely to enhance performance and persistence in an activity than extrinsic motivation [86]. Like the workload, this can be evaluated qualitatively using observations, questionnaires, and interviews [17, 62, 75]. This may also be assessed quantitatively using the Intrinsic Motivation Index (IMI) [60, 85] for each day of the SSGJ. The IMI is not domain-specific and has been used to this end in user-centred HCI design studies before (e.g. [96]). To evaluate the engagement in between SSGJ scheduled days, an evaluative questionnaire with open-ended questions at the end of the SSGJ may be a good option, as this is the most common tool used to evaluate game jams [9, 52].

## 3 Methodology

### 3.1 Serious Slow Game Jam Method

Based on the requirements for serious game design, recommendations from previous serious game jams, and the limitations of conventional entertainment-oriented game jam format identified in Section 2, we have proposed a Serious Slow Game Jam (SSGJ) methodology [3] which provides a multidisciplinary collaborative framework for serious game design, putting participants and experts at the centre of the design. It provides mentorship by application domain and game design experts to support participants, to support the value and validity of outputs, and to provide a structured, accessible, and educational experience. The SSGJ methodology differs from similar methods such as Quantum Game Jams (QGJ) [50] and Depth Jams [43]. QGJs address the need to introduce and present the application domain as well as the discipline of serious game design, but the participants are either experts in the application domain or in game design, and the QGJ format is particularly suited towards experienced game jammers. The ‘meaning’ aspect of Triadic Game Design is also not explicitly represented, whereas it is a crucial aspect of both process and mentorship in the SSGJ. In the SSGJ method the participants are not required to be experts in the application domain or (serious) game design, and might not have experience with game jams either [3]. Depth Jams [43] are spread over a longer period (i.e. 4 days) to allow time for reflection and refinement, but the participants are all game developers and focus is on refining (aspects of) an already

existing game, whereas the SSGJ focuses on ways to rigorously define learning outcomes and then select and map appropriate game mechanics to deliver them. Although the SSGJ method is applied here to the application domain of cybersecurity, it is intended to be flexible and generic so that it can be used irrespective of application domain [3].

The SSGJ methodology falls under the wider category of ‘applied game jams’, which are defined as “game jams that explore a range of different topics, issues, and objectives through game development” [80]. For this reason, we have adopted the applied game jam framework [80] which involves investigation of four aspects: the problem space, the jam design, the jam delivery and its outcomes, and any follow-on opportunities.

### 3.1.1 Problem space.

In terms of the problem space, the aim was to enhance participants’ understanding of the application domain, in our case cybersecurity, and reflect on the serious game designs [3].

### 3.1.2 Serious Slow Game Jam Design.

The game jam design is discussed in terms of the shared game jam design parameters [21, 28] identified in the literature and discussed in Section 2. The **Theme** is guided by domain expert mentors and structured educational materials. These are included in the SSGJ toolkit to facilitate the SSGJ (see the Support parameter) [3]. The cybersecurity theme for the specific SSGJ being evaluated here, is that of secure software development lifecycles.

For the **Time** design parameter, emphasis is on accessibility and inclusion, aiming for a non-crunch working environment with non-exhausting session durations for each day of the SSGJ [3, 49]. Based on lessons learned from previous serious game jams [6], the SSGJ is structured into three phases in the serious game creation lifecycle (i.e. design, development, and pre-release), consisting of two work days each, resulting in six days in total (see Table 1). The first phase consists of an introduction to the application domain and TGD. During this introduction phase presentations by domain experts, a deck of Cybersecurity, Learning Mechanics, and Game Mechanics cards (describing concepts within each topic, and are used throughout all days of the SSGJ), and a small provoking game are introduced to kick off discussions about the application domain. Phase two covers the design of the serious game loop and prototype design, and phase three covers the development of the serious game prototype and other deliverables. There is ample time in between each of these phase for reflection, feedback, and refinement (2 weeks), resulting in an overall duration for the SSGJ of 5 weeks [3].

For the **Location** parameter, due to the timing of this SSGJ which took place in spring 2022, the COVID-19 pandemic at the time, and the diversity of our target group, we wanted to see if we could run the SSGJ in a hybrid format, where participants may be in-person or synchronously online to prioritize inclusivity and accessibility [3].

For **Participation and Teams**, we followed recommendations from the literature [27] with the organizers of the SSGJ creating teams based on self-identified roles collected during participant registration. Where serious game research is an intended outcome, explicit inclusion of both domain experts and serious game designers as participant-mentors allows for the delivery of high-quality support materials (see [6, 25, 76]), guidance in framing the SSGJ theme [76], supporting and contextualizing domain related material, and validating its inclusion in the serious game [3]. Application domain experts in game design and cybersecurity rove between teams, to enhance contact and knowledge exchange between experts and participants [6, 76].

In addition to in-person communication and collaboration, **Technology** in the form of Discord [45] is used for online communication and Miro [66] with structured activity worksheets for online collaboration. Due to the wide and diverse skill set of the target audience, there are no limitations imposed for game platforms [3].

Regarding the **Support** of participants, the SSGJ methodology includes guided educational group activities, supported by physical and digital materials in the SSGJ toolkit [3]. The TGD method [41] is used to inform and guide participants with respect to serious game design. We propose this will result in strong learning outcomes for participants as well as serious game prototypes that have high rigour and domain validity [3]. The SSGJ toolkit to support the SSGJ includes presentations of domain experts, a provocative game [2], Miro boards [66],



Table 1. SSGJ structure showing time (in minutes), milestones, and evaluation activities.

Phase	Activity	Rationale	Procedure	Duration (minutes)
Prep	Participant information sheet	Inform participants	Online registration	5
	Informed consent form	Inform consent	Online registration	5
	Demographic Questionnaire	Participant profiles	Online registration	5
	Adjusted IMI	Motivation pre-SSGJ	Online registration	5
1	<b>Day 1:</b> Introduction to cybersecurity through provocative game and expert presentations. Introduction to TGD. TGD Reality session where cybersecurity issues the games will address are identified using the cybersecurity cards.			
	Pre-Test Questionnaire	Assess understanding.	Discord	10
	TLX: Day 1 (See Table 3)	Measure workload	Paper / Discord	4 x 5
	IMID: Day1	Measure motivation	Discord	5
	<b>Day 2:</b> TGD Meaning session: suitable learning mechanics are selected using the cards. TGD Play session: suitable game mechanics are selected using the cards and matched with learning mechanics.			
	TLX: Day 2 (See Table 3)	Measure workload	Paper / Discord	3 x 5
	IMI: Day 2	Measure motivation	Discord	5
	<b>Day 3:</b> Introduction to game loops. The Serious Game Loop is designed and a paper prototype of the game is created.			
	TLX: Day 3 (See Table 3)	Measure workload	Paper / Discord	4 x 5
	IMI: Day 3	Measure motivation	Discord	5
2	<b>Day 4:</b> Participants playtest their own paper prototype. Second round of paper prototyping.			
	TLX: Day 4 (See Table 3)	Measure workload	Paper / Discord	3 x 5
	Cybersecurity Cards Questionnaire	Evaluate cards	Discord	10
	Learning Cards Questionnaire	Evaluate cards	Discord	10
	Game Cards Questionnaire	Evaluate cards	Discord	10
	IMI for Day 4	Measure motivation	Discord	5
	<b>Day 5:</b> Two development sessions to create the serious game.			
	TLX: Day 5 (See Table 3)	Measure workload	Paper / Discord	2 x 5
	IMI: Day 5	Measure motivation	Discord	5
	<b>Day 6:</b> Final development session. Self- and peer-assessment of serious game with expert feedback.			
Post	TLX: Day 6 (See Table 3)	Measure workload	Paper / Discord	4 x 5
	IMI: Day 6	Measure motivation	Discord	5
	Post-Test Questionnaire	Assess understanding	Discord	10
	SSGJ Experience Questionnaire	Evaluate SSGJ format.	Discord	30

and three decks of cards: Cybersecurity [89] (i.e. for the application domain) (Figure 1), Learning Mechanics (LM) (Figure 2), and Game Mechanics (GM) (Figure 3).

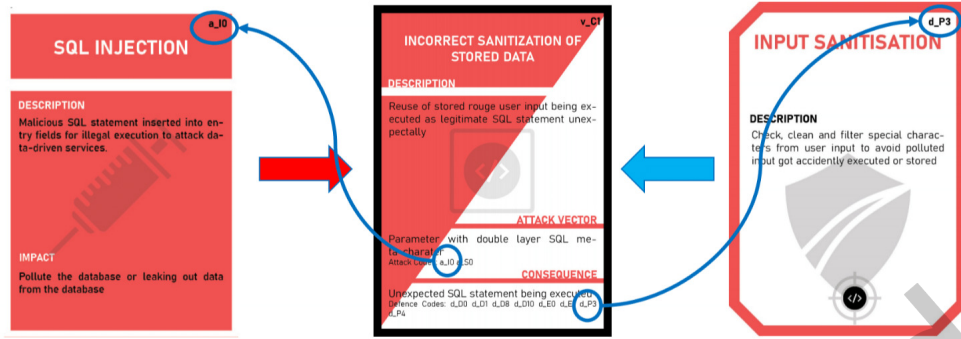


Fig. 1. Design of different types of Cybersecurity cards, with a detailed Attack card (left), Vulnerability card (middle), and Defense card (right) [89].

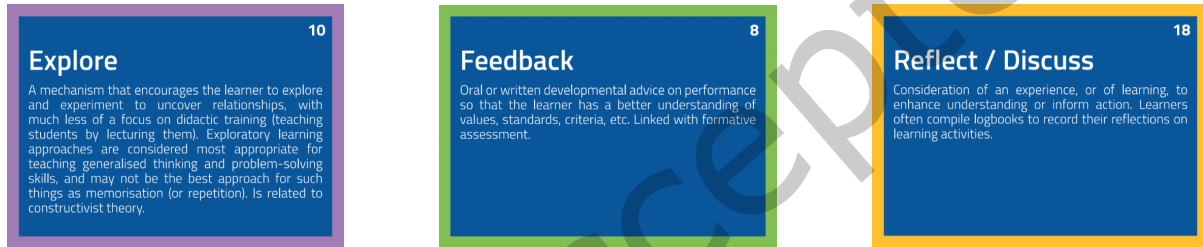


Fig. 2. Example cards of the Learning Mechanic deck based on the LM-GM framework by [54].

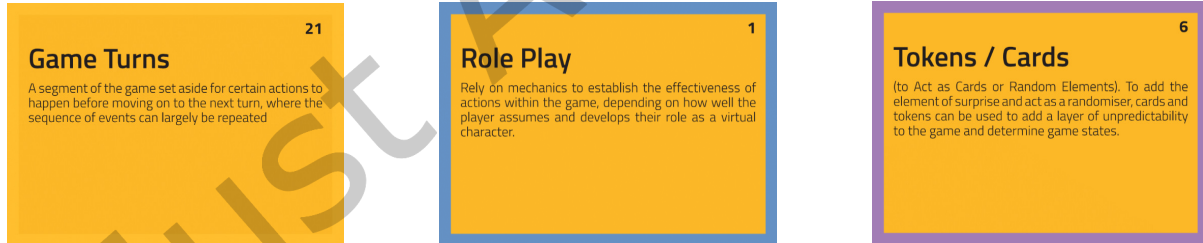


Fig. 3. Example cards of the Game Mechanic deck based on the LM-GM framework by [54].

The cybersecurity cards [89] have been developed based on CyBOK, a comprehensive body of knowledge to inform and underpin educational and professional training for the cybersecurity sector [69], while the LM and GM cards were created based on the LM-GM framework [54]. The Cybersecurity cards consist of general and more detailed Attack cards, Defence cards, and Vulnerability cards, which are related but not necessarily in a one-to-one relationship (Figure 1). The full decks of Cybersecurity cards, LM cards, and GM cards, which are part of the SSGJ toolkit, are freely available from our Secrious project website (<https://secrious.github.io/#cards>)<sup>1</sup>.

<sup>1</sup>Please note that the Secrious project website contains the final version of the Cybersecurity cards, LM cards, and GM cards, as discussed in more detail in Section 6.2 and by [89].

Informed by recommendations from the literature [21], **Deliverables** for each team include a serious game prototype, and a Serious Game Design Document (SGDD) which lays out the serious game design according to a provided template, which all SSGJ activities feed into [3].

### 3.1.3 *Serious Slow Game Jam Delivery and Outcomes.*

For the SSGJ delivery and outcomes, the aim is to provide an educational experience for participants, which is engaging, and reduces the time pressure. Outcomes of each SSGJ include (digital or non-digital) serious game prototypes, SGDDs, an analysis of each serious game prototype, the participants' knowledge and understanding of the application domain (i.e. cybersecurity), game design/development, and their confidence levels in key skills in those areas [3].

### 3.1.4 *Follow-on Opportunities.*

Through the integrated educational and analytical activities and the SGDD, the SSGJ methodology enables the subsequent additional analysis of SSGJ outputs by the researchers (e.g. pedagogical patterns suited to problems in particular application domains). The overall SSGJ methodology outputs also provides a plethora of digital and physical resources: The design of the SSGJ methodology and the SSGJ toolkit (e.g. the Cybersecurity, Learning Mechanics, and Game Mechanics card decks) can be adapted and reused freely to support future SSGJs in different application domains [3].

The theoretical context and the concept, definition, and design parameters of the SSGJ methodology, as well as their trade-offs and limitations in comparison to other types of game jams, are presented in more detail in a previous publication [3]. The focus of this paper is on a first evaluation of the SSGJ methodology as a mechanism for co-designing serious games to improve understanding of cybersecurity, and the presentation of a serious game that was co-designed with participants during a SSGJ as an output of the SSGJ methodology. Table 1 shows and outline of the SSGJ schedule and the evaluation activities, which will be discussed in more detail in the next section.

## 3.2 Evaluation Procedure for the Serious Slow Game Jam Method

Our aim is to evaluate the Serious Slow Game Jam methodology as a mechanism for co-designing serious games to improve the understanding of cybersecurity. This evaluation is guided by the research questions outlined in Section 1.1, and informed by the parameters of the SSGJ design, and the discussion of different methods for evaluating game jams in Section 2.2.

### 3.2.1 *Measuring Knowledge, Workload, Motivation and Engagement.*

Participants' level of understanding of cybersecurity and game design and development and their confidence in key skills in those areas, was collected before and after the SSGJ using a one-group pre-/post-test questionnaires (see Section 2.2.1). It consisted of seven 7-point Likert questions, with the key skills in the SICKS questionnaire [91] being replaced by the key skills in cybersecurity [31] and game design/development (see Section 2.2.1). It was administered individually online using Microsoft Forms [65] at the start of Day 1 and at the end of Day 6 of the SSGJ. A one-group pre-/post-test design was chosen over a pre-/post-test design with a control group, due to the timing and COVID-19 restrictions of the SSGJ at the time, the small number of participants recruited, and offering of an alternative teaching method besides the SSGJ not being practically and logistically feasible [78]. Self-assessment and peer assessment at team level combined with feedback from experts (see Section 2.2.1) has been chosen for the qualitative assessment of participants' understanding of cybersecurity and serious game design and development during the SSGJ. Each team first assessed their own game using the three decks of cards (see Figures 1, 2, and 3) and discussed and explained their selection to at least one of the experts. The game was

then played by another team, who also assessed it using the three decks of cards. The full decks of cards were provided in physical format and in digital format on the Miro board.

Workload was assessed using the NASA Task Load Index (NASA-TLX) [38, 39] (see Section 2.2.2). It was administered individually at the end of each activity, using pen/paper for in-person, and using Adobe Forms [5] for online participants.

Motivation to adhere and complete activities for each day of the SSGJ was measured using the Intrinsic Motivation Index (IMI) [60, 85] (see Section 2.2.3). The subscales of “effort” and “felt pressure” were removed, as these are already measured via each activity’s NASA-TLX. This does not compromise the construct validity or internal consistency for the subscales [36]. The IMI was administered individually by sharing a Microsoft Forms link via the dedicated Discord channel at the end of each day of the SSGJ.

Finally, an open-ended questionnaire was used to encourage participants to reflect on the “slow” format of the SSGJ and to evaluate their engagement between scheduled days of the SSGJ (see Section 2.2.3). It was administered individually by sharing a Microsoft Forms link on the final day of the SSGJ.

### 3.2.2 Cybersecurity, Learning Mechanics and Game Mechanics Cards.

Inspired by the SICKS [13] (see Section 2.2.1), a questionnaire to evaluate how each deck of cards was used during the SSGJ has been created. Based on input from the cybersecurity experts who designed the Cybersecurity cards and the game design experts who designed the LM and GM cards for the SSGJ, these questionnaires enabled participants to individually self-assess to what degree, if any, each deck of the cards has contributed to: providing a knowledge base (including, cybersecurity/LM/GM concepts, scope, relationships between concepts, and terminology); Independent learning and self-efficacy; Inspiration for design of the serious game; Communication with experts and others; and providing a reference point for grounding cybersecurity issues/LM concepts/GM concepts during game design and development. Items related to those aspects listed above were scored on a 7-point Likert scale (1=strongly disagree, 7=strongly agree). In addition, using checkboxes on the form, participants selected the activities of the SSGJ during which they used each deck of cards the most, the subset of types of cards within a deck they did not use, and which potential improvements to the design of the deck of cards should be made in their opinion. These three questionnaires (one for each deck of cards) were administered online by sharing Microsoft Forms link on Day 4 of the SSGJ via a dedicated Discord channel.

Table 1 shows the schedule for the SSGJ, and how the evaluation measures were integrated into the three phases across the six days of the SSGJ. Ethical approval was obtained from the researchers’ university ethics board. Participants were asked before the start of the jam to register online, this included: participant information sheet, informed consent form, demographics questionnaire and adjusted IMI to assess motivation prior to the SSGJ.

## 4 Results

In this section, the results of the evaluation of the SSGJ are presented. The findings will be discussed in Section 6. The questionnaires used in the evaluation are made publicly available via a link to the Open Science Framework digital repository: <https://doi.org/10.17605/OSF.IO/2MXDK> [92]

### 4.1 Participants

Sixteen participants were recruited on campus (Table 2). Only the data of participants that actively participated in at least 4 out of 6 days of the SSGJ have been included, resulting in data of 13 participants in 3 teams being analyzed. Due to the timing of this SSGJ which took place in spring 2022 and the COVID-19 pandemic at the time, we wanted to see if we could run the SSGJ in a hybrid format, where participants may be in-person or synchronously online. Participants were mainly there in person, but five of the participants opted to partially take part in the SSGJ online (see Table 2). Activities for each day of the SSGJ lasted from 10:00-16:00 (GMT).

Table 2. Overview of attendance during SSGJ, with maxima for participant attendance highlighted in bold underlining.

Day	Participant (In-person)	Participant (Online)	Participant (Part day)	Expert (In-person)	Expert (Online)
1	10	3	0	7	1
2	11	2	2	7	1
3	9	<u>4</u>	3	4	2
4	8	2	<u>6</u>	7	1
5	8	1	<u>6</u>	7	1
6	<u>13</u>	0	3	7	1

Participants were aged between 22 and 35 years (mean 26.3 years), (3 female, 10 male). All participants were MSc conversion students in computer science (but not in cybersecurity), and came from an electrical or mechanical engineering (7), mathematics (3), computing (2), or biology background. One participant indicated having specific experience with secure coding, two indicated having experience with gaming, and one participant indicated having intermediate skills as a game developer in Java. None had participated in any type of game jam before. During the SSGJ, an expert in cybersecurity and in game design would always be present [3]. For this specific SSGJ, at most 7 experts were present in person and at least 1 expert was present online (Table 2), and there were in total 4 cybersecurity experts, 3 game design experts, and 2 HCI experts. They would periodically go round different teams to check if they had any questions or wanted to have discussion with an expert, but the serious games were co-designed among participants (i.e. experts were not part of a team).

#### 4.2 Pre vs. Post Questionnaire

The 7-point Likert-scale data was categorized by the percentage of participants who reported they were confident (i.e. scored it 5/6/7 out of 7), neutral (i.e. scored it 4/7) or not confident (scored it 1/2/3 out of 7). These percentages were then compared pre- and post SSGJ [73, 91]. In addition, a Wilcoxon signed ranked test [7] was done to determine if there was a statistical difference between the pre- and post-test scores. The free-text answers were independently coded by two coders and grouped into themes, an analysis technique that was used in previous HCI research (e.g. [15, 67, 83]). Codes were analysed and verified by two postdoctoral researchers, one with expertise in HCI who had taken part in the SSGJ, and one with expertise in Cybersecurity who had not taken part in the SSGJ. Both are experienced in free-text coding qualitative data from questionnaires. Open discussion was used to systematically discuss and resolve the codes to reach consensus for the final coding [15].

##### 4.2.1 Cybersecurity (Pre vs. Post SSGJ).

The Wilcoxon signed rank test [7] showed participants' confidence in their knowledge and understanding of cybersecurity in the post test scores had improved significantly compared to the pre test scores ( $Z=-2.041$ ,  $p=0.041$ ). Responses relating to *Code Practices* indicated confidence in current level of knowledge and understanding of cybersecurity shifted positively from 12.5% to 62.5%. Confidence with reviewing and updating existing code regarding cybersecurity dropped from 62.5% to 50%. Responses relating to *Resources* indicated increased confidence to ask for more money or funding to improve code security from 62.5% to 75%. Responses relating to *Communication* showed confidence in raising a security issue with their non-expert manager increased from 37.5% to 62.5%. Responses for *Morality* showed confidence to bring up a security issue that will knowingly have implications for the end user increased from 50% to 62.5%. Confidence to go against your manager when volume of output is prioritized over a security issue decreased from 50% to 37.5%. Other items, such as asking for an increase in staff to improve code security, showed little change.

#### 4.2.2 Game Design and Development (Pre vs. Post SSGJ).

The Wilcoxon signed rank test also showed participants' confidence in their knowledge and understanding of game design and development in the post test scores had improved significantly compared to the pre test scores ( $Z=-2.112$ ,  $p=.035$ ). Regarding game design, confidence in current level of knowledge and understanding of game design (12.5% - 75%), and the ability to design a game (37.5% - 75%) shifted positively. Regarding game development, confidence in current level of knowledge of game development (12.5% - 62.5%), and in ability to implement a game (37.5% - 50%) shifted positively. Other items, such as teaching others about game development, showed little change.

#### 4.2.3 Free-Text Responses.

The free-text responses provided some additional insights in the quantitative data presented above. Three quarters of participants self-reported the main thing they had learned about cybersecurity through the SSGJ was the different types of vulnerabilities, attacks, and defenses: *"I learned [...], some types of attacks, defenses, and vulnerabilities"*. - (P7). Half of participants reported factors influencing cybersecurity (e.g. human factors), and almost a third mentioned the relationships between vulnerabilities, attacks, and defenses as well as terminology. There was an almost equal split between participant indicating they had learned a lot about cybersecurity during the SSGJ, and that they had not learned that much and wanted to learn more: *"[The SSGJ matched] 90% of my expectations [regarding learning about cybersecurity]. And personally I feel I have to learn a lot on cybersecurity. But the workshop has more than enough knowledge to get you started and understand cybersecurity."* - (P1). A third of participants felt the emphasis was too much on serious game design instead of learning about cybersecurity: *"Cybersecurity felt secondary to the concepts of serious games."* - (P2).

#### 4.3 Workload

The raw NASA-TLX workload data was analyzed by taking the mean value of all responses for each activity and each workload subscale [38]. The average workload values for each of the subscales can be found in Table 3, namely mental demand (MD), physical demand (PD), temporal demand (TD), effort (EFF), frustration (FRU), and performance (PER). The scores were classified as Low (1-3), Medium (3-7), Bit High (7-11), High (11-17), and Very High (17-21) [38, 74].

The highest workload came from the three development sessions in Days 4 and 5, with mental demand (MD) ranging from 15.3-17.1 and effort (EFF) ranging from 14.7-15.8. The lowest mental demand (MD = 5.5) and effort (EFF = 6.8) came from the first icebreaking and team-formation activity during the introduction on Day 1. Looking at the various subscales across all activities, mental demand (MD) and effort (EFF) are classified as "high" throughout the SSGJ, but temporal demand (TD) is only classified as "high" (TD = 11.6-12.7) during the development activities in Phase 3 (Day 5 & 6), and during Serious Game Loop Design on Day 3 (11.8). Performance levels (PER), were highest (indicating participants felt they performed badly) during the activity to extract cybersecurity metaphors from the provoking game and during the three TGD activities (Reality, Meaning, and Play session).

#### 4.4 Motivation

The IMI data was analyzed by averaging each subscale for each day of the SSGJ, and then refined further by looking at the percentage of participants who scored very highly (6/7 or 7/7) on each of the subscales (as per: [37, 46, 96]). Results in Table 4 shows that Interest/Enjoyment and Perceived Value/Usefulness are all positive ( $\geq 4.5/7$ ) on average and stay positive throughout the SSGJ, indicating the SSGJ had successfully engaged participants on the topic of cybersecurity. Perceived Competence is average prior to the start of the SSGJ, but becomes positive

Table 3. Overview of the workload for each of the NASA-TLX subscales and the average per activity of the SSGJ, with the top-5 highest values in the “high” and “very high” classifications per subscale highlighted in bold underlining.

Day	Activity	MD	PD	TD	EFF	FRU	PER
Day 1	Icebreaking & Team formation	5.5	2.8	4.2	6.8	2.8	4.4
	Playing provocative game	10.8	2.4	7.1	9.6	6.0	8.5
	Cybersecurity metaphors in game	<b><u>14.1</u></b>	3.0	10.7	<b><u>14.8</u></b>	9.2	<b><u>11.9</u></b>
	Reality session	13.8	3.9	8.5	14.0	6.1	<b><u>11.6</u></b>
Day 2	Reality session idea exchange	12.1	4.1	8.6	12.5	6.5	9.2
	Meaning session	12.8	4.1	8.9	13.7	7.3	<b><u>11.0</u></b>
	Play session	14.0	3.8	8.5	14.5	6.8	<b><u>11.5</u></b>
Day 3	SGD Document & Presentation	12.3	3.6	10.3	12.9	6.2	9.2
	Serious Game Loop Exercise	12.5	3.5	9.4	14.5	4.9	8.3
	Serious Game Loop Design	12.5	4.5	<b><u>11.8</u></b>	12.5	5.5	9.3
	Prototyping session	<b><u>14.1</u></b>	4.9	10.5	13.6	7.3	9.2
Day 4	Playtesting session	12.4	4.3	7.5	<b><u>14.9</u></b>	6.4	8.5
	Prototyping development	12.7	4.9	9.4	12.7	6.8	10.0
	Development teamwork	12.7	4.9	9.4	14.0	6.8	10.6
Day 5	<b>Development - Part 1</b>	<b><u>16.3</u></b>	6.4	<b><u>11.9</u></b>	<b><u>15.8</u></b>	8.6	9.0
	<b>Development - Part 2</b>	<b><u>17.1</u></b>	6.0	<b><u>12.7</u></b>	<b><u>14.9</u></b>	<b><u>11.3</u></b>	9.3
Day 6	<b>Development - Part 3</b>	<b><u>15.3</u></b>	4.4	<b><u>12.0</u></b>	<b><u>14.7</u></b>	8.4	<b><u>11.3</u></b>
	Deliverables Preparation	<b><u>14.4</u></b>	4.6	11.6	14.7	6.8	10.8
	Peer assessment Games	13.5	7.0	9.7	15.2	8.3	9.9
	Closing Group Presentations	13.8	4.3	10.5	14.7	6.7	8.9

on Days 2,3,4, and 6 of the SSGJ. The IMI sub-scale scores of each individual participant support the findings in Table 3, with Figure 4 visualizing very high scores on the sub-scales of the IMI per day.

Table 4. Average IMI scores for each subscale per day of the SSGJ, with very positive scores of 5.50 and over highlighted in bold.

Day	Interest/ Enjoyment	Competence	Choice	Value/ Usefulness
Pre-SSGJ	<b>5.71</b>	4.29	<b>5.66</b>	<b>6.11</b>
Day 1	<b>5.55</b>	4.37	<b>5.67</b>	<b>6.14</b>
Day 2	<b>5.54</b>	4.91	<b>5.70</b>	<b>5.85</b>
Day 3	5.05	4.72	4.79	5.41
Day 4	5.29	5.00	4.88	<b>6.17</b>
Day 5	5.00	4.39	4.88	5.48
Day 6	<b>5.60</b>	5.09	<b>5.52</b>	5.40

It shows very positive results with regards to Interest/Enjoyment, Perceived Choice, and Perceived Value/Usefulness. The SSGJ was rated very highly on Interest/Enjoyment by 50%-61.5% of participants for 4 out of 6 days, as well as

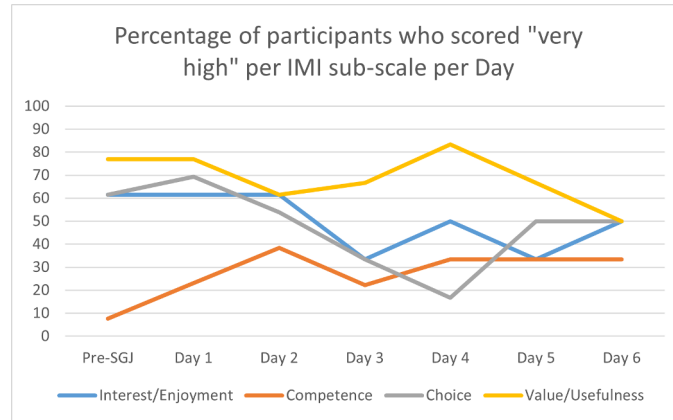


Fig. 4. Percentage of participants who scored “Very high” (6-7 out of 7) per IMI sub-scale per day.

perceived choice (50%-69.2%). Perceived Value/Usefulness is rated very high for all days of the SSGJ by 50%-83.3% of participants. The percentage of participants who rate Interest/Enjoyment very highly dips below 50% on Day 3 and 5, as well as Day 3 and 4 for Perceived Choice, but those sub-scales do stay positive on average. These days are the first day of serious game loop design and prototyping (Day 3), and the first days of creation and development (Day 4 & 5). The perceived Value/Usefulness of the activities of the SSGJ on those days remained very high though and even peaked on Day 4 to 83.3%.

#### 4.5 Cybersecurity, Learning Mechanincs and Game Mechanics Cards

The questionnaires for each deck of cards consisted of twelve 7-point Likert-scale questions, three questions with tick boxes allowing participants to select multiple pre-defined options, and four free-text responses to open questions for further clarification. The response rates were 85% (i.e. 11 out of 13 participants) for the Cybersecurity Cards and GM Cards, and 77% (i.e. 10 out of 13 participants) for the LM Cards Questionnaire.

##### 4.5.1 Cybersecurity Cards.

The cybersecurity cards provided a knowledge base for cybersecurity (see examples in Figure 1). Participants reported that they provided knowledge about individual cybersecurity concepts (90.9%), the wide scope of cybersecurity concepts (81.8%), the relationship between vulnerabilities, attacks and defences (90.9%), and terminology (63.6%). Participants reported they also provided a means for independent learning (72.7%) and self-efficacy by providing access to cybersecurity knowledge when the cybersecurity experts were not present (81.8%). They improved accessibility by acting as an interface to discuss cybersecurity topics with cybersecurity experts (81.8%) and others (63.6%) throughout the SSGJ. There were 63.6% of participants who indicated they provided inspiration for the design of the serious game. Furthermore, throughout the serious game design (63.6%) and serious game creation and development (72.7%), they were used as a reference point or reminder for ensuring the serious game stayed grounded in real cybersecurity issues (see Figure 5). The activities during which they were consulted the most were the discussion of the metaphors in the provocative game (54.5%), during the Reality session (45.5%) and Meaning session (54.5%) of TGD and during prototyping (54.5%).

##### 4.5.2 Learning Mechanics Cards.

Participants agreed that the LM cards provided knowledge about individual LM concepts (90%), knowledge about the scope of LM concepts (90%), the relationship between LM concepts such as Analyse and Evaluate (80%), and





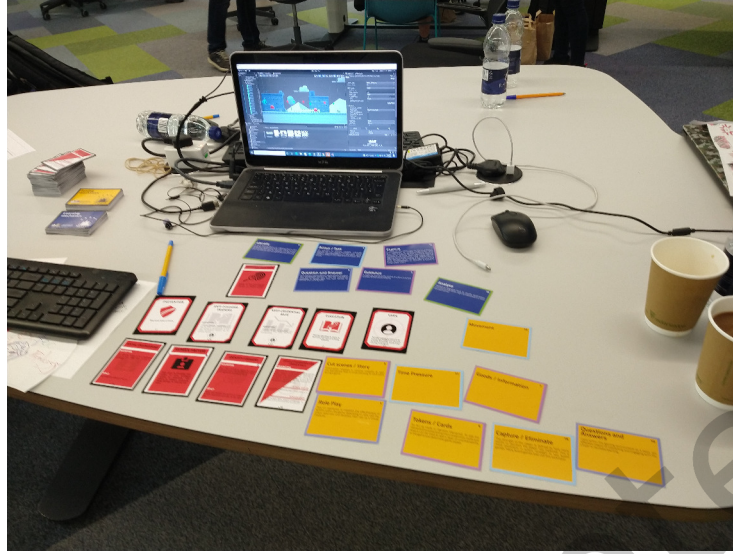


Fig. 6. Sub-selection of physical Cybersecurity cards, Game Mechanics cards, and LM cards being used as a reference point or reminder for ensuring the linkage with the serious game being created.

Cybersecurity cards and LM cards. The free-text option also indicated that almost half of the participants felt the Cybersecurity cards and LM cards limited their creativity for the design of their serious game.

Table 5. Overview of the percentages of participant selected limitations in the design of the Cybersecurity, LM, and GM cards.

Limitation	% for cybersecurity cards	% for LM cards	% for GM cards
Total number of cards is too high	45.50	50.00	27.30
Colour coding is not clear	45.50	30.00	18.20
Relationship between cards in the deck unclear	45.50	50.00	18.20

## 4.6 Assessment of Serious Games Using Cards

### 4.6.1 Self-Assessment.

Firstly, each team assessed their own game using the three decks of cards and discussed and explained their selection to at least one of the experts (see Figure 7). These discussions with the experts reflected an evolving understanding of both cybersecurity as well as serious game design, as participants could quickly, confidently, and adequately explain why certain cards were (or were not) part of their serious game design.

It also illustrated how many cards have been used the design of the serious game, which has been summarized in Table 6. It should be noted that a higher number of cards does not imply that the serious game design is better (or worse), but it does illustrate that the Cybersecurity cards played a prominent role in the serious game design.

### 4.6.2 Peer-Assessment.

The game was then played by another team, who subsequently also assessed it using the three decks of cards. A



Fig. 7. Participants selecting and discussing the Cybersecurity (red), LM (blue), and GM (yellow) cards used in their serious game design with an expert.

Table 6. Number of cards per serious game per team

Team	Cybersecurity	LM	GM	Total used
A	21	6	12	39
B	4	11	7	22
C	32	6	9	47
Total	57	23	28	108

member of the team that created the game would afterwards explain which cards matched in their opinion and which ones did not. The last column in Table 7 shows that, in comparison to the total number of cards used in the design, the number of cards selected that did not match the design according to the team who created it, is low. This indicates a high level of successful mapping of learning outcomes into the teams' games. It should be noted that it is not about a sub-selection of cards being "correct" or "incorrect", but about the discussion that occurred around this matching exercise, which provided valuable feedback from peers and experts on the design of the serious game, and how it was interpreted by others.

#### 4.7 Engagement Between Scheduled Days of the SSGJ

The response rate for this questionnaire was 54% (i.e. 7 out of 13 participants). All participants indicated they had engaged with their serious game project in between scheduled days, as a: team (57%), subsection of a team (29%) and individually (29%). Responses indicated activities such as content creation for their game (86%) and for reflection on things they had learned (29%). Furthermore, further research was conducted in: cybersecurity (57%), learning context (43%) and on games (14%). Free-texts answers clarified the amount of work participants undertook outside scheduled days of the SSGJ differed depending on the phase: *"During this SSGJ, there was a*

Table 7. Number of cards in the peer-assessment of the serious game that matched the team's self-assessment

Team	Cybersecurity	LM	GM	Total	Did Not Match
A	9/21	5/6	5/12	19/39	4
B	0/4	3/11	2/7	5/22	3
C	12/32	5/6	8/9	25/47	2
Total	21/57	12/23	15/28	49/108	9

*1-week time gap between Phase 1 day 1 and day 2. Being an introductory Phase 1 session there was not much to do during that week. So, while following the structured approach, selecting dates for the Serious Slow Game Jam are crucial. Also, there should be a one-day gap between Phase 3 day 5 and day 6. The last phase is a fast-paced event, and one extra day will help the participants a lot, to sum up and finalize their game development” – P4).*

## 5 Serious Game Output From Serious Slow Game Jam

From the SSGJ, all three teams managed to deliver a playable prototype of their serious game as an output (i.e. one digital prototype and two non-digital prototypes), as well as any supporting documentation in the form of both a rule book for their game and a Serious Game Design Document (SGDD). In this paper, we will discuss one of the serious games that was further developed by serious game design experts, from the co-designed prototypes delivered through the SSGJ methodology. This game was decided to be further developed by consensus decision, chosen by experts in serious game design, cybersecurity, and software engineering (one external expert) in the SSGJ as the most fruitful for future development.

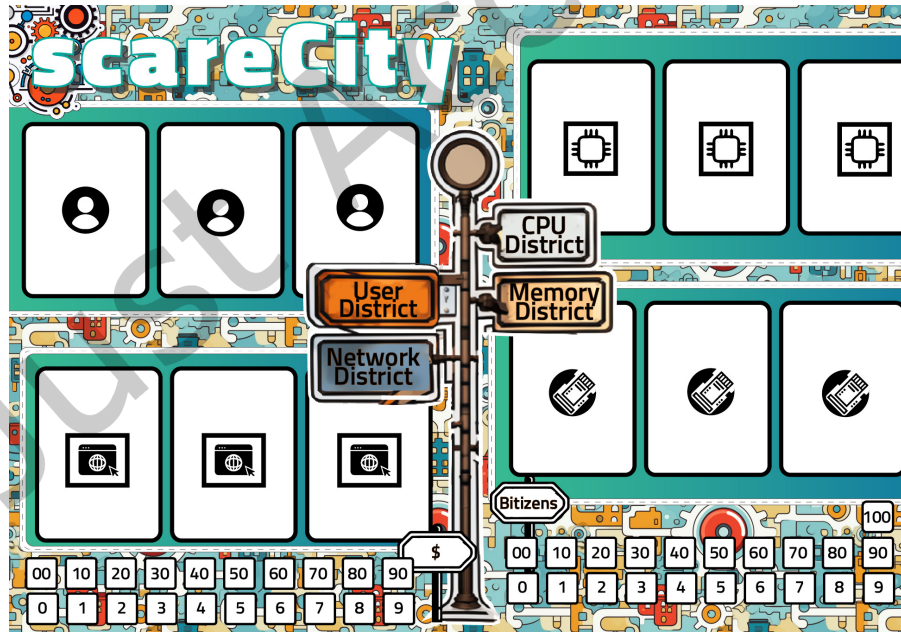


Fig. 8. The ScareCity game board showcasing the four program districts

### 5.1 ScareCity

ScareCity is a 2–4 player serious board game that is underpinned by the theme of secure software development lifecycles. This theme involves the integration of security into the software development lifecycle, coupled with additional processes such as risk analysis and security testing. In ScareCity, each player has their own game board (see Figure 8) and acts as the *mayor* of their city. The goal is to expand the city’s features through *Program Cards* to manage both the security of the city and improve the trust of its *Bitizens*. Program cards can be abstracted to strategic security decision making (i.e., implementing defences), and fall into one of four *Districts*: CPU, Network, User or Memory. During the game, before the end of each round, *Impact Cards* are drawn which are akin to security attacks or defences, which either cause havoc to the player’s program cards (causing them to degrade) or may bring benefits (i.e., increasing the number of bitizens). Examples of both *Program* and *Impact* cards can be seen in Figure 9. The first player to reach a total of 200 *Bitizens* wins the game.

Linking back at the theme of secure software development lifecycles, the goal of the game is to implement security into the player’s city (programs), with aspects such as risk analysis and security testing done through analysing the available program cards to minimise the potential for serious impacts to a player’s programs. The game also highlights the trade-offs that are often required to be made by cybersecurity experts due to limited resources. From this game design, it is clear that participant’s in the Serious Slow Game Jam also successfully met the jam’s intended learning outcomes regarding serious game design - understanding the importance of the three aspects of Triadic Game Design [41] evidenced by appropriate usage of reality, meaning and play elements during design.

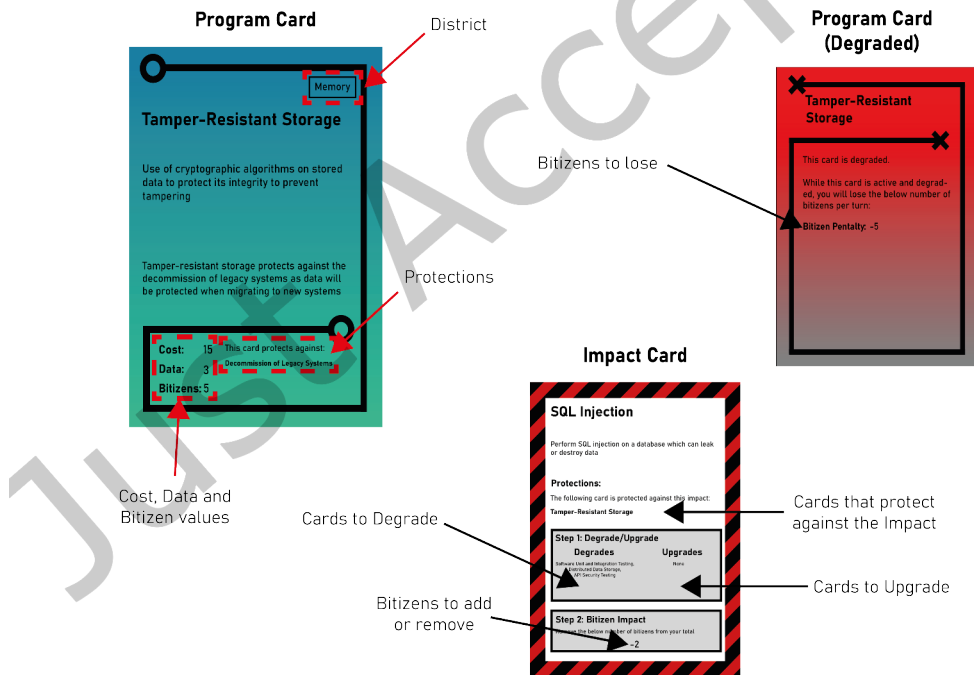


Fig. 9. Example of ScareCity Program and Impact Cards

The serious game ScareCity, including the game board, the Program- and Impact cards, and a detailed rule book, as well as other serious games produced as outputs of the SSGJ methodology, are all freely available from



our Secrious project website (<https://secrious.github.io/#seriousgames>). It should be noted that a full, detailed evaluation of the serious games, that are produced as outputs of the SSGJs, with the target audience, is outside the scope of this paper, but is the focus of future work.

## 6 Discussion

This paper presents a first evaluation of the SSGJ methodology. The aim of this research is to evaluate how this SSGJ contributed to improving the understanding of cybersecurity for people who have little or no knowledge of cybersecurity. To investigate this, we were guided by the research questions in Section 1.1. We will now use the results to reflect on each research question in turn.

### 6.1 RQ1: How has the SSGJ affected participants' understanding of cybersecurity?

The SSGJ has contributed to improving participants' confidence in, and understanding of, cybersecurity, and insight into where their skills may be lacking. The assessment of the serious games using the three decks of cards presented in Section 4.6 showed that participants were able to assess their own serious game design using the cybersecurity cards. Discussion of their card selection with experts showed that they could effectively explain why certain cybersecurity cards were (or were not) part of their game design. Secondly, participants were able to communicate their knowledge of cybersecurity to others by relating cybersecurity concepts to elements in their game, as presented by the serious game output ScareCity in Section 5. Thirdly, participants were also able to successfully match cybersecurity cards to the serious game design of another team of participants, as results in Table 7 in Section 4.6 show. Matching all cybersecurity cards would be difficult though, as it also depends on how abstract the in-game metaphor is, the interpretation of the participant, and metaphors can be interpreted in multiple ways, as interpretive flexibility is an element of serious game design [2, 88].

The SSGJ also contributed to confidence in key skills regarding cybersecurity. Increased confidence levels in skills has been shown to be particularly key for motivation, as it can drive future learning and have a positive impact on self-efficacy [9, 13, 61]. Instances where confidence decreased (e.g. updating and reviewing existing code) indicated areas where confidence may have been inflated or perhaps unrealistic, and the process of the SSGJ has allowed participants to reassess and find areas in which they may need improvement. This is supported by the literature, which shows that participants with less experience in cybersecurity were more willing to acknowledge their mistakes and lack of expertise in their skills and decision-making processes while managing threats in a cybersecurity game, compared to experienced cybersecurity experts [30]. Almost half of participants indicated they had learned a lot about cybersecurity, but also almost half indicated that they had not learned much about the topic and wanted to learn more. Therefore, the SSGJ provided a starting point and triggered curiosity to learn more about cybersecurity. The divide between the participants was due to the skills and expectations of individual participants prior to the SSGJ [3], and indicated that the balance between game design and learning about cybersecurity, in particular for some of the activities in the last phase of this specific SSGJ, could be improved.

In addition, the results of the pre-/post-test in Section 4.2 indicated not only an improved confidence in participants' knowledge and understanding of the application domain of cybersecurity, but also an improved confidence in participants' knowledge and understanding of (serious) game design (from 12.5% to 75%). This was supported by the participants' ability to assess their own serious game and assess another team's serious game using the three decks of cards as presented in Section 4.6. This indicates that for the participants in the SSGJ, who had no or limited experience in game design and development, the SSGJ contributed to a better understanding of (serious) game design and development. This is in line with findings by [8], who found that learning the process of developing a game is one of the main benefits of a game jam. This is an important finding, as for a serious

game design to be effective, there needs to be a balance between the three TGD constructs of Reality, Meaning, and Play [94].

A potential limitation of the one-group pre-/post-test results in the evaluation of this particular SSGJ, is that there is a possibility the difference in pre- and post test scores regarding participants' confidence in keys skills in cybersecurity and serious game design and development could partially have been caused by something other than participation in the SSGJ. This was mitigated by the qualitative evaluation of participants' knowledge and understanding of cybersecurity and serious game design and development during the SSGJ. This includes identifying cybersecurity metaphors in the provocative game and serious game design using TGD in Phase 1, the self assessment and discussion of the cybersecurity, LM and GM card selections with experts for their own serious game, and the peer assessment of another team's serious game in Phase 3, as can be seen in Table 1.

## 6.2 RQ2: How can the cards for the application domain (in our case Cybersecurity cards), Learning Mechanics cards, and Game Mechanics cards that are part of the SSGJ toolkit, assist in serious game design?

The intended role of the Cybersecurity cards, LM cards, and GM cards in the SSGJ toolkit, was to act as design tools and provide a knowledge base regarding the application domain and serious game design in the first phase of the SSGJ [3], and assist in the assessment of the serious games in the third phase of the SSGJ. However, regarding the design of the serious games, it was observed that the cybersecurity cards assisted in the design of the serious game in all three phases of the SSGJ, rather than participants' personal experiences with coding or with cybersecurity. As shown by the results in Section 4.5, the cards contributed to the SSGJ by providing a knowledge base for individual Cybersecurity, LM, and GM concepts and terminology, enabled independent learning and self-efficacy for when the experts were not present, and improved accessibility by acting as an interface for discussion. They also acted as a reminder to link and ground the serious game design in Cybersecurity, effectively mapped to LM and GM mechanics, which has been shown in the literature to be important in order to create an effective serious game [2, 40, 41, 54, 94]. However, the cybersecurity cards do not provide a complete overview of the domain and therefore could potentially limit the design of the serious games to the breadth provided by the deck. In fact, the cybersecurity cards and LM cards were sometimes challenging for participants to understand, and were both mentioned by participants as limiting their creativity for serious game design. This is unsurprising as a serious game needs to be grounded in the application domain and achieve the learning outcomes using learning mechanics, while an entertainment game does not have such restrictions. Furthermore, following the feedback from participants on the design of the Cybersecurity cards and LM- and GM cards presented in in Section 4.5.4, the design of those decks of cards will be improved accordingly [89].

## 6.3 RQ3: What are the Workload and Motivation levels of participants during the SSGJ?

In comparison to traditional, fast-paced game jams, which have a high workload and temporal demand [26, 35, 52], the SSGJ aimed to reduce the time pressure. Based on the NASA-TLX data presented in Table 3 it can be concluded that the SSGJ method has succeeded in this aspect. The mental demand is the highest for the three development activities on Days 5 and 6 (MD = 15.3-17.1), which is supported by free-text clarifications indicating participants found the developments activities the most challenging. This is not a surprise, as developing a game is an inherently high-mental workload task [11]. Temporal demand (TD) was only considered "high" (11-17) during the Serious Game Loop design in phase 2 (Day 3) and during the development activities in phase 3 (Day 5 & 6) of the SSGJ, with the final deadline of the SSGJ in sight. This may partially be related to participants' inexperience with those activities, which is a useful insight from a planning perspective. It indicates that participants may need additional breaks and support during these sessions to offset the fatigue from increased workload. However,

temporal demand was not high for 15 out of 20 SSGJ activities (see Table 3), meaning the SSGJ managed to reduce the constraint of time pressure for most of the SSGJ.

Motivation levels reported in Section 4.4 indicate the SSGJ managed to engage people in software security concepts. Average levels of the subscale Interest/Enjoyment (5.00-5.60), and Perceived Value/Usefulness (5.40-6.17) were positive for all days and phases of the SSGJ. Interest/Enjoyment was even very high on average for Days 1,2,6, and Perceived Value/Usefulness was very high for Days 1,2,4. Perceived Choice was also very high on Days 1,2,6, and above average on Days 3-5. The latter overlaps with the days that temporal demand was the highest (see Workload results in Section 4.3). This appears to be partially related to obligations participants had outside the SSGJ, as participants during the SSGJ reported having coursework deadlines around those days that they prioritized. This is supported by the highest number of participants (4 out of 13) who chose to participate online instead of in person which occurred on Day 3, as well as the number of participants (6 out of 13) who skipped (part of) the day on Day 4 and Day 5 (see Table 2). The average Perceived Value/Usefulness of the activities of the SSGJ on those days remained positive though, and the percentage of participants who ranked the Value/Usefulness very high even peaked during that time period on Day 4 to 83.3%. This is important, as it was during these days of the SSGJ that the serious games started to take shape.

As identified in the literature in Section 2.2, there is a gap in establishing a universal method with which to evaluate game jams against their intended outcomes [80]. One of the aims of the SSGJ methodology was to engage participants in the application domain, and reduce the workload in particular in terms of time pressure. However, workload and motivation levels are typically not quantitatively and systematically evaluated for game jams in a way that enables comparison, but are often based on observations of game jam facilitators during the game jam, or qualitative questionnaires and interviews with game jam participants regarding their game jam experiences afterwards [17, 62, 75]. As a result, there is no baseline for traditional, fast-paced game jams to compare the results regarding workload levels and motivation levels of the SSGJ methodology to. By systematically and quantitatively evaluating the workload after each activity of the SSGJ using the NASA-TLX [38, 39], and the motivation levels at the end of each day of the SSGJ using the IMI [60, 85], a contribution of this research is that it provides other researchers with an evaluation protocol to measure workload and motivation levels for their game jams, and provides a benchmark for both workload and motivation levels in other types of game jams to be compared against.

The SSGJ presented in this paper was organised as a hybrid event due to timing and COVID-19 restrictions at the time. This SSGJ took place in Edinburgh (United Kingdom) over a period of 5 weeks in May and June 2022. Local government guidelines on the Covid-19 protocol [34], which provided guidance on reducing risks from transmitting Covid-19 were followed, and made it possible to organise in-person events. Participants were therefore able to choose if they wanted to participate in the SSGJ in person or synchronously to prioritize inclusivity and accessibility for our diverse target group [3]. It was observed that the online participants engaged less with their team members and the SSGJ as a whole, and were more likely to miss part of the scheduled day. These findings are in line with findings in the literature on online events which were conducted during the COVID-19 pandemic and reported low turnout rates and low commitment effort of participants (e.g. [31]). Online participants in game jams in particular have been shown to interact less with other participants, would prioritize obligations outside the game jam, and had a tendency to work alone [22]. It also hampered the progress of teams on days when too many team members attended online instead of in person (e.g. by hampering the natural flow of feedback or taking too long to respond to questions). We therefore recommend participation in person rather than online. In addition, we recommend splitting participants over fewer teams with four or more participants at the start of the SSGJ, to be more resilient to absences.



#### 6.4 RQ4: How has the “slow” format of the SSGJ affected participant engagement?

The “slow” format of the SSGJ impacted the learning experience in several ways. Besides reducing time pressure, results in Section 4.7 show the “slow” format also encouraged engagement in-between scheduled days of the SSGJ. Participants engaged by actively creating content for their serious game, reflected on things learned during the SSGJ, and conducted further research in cybersecurity, learning context, or games. In addition, they indicated they would like to continue working on their serious game after the SSGJ had finished. However, spreading the SSGJ across multiple weeks also makes recruitment for a SSGJ challenging, as potential participants struggle to commit full-time (from 10:00-16:00 GMT) on all scheduled days. Coursework deadlines, work obligations, differences in time zones (for online participants) and childcare responsibilities were mentioned as reasons for this. The flexibility and accessibility provided by the SSGJ format made it possible in some instances to work around this as it enabled participants to make up for lost time and catch up with the rest of their team between scheduled SSGJ events. However, we recommended scheduling the days of the SSGJ in such a way that it fits the requirements of most participants outside the SSGJ. Finally, results in Section 4.7 particular to this specific SSGJ, show the “slow” aspect needs to be better balanced with the pace and perceived workload of the activities in various phases. The Days 1 and 2 in Phase 1 with the introduction to cybersecurity and TGD can be scheduled closer together, while more space for content creation and refinement is needed between Days 5 and 6 for the development of the serious game prototype in Phase 3.

#### 6.5 Limitations and Reflections

This paper has presented a first evaluation of the Serious Slow Game Jam (SSGJ) methodology. A potential limitation is the relatively small sample size of 13 participants spread over three teams participating in one SSGJ. In addition, all participants were MSc conversion students in computer science (but not in cybersecurity). Therefore, although we believe the presented findings for the evaluation of this specific SSGJ hold true for the SSGJ methodology in general, additional SSGJs with participants from different demographics are needed to validate these findings [93]. Furthermore, it should be noted that although the response rates for the various questionnaires throughout the SSGJ was high (i.e. 54%-100%), given the small sample size of 13 participants this could sometimes translate into a low real count in terms of number of participants. However, all results from the questionnaires are based upon the responses of 10-13 out of 13 participants, except the SSGJ Experience Questionnaire, which was the last questionnaire that was administered, and was administered after the SSGJ had finished. It had a response rate of 54%, meaning it was returned by 7 out of 13 participants.

As outlined in Section 3.1.3, for each team of participants, the outcomes of the SSGJ include a playable (digital or non-digital) serious game prototype, an accompanying rule book, and a SGDD. Although the resulting co-designed serious game prototypes are playable, further refinement and development by the serious game design experts might be necessary, in particular if a non-digital serious game prototype is to be translated into a digital serious game. The SSGJ methodology aims to enhance participants’ knowledge and understanding of the application domain, as well as produce playable serious game prototypes as an output. However, if the aim is to simply produce serious games for a given application domain, other types of game jams might be more suitable. Finally, as already discussed in more detail by Abbott et al. [3], running a SSGJ involves a significant commitment of time and resources from the organizers and experts as well as the participants. Also the challenges for recruiting participants, especially from mixed backgrounds and facing different accessibility barriers, should not be underestimated. Therefore, it is recommended, mainly for logistical reasons, that the SSGJ should be targeted to, and integrated with, formal or informal educational or continuing professional development programmes [3].

## 7 Conclusion

This paper has presented a first evaluation of the Serious Slow Game Jam (SSGJ) methodology, by evaluating a SSGJ as a mechanism for co-designing serious games in the domain of cybersecurity. The aim was to evaluate how this SSGJ contributed to improving the understanding of cybersecurity. To this end, we engaged 13 participants for 6 days over a 5-week period, into a multidisciplinary SSGJ involving domain-specific, pedagogical, and game design knowledge, and encouraged engagement in-between scheduled days of the SSGJ. The SSGJ provided support and mentorship from game design experts and cybersecurity experts throughout, while at the same time retaining the co-creation and supportive ethos of the traditional, fast-paced game jam. The confidence of participants improved (from 12.5% to 62.5%), and they reported that the SSGJ experience improved their understanding of cybersecurity, specifically in terms of vulnerabilities, attacks, and defenses. Also the confidence of participants improved (from 12.5% to 75%) for serious game design and development. The findings and resulting discussion in this paper provide useful insights into how the different aspects of the SSGJ, including the different phases and activities of the SSGJ and the different elements of the SSGJ toolkit, have contributed to enhancing understanding of cybersecurity and game design. As the SSGJ is intended to be flexible and applicable across multiple domains, these insights can be useful to researchers in the wider HCI community who are interested in using SSGJs to co-create serious games to improve understanding in other application domains. The findings regarding the workload and motivation levels of the SSGJ also provided a baseline for workload and motivation levels for other (types of) game jams to be compared against. The SSGJ format worked well in engaging participants in between scheduled days of the SSGJ, but the schedule for upcoming SSGJs will be slightly modified to better balance it with the pace of the SSGJ activities. Looking forward, we recommend in-person participation for the SSGJ, as in the hybrid format there was less active contribution from online participants who were also more likely to drop out. We will continue to use Serious Slow Game Jams as a mechanism to co-design serious games to improve the understanding of different themes within cybersecurity, focusing on code security, API security, and the security lifecycle. We believe the presented findings not only hold true for the specific SSGJ evaluated in this paper, but hold true for the SSGJ methodology. Therefore, those SSGJs will be evaluated following the same evaluation methods and evaluation procedures for the SSGJ methodology as outlined in Sections 2.2 and 3.2 to validate the findings presented in this paper, and investigate the usefulness and suitability of the SSGJ methodology for different target demographics. This will also allow the investigation of the potential effect of various participant backgrounds and skill sets on the learning outcomes. In addition, exhibitions for different audiences (i.e. cybersecurity-, HCI- and game design experts as well as the general public) will be organized to showcase the SSGJ toolkit and outputs. During these exhibitions, the serious games that have been co-created during our SSGJs will be played by their target audience, to evaluate their effectiveness to improve the understanding of cybersecurity for people who have little or no knowledge of cybersecurity.

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# PW10

## A Model for Mapping Serious Game Mechanics to Pedagogical Patterns

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# A Model for Mapping Serious Game Mechanics to Pedagogical Patterns

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**Abstract.** Pedagogical patterns facilitate the transfer of expert knowledge in teaching and learning. They are used to scaffold learning design for a particular purpose. Designing games for learning is a challenging, resource intensive, and inherently interdisciplinary activity. In this paper, we map the mechanics of twelve co-designed serious games in the domain of cybersecurity onto conceptually similar pedagogical patterns in order to identify fruitful common approaches and facilitate knowledge exchange. We present our methodology for this mapping process and provide examples for its usage to improve the quality and accessibility of serious games design.

**Keywords:** Pedagogical Patterns · Serious Games · Cybersecurity · Learning Mechanics · Game Mechanics · Game Based Learning

## 1 Introduction

Pedagogical Patterns (PPs) are a method of capturing and disseminating expert knowledge in teaching and learning, in the form of a reusable solution to a particular problem. They grow from the concept of design patterns and pattern languages more generally, which are common in computing disciplines. PPs offer a format and process for sharing successful teaching techniques, whilst allowing freedom of implementation to fit the needs of individual teachers [8, 12]. There has been little work addressing the potential advantages of utilising PPs in the analysis and design of serious games - either in terms of employing a PP mapping directly, or in discussion of methodologies for conducting such a mapping activity. Bridging this gap between pedagogy research and serious games design may lead to improved learning and gameplay outcomes from serious games, as their inherent interdisciplinarity is a challenge noted in recent literature [32, 2]. Therefore, a mutual understanding and interplay of concepts and language from serious game design processes (such as the Learning Mechanic - Game Mechanic (LM-GM) model [22, 5]) and PPs is a necessary step towards allowing serious game designers and researchers to take advantage of pedagogical patterns research. This would allow a more structured method to share and implement



learning designed through serious and also afford another avenue for researchers to analyse the learning being created during serious game design.

In this work we present an analysis of a research project case study comprising twelve co-designed serious games from three distinct game jams focussed on games for cybersecurity. PPs have been applied to assist educators in computer science generally [7], but there is less evidence of this approach being undertaken outside of computing. No work has been identified to date on applying PPs to cybersecurity pedagogy. Gameplay and content of each co-designed game is analysed using the LM-GM framework and each game is then mapped onto pre-existing PPs, as defined by Bergin *et al.* [8]. The goal of this pattern matching is to investigate particular types of PPs that can emerge from serious game design, therefore serving as a foundation on which future researchers, designers, and game jam organisers can base their expectations and understanding of the pedagogy embedded within serious game designs. Furthermore, we present our process for this mapping activity and provide a mapping of concepts and language from the LM-GM model [22, 5] to the PPs format [8], thus providing common ground for communication between these two disciplines. Finally, we offer recommendations, based on our experiences, for further work that could improve collaboration processes and outcomes by the different disciplinary experts involved in serious game design.

## 2 Background

PPs can assist with teaching and learning technical subjects in particular, and their benefit is not restricted to a Higher Education context; they have also been applied in various training scenarios. PPs have a consistent structure comprising: Title; Context; Key Problem; Solution; and Further Information (including examples) [8]. Relationships with other PPs are included throughout these sections where relevant. Patterns are categorized in different groups: e.g. Active Learning, Feedback, Experiential Learning, Gaining Different Perspectives, and Teaching From Different Perspectives to aid educators in selecting and linking suitable techniques, and guidance is offered on how each pattern can be used at different timescales from minutes to an entire course [8]. Furthermore, Bergin *et al.* identify the opportunity for relating several patterns within a common problem space as a resource for solving complex problems, and actively solicit further contributions [8]. The literature notes that patterns are useful in scaffolding the solutions to multidisciplinary problems and enabling the swift articulation and transfer of expert knowledge to novices.

Patterns exist for many learning contexts, often needing to be specialised for particular disciplinary or industrial uses, for example, software design and security patterns [26]. For game making, game design patterns have been extensively studied since the early 00s in an attempt to formally document gameplay [9], game mechanics, and non-player character (NPC) interactions [21]. Game design patterns are generally not presented as individual gameplay elements but

provide designers with a set of interrelated connections, causal relationships and structures that can be used as building blocks towards the design of new games. Whilst not focused on pedagogy, the game design pattern approach is directly relevant to the PP approach proposed in this article. There is a need for development of PPs for specific topics and to move beyond PPs in classrooms to facilitate learning in a wider context, such as through professional practice.

Cybersecurity (the application domain of the serious game designs to be discussed in this paper) is an increasingly complex problem, in particular as a wider and more diverse group of people become creators and users of software, often without any training and operating outside the software industry. “Security is an abstract concept which combined with the dematerialized world of software systems is difficult to grasp, comprehend and experience” [13]. Cybersecurity combines technical, theoretical, professional, human, and social factors [23] and developing both skills and attitudes towards security is equally complex. Georgiou *et al.* [13] note the swift evolution of the subject and its related disciplines, a lack of technical, time, and expertise resources leading to poor coverage of cybersecurity in university-level programmes [15, 11], and the need for (and challenges of) acquiring crucial practical skills [25]. Perhaps due to some of these challenges, computer science and cybersecurity as disciplines have been quick to adopt developments in teaching and learning, such as gamification and game-based learning. Whilst gamification aims to increase motivation through rewards (for example, points, digital badges, and/or leaderboards), game-based learning relies on the combination of interaction mechanics related to pedagogy with those related to games to create Serious Game Mechanics, i.e. a “design decision that concretely realises the transition of a learning practice/goal into a mechanical element of gameplay” [5]. In this way ‘serious games’ (games which have an educational or training purpose) can not only model large complex systems but also increase a player’s understanding of, and confidence within, that system [10] whilst moving towards defined pedagogical goals.

Therefore, coding, software engineering in general, and cybersecurity specifically have been the topics of a wide range of recent game interventions from coding apps for young children [1], to gamified ‘Catch the Flag’ contests [29], to a fully-fledged game for developer-centred security [24], for example. However, despite evidence of rigour in the development of game-based learning for cybersecurity, there is little research linking game design decisions and Serious Game Mechanics (SGMs) with PPs to aid in their re-use for similar problems across the wider cybersecurity teaching and learning community. A number of papers consider design patterns or PPs in digital learning generally or in computing science topics such as programming (e.g. [18]) without specific reference to cybersecurity. In 2012, studies discussed the current state and value of design patterns in security and proposed a PP to translate remediation techniques into a pedagogically friendly format to address the adoption challenges faced by Malware incident responders [26, 27]. The authors also conclude that “in or-

der for the pattern template and pattern knowledge repository to stay relevant, they should be maintained and updated by an open community of practitioners from the academia, security industry and security incident response practice” [27], however no more recent work on this topic has been identified. One recent study, focused on teaching computing science in general, noted the fruitful opportunity to map design decisions of a learning platform to PPs [31] but did not attempt this mapping and mentioned cybersecurity only briefly. Therefore, cybersecurity pedagogy and/or workplace training provides a useful and suitable context for this research.

In terms of game-based or gamified approaches, Hauge *et al.* note the potential for re-use of SGMs as design patterns driven by pedagogy [17] and there is evidence of studies which link PPs with sustainability in engineering [28] and professional training for accident prevention [6] but, until Georgiou *et al.* [13] no research linking PPs with a game-based approach in cybersecurity was identified. This paper defined ‘secure code’ mechanics based on attacks and mitigations around several cybersecurity themes. These were presented to workshop participants alongside selected gamification mechanics with the addition of learning elements and used to co-design game ideas for cybersecurity which mapped the secure code mechanics to suitable game elements. The authors note the centrality of pedagogical aspects to both cybersecurity as a discipline and in designing games to increase awareness and practice of secure coding [13] and present an abstracted design composition for cybersecurity games based on the co-designed game elements. This pattern was then analysed using the LM-GM framework for serious game design [5] and the resulting SGMs were presented, those that arose from the gamification toolkit used within the workshop and those that were generated by original participant contributions. This work provides a robust basis for building on by identifying SGMs created in a co-design process for cybersecurity games, mapping them to existing PPs, and reflecting on patterns that are potentially a good fit for this specific problem space. Therefore, this paper builds on the previous study’s findings and resources by using new data from serious game jam co-design events to: 1) broaden the identification and analysis of SGMs for cybersecurity beyond gamification and into game-based learning; 2) deepen the emphasis on pedagogical aspects of design; 3) map co-designed SGMs to PPs; and 4) produce recommendations for PPs for teaching and learning specific cybersecurity issues through game-based approaches.

### 3 Methodology

To improve multidisciplinary concept mapping and communication around the design of serious games, our methods also spanned disciplines. The relationships between pedagogical patterns, the LM-GM framework, a game jam method including Triadic Game Design [16], and our method of analysis are outlined below.

### 3.1 Serious 'Slow' Game Jam Method

The game jam format used to co-design the serious games discussed in this paper was the 'Serious Slow Game Jam' (SSGJ) [3]. For full details of the game setting and methodology, see this publication. This approach intended to ameliorate some of the key barriers to entry often found in traditional game jams, and added additional support and resources to reinforce and support the 'serious' aspect of the game jam. The SSGJ aimed to remove the main barrier of intense time pressure (the majority of traditional game jams take place over a 24-48hr period [20]), instead running over 5/6 working days spread over a 6-8 week period. Furthermore, participants are extensively mentored and supported in their serious game designs by:

- The provision of a 'provoking game' [4] used to encourage reflection and discussion on cybersecurity and serious game design.
- Support using the Triadic Game Design (TGD) methodology [30, 16].
- Support in understanding and using gameplay loops (the various interaction cycles within a game) [14].
- Domain expert mentors (in both cybersecurity and game design).
- Three reference card decks to be used as design tools - one domain-specific (cybersecurity) and two covering Learning Mechanics and Game Mechanics (LM-GM).

These cards served to both provide scaffolding and inspiration for participants who may be new to any of the three areas (gaming, pedagogy and the domain), as well as providing a method of communication between expert mentors and participants. Outputs from this game jam approach include documentation such as: paper prototypes, gameplay loops, and game design documents. This documentation underpins the analysis described below.

### 3.2 Participants

Data was collected from three distinct Serious Slow Game Jams [3], Table 1 shows the format of these jams, the number of participants that took part and the number of game designs produced.

### 3.3 The Learning Mechanic-Game Mechanic (LM-GM) Model

The LM and GM cards were used during the game jams as design tools to create an LM-GM map, following the procedure defined in [22, 5]. The goal of the

Table 1: Summary of game jam participants

	Format	Year	Participants	Games	Demographic
Jam #1	Remote	2021	6	3	University students
Jam #2	Hybrid	2022	13	3	Masters students
Jam #3	In-Person	2022	23	6	11-16 year olds

LM-GM mapping is to “highlight [a serious game’s] main pedagogical and entertainment features, and their interrelations” [5], Figure 1 shows an example LM-GM mapping. This process not only clarified the learning and gaming aspects for participants but also functioned as clear documentation of design decisions, allowing mentors (and subsequent researchers) to understand the participants’ designs. This combination of a Learning and Gaming Mechanics results in a *Serious Game Mechanic* (SGM) which demonstrates how the pedagogical approach is implemented through gameplay. Resultant SGMs extracted from each game jam team’s designs were used to inform the process of PP mapping. LMs and GMs are defined in detail in [5] and for readers unfamiliar with this framework it is recommended that this associated literature is read in conjunction with our analysis and mapping, below.

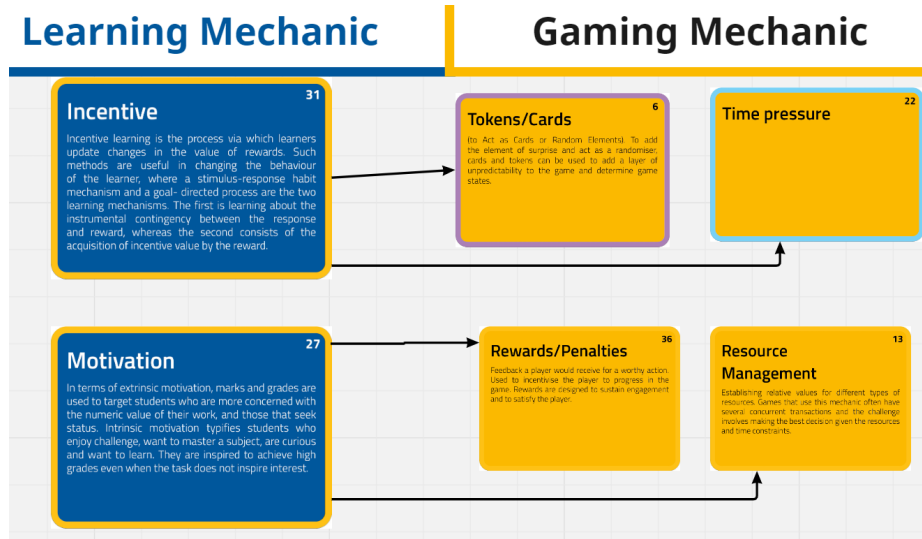


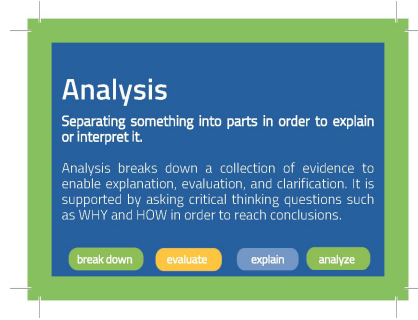
Fig. 1: An example of an LM-GM mapping created by a SSGJ team.

### 3.4 Pedagogical Pattern Mapping Approach

Using the documentation of each game (including gameplay loops annotated with LM-GM cards, game design documents, and the LM-GM mapping exercise) we identified the LMs and GMs used in each game design and their various relationships which form SGMs. It should be noted that this data is based on the participants' own use of the LM and GM toolkit and therefore may not be fully accurate (for example a relevant LM or GM that was not well understood by participants may have been omitted). However, teams were supported by both cybersecurity and serious game design mentors which increased the rigour of the process and gives confidence that the documentation produced is a good indication of the core SGMs for each game. Some SGMs were one-to-one relationships between a single LM and a single GM, however, in general these relationships were complex with one-to-many and many-to-many relationships. In order to analyse the respective popularity of different LMs and GMs across all co-designed games, they were then recorded as separate dyads (one-to-one mappings). Therefore, every LM-GM relationship was individually recorded, for example, a high-level LM such as *Analysis* was mapped separately to every GM with which it shares a relationship. The most commonly occurring SGM dyads (those that appeared in 25% (3) or more of the co-designed games) are shown in Figure 5 in the Results section below, which also gives a sense of the simplicity or complexity of different SGMs. Note this figure is provided as an overview and is not intended to be used as an in-depth resource

Note: to ease the use of the LM-GM framework in the SSGJ itself, we simplified some terminology from Arnab *et al.* [5]. **LMs:** *Participation* was removed as it is omnipresent in game-based learning; *Explore* and *Discovery* were combined as they are conceptually very similar; similarly, *Imitation*, *Modelling*, and *Shadowing* were combined with *Observation*; and *Accountability* and *Responsibility* were combined with *Ownership*. **GMs:** *Communal Discovery* was combined with *Collaboration*; *Goods* was combined with *Tokens* and separated from in-game *Information*; *Pareto Optimal* was retitled *One-Player Must be Better-Off*; *Pavlovian Reactions* was retitled *Conditioning*; *Protégé Effects* was retitled *Learning by Teaching*. Some definitions were rewritten in simpler terms, based on current pedagogy literature and clear examples of each concept in use were added to the toolkit cards. Therefore there may be minor differences in LM-GM terminology used here, nevertheless the concepts remain as defined. Example LM and GM cards can be seen in Figures 2 and 3.

The next step was to establish relationships between the SGMs identified in the above process and the PPs defined in Bergin *et al.* [8]. A detailed reading of each PP was undertaken and each was mapped to the SGMs that are likely to implement the pattern within each game. The PPs are shown on the left and right sides of Figure 5, linked to the relevant SGMs. See Bergin *et al.* for full definitions of each PP.

Fig. 2: *Analysis* LM Card.Fig. 3: *Movement* LM Card.

## 4 Results and Discussion

### 4.1 LM-GM Framework Language

A particular advantage of the three game jams conducted as part of this work is that we were able to observe the LM-GM framework being used by a range of individuals, from primary school children, through to Master’s students. The most striking observation from this is the need for the LM-GM framework’s language to be revisited and revised for different user groups and desired learning outcomes. For example, participants in this case study were not familiar with the language of pedagogy and required support in their understanding of some LMs concepts. Conversely, if the same methods were used with educators, it is likely that the language of GMs would need additional explanation. One example of particular note is the usage of the *Pavlovian Reactions* Learning Mechanic. In the first two game jams, *Pavlovian Response* was an LM available to participants and even though expert mentors deemed that it was a mechanic present in some of the games developed, it wasn’t included in any of the participants’ chosen SGMs. However, when this mechanic was renamed to *Conditioning* for the final game jam that was aimed at schoolchildren, the mechanic was included in two separate designs. Whilst we are confident overall that most of the SGMs in the co-designed games were successfully documented, a lack of understanding of some of the LMs or GMs leading to their omission is a limitation of this research.

### 4.2 Frequency of Pedagogical Patterns arising from the SGMs

Figure 4 shows the frequency of PPs which the SGMs were mapped to. *Active Student*, *Repeat Yourself* and *War Game* are considered to be inherent to serious games, hence these PPs have 100% frequency and are shown in their own section at the top of Figure 5). *Feedback* is also present in 100% of the games, however this PP arises from specific SGMs identified by participants in their gameplay loop designs so is shown in the body of Figure 5. Note that many PPs refer to specific formal educational contexts therefore all other PPs defined by Bergin

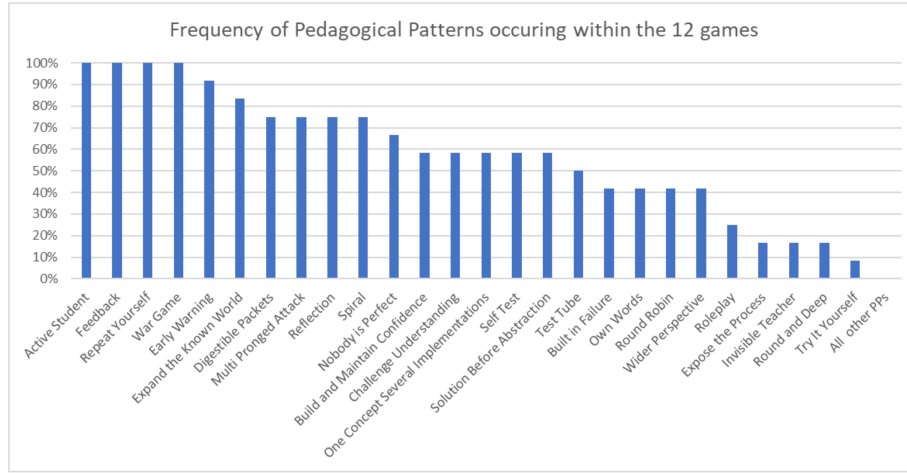


Fig. 4: Frequency of PPs which were mapped to participants’ SGMs.

*et al.* [8] that do not appear in Figure 4 were not relevant in this mapping. It can be seen that PPs appearing in over 50% of the games are themed around incremental feedback based on manageable learning and/or actions, for example: *Early Warning*, *Digestible Packets*, *Reflection*, *Spiral*, *Build and Maintain Confidence*, *Challenge Understanding*, and *Self-Test*. Another theme emerging from these most popular PPs is that of applying lessons learned in the game to out-of-game contexts, for example: *Expand the Known World*, *Multi Pronged Attack*, *One Concept Several Implementations*, and *Solution Before Abstraction*. Figure 4 gives an indication of which PPs may be a fruitful starting point for game-based learning, both for cybersecurity and for topics beyond this case study.

### 4.3 SGM-to-PP Mapping

Figure 5 shows the proposed SGM-to-PPs mapping arising from our analysis. SGM groups are identified in the central column with interrelationships shown by linking arrows with an indication of how frequently the SGM dyad was used across the twelve co-designed games. All game designs employed the *Feedback-Quick Feedback* SGM (meaning the combination of the *Feedback* LM and *Quick Feedback* GM) and exactly half of the game designs used: *Plan-Strategy/Planning*, *Analysis-Selecting/Collecting* and *Question & Answer - Question & Answer*. For clarity, SGMs which were used in fewer than 25% of the games have been omitted from this diagram. Bounding boxes show where there is no overlap between SGM dyads – this gives an indication of those LMs and GMs which have many-to-many pairings and those which are more likely to be one-to-many or one-to-one.



The PPs are shown on the left and right of Figure 5 as nodes with a white background. Linking arrows show relationships between each SGM group and the associated PP. Those shown on the left are more influenced by the linked LM(s) and those shown on the right are most influenced by the linked GM(s). Seventeen PPs were mapped to these particular SGMs (alongside the three aforementioned PPs inherent to all serious games). Again, the linking arrows show individual relationships and also give an indication of how wide-ranging a PP might be; most are linked to three or more different SGMs. However, it should be noted that this diagram shows only SGMs occurring in 25% or more of the games. Simply because SGMs and PPs occur more rarely does not mean that they lack value for specific approaches and learning outcomes. For example, 2 co-designed games demonstrated a very clear mapping from *Identification* and/or *Ownership* LMs to *Roleplay* GM, which in turn activates the *Roleplay*, *Own Words*, *Build and Maintain Confidence*, and *Try it Yourself* PPs. For players to identify with the wider problem of cybersecurity and take ownership over it was a major aim of the case study this paper is based on, and this particular SGM and related PPs would be considered very fruitful in, for example, workplace cybersecurity training. Recommendations for how to use the SGM-PP mapping diagram (Figure 5) are detailed in Section 5, below.

**Depth of Learning Design** Further reflections on Figure 5 identify a high use of SGMs that are aligned with lower-order levels of understanding (as defined in Bloom’s Extended Taxonomy [19]) such as *Question & Answer*, *Repetition*, and *Feedback*. This suggests that co-designers (based, as most of them were, in a didactic educational context) may associate serious games with simple quizzes, or have struggled to escape the model of demonstrating knowledge followed by feedback from an educator. This was particularly noticeable in the school-age teams. This shows that more support is needed in the game jam process, particularly during the ‘meaning’ phase of the Triadic Game Design process [16], in order to provide participants with the appropriate scaffolding to allow them to explore more higher-order learning designs. That said, 50% of games used much higher-order LMs such as *Analysis* and *Plan* and incorporated these incremental developments of understanding (or conceptually similar variations, such as the *Cascading Information* GM) into their core gameplay and feedback loops. Neither lower nor high level learning outcomes are ‘better’, rather it is important to note that the specific learning outcomes of a serious game will suggest suitable SGMs and PPs to use. Lower order SGMs are very appropriate for knowledge acquisition games whereas, as noted above, higher order SGMs leading to understanding and ownership of a problem space would likely be more suitable for behavioural change outcomes such as cybersecurity workplace training.

**Salience of Participant-Chosen Serious Game Mechanics** Further to the above, during our analysis there was some evidence of participants selecting and documenting SGMs that were valid, but not necessarily the most salient for their

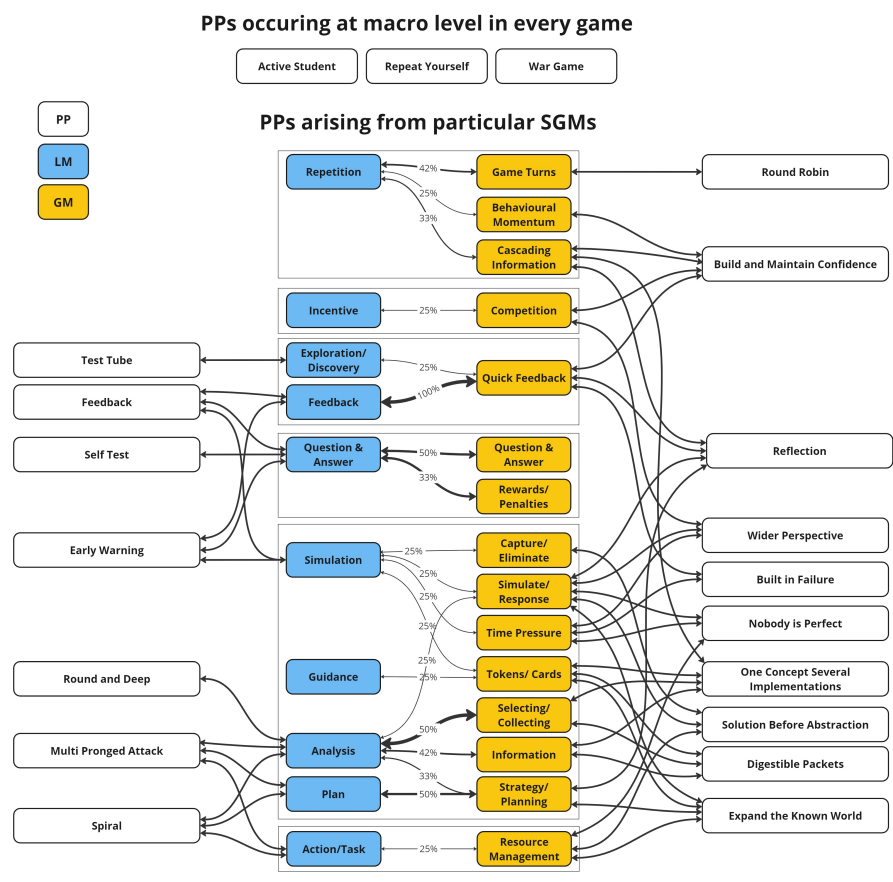


Fig. 5: The Serious Game Mechanics to Pedagogical Patterns Mapping

purpose, as designed earlier in the game jam process. In other words, SGMs were correct but some were omitted that would most effectively and accurately convey the learning and gameplay intended. This reinforces the need to tailor language and support specifically to the participants, as mentioned above, and the limitation that a lack of understanding can affect documentation accuracy, even where the game itself is rigorously designed. For example, in the Serious Slow Game Jams conducted as part of this work the target audience was “code-citizens”, or people who are code-literate but may not have explicit software engineering training [13]. Therefore, the goal of these jams was not just knowledge acquisition but to encourage behavioural change to improve these code citizens’ software development habits and practices. The *Identify/Generalisation - Metagame* SGM, which could map to PPs: *Wider Perspective*, *Expand the Known World*, *Solution Before Abstraction* and *Roleplay* is one SGM and several PPs that we considered to be a particularly salient one for this particular context, however, this particular SGM was not recorded in any of the game designs produced by participants. On the other hand, *Metagame* was associated with *Incentive* and *Ownership* LMs in one game each, both by adult teams who were close to entering the world of work. This reflection shows that there can be a great deal of subjectivity and ‘fuzziness’ in the creation of some SGMs, so individual SGMs should not be taken as the only useful articulation of a particular serious game design approach. We also propose that this identifies the potential for reverse-engineering SGMs through PPs to either strictly ensure, or gently guide, designers towards learning and gameplay mechanics which are more salient in terms of the actual learning outcomes of the game being designed.

## 5 Usage of Pedagogical Pattern Mapping Diagram

We propose two approaches to using our PP mapping diagram (Figure 5) in preparation for supporting serious game design depending on the disciplinary needs of the intended audience: 1) for educators and 2) for game designers. We reiterate that bridging the disciplinary gaps between all three aspects of a serious game (the subject, the pedagogy, and the gameplay) is widely noted in the literature as a priority. Therefore easing communication for experts in each of these three groups is crucial. For educators, familiar with pedagogical concepts but perhaps not game mechanics, we propose approaching the model via the PPs. For example, an educator may be involved in co-designing a serious game to teach students what photosynthesis is. The educator can use their expertise to identify an appropriate PP for their learning outcome (based on adapting the closest template from the PP source literature [8]). This could be an approach already being used to teach the topic that the educator wants to see reflected in a game-based approach, or they could be inspired by the patterns and elect to try a new, potentially more effective pattern. Once a pattern (or several) are selected, they are then able to see what SGM mechanics are related to, and most likely to deliver, that pattern in a serious game context. Conversely, beginning from SGMs and moving outward towards PPs may be the most fruitful approach

to those coming from a game design background. By defining appropriate SGMs for a proposed serious game (or identifying them in an existing game), a game designer can then associate the approach with the wider pedagogical theory to validate (or question) a particular serious game design approach. This not only provides additional pedagogical resources to assist in game design, but can provide a shared language and improve communication between game designers and educators.

### 5.1 Example scenarios of each approach for cybersecurity

Rather than directly instructing her students of some appropriate ways to eliminate the vulnerabilities related to a particular cyber attack, an educator would prefer that the students figure out the answers for themselves, whilst simultaneously becoming more self-reliant. She identifies *Test Tube* as a fruitful PP. Using the SGM-PP mapping (Figure 5) she identifies the *Exploration/Discovery - Quick Feedback* SGM. After reading the definition of both LM and GM she confirms her choice and shares this information with the game designer, who reads *Test Tube* in order to cement their understanding. They then suggest a way in which the game system can support experimentation with clear results to allow the players to draw their own accurate conclusions on the impacts of different cyber defence mechanisms. As they collaborate, both the educator and the designer use the mapping as a facilitation tool for knowledge exchange.

From a game designers perspective, the SGM-PP mapping (Figure 5) could be used to adapt the learning design of an existing serious game from a different application domain. For example, a company approaches a serious games company to produce a game to support workplace learning and practice of secure coding. The company has previously designed a serious game about common nursing procedures that used the *Incentive - Competition* SGM (Figure 5). Looking at the SGM-PP mapping they can see that this SGM is mapped to *Build and Maintain Confidence*, which seems appropriate. The company checks with their client who clarifies that this pattern should be emphasised but that *Competition* should be represented as their company against other companies, not employee against employee! The game designers then follow *Build and Maintain Confidence* back to other SGMs and note that *Repetition - Cascading Information* wasn't in their nursing game, but would be valuable to add in the cybersecurity game, as it involves knowledge acquisition as well as developing professional practice.

## 6 Future Work

### 6.1 Dynamic Presentation of SGM-PP Mapping

Figure 5 is challenging to parse in its current, static format, therefore we propose designing and creating a dynamic, web-based presentation of the SGM-PP

mapping, so that it can be navigated and read more easily. This would also allow rarer but still valuable SGM-PP mappings to be added without making the diagram unreadable.

## 6.2 Audience-Specific Language in the LM-GM Framework

The LM-GM framework is rooted in serious games theory and therefore can use terminology that may be inaccessible to game jam participants including (but not limited to) participants who are young, speak English as an additional language, or have limited experience of either games or pedagogy theory. This was our rationale for simplifying the framework language used in the SSGJ toolkit card decks. Further work towards making the LM-GM framework more accessible and understandable to different audiences is recommended.

## 6.3 Built-for-Purpose Subsets of the SGM-PP mapping

As mentioned above, there are situations where lower-order learning is appropriate and others (such as the cybersecurity domain example used here) where imparting higher-order learning and behavioural change is the goal. Therefore, subsets of SGMs, PPs, or both could be curated by experts to facilitate co-designs with particular learning goals, desired learning, behaviours, or contextual limitations. For example, the goal of teaching young children to play piano using a mobile device would benefit from a subset focused on learning-by-doing and repetition which would not only be more usable and less overwhelming to co-designers but would also reduce the risk of inappropriate SGMs being included.

## 7 Conclusions

Pedagogical patterns focus on transferable yet adaptable solutions and disseminating expert knowledge within teaching and learning. With a similar goal focused on serious games design - in particular co-design between experts from different disciplines - we have presented an analysis and subsequent mapping of twelve co-designed serious game designs onto established pedagogical patterns. This results in the proposed SGM-PP mapping diagram for which we describe our methodology and provide examples of potential usage. We propose that mapping serious game mechanics to pedagogical patterns is a helpful resource and process as it facilitates knowledge exchange and accurate interdisciplinary communication between educators and game designers, an activity which is at the very core of effective serious game design.

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