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Developing a best practice approach to the design process of game-based learning and gamification applications

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Developing a Best Practice Approach to the Design Process of Game-Based Learning and Gamification Applications.

By

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This Thesis is dedicated to my Grandfather Frederick, who told me to always "get the pieces of paper".

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1. Introduction

1.1 Overview

This critical overview brings together both written and practical applications of Serious Games (SGs) and Gamification examples that were developed and published between the time period of 2011 to 2019, covering the researcher's time working as a serious games' designer and researcher at Coventry University. The critical overview presents the overall theory, processes and components that have made up the principle methodology (Trans-disciplinary Model) behind the design and development of these pieces of work. It provides a focused discussion as to the essential systems that have surfaced as best design and development approaches through a critical analysis of the creation process behind these examples. A further in-depth analysis of the process of understanding behind these essential systems is provided, alongside a discussion of why they were selected and adapted and how they were brought together to create a new trans-disciplinary design process that is developed and explained in Output 1 & 2 of the Prima Facie to provide guidance for other developers and researchers in the field. The critical overview goes on to present a digital game example (Output 3) that utilises the design approach of the Trans-disciplinary model and discusses how SimAULA was used to trial the adaptation of the LM-GM (learning mechanics to game mechanics mapping) approach into the LO-GO (learning objective to game objective mapping) to emphasise the learning process to game mapping process as one of the best practice methods to undertake in the design process.

The critical overview then continues to explore how the principle methodology was further adapted to produce a secondary methodology (escapED Framework) that would continue to provide the core principles of the Trans-disciplinary Model, but in addition, provide specialised guidance suitable for live interactive games which include game types escape rooms/ live action role play and mega games, and an explanation as to why this was required. From the development work outlined in Outputs 1 to 4, the overview goes on to present a selection of the authors work that were developed using the Trans-disciplinary and escapED methodologies. The thesis will look at how these examples are in current use at Higher Education establishments as teaching and learning tools, and consider what impact the work has had on the researchers current understanding of SG and gamification design, for use in real 'messy' learning environments. These examples also provide a development account of strategies and actions for non-game related considerations such as; strategy for sustainability, cost, maintenance, adaptability and permission/ ease to innovate for teaching professionals. A final discussion draws conclusions surrounding key external factors that must also be considered to ensure a best practice approach to SG and gamification development.

The definition of 'best practice' within this work is used to describe the standardisation and organisation of core design processes, by benchmarking these against other known examples and methodologies in relevant disciplines and through a practise-based design research approach. Due to the multi-disciplinary and complex nature of creating SGs/ gamification applications, and the continuous growth that Game-Based Learning (GBL) and its synonymous divisions (serious games/ playful learning/ gamification/ edutainment) (Prensky, 2003; Gee, 2011; Wilkinson, 2016) have had in its acceptance and adoption for use in Higher Education, this body of research was defined out of an identified concern, in that there were no multi-disciplinary guidelines available (at the time of development), that corresponded to an authentic multi-disciplinary and multi-teamed SGs development process. The lack of such in the academic community was seen to be detrimental to the development of the discipline by limiting our understanding of the task, effecting areas such as quality control, replication, validity and effectiveness, expectations and resource management. Collecting perspectives from relevant disciplines through both a theoretical and practical application of the work presented in this overview, the ongoing research has linked up knowledge and skills that have been gained over time from efforts of several applications of SGs and gamification tools. This knowledge has been used to develop a unified and trans-disciplinary understanding of the SG development process, in support of providing insight into the development approaches that have been defined as best practice through adoption within the SG and academic community.

The outputs and the critical overview contained herein, are the accumulated products and research of both external and internal University financed projects, with external funding from providers; HEFCE[1], Newton[2], & EU FP7[3]. All pieces of work were developed whilst working at and in conjunction with Coventry University, UK. The work presented in this thesis highlights the research impact that the written and practical outputs have achieved in the context of national and international recognition, and its wider impact into the academic community and beyond.

[1] The Higher Education Funding Council for England (HEFCE) was classed as a non-departmental public body in the United Kingdom, which was responsible for the distribution of funding for higher education to universities and further education colleges in England since 1992.

[2] The Fund was launched in 2014 and was extended from 2019 to 2021 and expanded by doubling the £75 million investment to £150 million by 2021, leading to a £735 million UK investment to 2021. It focuses on people, research and translation.

[3] EU FP7 was the European Union's research and innovation funding programme for 2007-2013. The current programme of funding is Horizon 2020.

1.2 Positioning, Scale and Scope

Much discussion and academic debate in the SGs and gamification community, is centred around an overwhelming desire to find the perfect formula. A fundamental set of instructions that will help practitioners and academics create a perfect product that is effective in its use. Unfortunately, whilst a number of SGs have been developed over the last couple of decades, these products have been met with varying degrees of success (Vogel et al., 2006; Wouters et al., 2009; Ke, 2011; Sitzmann, 2011; Chamberlain et al., 2013; Hess & Gunter, 2013; Moser et al., 2013). Whilst this can be put down to a number of influencing factors, it can in part, be attributed to no clear standards/ guidelines for understanding the complexities of the design and development process.

There have been several conceptual models and frameworks that have focused on documenting a best practice approach to SG and gamification design and development (although mainly focused around SG design rather than specifically gamification) that have come before the work detailed within this overview. The models and frameworks in which the groundwork in theory and part practice have been set, and in which are taken forward for further exploration later in the critical analysis, include that of the following: Game Object Model (Amory & Seagram, 2003), Experiential Gaming Model (Kiili, 2005), Four Dimensional Framework (de Freitas & Oliver, 2005), Theory-Orientated Evaluation (Kriz & Hense, 2006) (Kriz & Hense's work has been included, to understand the use of participatory design), Serious Games Conceptual Framework (Yusoff et al., 2009), Serious Games Design Model: Process, principles and tools (Jarvis & de Freitas, 2009), Triadic Game Design & Evaluation (Harteveld, 2010) and the Six Facets of Serious Games Design (Marne et al., 2012).

Alongside these models and frameworks listed above, there have been other examples within the timeframe of the literature review (1990 – 2014) that have been excluded in the further analysis section due to their specific nature of focus, rather than a general approach to SG design, either from a technological perspective such as the Cloud-based pervasive Serious Games Framework (Alamri et al., 2013), Model-driven Serious Games Framework (Tang & Hannegan, 2010), Technology Acceptance Model (Yusoff, Crowder & Gilbert, 2010) and the Game Engine Selection Framework (Petridis et al.,2012) or an evaluation and assessment focus which covers frameworks such as the Game-Based Learning Evaluation Framework (Connolly, 2009) and Research and Evaluation of Serious Games (Mayer et al., 2014). However, these examples are highlighted here to show the researcher's awareness and acknowledgement of the literature's contribution to the field.

As evidenced above, there are several significant frameworks and models that emerged into the SGs academic field, particularly during the period of the early 2000's onward, that were concerned with documenting a best practice approach to SG design and development. Whilst some of these examples provide noteworthy processes which have been adopted and are reviewed in detail later, others are insubstantial and/ or light touch at best, with little in-depth exploration as to how certain activities are accomplished. Furthermore, the models and frameworks that are highlighted, centre solely around the understanding and combination of the disciplines of games design and education practices (with the exception of work conducted by Kriz & Hense, 2006). Whilst this stands to reason that education would be an obvious field in which we draw our observed best practice examples from, particularly as it is has been those academics and practitioners with a vested interest in education that have long since been championing the use of games for other purposes, the researcher argues that this is detrimental to the practice to consider such a two-dimensional approach.

It has been known for some time that games are highly complex and at their basic makeup are formed by multiple psychological theories and behavioural factors in order to engage, motivate, influence and emotionally affect players (Bryant & Fondren, 2009; Granic et al., 2014; Cohen, 2014). In addition to this, much in the ways of educational practice that we now know, is not just about imparting knowledge in an innovative format, but also about understanding, empathising and connecting with the learner to understand their motivations. Part of this, is the ability of learning practitioners to identify barriers, understand challenges and be able to propose simple change objectives in which learners, especially in a HE/ further education setting can achieve on a long-term basis so that they may build healthy and lifelong learning habits. In reflection of this, the researcher proposes a greater multi-disciplinary approach to the design and development of SGs and gamification. This is achieved through extending the design and development approach past that of only games design and educational practices, and considers the inclusion of best practice approaches from psychology and health processes as well. The inclusion of such practices allows practitioners to have greater understanding and control on the psychological and behavioural change elements and outcomes that can be used to design SGs, including those that arise from a need's analysis, objectives, narrative, mechanics etc.

By applying and merging the understanding of these trans-disciplinary practices, including those of a health and life sciences focus, through a design-based research approach, the combination of trans-disciplinary practices is further realised in to the Trans-disciplinary model, and later into the escapED Framework. Both examples have provided transferrable knowledge and practical demonstration for

practitioners elsewhere, and has formed the foundation of other SGs and gamification projects in education and beyond. The Trans-disciplinary framework and the escapED framework, have both been recognised on a national and international level within the academic community. All models and frameworks that are listed, and that were used to inform and establish the theory and practice of the research, are from existing models of SG design and development research that were written and conceptualised before 2013. This corresponds to the timeline of the conception and development of the Trans-disciplinary Model.

1.3 Overall aim of research

Through the synthesis of multiple projects that have required a SG/ gamification design and development approach, the overall aim of the research is to develop a series of best practices presented in the form of a formal methodology, to aid in the design and development of serious games and gamification applications. The research will provide a series of practice-based outputs that will be reflected upon and analysed to provide a new theoretical model of design practice, and will address how this practice then fits within the current practice of teaching and learning in Higher Education.

1.4 Overall objectives of research

Within this context, the overall objectives of the research are:

i. To review the literature and draw out key methodologies and frameworks that are currently being used for aiding the design and development of serious games, gamification applications, educational and intervention approaches.

ii. To analyse and synthesise these key methodologies through a design-based research approach using the design and development of a game/gamification application for serious purposes.

iii. To reflect on the key methods used and combine these to create and provide a trans-disciplined design process for future intervention based serious game and gamification applications development.

iv. To implement the design process and develop scope through analysis for future development and implementation within teaching and learning in Higher Education and the greater research and development communities.

1.5 Other works and Justification

The journal articles and game-based learning examples have been carefully selected to provide a critical and consistent narrative thread throughout the body of work. Other published papers and practical game outputs have been excluded in order to maintain this approach.

1.6 Evidence of skills in Submission

In bringing together a coherent body of both conceptual and practical research outputs on the design and development of SGs and gamification applications, the body of work:

- Evidences sound knowledge and understanding of the general discipline of GBL (including that of SGs, gamification, playful learning and other relevant and connected terms used to describe related research in the area).

- Provides evidence of an in-depth and specialised theoretical knowledge of GBL design practice, existing theoretical and conceptual models and understanding of current trends in the field.

- Evidences knowledge and application of relevant research methods appropriate to the discipline and area of study. Primarily demonstrated, is a design-based research approach with evaluations of practical outputs undertaken in both a qualitative and quantitative capacity.

- Demonstrates evidence of originality and a clear individual contribution to the body of work through written publications, award recognition and conceptualised practice-based outputs created by the researcher.

- Demonstrates a common theme that links the individual contributions of the portfolio together, and presents an ongoing body of further research based on the work herein.

- Demonstrates evidence of ability to critically analyse and reflect on own contribution of knowledge to existing research, including

1.7 Organisation of portfolio

The critical overview is organised into five main sections of discussion:

- An autobiographical context for the research.

- An impact analysis of the research in terms of its contribution to SG and gamification design and development knowledge and practice. Inclusion of national and international recognition and adoption within the academic community.

- An extended review of the primary research methods, theory and practical applications that link the outputs together.

- A critical review of the portfolio of evidence.

- A statement on the recognition of contribution of other authors and practitioners to the outputs.

- Conclusions and further research.

2. Autobiographical context

2.1 Practice Based Experience and Prior Work

Work by the author in the area of SG and gamification practice and research dates back to 2009 when employed on several client-facing projects relating to the design and development of SGs for autistic children. Experience and expertise in traditional games design practice was further gained during time from 2009 placed as an entertainment games designer for several entertainment companies. This includes work carried out at a AAA company, *CodeMasters*[4] on several of their racing IP games. Since 2011, the author has been employed at Coventry University in a practice-based research role. In this time, the author has developed an extensive portfolio of practical and written outputs based on internally and externally funded project research in the field of SGs, gamification and playful methodologies. The combination of traditional entertainment game design training and specialised SG research, that has been developed over time, has allowed the author to meaningfully enhance their theoretical knowledge of the field, research training, academic contribution and practical/ technical skills development. The selected outputs have been chosen from the authors' body of work, to reflect a professional growth of knowledge acquisition and individual contribution to the field within the Prima Facie, in support for the submission of Degree of Doctor of Philosophy by portfolio.

2.2 Contribution to the Serious Games and Gamification Field

Research, in both a theoretical and practical form of contribution to the field, include 28 published outputs. This includes outputs in the form of conference proceedings, Journal articles, special edition sections, applied research reports and documentation that have formed policy and practice within the academic community (please see Section 3: Impact of the Research Contribution to Knowledge, policy and practice), and have contributed towards national and international project development and dissemination (including projects funded under the Newton, HEFCE & EU H2020[5] programmes).

Practical contributions to the field include four completed (developed to evaluation stage) digital outputs, three of which are part of submission, and numerous trans-media and analogue games that have been developed for use in education.

[4] The Codemasters Software Company Limited, doing business as Codemasters, is a British video game developer and publisher based in Southam, England, from 1986 to current.

[5] Up to €17.5 million in financing for innovative companies under the European Innovation Council, to support rapid growth of breakthrough, market-creating ideas

The author has been responsible for facilitating numerous SG/ gamification/ playful training, consultation and workshop activities both internally and externally to the University. The author is research active, and continues to present and speak at international events and conferences. The author is a named investigator on several funded projects and has contributed to the development of these bids.

3. Impact of the Research Contribution to Knowledge, Policy and Practice

- Research presented in the critical overview and Prima Facie, indicate a significant contribution to knowledge through the review and union of multi-disciplinary theories, frameworks and methods of education, behavioural science, entertainment games design and serious games/ gamification design and development. The extension to the consideration of behavioural science as part of the design process has helped to shape our understanding of the make-up of games at their core.

- The research selects appropriate theories and methods, and further examines these practices to understand which best practice approaches can be taken forward from each discipline to produce two new frameworks for guiding SG/ gamification design and development processes. The research builds upon several best practice approaches that have been discovered from both a theoretical review and practical application of the methods through an iterative and DBR-led approach.

- The research presents evidence via a number of mixed methods techniques (quantitative, qualitative, descriptive) to provide a deeper understanding of the complex nature of developing and evaluating different types and genres of SGs and gamification applications.

- The game PR:EPARe, helped students identify coercion and led to a student stepping forward to gain help from a toxic relationship. The game was nominated for a Pamela Sheridan award.

- Following the development of the Trans-disciplinary model, the academic community has recognised that the model has identified several best practice approaches of developing SGs and gamification applications, and has such informed a number of practical developments and research outputs not directly connected to the authors (De Lope et al., 2017; Proulx et al., 2017; De Troyer et al., 2017; Lee & Kim, 2018; Bourazeri et al., 2017; Santos, 2018; Mckenna, 2017). The model was further adapted into several short videos to become part of the resources available to inform the open game course on gamify.org.uk.

- The research has provided a significant impact to policy and strategies within the context of best practice application to national and EU funded projects. The Trans-disciplinary model has been used as a basis to form the theoretical underpinning and guidance in the development

of game and gamification applications behind award winning projects such as GameChangers (HEFCE funded), Beaconing (H2020), Crowd 4 Roads (H2020) and Creative Cultures (Newton) and BOND (H2020).

- The escapED framework has gathered a great deal of interest and application within the academic community. At time of writing, the journal paper has been downloaded over 2400 times and has been used to inform the development of several live-action games in education (Giang et al., 2018; Lopez-Pernas et al., 2019; Wilson et al., 2018) and has formed the underpinning for other academic frameworks of escape room design. The research was formally recognised by Gamification Europe[6], an international community of practitioners and academics, and received the award for 'Outstanding Gamification Research' in 2018. Several short videos were created for further dissemination to describe the escapED framework and its process. These are currently in use as resources to students and the larger community, on the open game design course (gamify.org.uk).

- Work conducted following the development of the Trans-disciplinary model and the escapED framework has led to the creation of several SGs and gamification applications as part of the Game Changers project (HEFCE), including Book Runner (output 6) which was nominated for the Digital Information Literacy award at LILAC: Librarians Information Literacy Annual Conference and for a Coventry University Teaching and Learning Excellence Award: Digital Fluency and Innovation, and Bothersome Beasties (output 7) which gained a Certificate of Merit from ACPI E-leaning Excellence Awards and had a featured chapter in a book for 'Best practice digital tools for learning'.

- A number of international and national workshops based on the research have been designed and delivered to academics and practitioners, including running escape room experiences and serious game design workshops at Online Educa Berlin (OEB). The work conducted is all open source and readily accessible to ensure that the author is an ethical practitioner. The research has been implemented within the authors workplace environment and is currently being adopted to change teaching and learning practice at a local level. An example of this is the creation of several mock workplace environments to mimic a work placement for students

[6] Gamification Europe is the conference and networking event for gamification and engagement professionals, created by Gamification+ in 2017.

enrolled on Health and Life science courses at the university. This work is based on the research conducted in Output 5.

- The research has helped form the basis for around 28 written research outputs including peer reviewed Journal and published conference proceedings, applied and theoretical research reports, invited keynotes and conference presentations. The research has gathered impact through citation and adaptation by other academics. An example of this can be found with Output 1, Arnab et al., (2013) which has been cited at least 88 times, whilst Output 2, Arnab & Clarke (2017) has been cited at least 37 times.

The research has contributed to the greater understanding of the field of SG and gamification design and has identified several areas to build upon for continuing the conversation around best practice approaches. It outlines further work and research that is currently in progress and that is planned to be conducted at a later date.

4. Research Methodology, Practice and Theories that Link the Outputs Together

The aim of this section is to demonstrate the research design that has provided the theoretical and conceptual evidence to support the body of research.

4.1 Methods

The overall research philosophy of this body of work adopts that of a critical realist's perspective (Bhasker, 2013; Sayer, 1999). Critical realism is broadly defined as a series of philosophical positions that cover matters including 'ontology, causation, structure, persons, and forms of explanation' (Archer et al., 2016). As a response to the post-positivist crises arising in the fields of natural and social sciences in the 1960s, the paradigm of critical realism arose to present a post-positivist social science perspective that bridged and provided a link between the natural and social sciences. Archer et al., (2016) present a definition of critical realism as:

> *"an alternative paradigm both to forms of positivism concerned with regularities, regression-based variables models, and law-like forms; and also, to the strong interpretivist or postmodern turn which denied explanation in favour of interpretation, with a focus on interpretation and description at the cost of causation."* (Archer et al., 2016)

It is in this position of a coalesced positivism and interpretivist belief, that Archer et al., (2016) draws an understanding to the position that there any many elements that are to be considered for formulating our investigation of the world. Following this thought, Bhasker (2013) proposed that scientific understanding is in of itself a constant ongoing process, subject to change and transformation as new information presents itself. Information as formed from social science research in which human structures are central to observation, is subject to a greater state of flux than that observation and understanding of the natural world, due to complex social constructs and entities that it affects (Archer 1982; Bhaskar, 2013). Critical realism further puts forth the perspective that this does not mean that information gained is wrong, but that we look to constantly adapt and reassess, using new knowledge to build on top of the out-dated.

From this perspective, the research presented in the thesis observes a critical realist stance in that the author has built towards the compilation of experience through the application of a number of small experiments using a mixed methods approach. Based in existing theory and practice, evidence is further gained from the authors own application and her experience is pulled together to understand

the complexities of the design process. Through the work presented, the reader will notice that best practices put forward in early works are subject to revision and iteration that is then presented in later works. This approach is reflective of the critical realist stance, in that the study of research is an ongoing process and in which we must constantly and consistently improve upon our own processes to understand the mechanisms in that which we study. As a lifelong learner and a working practical-based researcher, the author continues to work upon, iterate and refine the work presented in thesis.

Following on from the philosophical positioning of the research, a design-based research (DBR) methodology was chosen as the primary research methodology, due to its alignment with both the researchers ontological views, epistemological philosophy of the work and the ability to provide a practical methodology that could be adapted into a working environment (Brown, 1992; Collins, 1992). To further understand why the author has adopted this approach (and continues to do so in ongoing practice), a definition of DBR can be taken from Wang and Hannafin's (2005) work that describes the method as a:

> *"systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories."* (Wang and Hannafin, 2005, p. 6).

DBR blends empirical educational research and theory and combines this with the application of practice for the purpose of understanding how, when and why innovative educational concepts work. This is conducted through a practical application of the new approach and/ or intervention, and examines the evidence produced from its placement within an authentic environment and with authentic end-users. Positioning itself as the balance between positivist and interpretivist epistemologies, DBR looks to bring the ideals of theory and practice together in a way that attempts to find structure in the process, but also highlights the need to be flexible and iterative in its approach. DBR is a unique process that produces both theories and practical educational interventions as its principle outcomes, looking to develop both form and function. It is for this reason, that the methodology was chosen by the author due to its alignment with the need to produce practical outputs, but also seek to uncover best practice approaches to the process of designing and developing SGs and gamification applications.

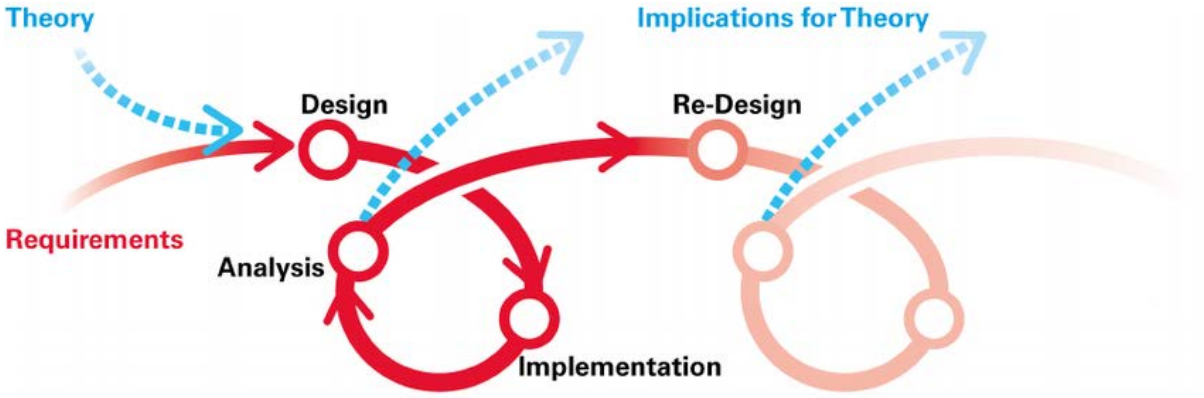

Figure 1: Design-based Research Cycle (Barab, 2014)

DBR was first conceptualised by Ann Brown (1992) and Alan Collins (1992) to enable research to be conducted in authentic educational settings, and in which interdependence of theory and practice formed the central philosophy of the methodology. (Brown, 1992; Collins, 1992; DBRC, 2003). It should be noted here that various terms have been used to describe DBR across the academic community, including that of design science (Van Aken, 2004; Van Aken, 2005), design research (Collins, Joseph, & Bielaczyc, 2004; Romme, 2003), design experiments (McCanliss, Kalchman, & Bryant, 2002), and design studies (Shavelson, Phillips, Town, & Feuer, 2003). The author follows the term taken from the Design Based Research Collective (2003) of 'design-based research' to explain the methodology and uses this throughout the work to provide clarity to the reader.

DBR was developed with the founding idea that a practice-based researcher needs to be able to adjust elements of a project through several iteration and refinement steps throughout the course of a new products lifecycle. Each new adjustment would allow testing and analysis of each new refinement to provide an advanced look at their effects on the product and audience. To further understand the principles of DBR as a research methodology, the author draws on the literature conducted by Wang and Hannafin (2005), of which they suggest that DBR is made up of five basic characteristics: Pragmatic, Grounded, Interactive, Iterative and flexible, Integrative and Contextual.

Wang and Hannafin (2005) state that DBR is Pragmatic, in that its overall purpose is to use design principles in a way that actively seeks to solve existing real-world issues. By creating theory-led interventions that are applied to 'real-world settings', DBR allows continual refinement and extension of design principles (Design-Based Research Collective, 2003; Van den Akker et al., 2006).

Secondly, they state that DBR is a Grounded approach because it is 'grounded in both theory and the real-world context'. Conducting small scale evaluations on theories and practical educational interventions simultaneously, allows for multiple testing of best practice approaches that work in an authentic setting.

Thirdly, that DBR embodies an 'interactive, iterative and flexible' approach. One of the key principles of this methodology (and why it has been selected for this research) is that by its very nature it looks to include stakeholders and end-users in the design process. Using an iterative approach allows the researcher to feedback crucial information gained from stakeholder interactions to strengthen the efficacy of the designed intervention.

Fourthly, that DBR considers the needs of the research by being integrative to different design methodologies, both from quantitative and qualitative means. This has been a significant consideration of the use of DBR from the author, in that it allows for the use of multiple approaches and processes that can be brought together and situated under one overarching methodology. Based on this allowance for multiple theories, DBR is further justified in its adoption for the body of work, as it reflects the authors need to incorporate case studies and processes from multiple disciplines in order to provide a best practice approach to SG and gamification design and development.

Fifthly, that DBR is contextualised in its approach because:

> "research results are connected with both the design process through which results are generated and the setting where the research is conducted" (Wang & Hannafin, 2005, p. 11)

Considerations under the design principle of 'Contextualised' that Wang & Hannafin (2005) put forward, is that research should always keep detailed accounts of the process, outcomes and theories that have had or have not had successful results. Documentation can be used to further understand why an intervention has furthered understanding on these processes, and can provide other practitioners and researchers access to information and findings that they can adapt and review for their own needs. This principle aligns with the authors own research principle and reasoning of this body of work, in the need to document and pull together key processes of SG and gamification design and development, to identify those best practice approaches. Another essential suggestion that Wang & Hannafin (2005) put forward under this principle is the need to *'increase adaptability of the findings in new setting'* and that '*guidance on how to apply findings is required*'. The need for findings not only to be documented, but also to be adaptable to different domains, is a crucial process for ensuring adoption of these findings into the wider communities of practice. It is also noted that it is a

responsibility of the researcher to provide necessary and clear guidance for other practitioners to confidently use and adapt the findings to their own research needs.

As identified above, DBR represents a series of principles that make the methodology wholly flexible and naturalistic to use within a genuine working environment. In relation to the overall aim and objectives of this research, its use will, as Barab and Squire (2004) observe, will provide a:

> "*valuable manner for producing new theories, artefacts, and practices that account for and potentially impact learning and teaching in naturalistic settings"* (Barab & Squire, 2004, p. 2).

Barab and Squire (2004) furthermore bring to attention, that DBR is interventionalist by its very nature in that it involves design at its core philosophy. This interventionalist approach fits harmoniously alongside our current understanding in that behavioural science features significantly in the make-up of games design. In order to effectively design and test learning theory and practice in SG design, further experimentation on the amalgamation of behavioural science and educational theories must be examined to tease out the best practices from each discipline.

As already described in its five design principles (Wang & Hannafin, 2005), DBR provides the mechanism in which it is assumed that iterative experimentation is a core process of the development cycle. In order to discern how central iteration is to the process, Cobb, diSessa, Lehrer, & Schauble (2003) offer their interpretation:

> *"Prototypically, design experiments entail both "engineering" particular forms of learning and systematically studying those forms of learning within the context defined by the means of supporting them. This designed context is subject to test and revision, and the successive iterations that result play a role similar to that of systematic variation in experiment."* (Cobb, diSessa, Lehrer, & Schauble, 2003, p. 9)

With this in mind, the reader will become familiar with the iterative style in which the work is conducted and in which this DBR-led process informs the analysis of best practice approaches, as evidenced in the Prima Facie. These are reflected upon and then used to form the basis of the Trans-disciplinary model and escapED framework, with further proposals that sit outside this body of work for future exploration.

On a final note regarding DBR as the methodology that has been adopted throughout the body of research, the author wishes to highlight that of another methodology; action-based research (ABR).

DBR has often been compared to ABR in that both methodologies share very similar approaches to the design and implementation of educational learning theory and practice (Cole et al, 2005; Järvinen, 2007). However, DBR and ABR do observe some differences in their approach. DBR resembles ABR in that both methodologies identify real world issues and present a series of practical action points to improve upon or solve an identified issue. They are also similar in that practitioners and educational facilitators sit at the heart of the research and design process and lead the implementation of outcomes derived from the research. However, there are two fundamental differences that sets DBR aside from ABR; firstly, in the difference of the overall objectives and goals to be carried out within the research and secondly, in that of the roles of the researchers and educational facilitators in the process (Oliver et al., 2005; Wang & Hannafin, 2005). According to Wang & Hannafin (2005) the first difference is its need to generate theory as part of the outcomes of the research process in order to solve authentic problems. This separates DBR from ABR, in that the methods help to form new theories alongside that of a practice-based output, whereas ABR is wholly concerned with the practice-based output. The second difference Wang & Hannafin (2005) state is that the role of the researcher in DBR is to take the lead as both a researcher and designer in the design and development process, whereas ABR it is usually the educational practitioner who leads the research which is then facilitated by a researcher later on in the process.

As such, the DBR methodology was selected to provide the basis of underlying principles in which to conduct research and the unified approach that forms the underpinning behind the design and development process of the authors research. Through this underpinning lens, the outputs are linked together to form the Prima Facie, based on a clear and established methodology of educational practice.

Due to the diverse nature of SGs and gamification to be created and applied for multiple purposes and discipline use, the evaluation of the games that are presented in both written and practical outputs contained in the Prima Facie are evaluated using a mixed methods approach. This approach has been adopted across the outputs for formative evaluations of the SG and gamification outputs and was applied to the research presented in outputs 1, 4, 5, 6, 7. The process for pulling together best practice approaches from the work conducted across these outputs have used an interpretative qualitative approach which draws on the DBR methodologies principles. These are then observed alongside the authors own reflection of the processes, to inform new theory to be put forward in terms of best practice approaches.

4.2 Educational Theory

There are numerous research articles available that look to assess the efficacy and effect of SGs and gamification within education (Backland & Hendrix, 2013; Kim & Chang, 2010; Lieberman, 2006; Pandey & Zimitat, 2007; Squire, 2003; Virvou et al., 2005; Zepp, 2005; Koivisto et al., 2019; Boyle et al., 2016). For the most part, a general conclusion within the academic community is that the use of games in education can see an increase in motivation within the learners. This in turn leads to a greater chance that through repetition of play of the learning cycle (fail, repeat and mastery), learners will enhance their chances of successfully attaining the learning requirements of the content.

SG and gamification-based learning embodies a number of educational theories including that of user preferences (this includes gender/ race/ age/ social studies), educational psychology, learning and instructional design and constructive influences. At their basis, SGs and gamification approaches are constructed of four major learning theories; constructivism, behaviourism, cognitivism and humanism (Smith, 1999; Wu et al, 2012).

The constructivist theory whose formation, largely contributed to Vygotsky (1896) Piaget (1977) and Dewey (1997) is based on the philosophy that:

> *"knowledge is constructed by learners as they attempt to make sense of their experiences. Learners therefore are not empty vessels waiting to be filled, but rather active organisms seeking meaning"* (Driscoll, 1994, p. 387)

A constructivist perspective positions itself with the view that '*people learn through active exploration, and that learning occurs when the experience*' (Piaget, 1977) and that '*learning occurs within a social context, and the interaction between learners and their peers is a necessary part of the learning process*' (Vygotsky, 1896). Understanding these two principles are central for understanding how games align with existing educational psychology and theory. By their very nature games embody these principles and provide opportunity to gather meaning from exposure to experience and facilitate social play or 'Experiential Learning' (Kolb, 2014) and forms a basis of the learning process.

Behaviourist theory (Watson, 1913; Skinner, 1938) is the position that a learner is subjected to environmental stimuli in order to change their behaviour and response to engagement with the learning context. In this theory, learners are viewed as passive vessels or clean slates and through the principles of reinforcement, both positive and negative, that desired behaviour can be produced and

replicated. It is easy to see how behaviourism fits into the makeup of games, in that reinforcement theories are a core element of the feedback and reward systems built into a games design, that ultimately is used to engage players to want to continue playing (Loftus & Loftus, 1983).

Cognitivism theory (Piaget 1977; Bruner, 1966; Bandura & Walters, 1977) is the position that prior knowledge and experience have a central role in the learning process. Cognitive psychology proposes that learning comes from the understanding of processes concerned with memory, motivation, reasoning and reflection. As previously discussed under the behaviourist theory, motivation is central to the game design philosophy in that to be successful, a game must keep a player interested for the majority of its narrative/ gameplay arc. Furthermore, games rely on the use of pattern recognition and memory (Koster, 2013)

The Humanist theory that emerged in the 1960s (Rogers, 1970; Maslow, 1968), is the belief that the individual is central to the learning process. A proponent of humanism, W. Huitt (2001), believed that people act with '*intentionality and values'* and that they are responsible for their own learning processes. A key element of this is the recognition that educators take on the position of facilitators and that they are there as a guide. This aligns to the ideas that SGs are used as facilitation environments, and that the player takes autonomy for the exploration and growth within that environment (Rieber et al., 1998; Thompson et al., 2010; Hess & Gunter, 2013). Humanism furthermore puts forward the position that a person is in a constant state of learning and grows over the course of a lifetime. The study of the self, motivation, and achievable goals form the basis of the learner's interest (Hutchinson & Estabrooks, 2013). The humanist belief in that the setting of goals and achievements provides an internal motivation to the learner, can be seen to be mirrored in the approach that a player might take whilst playing a game. The setting of internal goals such as '*I wish to reach/ master the end of this level*', are central to the understanding of how learners would take responsibility for their own learning process within a SG/ gamification environment. Whilst other psychological theories such as, but not limited to; flow (Csikszentmihalyi and Lefever, 1989), mastery (Gee, 2003) and fail theory (Loftas & Loftas, 1983) can all be attributed to also affect engagement and internal motivation, players often set themselves little goals that they wish to achieve before leaving the game if they are enjoying play. The role of the players autonomy and direction of how a game is interacted with, illustrates just how the humanist theory plays into the make-up of games and into the overall SG/ gamification philosophy.

Often when these four principles of educational psychology are observed as stand-alone theories, it is noted that these theories often form opposing philosophies to the approach and focus that should be taken towards the learning process. However, and perhaps this is a significant reason why SG design is such a complex endeavour, is that in the case of SGs, each of these four theories combine and contribute elements of their being, that form the foundation of the SG philosophy (Smith, 1999; Wu et al., 2012). The author acknowledges here the importance of these educational theories and particularly the four principle theories of constructivism, behaviourism, cognitivism and humanism that structures the SG and gamification philosophy. It is essential that these theories are understood, applied and built upon to inform the basis on which best practice approaches are founded.

4.3 Serious Games Frameworks & Models

A crucial element of the research that was to be conducted was a review and assessment of the current thinking and theory in the academic community surrounding SG and gamification design and development methods. The researcher identified several frameworks and models of note during their background literature review that were concerned with solely the design/ development considerations of the task. As previously mentioned, several frameworks/ models were disregarded from the authors consideration due to their primary focus on other non-design related matters such as assessment or technology selection factors. Frameworks/ models were also reviewed and selected up until the year 2013, in which game development of the PR:EPARe project (see output 1) commenced.

The nine frameworks/ models that the author reviewed to identify and inform their own design and development practice in preparation of the PR:EPARe project were the following:

- Game Object Model (Amory & Seagram, 2003),
- Experiential Gaming Model (Kiili, 2005),
- Four-Dimensional Framework (de Freitas & Oliver, 2005),
- Theory-Orientated Evaluation (Kriz & Hense, 2006)
- Serious Games Conceptual Framework (Yusoff et al., 2009),
- Serious Games Design Model: Process, principles and tools (Jarvis & de Freitas, 2009),
- Triadic Game Design (Harteveld, 2011)
- Six Facets of Serious Games Design (Marne et al., 2012).
- Learning Mechanics to Game Mechanics Mapping approach (Lim et al., 2015)

Presented in this section is an overview of the main points of these frameworks/ models and how the author considered each in their suitability for informing their design process.

The author wishes to acknowledge at this point in the critical analysis, the difference between SG design and development and gamification design and development processes. Whilst the author recognises that SGs and gamification applications are different in form and practice, the author believes that they should follow the same design processes due to the fundamental nature of linking game mechanics to desired learning/ behavioural outcomes. The view is shared by gamification expert Karl Kapp, who believes that '*the two are relatively the same, both are trying to solve a problem with game thinking*' (Kapp, 2011).

4.3.1 Game Object Model

The 'Game Object Model' (GOM) by Amory & Seagram (2003) as seen in Figure 2, is designed to connect educational theory with game design principles and is based on Object Orientated programming concepts. It is also a theory that sits alongside two other models, the Game Achievement Model (GAM) and the Persona Outlining Model (POM), that help make up the overall process of designing a SG. Formed from a series of 'Components', the theory works on the discussion of the relation of these components to the spaces that they encompass. There are a number of elements that make up the GOM including considerations for players, story, game space and social space. The overall purpose of the GOM is to aid designers in their development of learning objects and the necessary game components that would make up a defined storyline.

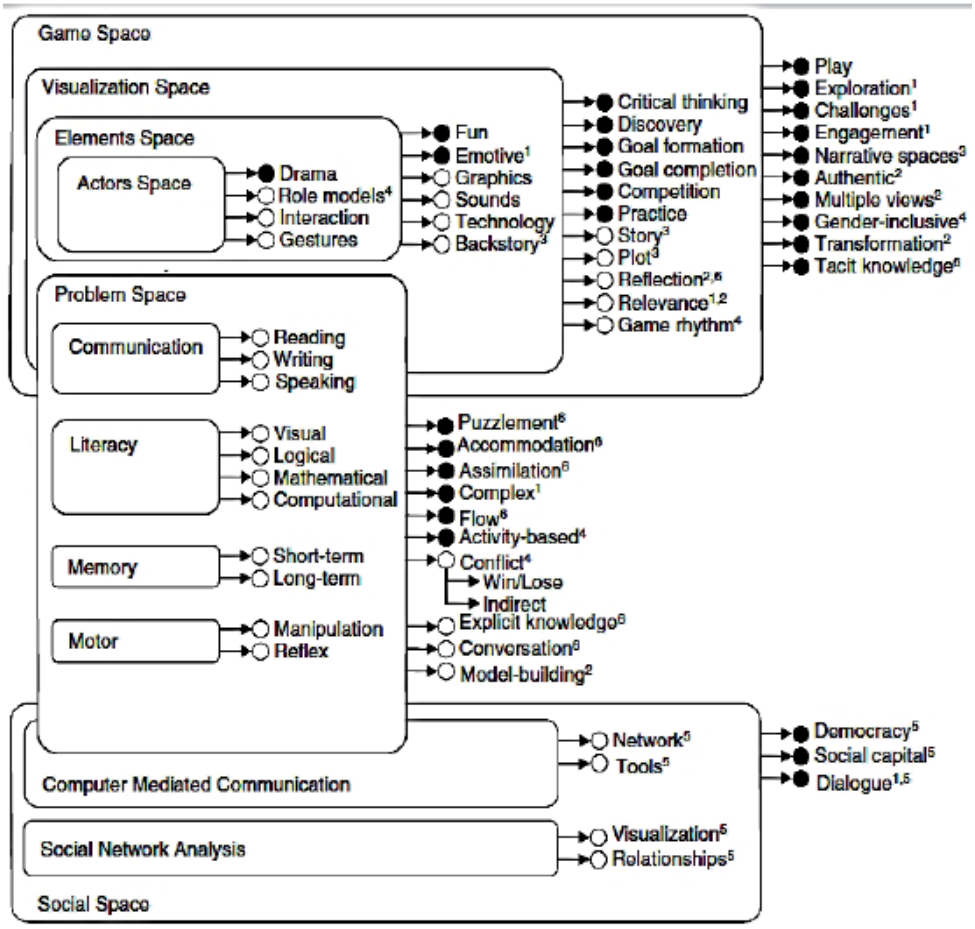

Figure 2 Game Object Model

The GOM informs the process behind the POM, which is used to inform the who and what of a fictitious user of the system, and the GAM, which informs the processes behind the design and selection of necessary learning objectives and matching these up to a relevant storyline that will promote intrinsic motivation within the players. Whilst the GOM, POM and GAM provides a good insight into a number of design considerations particularly within the POM and in the development of user properties in relation to the issue, the author considered the model to be too centred in a technology driven process. The use of three methods in one model and the structured approach felt too complex and rigid for the use within the authors research. Due to these considerations, the GOM, POM and GAM were not included as the lead theoretical models within the research.

4.3.2 Experiential Gaming Model

The Experiential Gaming Model (EGM) that was developed by Kiili (2005) was developed to acknowledge the differences between game design and pedagogy. Like the GOM (Amory & Seagram, 2003), Kiili wanted to explore the transition of defined learning objectives into a game environment

and also highlights the importance of areas such as a needs analysis, design knowledge, solution generation and evaluation. The EGM consists of two cycles, a gaming cycle and a design cycle and is shown in Figure 3.

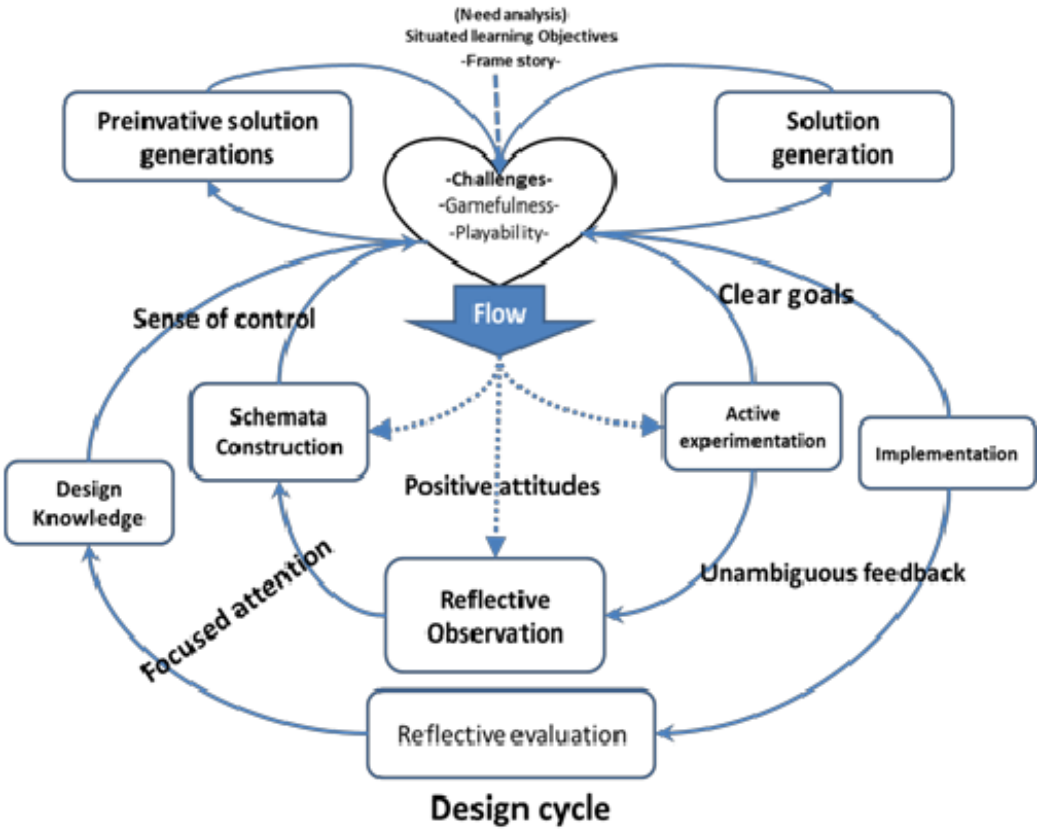

Figure 3 Experiential Gaming Model

Working on two cycles of understanding, the EGM looks to provide both a theoretical underpinning of the design process but also helps the designer to focus on what are the important factors that make up the game and learning experience of the player. As observed from Figure 3, the EGM follows an iterative cycle in its style and is the first in the selected frameworks/ models to consider behavioural psychology concepts such as the use of flow and positive attitude generation as part of the design and development process. For Kiili, the use of flow (Csikszentmihalyi, 1991) is an essential component of the design process of SGs in that 'flow' has been shown to have had a positive impact on learning in other studies (Ghani, 1991; Kiili, 2005; Skadberg & Kimmel, 2004; Webster, Trevino & Ryan, 1993).
There are several best practice approaches that can be abstracted from Kiili's (2005) EGM, including that which the author considers as a vital step of the design process, in the use of a 'needs assessment' approach. Kiili puts forth that the first step of the design process should be to conduct a needs assessment of the intended end-users to identify issues and understand user preferences that can be linked out to the learning outcomes. This attention to the end-users and Kiili's observation of the need

to address psychological concepts such as 'flow' puts the EGM forward as a model that embodies several processes that the SG design and development process could be built upon. Whilst Kiili's work was used to inform some of the processes behind the design approach, the EGM was not used as the lead framework for the theoretical development of the SG/ gamification strand. This was due to how the theory and basis of the EGM was considered and developed into the 'Four-Dimensional Framework' by de Freitas & Oliver (2005).

4.3.3 Four-Dimensional Framework/ Serious Games Design Model: Process, principles and tools

The 'Four-Dimensional Framework' (4DF), and its later counterpart, the 'Serious Games Design Model: Process, principles and tools', were developed to form a cross-disciplinary approach to the design and evaluation of educational SGs. The framework emerged originally as a way for educators to assess the acceptability and use of a SG in a classroom, but in its second iteration has moved more towards supporting the design and development process of SGs (de Freitas & Jarvis, 2009). The framework is made up of four dimensions as seen in Figure 4 and considers; learner specifics, pedagogy, representation and context.

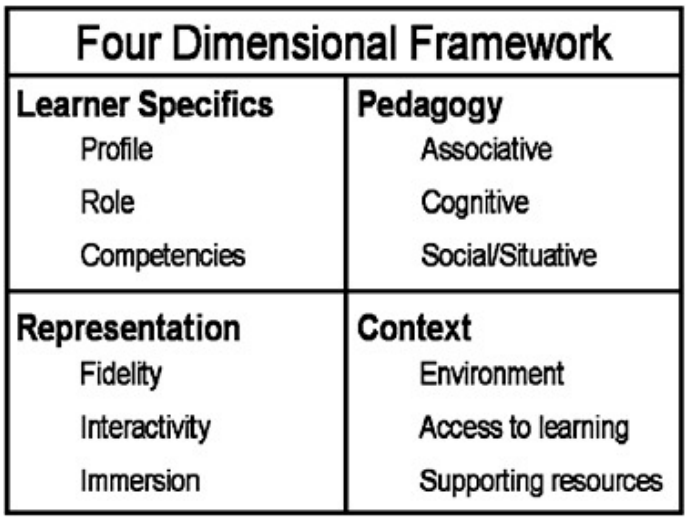

Figure 4 Four-Dimensional Framework

The first step, much like Kiili (2005)'s EGM, considers Learner Specifics and addresses the need to profile the learner and consider any learner requirements. The second step, Pedagogy, looks to consider learning activities and the methods to which they will be supported and delivered to the learner. The third, Representation, looks to consider the players interaction and experience within the environment. And the last, Context, looks to consider how the surrounding environment and

supporting resources available may impact the experience of a SG. It was in the inclusion of the final step, Context, that the author saw how the 4DF could bring a wider discussion to the development of best practice approaches outside that of purely bridging learning theory to game theory. Alongside its theoretical basis developed from Kiili's (2005) work, the 4DF was chosen as the lead method to inform the design and development approach of the PR:EPARe project (see Output 1 & 2). Further discussion and analysis of how the 4DF was adopted and developed to inform the recommendations for best practice approaches to SG and Gamification design and development can be found in Output 1 & 2 of the Prima Facie.

4.3.4 Theory-Orientated Evaluation

The Theory-Orientated Evaluation method that was developed by Kriz & Hense (2006) was originally excluded from review due to its focus on evaluation rather than the design and development process of SGs/ gamification. However, the author chose to note this method during the review process due to its emphasis on the use of participatory design as a way to ensure all stakeholders involvement and to iteratively build in end user feedback and testing in the product. This is done to ensure that the final product is suitable and received well with the intended audiences. Discovery of participatory design (Schuler & Namioka, 1993) had a clear impact on the research, not only from the stance of SGs system design approach but from further research into Intervention Mapping (Bartholomew et al., 1998). As a result, the work by Kriz & Hense (2006) was often referred back to, to understand how the process had previously been adopted in the SG field.

4.3.5 Serious Games Conceptual Framework / Six Facets of Serious Games Design

Both of the frameworks 'The Serious Games Conceptual Framework' developed by Yusoff et al. (2009) and the 'Six Facets of Serious Games Design' developed by Marne et al. (2012) are other early examples of SG design frameworks that were developed to help understand and map out the SG design process. Again, these frameworks as stated by the authors, were mainly developed to 'establish a conceptual model in which learning and pedagogy theory is combined with gaming requirements' (Yusoff et al., 2009; Marne et al., 2012).

The Serious Games Conceptual framework was developed from the input-process-outcome game model developed by Garris et al. (2002) and is formed of nine components in total including; Capability, Instructional Content, Intended Learning Outcomes, Game Attributes, Learning Activity, Reflection, Games Genre, Game Mechanics and Game Achievement as seen in Figure 5.

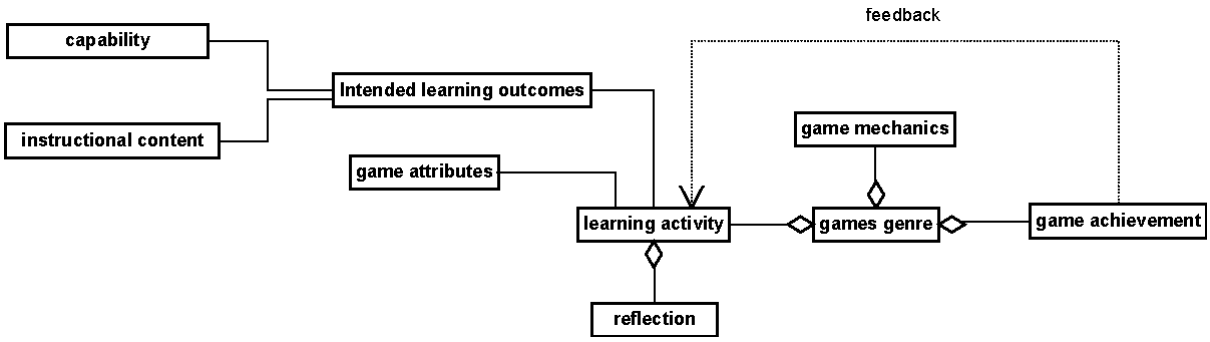

Figure 5 A Conceptual Framework for Serious Games

Whilst the Serious Games Conceptual Framework highlighted many interesting elements of the design and development process, previous work from Kiili (2005) and de Freitas & Oliver (2005) had examined these elements in detail, so much so that the author felt that the framework by Yusoff et al. (2009) added little value to furthering the discussion from a design perspective.

Similarly, the Six Facets of Serious Games Design framework as shown in Figure 6, is made up of six facets to consider for a SG design process that include; Pedagogical Objectives, Domain Simulation, Interactions with the Simulation, Problems and Progression, Decorum and Conditions of Use.

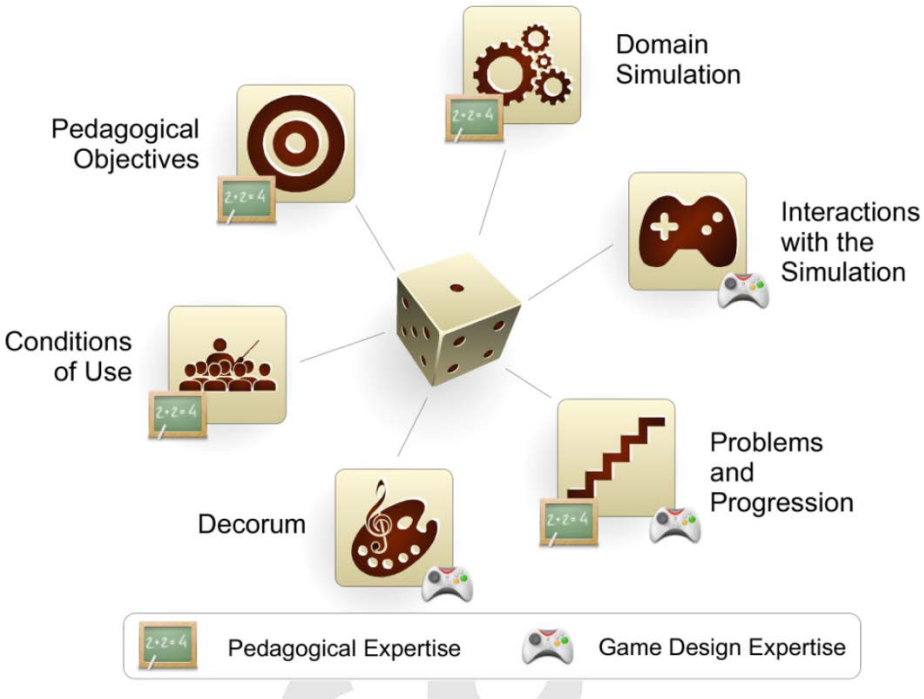

Figure 6 Six Facets of Serious Games Design

Marne et al's., (2012) contribution focuses mainly on the assignment of 'the right expert for the right design area'. Their work states that different experts should be placed in the design process based on individual expertise and understanding. However, this is a point in which the author believes is detrimental to the design process in which this approach feels to focus too much on segmenting the work to those with domain proficiency. Instead, the author believes a participatory design approach, as highlighted by Kriz & Hense (2006), in which the design process is a shared working environment that builds on everyone's expertise and includes domain experts is adopted. This allows for a greater understanding of the whole process within and between the developers and stakeholders.

Other points that Marne et al., (2012) raise in their consideration of the design process in their framework, have previously been seen to be discussed in other earlier frameworks (Kiili, 2005; de Freitas & Oliver, 2005). Whilst the knowledge contribution is not poor by any means and echoes other best practice approaches that have been put forward, the contribution was not seen to add anything innovative to discussions of SG design and development. Therefore, the author felt that the Six Facets of Serious Game Design brought no new knowledge that could be used to develop the research forward in terms of best practice approaches to SG and gamification design.

As such, neither the Serious Games Conceptual Framework or the Six Facets of Serious Games Design framework were revisited to help develop the design process behind the PR:EPARe game.

4.3.6 Triadic Game Design

The Triadic Game Design approach developed by Harteveld (2011) is based on a three-dimensional approach to understanding the design process; Play, Meaning and Reality.

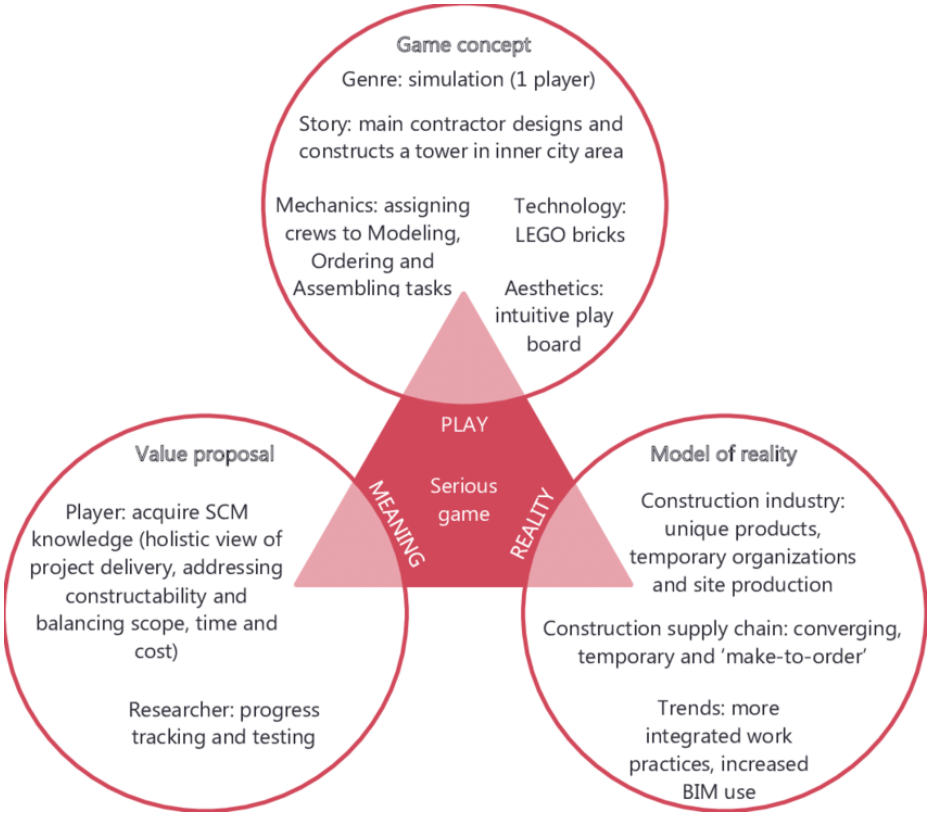

Figure 7 Triadic Game Design

Harteveld (2011) puts forward that Play (technology behind the games), Meaning (learning sciences and objectives) and Reality (representation of the real world) are the three worlds of which a SG designer must find a balance between for good design. Whilst Harteveld's work (2011) goes over some processes that have already been covered in other frameworks, such as pedagogic considerations and game concepts development, the author found the discussion surrounding the 'Reality' criteria to be insightful and understanding the design process. Harteveld states that regardless of how fantastic or abstract a game may be, that game will always have a connection to the real world. In the case of SGs, Harteveld (2011) believes that this connection to the world should be even stronger, because 'the real world needs to be affected by the game'. The concept surrounding 'Reality' as a criterion to consider as part of the design process was unique and provided a valuable insight into the crossover between player realities. This understanding was used to help frame the development of materials that bridged both realities, such as supporting documents, trans-media resources and guidance on stakeholder/ facilitator-led contributions both in and out of the experiences. It was particularly useful to theorise how the research looked to build connections between the game and the real world, and how this could affect the players game and learning experience. Although the Triadic Game Design model (Harteveld, 2011) is not formally acknowledged in the outputs of the Prima Facie, the theory of 'Reality' in SG design, was used to inform elements of the design process, which also linked to the

context dimension of the 4DF (de Freitas & Oliver, 2005) in which design must be situated within the context, deployment and practice of the intervention.

4.3.7 Learning Mechanics to Game Mechanics (LM-GM) Mapping Approach

The LM-GM Mapping approach originally explored by Lim et al., (2015) was developed to help practitioners identify and map pedagogical elements to traditional game features. It provides a set of pre-defined game mechanics and pedagogical elements as seen in Figure 8, which have been drawn from both learning and game theory.

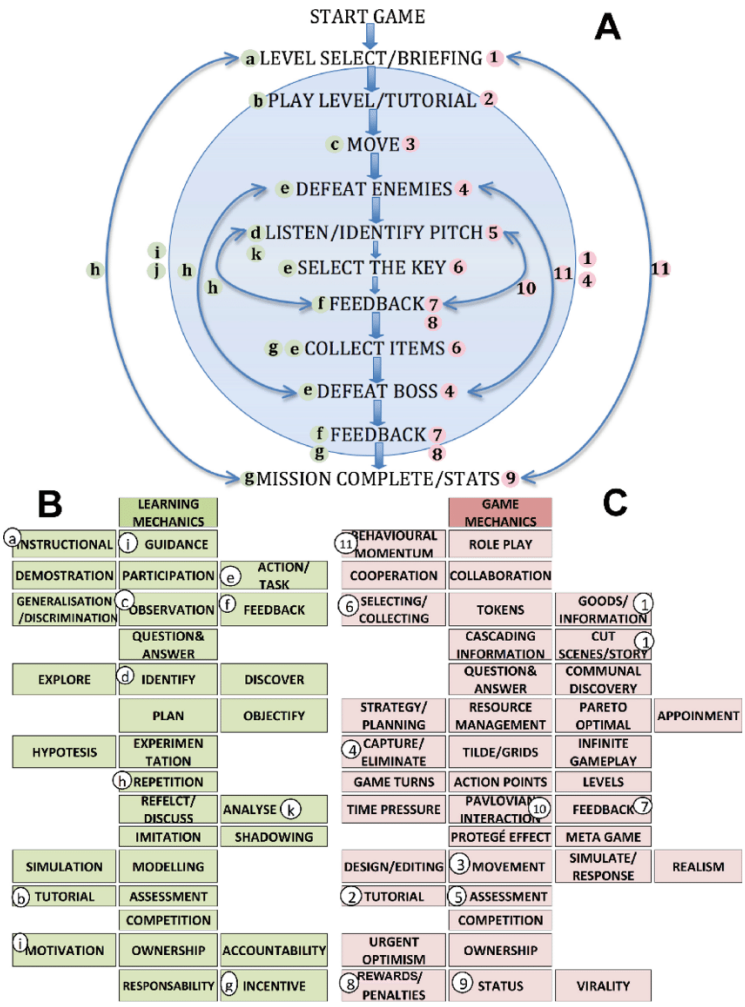

Figure 8 LM-GM Mapping Approach

One of the key positions of the LM-GM Mapping approach and its research, is that game designers and educators do not traditionally share a similar vocabulary, which provides issues with effectively translating learning outcomes effectively into game elements (Arnab et al., 2015; Gunter et al., 2006;

Kiili and Lainema, 2008; Lim et al., 2015). Lim et al., (2005) puts forth that by creating a framework that identifies and discusses key learning and gaming theories, it provides the reader with a concise means to relate to both educational and game design theories, and provide a means to help identify the right gaming mechanic against that of the chosen learning approach. Based on Blooms ordered thinking skills (Bloom, 1956), the model aims to provide a format in which the barriers of language are addressed and to help practitioners meticulously examine whether design decisions are suitably matched early on in the design process. This is of particular note to the research, due to the analysis of SG design frameworks that all highlight the importance of effective transfer of learning content to game environment, but provide no practical guidance on this process. Furthermore, the LM-GM is a recognised framework in the discipline, and has been used successfully by academics and practitioners to inform and develop the design of SGs (Callaghan et al., 2015; Imbellone et al., 2015; Savin-Baden et al., 2016).

Due to its practical nature in application, the LM-GM Mapping Approach was chosen as one of the lead frameworks to help guide and inform the design and development approach of the PR:EPARe project (see output 1 & 2). It was used to aid the process of mapping the learning content to the game content. Further discussion and analysis of how the LM-GM approach was adopted and developed to inform the recommendations for best practice approaches to SG and Gamification design and development can be found in Output 1 & 2 of the Prima Facie.

This section has provided a theoretical review of the SG frameworks and models that helped to develop the researchers understanding of how the process of SG and gamification design was approached and executed in the academic community. Through an overview of the different models that were available to the researcher, insight is offered into the choices of made in the research, particularly in reference to the selection and use of the 4DF as the leading educational SG framework that was used to inform output 1 & 2 of the Prima Facie.

4.4 Behavioural Science and Intervention Theory

As observed from the literature in Section 3.2 Educational Theory, the principles that make up the ideals and philosophical structure of SGs and gamification are heavily imbedded in educational psychology and in general, behavioural science. It is therefore essential (and is in part justification of the contained research), that we observe and understand that within the process of SG design, learners are different and will respond contrarily to learning through a SG. It is necessary to then plan

from a behavioural science perspective in which a practitioner accounts and designs for the human element (including that of behavioural change) to ensure a holistic design process.

As observed from the selected SG frameworks and models discussed in Section 3.3, most of these approaches have drawn focus to the need for developing clear learning objectives and design elements that improve upon the process. However, whilst these frameworks/ models provide a significant contribution to the understanding of the design and development process, they give little to no examination as to the discussion of how to design with a learners' psychological attributes in mind, or a discussion as to how these may affect learning outcomes. And whilst there are undoubtedly discussions and the recognition of psychological theories as imperative considerations to the design process, such as flow (Csikszentmihalyi and Lefever, 1989) and mastery (Gee, 2003), less emphasis is still placed on how to design for that behaviour change in a formal SG design methodology. The author therefore puts forth the stance that by building understanding of behaviour change objectives through using established psychological theory into the design process, a more comprehensive and best practise approach to developing effective SGs can be achieved.

And whilst little attention has been given for the active design process of psychological attributes in formal SG frameworks, plenty of successful work has been carried out within the health-related SG sector (Baranowski et al., 2008; Gobel et al., 2010; Thompson et al., 2010; Wang et al., 2016; Fleming et al., 2017). Such examples have looked to encourage positive behaviour change outcomes in the players. One such example of how psychology-based theory has been used to create an effective SG, is how Baranowski et al. (2008) applied the use of social cognitive theory (Bandura, 2009) in their SG-based intervention, in order to have a greater chance of encouraging better self-care of asthma within the players (Baranowski et al., 2008). They also conducted a review within this work, of other health-based SGs that had adopted the use of behaviour change planning in the design and development of the SG. In Baranowski et al. (2008)'s final discussion of the work, they stated that;

> *"Playing most of these behaviour-change video games led to a broad spectrum of desirable outcomes from knowledge increases, to attitude changes, behaviour changes, and other health-related changes. This bodes well for the future use of video games to promote health-related behaviour changes and warrants an intensive analysis of aspects of video games that offer the most promise of promoting behaviour change"* (Baranowski et al, 2008, p.4).

This highlights that when used as part of the process of SG design, behaviour change planning can and has had an impact on the efficacy of the desired outcomes of the SG. As such, the position of the research and belief of the author, is that behaviour change planning should form one of the processes that demonstrate a best practice approach to SG design. One addendum to this position however, is that the author recognises that behaviour change strategies and theories are not a guaranteed course of action for bringing about desired behaviour change due to the multiple complexities of the internal and external factors on the human position. However, what can certainly be achieved is a deeper understanding on how these complexities affect behaviour, and can be used to better inform policy makers and practitioners as to the barriers they are facing.

There are many behaviours change theories and the review of each of these in relation to their individual suitability to form part of a SG/ gamification design and development process falls outside of the scope of the research. However, behaviour change approaches can broadly be placed into three categories of; (1) theories in which a focus is placed on individual behaviour change, (2) theories in which focus is placed on behaviour change at a community level and (3) theories that try to incorporate internal and external factors, subsumed under 'integrative theories of behaviour' (Prager, 2012). Generally, SGs tend to operate on the premise that there is a wish to change an individual's behaviour, and therefore operates on an individual-level behaviour change intervention approach. This type of approach means that the intervention is focused on creating measurable change in a specific person. Whilst the intervention focuses on the individual, the delivery of the approach can incorporate a number of methods including one-to-one and group-led activities. This approach gives the flexibility needed for deciding whether a SG/ gamification intervention can be a single or multi-player experience.

To help address the need for building in behaviour change theory and processes to help inform a best practice approach to SG design and development, Bartholomew et al's., (1998) Intervention Mapping approach is adopted as the primary behaviour change process in the research. Intervention Mapping (IM) draws together the known theory and evidence of an issue to form the foundation in which to assess and pose new solutions to overcoming that problem. Building on the understanding that the key words that make up IM are planning, research and theory (Bartholomew et al., 1998), the process identifies theory-based determinants and matches them with suitable methods for encouraging desired behaviour change. Intervention Mapping as described by Bartholomew et al., (1998) and illustrated in Figure 9, presents five steps: (1) creating a matrix of proximal program objectives, (2) selecting theory-based intervention methods and practical strategies, (3) designing and organizing a

program, (4) specifying adoption and implementation plans, and (5) generating program evaluation plans.

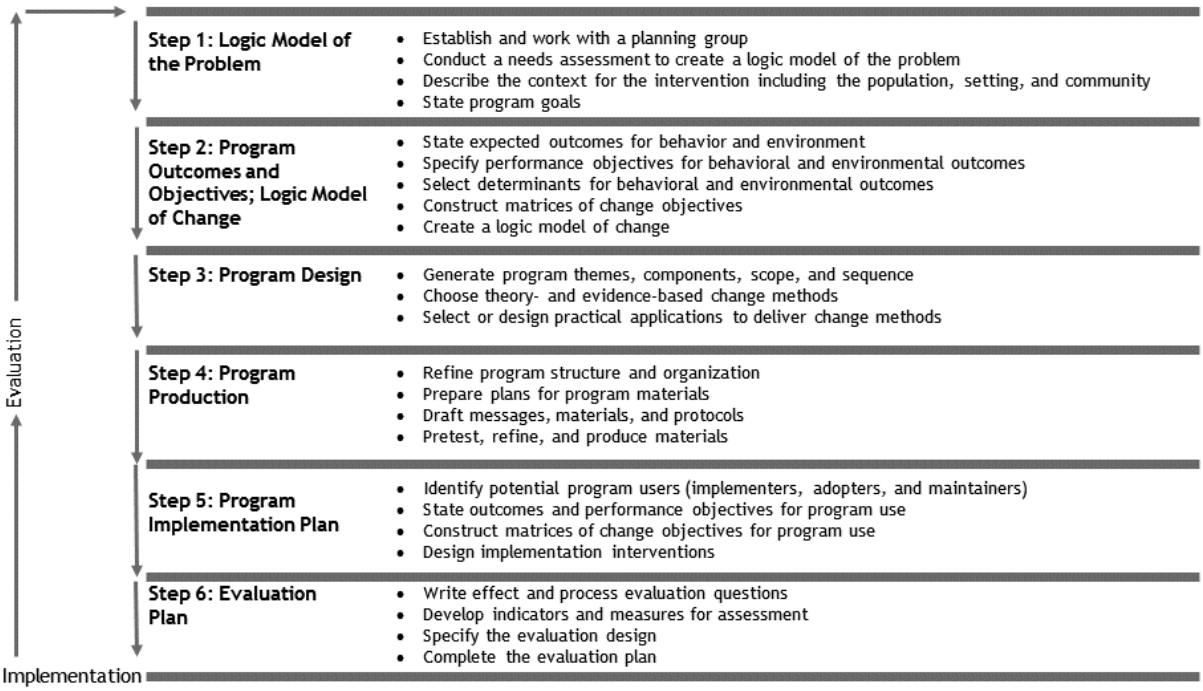

Figure 9 Intervention Mapping Framework

The use and selection of the IM approach is two-fold, in that it is considered as an iterative planning process rather than a linear approach which allows for practitioners to move back and forth ensuring flexibility, and that it draws on stakeholder engagement, theory and evidence to support the planning process. As such, IM with its iterative and participatory approach to planning, is a compatible framework that follows a similar philosophical approach to that of DBR, the overarching methodology used throughout the research. Further discussion and analysis of how the IM framework was adopted and developed to inform the recommendations for best practice approaches to SG and Gamification design and development can be found in Output 1 & 2 of the Prima Facie.

4.5 Entertainment Games Theory

One of the most surprising elements the author has observed whilst conducting this research, has been the discovery that there are significantly fewer formal entertainment games design and development frameworks and/ or methods available for the use of other practitioners. Due to the nature and secrecy of the games industry regarding intellectual property (especially prevalent in the AAA games industry) and with focus generally on milestones and submission of market ready games, it is possible that the premise of developing a formal methodology is a highly undervalued area for

the general games design and development community. Another reason for this gap could be simply attributed to the complexity and scale of the games industry. In large game companies that can employ similar numbers to the movie industry of 3k+, it can be assumed that a dissection of all of these different roles and methods that go forward in to creating a game is just too large to track and compile. On the other end of the scale, indie game companies that employ small numbers of employees or even single developers may develop their own strategies and processes for the design and development cycles, however once again focus may be drawn to successful completion of a game rather than wanting to dissect and refine the process that got them to that point.

Whilst there is little to be glimpsed from the entertainment industry, there are game design frameworks/ models that come from the understanding drawn together from the academic community (whose members include professionals from the entertainment industry that have since moved into an academic position). Some of these examples can be found in several books and workshops that look to understand the process of creating games. These include such examples as Bates & LaMothe (2001) book *'Games Design: the art and business of creating games',* Fullerton's book (2014) *'Game Design Workshop: a playcentric approach to creating innovative games'* and Schell's (2014) *'The Art of Game Design: A book of lenses*. There are also a number of papers in the research archive of DiGRA (Digital Games Research Association), such as *'Describing Games: An Interaction-Centric Structural Framework'* (Bjork & Holopainen, 2003) and *'Games Design Patterns'* (Bjork & Peitz, 2007), that take a look at what contributes to the process of games design from a non-learning point of view. The author has used information from these articles to help frame the recommendations for SG/ gamification specific tools in which to reach the wider community which are discussed in Section 7- Conclusions and Further Work.

Despite the fact that there are a number of informative and suitable game design resources that could have been put forward to inform the theory and best practice section of the research, there were two that stood apart from the others due to their authors previous position and recognition as games industry expert, Jesse Schell (*Imagineer at Disney*) and Robin Hunicke (*Producer at 'That Games Company'*). Both authors have led and produced AAA games that have won multiple awards and praise from critics and audiences. Due to their involvement and success with creating games in the industry, the author selected Schell and Hunicke from the literature as they were considered practicing experts that could identify best practices in games design and development.

Exploration of Schell's work ''*The Art of Game Design: A book of lenses'* (2014) was illuminating as it listed and explained through many different game's mechanics and the experience that it would

inspire within a player. Further examination of the work, revealed that it was unsuitable to be used as a method as it was less about the process, but more on the investigation of different types of mechanics. However, this examination on the different mechanics is planned as part of further work to inform and further develop upon the authors understanding and application of learning mechanics to game mechanics (Arnab et al., 2015).

Instead, to understand best practice approaches from an entertainment games design and development background, the author selected Hunicke's work, the MDA (mechanics, dynamics and aesthetics) framework (Hunicke et al., 2004) to help inform the research. The MDA framework as seen in Figure 10 (standing for Mechanics, Dynamics, and Aesthetics), was developed and taught as part of a Game Developers Conference, (San Jose 2001-2004). At its core, the MDA describes games as more akin to 'artefacts than media' in that games are concerned with the development of behaviour, both in how the game works and in how the player interacts with that game. Again, this both informs and reinforces the premise that games should be considered and developed in part, with an understanding of behavioural science if best practices are to be drawn out.

The MDA breaks down games into three distant components to consider for design.

- Mechanics: which describes the components and data representations of a game
- Dynamics: which describes the behaviours of the mechanics which in turn are reacting to player input and output over time.
- Aesthetics: which describes the emotional outcomes that are felt in the player through their interaction with the game.

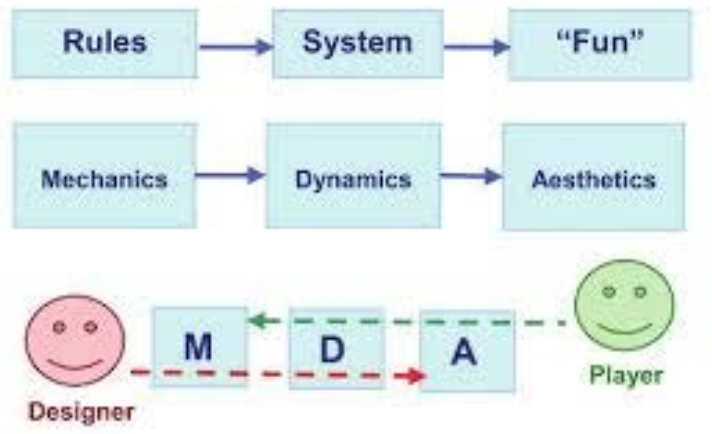

Figure 10 the MDA Framework

Hunicke et al., (2004) that each of the three components are separate but connected when considering the design process that the:

> *"mechanics give rise to dynamic system behaviour, which in turn leads to particular aesthetic experiences"* (Hunicke et al., 2004, p. 2).

As the process allows for the dynamic interaction and inspection of the game and player behaviours at each stage of the MDA framework, it is easier to pinpoint different interactions and assess how these affect the overall game process. As a result, Hunicke et al., (2004) recognise that the MDA framework presents an iterative approach to design allowing for "*control for undesired outcomes, and tune for desired behaviour knowledge, policy and practice*" (Hunicke et al., 2004).

The discussion and reflection within Hunicke et al's., work surrounding the need to understand game and player behaviours, and the focus on end-user experience as a primary consideration, was considered instrumental to aiding the process of informing best practice approaches to SG design by the author. For these reasons, the MDA framework was selected to lead the theoretical underpinning of the research from an entertainment games design perspective. Further discussion and analysis of how the MDA framework was adopted and developed to inform the recommendations for best practice approaches to SG and Gamification design and development can be found in Output 1 & 2 of the Prima Facie.

5. Analysis of the Portfolio of Evidence

5.1 Introduction

The Prima Facie is made up from seven selected outputs developed and published between 2012 and 2019. Included within; peer-reviewed Journal Articles (1, 2, 4, 5), and applied research outputs (3, 6, 7). Published peer-reviewed conference proceedings (3, 7) and a case study (6) have been included in the Prima Facie to ground the practical outputs and provide context for review. To conceptualise these outputs against the objectives of the research, a logic pathway as seen in Figure 11 presents the overall flow that forms a clear path and links the work together in terms of the objectives which looks to (i) draw out key methodologies and frameworks used for aiding the design and development of SGs/ gamification (ii) synthesise these findings through a design-based research approach (iii) provide a reflection and amalgamate these findings to provide a multi-disciplined design process (iv) implement the design process in live learning environments and develop scope for future development.

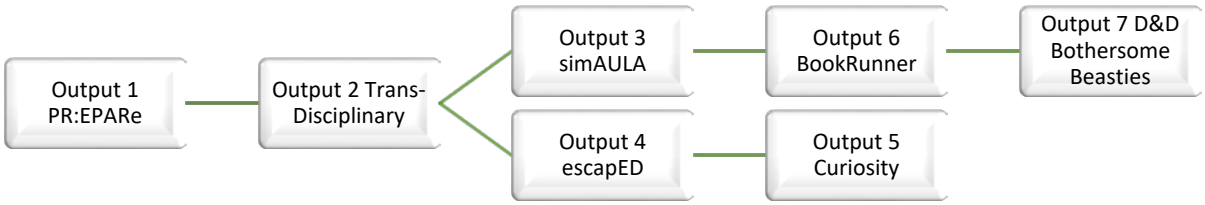

Figure 11 Output Mapping

This section is presented in five parts:

Part A: Identification of existing key frameworks and methods to inform the design of a Serious Game.

Part B: Creation of a Trans-disciplinary Model for SG and gamification design.

Part C: Developing from the Trans-disciplinary Model to inform the escapED framework.

Part D: Practical Implementation

Part E: Discussion of best practices

5.2 (A) Identification of Existing Key Frameworks and Methods to Inform the Design of a Serious Game.

The primary stance of the research is that in order to develop a best practice approach to SG and gamification design and development, a trans-disciplinary approach to development must be adopted. In the journal paper, **Output 1 'The Development Approach of a Pedagogically-Driven Serious Game to support Relationship and Sex Education (RSE) within a classroom setting'** (Arnab et al., 2013), the peer-reviewed Journal article describes how The Serious Games Institute (SGI) at Coventry University was commissioned with developing a digital game PR:EPARe (Positive Relationships: Eliminating Coercion and Pressure in Adolescent Relationships) to assist in the delivery of Relationship and Sex Education (RSE) within secondary schools in the Coventry and Warwickshire area. The project was a joint endeavour with Studies in Adolescent Sexual Health (SASH) research group and was funded by the Health Innovation and Education Cluster (HIEC) for West Midlands (South). Output 1 is linked to the first two aims of the research: (i) draw out key methodologies and frameworks used for aiding the design and development of SGs/ gamification (ii) synthesise these findings through a design-based research approach.

The journal documents the development approach of the serious game PR:EPARe that is undertaken using a DBR methodology, and draws on multiple theories and frameworks from the fields of education, serious games design, behavioural sciences and entertainment games design that were used to inform the design process. The reasoning and selection of the leading frameworks and methods as detailed below are discussed in detail under Section 3: Research methodology, practice and theories that link the outputs together. The four leading methods that informed the design process were the following:

- The Four-Dimensional Framework (4FD) by de Freitas & Oliver (2005). This framework was used to inform the educational and serious games design component of the research.
- Learning Mechanics to Game Mechanics Mapping (LM-GM) by Lim et al., (2015). This mapping approach was used to translate the learning mechanics to that of suitable game mechanics.
- Intervention Mapping approach (IM) by Bartholomew et al., (1998). This approach was used to understand user needs and develop behavioural theory into change objectives to be used in the game.
- Mechanics, Dynamics and Aesthetics (MDA) by Hunicke et al., (2004). This approach was used to understand the relationship of behaviour and player experience in an entertainment games design approach.

The Journal article is split into two main sections for consideration, the first describes the design and development process of the PR:EPARe game, and the second describes the deployment and evaluation of the game. The analysis will focus on the first section of the journal paper that is concerned with the design and development approach of PR:EPARe.

The journal begins by illustrating that the use of games for formal educational purposes is now an established and respected practice of teaching and learning due to a large number of educational practitioners adopting and evaluating games as effective learning platforms (Ulicsac, 2010; Kim & Chang, 2010; Yang, 2012). One element that hinders the take up and adoption of SGs however, is the barrier to the design of such games. The work builds upon this issue and highlights Bourgonjon et al., (2013) theory, that '*games are more likely to be used if they can be seen to inspire'*, or if '*there is a direct link to the curriculum and that teachers play an important role in the adoption and effective use of a GBL approach'*. It is this combination of not enough support and/ or effective application of teachers/ facilitators in both the design and delivery process of a serious game, that the authors draw upon as an area to further challenge and build upon. This is drawn from Dewey's beliefs (1916) that education is an active constructive process, and in which active participation should be for all involved. The authors pose that the design process to be taken in the development of PR:EPARe, should therefore be a participatory and iterative approach that develops with the need in mind to provide better and inclusive design guidance. This is to ensure that teachers and facilitators who wish to adopt SGs as a teaching method, understand a game to the best of their ability and can act as mediators to prompt and facilitate active discussion around the materials within a game.

Following the contextual positioning of the readers, the article considers the pedagogical considerations that were drawn from two of the four leading methods/ frameworks, the 4DF (de Freitas & Oliver, 2005) and the LM-GM (Lim et al., 2015). As discussed in Section 3.3 Serious Games Frameworks and Models, most of the methods that were reviewed focused on the need to develop educational constructs effectively into a game context. The 4DF was used to aid the deconstruction of these educational constructs that could be managed within PR:EPARe's design process. Key components highlighted by the 4DF were crucial in the development of the PR:EPARe game, and were used as part of a pre-planning process in which key considerations were highlighted before development began. A deconstruction of the characteristics of intended end-learners alongside the various constraints that the project was facing, was used effectively to determine that the game should adopt a blended learning approach to delivery and that it should be delivered within a formal learning environment setting. These types of factors need be understood at the beginning of the

design process, as they shape all manner of design choices including appropriate technology to use, type of game play and delivery of game. Understanding how to profile learners and their needs through a participatory approach, led to the PR:EPARe game being developed from the requirements of the end-users. A high-concept game design document was utilised to provide an overview of the games early design to the stakeholder guidance groups.

The article goes on to look at how pedagogical constructs are linked to game constructs. As discussed in Section 3.3 Serious Games Frameworks and Models, the theory surrounding best practice approaches to SG design and development at the time, were concerned mainly with the translation of developing learning objectives effectively into game-play scenarios. Whilst the need to do this was often discussed, no guidance on how to effectively create this translation was offered up in these frameworks/ models. To address this, the LM-GM was implemented in the PR:EPARe design process to form the pedagogic-game mechanic mapping approach that would look to bridge this gap in the theory. The application of the LM-GM in a formal design process, provides a unique contribution to a best practice approach of SG design, as it is the first that offers up practical guidance on how to develop the right learning approach into the right game mechanic. To support the application of the 4DF, the IM approach (Bartholomew et al., 1998) was implemented by SASH to ensure that the factors associated with the topic 'what puts young people at risk of sexual coercion?' were addressed. The IM approach in the design process was used to frame the analysis of the needs of the end-user relevant to their experiences of sexual coercion, objectives or targets for behaviour change, strategies/ planning for the game-based solution and the deployment and evaluation of the game into a real environment. Several design and development approaches were discovered from the application of the IM approach, including that of the need's analysis step, stakeholder planning and the games evaluation design. Building on the researchers' philosophy and need for a participatory approach to the design process, a number of major stakeholders including sexual health & sex education professionals and four different groups of young people were engaged as part of the IM process, to discuss what the PR:EPARe game should cover, who should be the target audience and what game preferences could be uncovered with the target audience? These best practices are later taken forward and discussed in Part B: Creation of a multi-disciplinary model for SG and gamification design.

Following the implementation of the IM process into the design cycle, the MDA (Hunicke et al., 2004) was employed to look at how the choices made through the LM-GM mapping approach was then executed into effective game behaviours that would lead to desired player behaviours. Perhaps one of the most difficult stages of the design cycle for PR:EPARe, was the translation of the right mechanics

to deliver the desired behaviours. Drawn from the understanding that came out of the mapping process of the LM-GM, PR:EPARe was to provide the following learning to game mechanics:

1. Discovery, analysis and identification. The ability to identifying the nature and levels of coercion is a key target of PR:EPARe, which are supported by the different scenarios on coercive behaviour.

2. Competition and feedback: As part of the game mechanic, competition and feedback promotes real-time and positive interaction and engagement within game play.

3. Active participation and reflection: exploratory learning promoted by encouraging communication, reflection and debriefing during and after game-play. Cooperation and teamwork promoted by blending technology into the traditional classroom setting.

Allowing the identification of game mechanics like 'role-play, time pressure and competition' from the learning mechanics that were identified in the IM/ Stakeholder participatory design process, helped to further narrow down the game design decisions that the author was facing. This part of the design process was a difficult but essential task, due to the sheer number of game types/ genres/ mechanics that can make up any given game. The LM-GM approach helped to bridge the gap that other serious game design frameworks/ methods lacked, in the guidance of how to translate the learning outcomes effectively into game mechanics. An outcome of the research conducted by the author in Output 1, 2 3 & 7, outlines scope for further development on the LM-GM mapping approach based on the understanding that there are different sub-genres of the mechanics mentioned (role-play for example can be LARP/ D&D based, first person camera, sex games etc.), in which it would be useful to have further analysis and guidance about how the chosen mechanic fits into a games genre and experience type.

The MDA (2004) was used here to help frame the genre and experience, based on the selection of the game mechanics, and other considerations that were identified in the need's analysis and participatory design sessions, that the experience could mimic that of a game show. Drawing on other popular entertainment game examples such as *Buzz! The Mega Quiz*[7] emphasis was put on the delivery of the game. As a result, social and multiplayer player interactions and experiences (dynamics and aesthetics) were focused on to ensure elements such as discovery, active participation,

[7] Buzz! The Mega Quiz was developed by Relentless Software in 2007 and is the fourth game in the Buzz! series for the PlayStation 2.

competition and reflection were at the heart of the players game experience. The use of the MDA at this stage helped to understand how a player experiences a game, what emotions the player is meant to feel and how to effectively consider and design for these from a player's perspective using an iterative approach to design. The approach of understanding the 'experience' of a game from a player's perspective, was not an area that was discussed In any of the serious games design frameworks. It was only by looking to the entertainment games design research, that a discussion on 'player experience' was uncovered. This indicates a need for further discussion and development of SG research in this area.

The application of the multi-disciplinary frameworks/ methods that were selected to help the theoretical and practical implementation of the PR:EPARe game helped to bridge gaps in guidance that was lacking from the use of just one or two methodologies. Understanding that games are multi-faceted and as such require a broader approach to design is a key finding in the research. It is worth noting on the design and development cycle; another finding from this research whilst frustrating but relevant to acknowledge, not every user will like the game experience that is created even when you include end users/ stake holders and implement experience/ behaviour design. Most SG design frameworks/ models focus on the finding of the perfect formula to create the perfect game, but the ideal of a perfect game does not exist, not even in the entertainment games industry. Instead, what is needed, is to provide the best possible approach to the design and development of a SG/ gamification application to ensure that from a practitioner's point of view, all has been done to provide the best version of what can be achieved. By drawing out the key methodologies and frameworks from a review of the literature (4DF, LM-GM, IM & MDA) and by applying these to a design and development cycle through a DBR approach of the serious game PR:EPARe (Output 1), objective (i) and (ii) of the research has been achieved.

5.3 (B) Creation of a trans-disciplinary model for SG and gamification design.

Objective (iii) of the research was to provide a reflection and amalgamate the findings from the literature and DBR process of PR:EPARe, so as to provide a trans-disciplined design process that incorporated the most helpful/ effective elements from each of the four frameworks/ models that were used. In the journal paper, **Output 2 'Towards a trans-disciplinary methodology for a game-based intervention approach '** (Arnab and Clarke, 2016), reflects on these elements and presents the Trans-disciplinary model as a unified guide to SG/ gamification design.

The peer-reviewed Journal article is split into four main sections. The first concerns itself with providing an overview of SG design and development. The second section introduces the PR:EPARe game as the test case alongside the four frameworks/ models that were adopted for the theoretical underpinning of the research (4DF, LM-GM, IM, MDA). The third section discusses the evaluation and the outcomes of the PR:EPARe game with the end-user audiences, and the fourth section presents a discussion on the multi-disciplinary design process leading to a united design methodology. The analysis will focus on the fourth section of the journal paper that is concerned with the discussion of the multi-disciplinary design process and the Trans-disciplinary model (TDM).

The fourth section of the journal begins by providing the reflection that games require the need of multiple specialists to help succeed in their development. However, unlike large AAA game industry design studios, multiple people with these different skills are not generally on hand for development of a SG. This means that practitioners need to be smarter and more efficient with their adoption of time and resources. Ensuring that the design and development approach available to practitioners is streamlined with best practice approaches from multiple disciplines, provides the best start to achieving the set objectives of the project.

First and foremost, the Trans-disciplinary model that is described embodies the two practices of participatory and iterative design. Taken from the research on existing SG and game design frameworks/ models that were used to inform the research, an iterative approach to design practice featured highly within many of the frameworks/ models (de Freitas & Oliver, 2005; Hunicke et al., 2004; Kiili, 2005). Part of the use of iterative development comes from the understanding that these categories of educational resources need constant adaptation; whether this is to reflect different end-user needs, to work in new content or to ensure that any technology/ materials are operational. Ultimately this means that practitioners who are interested in adopting SGs/ gamification resources for use, will need to consider the time and resources that they can realistically put forward into developing and maintaining the outcomes. However, if a practitioner can commit to an iterative process, the benefits of such a resource for the end-learners can be significant. Whilst participatory design was less popular within the research on SG/ gamification design frameworks/ methods, it stood out within the behavioural intervention field (Waller et al., 2006; Owens et al., 2011) and is a popular method for ensuring that an end product is designed from an end users' point of view. Within the IM approach (Bartholomew et al., 1998) a participatory approach to design is central to the process, inviting stakeholders and end user groups to input their opinions and feedback into the project. The author believes that the participatory design approach that was taken during the PR:EPARe project from the IM approach, was one of the most useful elements of the whole design process. Working

directly with different experts and end-users, there were several cases where the games design was not fit for purpose or didn't reflect user perceptions and was changed to reflect the users input and feedback. This ensured that the project felt like it was the users leading the design process rather than the developers. This combined with the iterative approach, allowed for a design cycle that was reviewed at every stage.

Although none of the reviewed frameworks/ models suggested splitting design tasks into different production stages, work conducted by Ramadan & Widyani (2013) helped to define a production cycle in which the authors felt was lacking from other SG design frameworks. The TDM is described as a three-phase iterative cycle of development, in which the phases are split into; pre-production, production and post-production. This is done to ensure that specialised knowledge and attention are given at the right points in the process, and that the development team do not accelerate design decisions such as choosing mechanics or art style before conducting a needs analysis of the project's users and objectives. This also ensures that iteration and participatory design can be used at each phase. Each phase of the model, is further broken down into several steps that align with methods that have been adopted from the four frameworks/ models. Figure 12 shows the phases alongside where specific frameworks/ models have been utilised (4DF and IM utilised in IM1/2/3/4/6). Further discussion on this breakdown can be found in Output 2 in the Prima Facie.

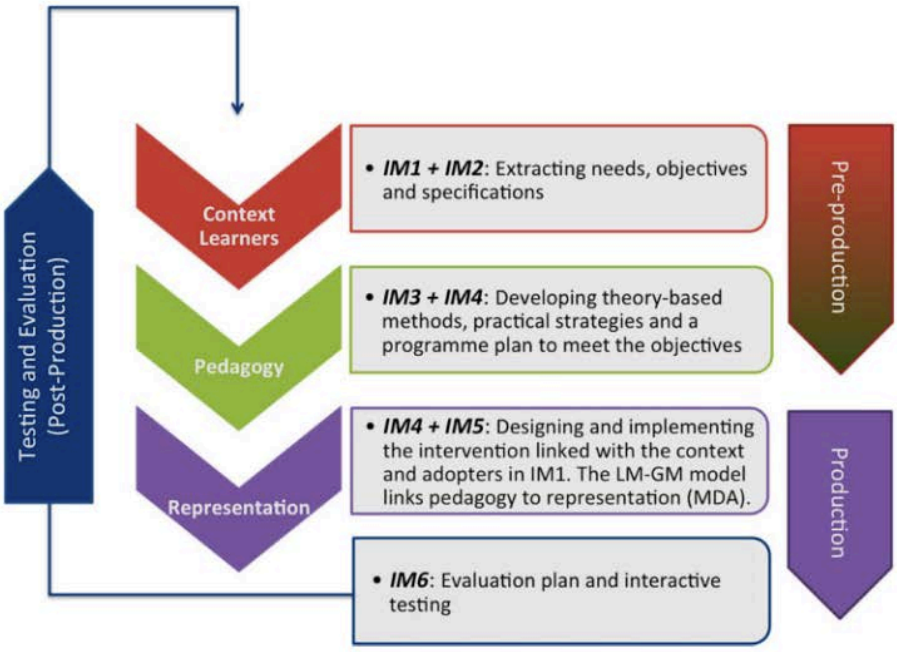

Figure 12 The trans-disciplinary model infusing 4DF, IM, LM-GM and MDA

The pre-production phase is broken up into five stages; needs analysis, pedagogical and methods strategy, aesthetics and learning objectives mapping, technology and end-user requirements planning and concept development. The pre-production phase is used to conduct research, define problems, undertake stakeholder and end-user participatory design groups and to present a guideline before formal development commences. Regardless of whether a digital or analogue application is developed, the research puts forward that to ensure a best practice approach to managing resources of a SG/ gamification design and development project, the pre-production phase and each of its steps should be carried out to define in which direction the project should develop. Without conducting this phase, the game is ill-fated to follow the designer/ developers own preconceptions of what the game should be, and never truly identify or meet the outcomes that the project sets out to do. Each of the steps in this phase, are demonstrated by the model to be essential to ensuring a best practice approach, as they make up the schema and specifications in which the product is to be developed to.

The production phase is broken up into three stages; game development, resource development and alpha/ beta testing. This phase is concerned with the practical development tasks of the game. A particularly key area here, which again is not a defined area taken from the reviewed SG design and development frameworks but through the DBR process itself, is putting aside ample time for alpha/ beta testing of the product. Taken from experience in the AAA industry, quality assurance and testing are an area that has whole teams dedicated to these processes alone. However, this is a greatly overlooked area in the SG/ gamification field particularly in large EU/ national projects where most of the projects time is given to the theory and development of the product. By building a step which solely focuses on this area, practitioners can employ iterative and participatory practice through engagement with both internal and external users and analyse for critical bugs & errors/ content clarity/ offensive or inappropriate materials. This gives opportunity for opinions and feedback that are distanced from the project, allowing for fresh perspectives and discovery of unnoticed issues.

Another often-overlooked area, and one that was not brought to light in the other reviewed SG frameworks, but was featured in the IM approach (Bartholomew et al., 1998), was the development of resources to support the product. A lot of SGs and gamification examples exist without additional resources as the emphasis of design has largely been placed on that of the game itself. However, just like other educational/ intervention resources, effort should be allocated to providing multiple resources that support the delivery and engagement of the product. Whether this fits under a facilitator's manual, a video walkthrough online or a list of recommended exercises that goes alongside the product, practitioners must begin to view the development of a SG/ gamification

approach as a multi-trans-media resource. As there are always likely to be multiple end-user groups (stakeholders/ designers/ end-learners/ facilitators and parents) it is a designer's role to ensure that each of these groups are catered for in their understanding and use of the product.

The pre-production phase is broken up into three stages; evaluation, feedback and retrospective analysis. This phase is primarily concerned with evaluating the efficacy of the end product and ensuring that the information gained from the DBR approach goes forward to inform new theories and future research. Whilst quite a lot of attention has recently been given to developing understanding of how to effectively evaluate SGs and gamification studies (Mayer, 2012; Mayer et al., 2014; Zolotaryova et al., 2016), the author believes that this is a vital step to be done in conjunction with the other two steps feedback and retrospective analysis. By ensuring the process of assessing the efficacy of the project's outcomes against end-user feedback, can help to form insights, SWOTS (strengths, weaknesses, opportunities and threats) and new models of information to be fed-forward for the next project. Whilst a retrospective analysis of the project may take the form of an academic paper, it is also advisable to look at how to expand current academic thinking around dissemination practices, so that information is available and catered to a wide range of audiences, including students, practitioners and the general community.

The research conducted to bring together the findings across the four methods (4DF/ IM/ LM-GM/ MDA) has cumulated in the development of the Trans-disciplinary model. Whilst the research in Output 2 indicates a methodology that the author believes embodies an effective and efficient design process that has been developed from multi-disciplined theory and a DBR approach, this section has pulled out specific practices that the author would like to draw further attention to in relation to best practices in SG/ gamification design and development. These are discussed in more detail in Part E: Discussion of Best Practices.

5.4 (C) Developing from the Trans-disciplinary Model to Inform the escapED Framework.

In a similar means to Part B: Creation of a multi-disciplinary model for SG and gamification design, the author saw a need and gap in the literature arise between 2014 – 2015, to address the creation of a multi-disciplinary SG design and development framework that was adjusted for the live-action SG gaming genre (escape rooms, live action role-play, interactive theatre). Whilst the Trans-disciplinary model is not built specifically to help develop games from any particular genre, it was built from the development approach of PR:EPARe, a digital game that was delivered via PC/ Mac/ Smartboard technology. A growing interest in the SG/ gamification community around people-led SGs, led to the

questioning of the development process of such games and whether there were best practices to consider when tasked with designing for a different delivery approach/ genre in mind.

Continuing to build upon Objective (iii) of the research; to provide a reflection and amalgamate findings to provide a multi-disciplined design process, **Output 4 'EscapED: A Framework for Creating Educational Escape Rooms and Interactive Games to For Higher/ Further Education'** (Clarke et al., 2017), reflects on a pilot approach to developing a SG escape room and poses the escapED framework to help guide the design and development of live-action games.

The peer-reviewed Journal article is split into five main sections. The first section situates escape rooms in the literature and discusses their growing popularity that has arisen from their first documented inception in Japan (Nicholson, 2015). The second section presents the escapED programme under the Gamechangers[8] initiative and why it was created. The third section presents the pilot approach of trailing a SG escape room with staff members at Coventry University to assess the acceptability and usefulness of the approach with a HE institution. The fourth section presents the escapED framework as a guidance tool for the design and development of live-action SG games and initiatives. The fifth section presents a case study of a live-action game created by an external practitioner using the escapED framework as a design and development guidance tool. The practitioner presents their design methodology and thoughts of the process for the readers to gain further understanding of the process and whether the framework provided useful guidance. The analysis will focus on the third, fourth and fifth section of the journal paper that is concerned with the discussion of the pilot, the escapED framework and the case study of the frameworks use as a guidance tool.

Although escape rooms are fairly popular in the current entertainment games climate, little research had been developed by 2015 in the way of academic consideration for SGs/ gamification development, barring a white paper conducted by Scott Nicholson (2015) that presents a general review of escape rooms, demographics and use. Based on this gap, the author created a pilot escape room serious game that would be used to trial the approach with teaching staff members at a Coventry University teaching and learning conference. The Trans-disciplinary model was adopted to help form the design and development decisions of the game. The game itself focused on developing soft skills such as communication and decision making between the participants rather than knowledge exchange. As

[8] GameChangers is an open game design course and community, co-created by the Disruptive Media Learning Lab of Coventry University and is found at gamify.org.uk.

the main objective of the pilot was to observe different groups of teaching members as to their engagement and acceptance of the game type, the findings of the pilot indicated that there was further evidence to suggest that these genres of games could be adapted successfully into a HE environment. Two key questions that were raised in the feedback gathered from the participants of the pilot, was firstly how could participants create their own? and secondly how could participants create a game for larger groups of students?

To address the first question, the journal paper builds upon the foundations of the Trans-disciplinary model, adding additional development considerations in order to create the escapED framework. The escapED framework V1 as seen in Figure 13, is a guidance tool for other practitioners to use in the creation of serious live-action games. The framework is split into six sections: participants, objectives, theme, puzzles, equipment, evaluation. Each section is further split into several areas to consider. Whilst those familiar with the Trans-disciplinary model will notice that sections of the framework such as participants, objectives and evaluation follow very similar design suggestions (the participants section is described as a mini needs analysis to be conducted before development of the game begins) and that the framework follows the Trans-disciplinary model in that it is an iterative and participatory design method. However, there are other sections of the framework: theme, puzzles and equipment, that are much more tailored towards the design of live-action games. One of the findings from the adaptation of the Trans-disciplinary model into the pilot escape room serious game (DBR approach adopted), was that due to the live-action genres heavy reliance on puzzle design, narrative and specialised equipment (including actors/ Non-Player Character's), greater attention was needed to be drawn on these areas than was previously provided in the Trans-disciplinary model. To aid in the creation of these new sections, theory was drawn from Nicholson's (2015) white paper. Little could be gathered from other developer sources due to the highly secretive nature of entertainment escape room design.

Figure 13 The escapED framework V1.1

One of the issues that the author acknowledges with the escapED framework, is that it lends itself heavily towards the puzzle genre and therefore may not work as a guidance tool for all live-action game types such as traditional Live Action Role Play (e.g. Curious Pastimes[9], Vampire the Masquerade[10]). If puzzles are not a needed element of a game however, the puzzle section could be skipped and focus drawn to the other sections of the framework.

To address the second question put forward by the participants of the pilot approach: how to create serious escape games for large groups of students, the framework presents within the participants section the considerations of 'Mode' and 'Scale'. Mode is used to describe the type of experience in either a cooperation-based play style i.e. players work together to solve/escape the experience vs a competitive based play style i.e. players compete to be the first to figure out the objectives. This is important to assess whether the experience can be designed for larger experiences with multiple teams of people or is more suitable to a smaller individual play style. Scale is used to identify the number of participants that the game is intended to be designed for. Identifying these elements early, allows for quick design decisions on whether the game genre is suitable for the scale of the audience. From conducting the body of research, the author has come across the issue of scale at each starting point of a new project. As a result, the author puts forward that a discussion of scale is one that should be considered to form part of the process of understanding best practice to SG design and development. Often SG/ gamification projects start with a genre of game in mind (this could be digital or otherwise) which is quite true to the entertainment industry, however, with SGs this is different in that it is helpful to consider how many people need to interact with the game. For example, there is no point in creating a singular board game that six people can play at a time, if 400 students need to interact with the material. Understanding how to maximise resources for creating and maintaining SGs vs the practicality of delivery and reach.

The fifth section of Output 4 presents a case study of the game '*The Island of Dr. Moreau'* that was written by the developer. The game was developed to teach the subject of research methods to Southampton University students and was created using the authors escapED framework (Output 4). The case study describes how the developer approached the development of his game using the different sections of the framework to scaffold the process. The case study presents an insightful look

[9] Curious Pastimes formed in 1995, is an organisation that a live action role-playing campaigns in the UK. CP is a private, profit-making company headquartered in Moreton in the Wirral in Northern England.

[10] Vampire: The Masquerade is a table top role-playing game (table top RPG) created by Mark Rein-Hagen and released in 1991 by White Wolf Publishing

into how another practitioner approached the use of the framework for their own work. Notably, the practitioner describes how the authors escapED framework (Output 4) helped them to form the puzzles after they had developed the learning objectives, even though initially they thought to build puzzles beforehand. They also state that de-briefing and re-setting the experience was a useful area to consider as part of their design process. One of the areas in which they describe a deviation from the framework was in the area of narrative development. This was due to them finding it easier to build the story after they had set out learning objectives and puzzles. It is useful for the framework to be used in an alternative way to help showcase the reality of the design and development cycle for other practitioners. Whilst the author still maintains that narrative should be thought of earlier on in the process of development, it is useful to understand that others may find that the flow of the framework works slightly different for their needs. This serves as a reminder that frameworks/ models and tools should remain flexible to allow for diverse working practices, but still provide the structure and guidance to inform a best practice approach. The case study in Output 4 provides an account of the impact that the escapED framework has had within the academic community, and leads the way for other practitioners to experiment with developing their own live-action experience game.

Output 4 presents and describes V1 of the escapED framework that provides adapted best practice approaches to SG/ gamification design and development that have been formed as a continuation of work conducted in Output 1 & 2. Recent research conducted by the author, further continues the review into design and development of live-action serious games with a revision of the escapED framework as seen in Figure 14. Since developing the escapED framework, a larger body of academic work has become available concerning the use of escape rooms in non-entertainment settings (Wiemker et al., 2015; 2017; Nicholson, 2018).

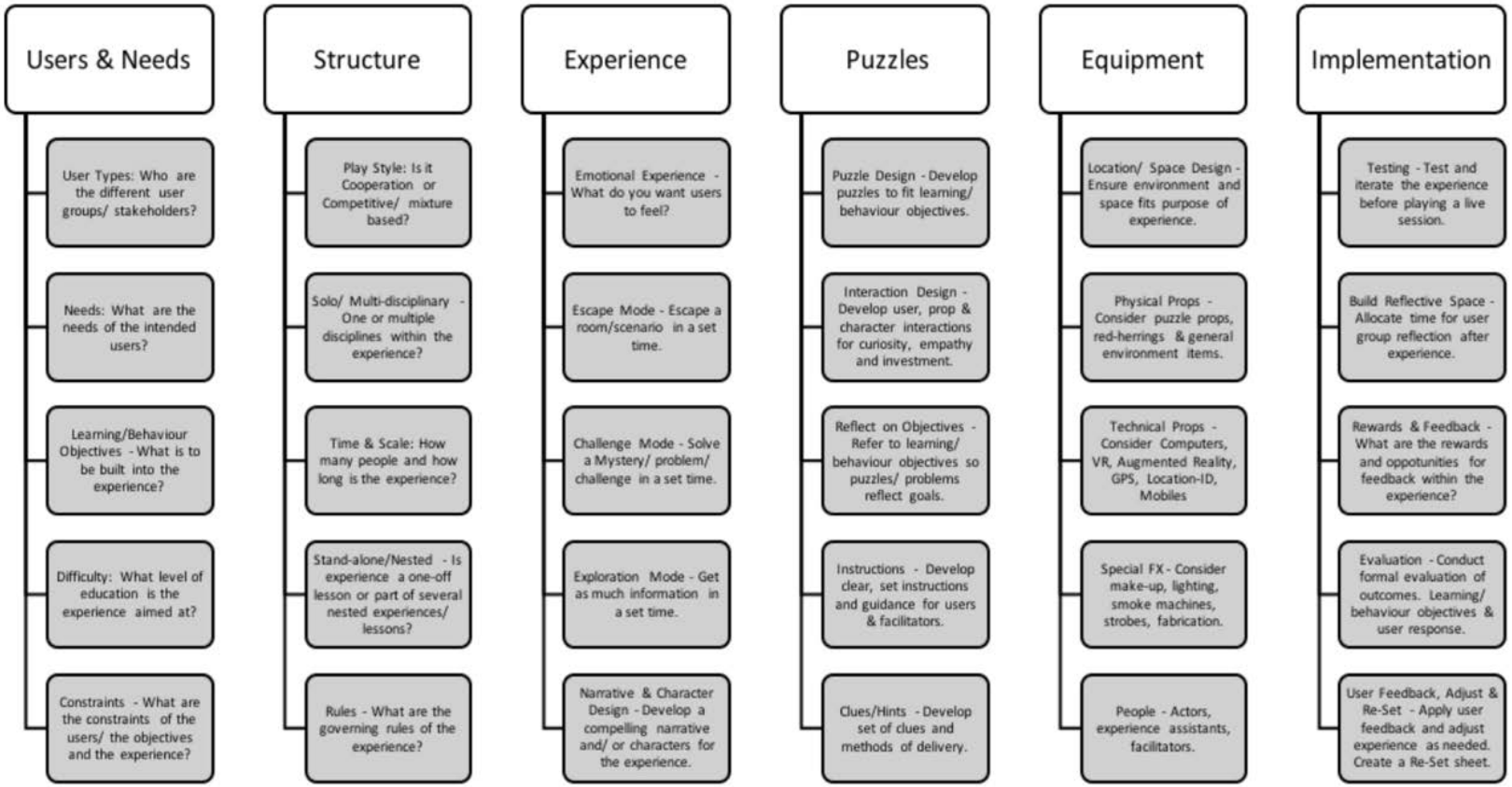

Figure 14 The escapED Framework V1.2

5.5 (D) Practical Implementation

Objective (iv) of the research sets out to implement the design processes created in both the Trans-disciplinary Model and the escapED Framework, and place these practices into live learning environments to develop scope for future development of these best practices. The work conducted in Output 3, 5, 6 & 7 (contained in the Prima Facie), present four examples of SGs and gamification projects that have been developed and created for facilitating the delivery of learning content with adult learners primarily situated at Coventry University (except for Output 3: simAULA, which was an EU funded project output to be delivered in the partner countries). This section presents a review of each of these outputs and the development approach, a discussion on the design processes and what was learnt. Each output is presented under its own review section in which the author will discuss the transference of the suggested best practice approaches from the model/ framework into the serious game and gamification examples.

5.5.1 Output 3: simAULA

The first example of a gamified approach that was developed using the Trans-disciplinary model is presented in **Output 3 'simAULA: Digital Game for Inquiry-Based Learning Tuition'** (Clarke et al., 2016). SimAULA was created as a gamified simulation to train teachers in using Inquiry-based learning (IBL) theory and practice. The project received funding from the European Union's ICT policy Support Programme as part of the Competitiveness and Innovation Framework Programme. The projects pilot activities (including delivery of simAULA) took place in 5000 primary and secondary schools in and across 15 European countries.

The overall aim of this external project was to translate the five primary areas of IBL practise; Orienting & Asking Questions, Hypothesis Generation & Design, Planning & Investigation, Analysis & Interpretation and Evaluation & Conclusion, into a virtual classroom environment to train, trainee teachers in IBL delivery style (Clarke et al., 2016). The trans-disciplinary model was adopted as the design process, and simAULA was created using a DBR methodology.

Employing the Trans-disciplinary model as part of the design process in the EU funded FP7 project: *Inspiring Science Education* caused significant issues for the author. Due to the multi-faceted nature of EU projects and the spread of project partners, responsibility for conducting the 'needs assessment' step of the project work was allocated to an outside partner group. This was difficult to work around due to the fact that simAULA was just one of the work activities that had to be conducted in the

project. This meant that the needs assessment that was conducted was general in nature and provided little in terms of more specific guidance that was needed to help inform the design of the gamified platform. Another issue with this was that the gamified approach would be made available for teachers all over the globe. This meant that considerations such as technology and classroom set ups could not be planned for effectively and had to be generalised to a one size fits all approach. An outcome of this research is the acknowledgement that in the case of large-scale projects these issues can arise, and it is necessary to allocate sufficient time and resources to the work schedule to allow project partners responsible for delivery of a SG/ gamification approach to conduct their own needs analysis.

Whilst the needs assessment step was difficult to accommodate in the project, a lot more work had been conducted around the theory and learning content of IBL that was to be developed into the virtual classroom (Cochran-Smith et al., 2009; Knight & Wood, 2005; Lameras et al., 2014). The work that had been done towards understanding the different areas and application of IBL was used to help inform the pedagogical and methods strategy/ aesthetics and learning objectives mapping steps of the Trans-disciplinary model and was aided further by the use of the LM-GM approach for these steps. It became apparent during this period of the design process that the practice had to slightly evolve from a consideration of pure game mechanics. After setting out the learning objectives and chosen game mechanics in relation to Lameras et al's work (2014), the author developed a series of game objectives that the learning objectives could be mapped against. Completion and repetition of the gamified objectives meant both player and facilitator could know whether learning objectives were being achieved throughout game play. Development of game mechanics was found to be an extremely useful process during the creation of simAULA, but further translation of these mechanics into feasible game objectives was found to be needed so that assessment of the learning progress could be conducted. This evolution of the design process was pivotal for the authors understanding of how learning objectives could effectively translate into game/ gamified scenarios.

Following the completion of the learning to game mapping approach, the rest of the Trans-disciplinary model phases and steps were applied. This was mostly unproblematic, except where direct contact with end-users was required (such as in the testing phase). As the model relies heavily on the idea that an iterative and participatory approach is adopted, the author found lack of direct contact with the audience in this project to be an obstacle in the design process. At the time, the author used multiple ways to address this including use of partners reports, a longer alpha testing phase and video conversations with testing groups to gather feedback and suggestions to work into the design.

Based on the work conducted in the design and development of simAULA using the Trans-disciplinary model, there are two themes that were uncovered in which the author has taken forward as part of the DBR process of practice reflection.

1. The LM-GM process of mapping mechanics is effective but can benefit to include game objective mapping alongside game mechanics mapping considerations. This is largely due to the difference of what makes up a game vs what the player must do in that game.

2. That the application of an iterative and participatory design process in a large project with international partner/ user groups, needs to be given appropriate time, planning and resources if it is to be achieved. This needs to be addressed at the outset of the projects planning process.

A tale of caution from this process that was experienced in the design of simAULA, is that in larger projects such as those funded from the EU (and that can happen in even smaller projects), discussions of game mechanics and objectives/ direction/ look and feel of game and delivery, can often be overlooked as trivial matters from non-expert game design associates. It is good practice on the designers' behalf that discussions and suggestions are taken on board and incorporated where appropriate during the design process as part of the participatory design element of the work. However, it is also essential that final design decisions rest with the designer to ensure design decisions are coherent and consistent. For this to happen, the author suggests that it is good practice for project leaders to trust and support the designer as an expert and to recognise when forced design suggestions may be detrimental to the intended outcomes.

5.5.2 Output 5: Gamification Approach using Curiosity and Mystery

The second example presented in the form of a gamified approach, was developed using the escapED framework and is presented in **Output 5 'A gamified and mystery-driven approach for facilitating problem-based learning in a postgraduate strength and conditioning module'** (Duncan et al., 2018).

The project was an internal piece of research conducted at Coventry University, and was developed between the author and a Sports Science Professor (Duncan) who is based at the Universities Health and Life Sciences department. The aim of the project as set out by Duncan, was to create a playful approach to an already established 20 credit MSc strength and conditioning module. The module itself ran over a term of 10 weeks, in which Duncan challenged students through a problem-based learning

(PBL) approach (Boud, 1985) to demonstrate practical and theoretical knowledge of sports science understanding, and apply this to the needs of a client. As this was a module that was already in place, Duncan had run the module using a paper-based approach to delivering client information to the students. This meant that the students believed this to be a University exercise and that all of the materials were given in a report style delivery (spreadsheets). Students were asked to then provide recommendations for a fictional client based on the information they were given. Duncan wanted to challenge this more traditional delivery of the materials and information and apply a playful approach to test whether student engagement in the module could be increased.

The formal learning objectives of the module were set to: Employ evidence-based reasoning to appraise the roles of the multi-disciplinary team in identifying the needs of the client(s); Demonstrate expert knowledge of how to apply appropriate screening and assessment methods to profile the client(s) and to; demonstrate a comprehensive understanding of practical techniques applicable to strength and conditioning and/or the sports scientist in the understanding of the needs of the client(s).

One of the greatest challenges that the author faced in the project outlined in Output 5, was that a playful interpretation of already existing materials was the requested outcome of the work. Developing learning materials to fit over an existing body of work provides different challenges and expectations of what can be done, and how a playful experience can be applied. However, around this time the author was developing work in the field of curiosity, learning and play. Undertaking a review of how curiosity could be applied, especially to address Duncan's objective of increasing engagement amongst his students, the author conducted a needs assessment from the Pre-production phase of the Trans-disciplinary model. In this, covered a review surrounding curiosity and its application in learning. To situate the reader, an overview of curiosity is presented to form the reasoning behind its selection in Output 5's process of creation.

Berlyne (1960) first published on the subject of arousal and curiosity that the scientific qualities of curiosity were examined. Berlyne described curiosity as the state of being presented with an environmental situation that exhibited "complexity, incongruity, doubt and/or difficulty". These conditions were responsible, he argued, for creating arousal of uncertainty. He identified the tension of uncertainty as the mechanism or behavioural shift which is used to drive exploration of a complex environment in order to ease anxiety of the unknown (Berlyne, 1960). Exploration, then, as Day observed, is the "behaviour elicited from uncertainty" which ultimately fuels the organisms' "search for knowledge" (Day, 1982).

Early work into the study of curiosity (Hume, 1777; Berlyne. 1954) recognised that there were in fact differing types of curiosity. Berlyne worked to explore these differences and, in 1954, termed two variants. He posed that it was either epistemic curiosity - the seeking out of intellectual information or the "drive to know", or perceptual curiosity, sparked through visual, auditory and tactile experience or the "drive to experience and feel". In light of these differing examples of what triggers curiosity, we as educators can begin to imagine rich learning experiences that are not only driven by learner interest or the pursuit of knowledge itself, but also by being wholly exposed to a range of sensory stimulants.

Curiosity as a core motivator for learner engagement has been the subject of investigation and experimentation in a variety of educational theories. One such area of experimentation, which aids a deeper understanding of how curiosity can be triggered by interactive learning experiences, is that of museum education (Wittlen, 1968; Shettel, 1973). Oppenheimer (1970, 1972, 1974) conducted a range of experiments with interactive exhibitions at the Exploratorium in San Francisco and developed a body of evidence to suggest that curiosity and attention were essential in supporting learning through the use of these types of hands on exhibits (Koran & Koran, 1983). Following on from Oppenheimer (1972), Koran & Koran (1983) observed that other experimental studies and experiments (Eason & Linn, 1976; Hoth, 1978) had yielded interesting results pertaining to learner engagement and interactive experiences. They found that:

> *"The compared subjects that were exposed to objects which could be approached, that perceived with all of their senses, and manipulated with subjects who could only view similar exhibits tended to support Oppenheimer's original arguments that participatory exhibits attract attention, stimulate interest, curiosity and participation."* (Koran & Koran, 1983, p. 1)

As evidenced, there is a strong body of existing work that was uncovered during the need's analysis stage of the project, concerning the effect of different types of curiosity of a person. In particular, the use of perceptual curiosity as a drive to engage subjects with their senses, as seen from Koran & Koran's work (1983), was of particular interest as an engagement tactic. Due to the practical nature of the module and its learning objectives, and the interest from Duncan around the concept of mystery boxes that were being developed by the author at the time, it was decided that a live-action gamification style would be adopted for the project. It was here that the escapED framework was employed in place of the Trans-disciplinary model.

Due to the existing learning objectives, content and materials, step one (participants) and step two (objectives) of the escapED framework, were completed fairly quickly. The 'mode' was set to have students work throughout the module in a team for drawing on collaboration soft skills, but ultimately against other teams for the drive of competition. Scale was defined to last for across the entire 10-week period of the module and was built to accommodate a small cohort of students (under 30). The 'Theme' step was decided on reflection with Duncan, to mirror the existing modules objectives. Students would work to present an account of recommendations for an athlete. However, in the gamified version of the module, the students (following ethical approval) were led to believe they were working for a real company, and a real client. The Puzzle and Equipment steps were developed together, feeding in the use of different materials, such as videos on USB drives and fake supplements made up by Duncan, to form the content in which the students would draw information from. The author took a flexible approach to the guidance of the escapED framework during these two steps, moving back and forth between them to get the right mixture of information for the students and props to inspire perceptual curiosity.

A key difficulty that was found with the style of gamified approach with regard to the application of the escapED framework for guidance, was found in the final step (Evaluation), in the 'testing' approach. Due to the nature of the game type and the time limits that were placed to get the project ready for the next intake of students, testing was not a viable option at the time of development. The author believes that this was detrimental to the project, in that subtler content that was hidden in the materials, needed to be tested to see if it could be noticed, or whether it was too well hidden. It would have been useful to see how people reacted to the different materials and then these could have been adjusted accordingly. As the project acted on the element of the players not knowing that they were playing a game, a participatory approach with the end users could not be conducted. Whilst a participatory design approach was adopted with Duncan and colleagues as the stakeholders, lack of feedback and design suggestions from the end-learner audience made it difficult to fully design an experience that was suitable.

As the work is ongoing with further developments into the ideas around mystery and curiosity boxes used in a learning environment, the work presented in Output 5, the reflections of the design approach using the escapED framework and the issues that were faced, have been put forward for considerations on the projects that have grown from this initial research. The key outcomes for reflection of best design practices from this project is that firstly, the design path did follow the escapED frameworks suggested best practice approach. However, a linear pathway was not formed,

and the author moved back and forth during certain stages depending on project need. It is interesting to highlight this here, as this echoes the approach taken by the developer from Southampton University and his escape game as described in Output 4. Perhaps then, this is something to note about the flow of the escapED framework. Rather than seeing it as a rigid process, it is best to see it as a suggestion of the key considerations alongside the addendum that it is ok to move back and forth between these concepts as fit for the purpose of the project's outcomes. That being said, the author maintains that each of the steps in the escapED framework should be considered for the design process.

5.5.3 Output 6: Book Runner, the Library Induction Game

The third example presented in the form of a serious game approach was developed using the Trans-disciplinary model and is presented in **Output 6 'Book Runner: Library Induction Game'** (Clarke et al., 2018).

The project was an internal piece of research conducted at Coventry University, and was developed between the author and two academic liaison librarians (Flynn & Collins) who are based in the Universities Library department. The aim of the project was to provide an engaging and alternative approach to traditional University library induction services. Following an introduction to the already available services the library offered, and a discussion with Flynn and Collins regarding the problems connected with library games in general (not scalable, delivered on campus, not easily maintained), a needs analysis was conducted to assess the problem and potential solutions for delivering an induction game.

Using games and play at HE libraries is not a new practice, with many different examples available to the academic community (Pagowsky, 2013; Markey et al, 2010; Walsh, 2013; Clarke et al., 2017). However, Flynn and Collins wanted to develop a game that delivered tangible learning outcomes that went further than the often-covered materials of orientation.

The Trans-disciplinary model was used to conduct a needs assessment of the issues, research and end-learner considerations. On reflection of other work in the area, it was found that a digital solution would be the best approach to take with the project due to scalability and the issue that any solution created couldn't be a permanent fixture within the University library. In the 'Pedagogic and Methods Strategy' and the 'Aesthetics and Learning Objectives Mapping' steps of the model, the author worked alongside Flynn and Collins to develop a series of learning categories and objectives that would be

worked into the game. Flynn and Collins were then tasked to number the objectives with a priority rating so that it was clear what the main learning outcomes of the project would be. This proved to be a valuable exercise as it highlighted how the librarians saw the importance scale of each of the outcomes that were listed, and gave the author a clearer idea as to which outcomes to focus on developing first. Once the learning outcomes were set, suggestions of game objectives that would map to the learning objectives were developed presented in Table 1. This gave an overview of the purpose and evaluation points of the project. Alongside these steps, it was decided due to resource restrictions, this being an internal driven project, that the RPG Maker MV[11] game engine would be used to create a game.

[11] RPG Maker is a program that allows users to create their own role-playing games. Most versions include a tile set based map editor (tile sets are called *chipsets* in pre-XP versions), a simple scripting language for scripting events, and a battle editor.

Table 1 Learning Outcome to Game Objective Mapping

Category	Learning Outcome	Game Objective
Orientation	IT Services	Mini task - finding it
Orientation	Sigma	Mini task - finding it
Orientation	CAW	Mini task - finding it
Orientation	Group Study Rooms (that they exist)	Mini task - finding it
Orientation	Rovers Podium	Mini task - finding it & source of help
Orientation	2nd Floor Enquiry Desk	Mini task - finding it & source of help
Orientation	Subject Librarian Office	Locating it, then more additional tasks
Orientation	Mobile Shelving	Include it if we can make it some sort of puzzle (move the shelving to get to another location/NPC)
Online Orientation	Library Basics Libguide	Code on Libguide
Online Orientation	Libguides	Code somewhere on a guide
Online Orientation	Twitter page	Codes hidden on pages
Online Orientation	Facebook page	Codes hidden on pages
Online Orientation	YouTube Channel	Codes hidden on pages
Online Orientation	Document Supply	
Online Orientation	YouChose	Place request for specific dummy book, reply with code.
Online Orientation	Referencing Guide	Code on Libguide
Library Skills	Construct a reference in CU Harvard	Making the reference provides a code (e.g. first letter of each part)
Library Skills	Find a book in the library	Finding a book in the game's bookcases
Library Skills	Find an eBook	Dummy eBook on Locate - code within book - also covers navigating an eBook
Library Skills	Find an article on Locate	Dummy article records on Locate
Library Skills	Reserve a book	Reserve a dummy book within the game, collect it later.
Knowledge	Loan limit is 20 items	Character giving quiz
Knowledge	Books can be borrowed for one or three weeks	Character giving quiz
Knowledge	Fines	Character giving quiz
Orientation	Self-issue machines	Game/puzzle using the machines
Online Orientation	Accessing databases	Dummy dragon -slaying Libguide
Knowledge	Support offered by subject librarians	Interaction with in-game characters
Knowledge	Support offered at service desk and enquiry desk	Interaction with in-game characters (If you get stuck in the game you can always go to the enquiry desk)
Knowledge	Support offered by Rovers	Interaction with in-game characters (If you get stuck in the game you can always find a Rover)

The use of the RPG Maker MV game engine as considered in the 'Technology and End-User Requirements planning' step of the model, fitted the needs around scalability and accessibility in that the platform could be a web-based browser game with no user log-in required. It could also be accessed by anyone, on any device that had a stable internet connection.

The development of the final 'Concept Development' step of the pre-production phase took the form of a shared online concept Google document. This allowed for real-time change as the author would write part of the narrative script, and when needed, Flynn and Collins would change this with something more appropriate. This ensured a participatory design approach throughout the project, with all members of the team actively contributing the design and development of the game.

The game went through an extensive Alpha and Beta testing step as indicated in the Production phase of the Trans-disciplinary model, in which staff and student members within the University were first approached to test the game. Once this was completed, Flynn extended the invitation to University librarian/ literacy support teaching and learning staff external to Coventry University to Beta test the game. Student feedback and advice was particularly useful during the process, and was used to iteratively refine the game play. The overall time that was allocated to this step was around two months, and in which time the game was refined and made ready to be trialled for its evaluation with first year undergraduate students. This amount of time for the size and scope of the game felt about right. At the same time, resources including a video walk through of the game and an instruction/ cheat sheet manual were created as part of the 'Resource Development' step in the Production phase, to help aid the implementation and understanding of the game.

The 'Evaluation' step in the Post-production phase was conducted using a mixed methods analysis approach, of pre and post confidence questionnaires and written feedback on the game. The analysis of the data is part of an ongoing research project, however initial findings present overwhelmingly positive findings of an increase to student confidence across the learning objectives after playing the game. The written feedback gathered from the student evaluation, will be used to upgrade the game.

As part of the DBR process and in line with the end step 'Retrospective Analysis' of the Post-production phase, feedback from both Flynn and Collins, other library staff that helped to facilitate the game, and students involved in the evaluation of the game, is planned to be iteratively fed back to form the development of the next version of the game. In terms of theoretical development, the findings that have come from the design and development of Output 6 to feed forward as best practice approaches,

have mainly been discovered around the issues of length/ time and written type on screen. A quick review of the feedback received from the student evaluations, shows that the game was overall received positively. However, students wanted the game to be shorter, condensed and with less text to read on the screen. This brings up questing surrounding suitability of certain game types such as RPG's to learning scenarios and to ensure audio can be used in place of text. This would be of particular advantage for international students who may struggle with language barriers.

The additional use of a priority ranking system used at the learning objective stage, was an unexpected but useful addition to the development system. Often when SG and gamification projects start out, there is a want to create something that will cover a lot of information and learning objectives. By implementing a priority system to the stakeholders, this helped to focus down on to what the real aims of the project were, and where to start development. This is a system that has not previously been noticed in academic literature surround SG and gamification design and development best practices.

It is worth noting that the game felt like a high-fidelity product after the intense testing period that was taken. External testers also brought to light potentially upsetting/ sensitive dialogue sequences that were not intended to be read that way. With external help, these dialogues were re-designed to ensure that offense would not be caused, and further highlighted the need to bring onboard multiple testers both internal and external to the project.

The author was solely responsible for conducting a series of qualitative and quantitative methods towards the evaluation of this work, including mixed methods, pre and post questionnaires. Data analysis was conducted through the application of a Wilcoxon signed-rank test. Results indicated that playing the '*Book Runner*' game did elicit a statistically significant change in increase to student confidence to perform library induction tasks and library knowledge gain as seen in Table 2. Qualitative feedback is currently being analysed using Thematic Analysis to understand core reactions to the game from the students.

The project is in its next stage of development to assess the benefits of developing SGs using the RPG Maker MV game engine. The author believes with further analysis and development of different SG examples using the engine, further work can be done to encourage new practitioners, especially HE academic staff, into the field of SG and gamification design. Providing simple tools, that can be adapted and updated easily will help break down the barriers that the process of SG and gamification

design and development is a resource heavy commitment. A full analysis and dissemination of project findings is expected by March 2020 and the second version of the game is due to start development in Aug 2019.

Table 2 Results of Book Runner Pre/Post Questionnaire

	Q1 Post - Pre	Q2 Post – Pre	Q3 Post – Pre	Q4 Post – Pre	Q5 Post – Pre	Q6 Post – Pre	Q7 Post – Pre	Q8 Post – Pre	Q9 Post - Pre	Q10 Post – Pre	Q11 Post – Pre
Positive Ranks	65	58	55	41	45	53	55	48	49	65	59
Negative Ranks	7	8	8	10	8	10	11	4	4	4	5
Ties	24	21	31	42	42	34	32	42	39	21	22
Median Pre	3	2	2	4	3	3	3	4	3	2	2
Median Post	4	4	4	4	4	4	4	4	4	4	4

5.5.4 Output 7: Bothersome Beasties

The fourth example presented in the form of a gamified website was developed using the Trans-disciplinary model and is presented in **Output 7 'Bothersome Beasties'.** (Clarke, 2018).

The project was an internal piece of research conducted at Coventry University and is the only piece of research contained in the Prima Facie where it could be argued that the methodology of Design Based Research crossed paths with Action Based Research. This was due to the project being created for the authors own teaching activities with second year undergraduate students rather on behalf of someone else. The aim of the project was to find an engaging way to encourage students to self-reflect on their learning process, as it was found to be an issue that the students struggled with in the authors class. Whilst there is plenty of research into the benefits of self-reflection (Dewey, 1997; Jarvis, 1992; Nesbit, 2012), there is often a disconnect with what the student learns in class, against their understanding of how this learning can be applied elsewhere. There was a need for reflection to be built into the learning materials in the class in a manner that made it a crucial and regular element to the learning process.

After playing through a popular table top role-playing game '*Dungeons and Dragons'*[12] (D&D), the author saw overlaps and potential for developing some of the game mechanics into reflection tools for the students. The D&D game type was chosen for its novel game elements that are focused on role-play. These included player character attributes which were first implemented in D&D systems and the *'Monster Manual'* system that could support the reflection of student issues (Clarke et al., 2018).

D&D mechanics were assessed to see whether they may fit within a gamified reflection exercise to be delivered in a University Addvantage+[13] module. Character development via character sheets, character attributes, monsters and team-based role-play/narrative were some of the game mechanics in the game of D&D that the author wanted to explore further. A needs analysis was conducted to assess the learning needs, user environment, and to identify any barriers such as limitations of time and user acceptability/ understanding of a D&D reflection process.

As time was identified as an issue for the project, the author laid out simple awareness learning objectives for the students to achieve during the 'Pedagogic and Methods Strategy' step of the model. Students would be able at the end of the module to carry out simple reflection exercises and be able to identify strengths, weaknesses and areas to improve upon in relation to how they wished to grow.

During the 'Aesthetics and Learning Objectives Mapping' step of the model, the author mapped key learning strategies to suitable D&D mechanics such as a reflective journal. Journal writing is thought to enable students to process their learning and help them to reflect and build their own strategies to help towards personal development (Gleaves et al., 2008; Hiemstra, 2001; McCrindle & Christensen, 2005). This process was designed so that it would support the author and supporting lecturers to use the journals as an opportunity to provide written feedback, formative assessments and view progress on a weekly basis. This journal was to sit alongside a character development sheet.

Mapping of learning objectives to game mechanics (journals, character development sheets, monsters) was created as part of a participatory approach with another lecturer of the module and student activators that worked at the Disruptive Media Learning Lab.

[12] Dungeons & Dragons (commonly abbreviated as D&D) is a fantasy table top role-playing game (RPG) originally designed by Gary Gygax and Dave Arneson. It was first published in 1974 by Tactical Studios Rules(TSR)

[13] Addvantage+ modules are short, one semester modules that teach a range of work experience and career development activities that are taken each year, and which broaden student's knowledge, skills and qualifications within a work focused environment

After the author obtained ethics through Coventry Universities internal process, a pilot was undertaken as part of a self-reflection task for the next second year undergraduate, Addvantage+ module. Addvantage+ modules are unique to Coventry University, and are optional modules that undergraduate students can pick to complement their core studies. These modules run for a course of eleven weeks and are flexible for the first three weeks in that students can have a taster of the module and if they wish to try something else then they can move to different module. The module ran for 2 hours on a Wednesday evening for 11 weeks.

Findings gained from pilot interviews conducted in week 8 of the module's delivery indicated that the students (n = 11) overall found the process of using the D&D reflection tool useful with comments:

> "It helps with motivation and I can reflect about it when the class is finished" Student A

> "Help you to realise what's there. Helps you to see things that you should" Student B

> "Organises your thoughts and gives them a certain meaning so you can follow them up step by step and at the end create something". Student C

Although it was mentioned that the journals were "really nice", all students who took part in the group interviews indicated that they would have preferred an online version citing:

> "Instead of a physical journal, an electronic survey would be better to do in class" Student B

> "We could edit points through a digital system that would be easier to manage". Student D

Using the methodology of DBR, the pilot evaluation was used to help iteratively develop student feedback into a new tool titled: 'Bothersome Beasties (and how to deal with them)' to reflect student needs more accurately. The tool acts as an open source platform that students can use anonymously to document their 'monster' reflections. This development was taken directly from the activity of selecting a 'monster' to reflect on in class and updated to reflect the students desire for an online tool. Students can build and create their own 'monster' to better reflect on their needs and are not limited to the paper ones that were developed for the classroom activities. The compendium acts as an online guide in which students from across any number of modules can view other student's issues and comment on them in a helpful way. The author was solely responsible for conducting a series of

qualitative methods towards the evaluation of this work, including one to one and group semi-structured recorded interviews.

The development approach undertaken in Output 7, selected the Dungeons and Dragons game genre and mechanics early in the process to analyse for their compatibility in an educational setting. The project has gained valuable insights into how D&D mechanics can be used in helping facilitate student reflection. As a result of identifying the game genre early in the process, the Trans-disciplinary model was therefore adjusted with this selection in mind. It was found that the Trans-disciplinary method could be applied flexibly to focus on a specific genre which led to the outcome that flexibility of process should be encouraged so as not to provide a too rigid structure in which practitioners feel they cannot step from the path. In this research, the author found less need for the learning objective to game objective mapping approach, although the foundational LM-GM approach was used. This was in part due to the fact that less formal learning objectives were developed for the project, but instead students were tasked with working through the process of reflection. With more time and development, formal learning objectives could be applied for a greater insight into any skills gained and how they affected assessment and growth of the learner. The outcomes of the research also identified a need in the development process to understand gamification objectives further as to whether there are differences that need to be accounted for in the development of SGs vs gamification-based applications. These questions will be taken forward into the next iteration of Output 7.

This project is an ongoing research project to look at to the use of D&D game elements in HE, both for reflection and other areas. The next iteration of the Bothersome Beasties tools as described in Section 7: Conclusions & Further Research, will look to build upon the character sheet elements of the project, and work on how this can be replicated in an online space.

5.6 (E) Discussion of Best Practices

Based on the work conducted and presented in the outputs contained in the Prima Facie, the author has presented two overall best practice guides for the design and development of SG and gamification applications in the Trans-disciplinary and escapED guidance model/ framework. In this section, a selection of best practice methods taken from the two guides alongside general reflections that arose from the work are discussed. These are considered by the author to be the most beneficial processes that were found from the overall research, and in which further work will look to build upon.

The first half of this section presents nine considerations for best practice methods that were found to be instrumental to aiding the design and development processes of the practical applications that were developed into the Trans-disciplinary and escapED guidance model/ framework for the research.

The first consideration is that the design and development cycle must be iterative in its nature. Taken from the theoretical research into SG/ gamification/ entertainment games design and development of the time (de Freitas & Oliver, 2005; Hunicke et al., 2004; Kiili, 2005), it must be recognised as best practice to mirror the games industry and traditional education in that resources never stop being refined for the needs of the end-users. This ensures that end-user feedback is taken onboard and used to refine the product helping to ensure as much as possible that the product is fit for its audience and purpose. Another issue is that often SGs and gamification applications, particularly in externally funded projects stop being developed after resources are depleted and the project comes to an end. Whilst this is unavoidable and no one can be expected to work for free, it is also a huge waste of time and effort when project outcomes could be re-purposed and built upon for other projects. To aid this, the author offers a discussion and suggestions to 'open practice and file/ product sharing' further along in the section.

The second consideration is that the design and development cycle follow a participatory design approach. Taken from the theory and practical implementation of the Intervention Mapping approach (Bartholomew et al., 1998), the approach sets the course of action that stakeholders and end-users should be involved in the pre-production planning stage of the project. By using this process, practitioners develop empathy and understanding of the people for who the solution is aimed at, and the project benefits directly from the insight into unknown barriers, fears, suggestions and support. It can also be a fantastic way to onboard users in the early stages of the project so that they feel more attached and invested in the project's outcomes further down the line. This translates to ongoing support and dissemination of project activities to end-user groups that may be hard to reach.

The third consideration is that the design and development cycle use a needs analysis at the planning stage of the project. This can work in tandem with participatory design in that end-users and stakeholders are brought onboard in the planning phase of the project to set out the reasoning, objectives and desired outcomes of the project. Based on the theory and practical application of the Intervention Mapping approach (Bartholomew et al., 1998), the approach draws on behavioural intervention development. The need to understand the issue, users and objectives of the project, give a clear direction early on in the cycle. This cuts down on resources and the potential for developing in the wrong direction.

The fourth consideration is that the design and development cycle use a Learning mechanics/objective into game mechanics/ objectives approach. Taken from the theory and practice of implementing the LM-GM (Lim et al., 2015) and the LO-GO approach directly developed from this (Clarke et al., 2016). As previously discussed, many of the serious game design frameworks acknowledged that learning objectives needed to be translated directly into game play. However, these were less forthcoming with instructions on how to achieve this. The LM-GM (Lim et al., 2015) approach which was translated into the 'Aesthetics and Learning Objectives Mapping' step of the Trans-disciplinary model, gives the necessary instructions on how to do this direct translation. This gives more depth of understanding behind the game mechanics chosen and therefore a greater chance of effective project outcomes.

Building upon the fourth consideration, the fifth consideration of 'experience development' is an area that considers not just game mechanics and objectives, but also how the game makes the player feel through its experience. Based on the theory and practical application of the MDA (Hunicke et al., 2004), one of the fundamental purposes of games is the understanding that they are designed to make players feel and behave in certain ways. Practitioners and stakeholders should look to ask themselves in the pre-production phase of the project; what should the end-users feel? Identifying whether the application should be humorous, emotional or inspire change through anger is an essential part of the design process. Games can be highly emotive and story-driven, and in being so, can be used as powerful tools for behaviour change and learning acquisition. Understanding that games are fore mostly experiences, allows practitioners and stakeholders to keep in mind that a balance must be struck between practical outcomes i.e. learning/ behaviour change and maintaining the essence of a game experience.

The sixth consideration is that the design and development cycle must have an adequate and rigorous 'quality assurance' (QA) process. Too often this process is overlooked or too little time is dedicated to the testing step of a project. Taken from the authors personal experience of working in the AAA games industry, in which games are constantly being tested, bugs identified and then fed back to the developers for further refinement, QA is essential for ensuring a product works, is not found to cause offensive and is presented to the end-users in its best possible iteration. Two phases of QA are suggested and outlined in the Trans-disciplinary model; Alpha and Beta testing. Alpha testing is used as an in-house testing phase to ensure that all critical/ major bugs are identified and the product is worked through until developers are confident it can be released to external testers. Beta testing employs a selection of external testers who are not familiar with the project to look for missed bugs

and to provide suggestions on content usability/ experience. This is an essential process that should not be overlooked as fresh eyes on a project can pick up and highlight areas of concern that are not obvious to someone closer to the project. A popular movement in the entertainment games industry is the use of early access for testing purposes. Game companies are moving more towards releasing early access builds of games and using crowd sourcing to test and quality assess the games. With limited resources in serious games and gamification projects, the author believes early access and crowd sourcing for QA could further be explored as a best practice in future work.

The seventh consideration is that 'supporting resources' should be designed and developed alongside a game/ gamification application as if they were equally important components of the project. Taken from the theory and practical application of the Intervention Mapping approach (Bartholomew et al., 1998), an acknowledgement is needed early in the planning stage of the project from the practitioners and project stakeholders that game-based applications need sufficient support, instructions and supplementary resources for maximum impact. SGs and gamification applications that are developed as stand-alone resources are potentially isolating users by not providing enough information on how to deliver, facilitate or play through the experience. This also doesn't replicate the games industry standard in that walkthroughs, cheat sheets, reviews, manuals and video play-throughs of games are provided by both the releases company and the general games community as an ongoing layer of support available to players. As practitioners, this must be recognised and developed to ensure maximum support and follow up resources are available to facilitate maximum end-user ease of use of the end product.

The eighth consideration of the design and development cycle is the 'building in of reflection time' for the end-users to discuss what they achieved in the game/application. A core insight that has been observed from the work conducted in the Prima Facie is the usefulness of a discussion and reflection session directly after an end-user has experienced and interacted with the product. It was observed by the author that in several cases of games developed, much of the understanding of the learning content occurred directly after the game in a dedicated reflection session. It was also observed that there were more interesting conversations and connections to the different learning outcomes were articulated when these were student-led group discussions that were facilitated by a practitioner. The author believes that dedicated reflection time that sits alongside, but outside of the game experience could help scaffold and help further end-user understanding of the learning/ behaviour objectives of the project.

The ninth and last consideration of the design and development cycle is the process of including a 'retrospective analysis' process to help feed forward lessons learnt and to disseminate practice related findings to interested parties. Based on the underlying methodology of design-based research (Collins, 1992; Brown, 1992), the end step as outlined in the Post-production stage of the Trans-disciplinary model, is to reflect on the design process alongside the outcomes of the project, and to put forward suggestions and a discussion of implications for updating existing theoretical knowledge. As end-learners are expected to reflect on their learning, practitioners must also observe a similar practice to identify strengths and weaknesses of different design processes applied in different projects. It is only through continuous efforts of observation, reflection and the provision of honest accounts of the design process, that practitioners can collaborate to find approaches that will make game-based applications easier and quicker to produce to a much higher standard.

Aside from the expected outcomes of recommendations for best practice approaches that form a direct part of the design and development process (see above discussion), some unexpected considerations of the research brought to light best practices that were not directly connected to the design of a product. Instead these practices contribute to the wider discussions and understanding of the field outside of a specific product. Five main areas were identified through this research that fit within this category. These are; practical tools and training resources, conversations about game types and desired outcomes, understanding resources and scaling, open practice and file/ product sharing and honest conversations.

5.6.1 Practical Tools and Training Resources

The first consideration for non-direct best practice thinking, is the development and sharing of 'practical tools and training resources. This relates to the need for simple but effective and accessible tools that can help aid teaching and learning practitioners to create their own serious games and gamification solutions. The author takes the position that the development of training workshops, tutorials and design templates will help ease others into the field. The author also sees this as an extension of the DBR approach in that, dissemination of findings needs to be available to a wide range of groups and not just published in journals/ conference papers. Taking a pro-active approach and training those around us will allow for a greater body of knowledge in different design and development approaches to emerge. To aid this, the author has created a number of workshops, video tutorials and a serious game/ gamification design document which are all open access, to help others plan and build their own products. The authors ultimate wish is to see more serious game/ gamification designers share their working documents and projects during the early pre-production

and production phases, so greater discussions surrounding methods and ideas can be gained towards creating better products.

5.6.2 Conversations around Game Types and Desired Outcomes

The second consideration 'conversations around game types and desired outcomes', relates to the need for a greater discussion into the different types of games and playful activities that are available for experimentation. The academic discipline is starting to experiment with different varieties of game genres such as escape rooms, board games, dungeons and dragons, choose your own adventures and trans-media experiences. However, there are still many different game types and genres that have not been looked into in such depth such as collectable card games, Japanese Role-Playing Games, Live-action Role Play and live-simulation gaming. Whilst the author acknowledges that you only know what you know, a local database of game examples alongside examples of serious games/ gamification projects that have been made in the corresponding genre would be extremely useful for other practitioners to not only see if they can reuse and repurpose existing games, but understand the breadth of game types available. This would give greater choice and understanding to decisions made at the 'Pre-production' phase of the project, particularly in the 'Aesthetics and Learning Objectives Mapping' step of the Trans-disciplinary model in which objectives are mapped to game mechanics. This would also allow for the development of a community to share practice openly and connect practitioners to other like-minded people.

5.6.3 Understanding Resources and Scaling

The third consideration 'understanding resources and scaling' relates to building a greater awareness that serious games and gamification projects require adequate resource allocation in order for them to work effectively, the greatest of which is time. As previously discussed, development should be an iterative process in which evaluation and end-user feedback are processed back to refine an application. In order to ensure this happens, awareness of this process must be addressed at the start of the project to assess with stakeholders and project leaders whether adequate resources and maintenance can feasibly be allocated for the duration of the project. If not, a SG/ gamification solution may not be the route to take. It is only through a greater awareness of the resource commitments (and what these translate into as a product) at management level, that projects can receive the appropriate time and care that are needed to be developed into effective solutions. The other side of this conversation concerns scalability. With education currently receiving less and less funding, it is imperative that where possible, practitioners and project stakeholders look at how more

students can be reached for less. This means that some sacrifices to game type selection may need to be made at the 'Aesthetics and Learning Objectives Mapping' step of the Trans-disciplinary model. For example, it may transpire that a board game maps well onto the learning objectives of the project, however, the aim of the project is to deliver to a class of 400 students. It is simply not a feasible allocation of institution limited resources (unless specifically paid through a research project or allocated funding) to choose a board game to deliver the experience which can only facilitate a maximum of 6-8 players at a time. In this case, scalability would need to be carefully considered. Being able to have these conversations in the 'Needs Assessment' step of the project, will help define the game type later on in the Pre-production phase.

5.6.4 Open Practice and File/ Product Sharing

The fourth consideration 'open practice and file/ product sharing' relates to the need for practitioners to be open and honest about the games and gamification projects that they create. This feeds back into the suggestion of an open online community, where examples are shared and catalogued for easy access and discussion. Where possible, open source files should be shared to allow for others to use, mod and adapt to fit their own needs, even if it's to show the potential of how serious games and gamification could be used as learning resources to other institute teaching and learning staff. A barrier to overcome, much like the issues concerning intellectual property (IP) and secrecy in the entertainment games industry is the unwillingness to share information on SG/ gamification projects. This can be for numerous reasons including recognition and IP, not wanting to duplicate publications/ journal results before submission, financial investments and unfavourable findings. However, it is only with true recognition that the field grows on the knowledge of what has come before, that practitioners must strive to be more forthcoming with sharing their practice, mentoring others and leading discussions to where they've had successes and where they have had failures.

5.6.5 Honest Conversations

The fifth consideration 'honest conversations' relates to the need to carefully reflect on what can actually be achieved through games/ gamification alone. Often projects set out to achieve an unreasonable expectation on how many learning and/ or behavioural change objectives can be achieved within one product. Expecting too much from one project sets the likelihood high that the product will not achieve all that it sets out to, and then be considered a failure. By being honest with what the project can achieve and selecting a small number of goals, the project has a greater chance to focus on these areas and be more effective, just like any other learning resource or exercise. The

other side of this is the recognition that no game/gamification project will be perfect in that it engages everyone. This is common even in the entertainment games industry where long-term players of well-known titles such as Assassins Creed[14] or Call of Duty[15], will disengage from a new version of a game because they don't like the storyline or another mechanic is changed. As is the case here, is the case in serious games and gamification. Practitioners and project stakeholders have to consider that the product should form just part of a larger group of teaching resources in which students can interact with a variety of delivery methods. Student reflection on the process and choices that were taken within the game/ gamification application should be at the forefront of the learning process.

The best practices (both directly and non-directly related to the design process) presented in the section form the accumulation of theoretical and practical knowledge gained through the application of the project work as laid out in the Outputs presented in the Prima Facie. Ongoing and further work will continue to refine these practices and build upon the knowledge gained up until this point of experience, with a policy to contribute to the ongoing discussions of serious games and gamification design and development practice.

5.6.6 Closing the Identified Research Gaps

In Section 1.2 Positioning, Scale and Scope, the author identified a number of met-studies on serious games analysis and design that observed areas for further development (Vogel et al., 2006; Wouters et al., 2009; Ke, 2011; Sitzmann, 2011; Chamberlain et al., 2013; Hess & Gunter, 2013; Moser et al., 2013). To present how the authors research has responded to these identified gaps, the work that has made up the Critical Overview has been mapped against the needs to show a clear contribution to the academic field.

Table 3 Field Research Mapping to Author's Work

Academic Study	Identified Needs	Output Contribution	Discussion
Vogel et al., 2006	• Lack of Research base. • To be able to translate needs of the users into an attractive product.	Outputs 1-7 with particular emphasis on Output 1, 2 & 4.	In Output 1 & 2, the work centres on developing a design approach that places the users' needs at the forefront of the design process. By using a Needs Analysis taken from an Intervention Mapping approach, the design

[14] Assassin's Creed is an action-adventure stealth video game franchise created by Patrice Désilets, Jade Raymond and Corey May, developed and published by Ubisoft.

[15] Call of Duty is a first-person shooter video game franchise published by Activision in 2003.

	• The product must be practical for the teacher . • It must be Interactive.		begins with the question what does the user need? The process is also developed to guide how to translate those needs into gameplay by the use of the LM-GM mapping approach. The work also builds design practices on how to consider the different users of the product, be that students or educators/ parents. Through considering issues of context, guidance and delivery, these areas of design focus on the practicalities of how to implement such products.
Wouters et al., 2009	• Align learning outcomes to game type. • Choose appropriate game type. • Instructors guidelines. • Gender Considerations. • Understand psychological considerations. • Assessment of learning outcomes.	Outputs 1-7 with particular emphasis on Outputs 1, 2, 3 and 6.	The alignment of learning outcomes and game type were also featured as a key gap within Wouters et al., study. The development of the design approach in Output 1 & 2 to include the LM-GM to map LO's to game mechanics has gone some was to responding to this identified gap. This was taken further and aligned with the gap of 'assessment of learning outcomes' in Output 3 and 6, in that the author developed the LM-GM to include a LO-GO mapping process in which learning objectives were given game objectives for players to complete within the game. Once an objective was completed, assessment could be taken. Similar to Vogel's observations of appropriate Instructor support, the authors work developed in Output 1 & 2, saw a design section where 'Resource Design' was part of the overall process. This includes tutorials, guidebooks/ manuals and any additional support that may not make up part of the main game.
Ke, 2011	• Knowledge Base • Empirical Data	Outputs 1-7 with particular emphasis on Outputs 4, 5 & 7.	The two identified gaps in Ke's work that haven't

	• Alignment of gameplay and task. • Instructional support of features. • Teacher Facilitation. • Gender Considerations.		already been discussed, gender and facilitation. Whilst the authors work never focused on gender (the author has the stance that gender is not a defining characteristic of ability to play), it was noted in Outputs 4 & 5 that previous studies into escape room games presented a 50/50 split of player gender attendance to the games. This could indicate further research into the preferences of gender for puzzle-based games. In Outputs 4, 5 and 7, a discussion is drawn around the role of the facilitator and what support is needed to help them address barriers of ease of use, delivery and perception of use. Also, how the facilitator can be used to support the game – In Output 4 & 7, the facilitator is considered as the Game-Master which raises questions of how to build comfort levels and easy delivery solutions into the design processes.
Sitzmann, 2011	• Iterative process • Guidance by organisers of the game • Case Studies to be provided • Give the player responsibility • Utilise knowledge within the game.	Outputs 1-7 with particular emphasis on Outputs 1, 2, 4, 5 & 6.	As part of the overall Transdisciplinary design process developed through Output 1 & 2, one of the key elements of the process was that it was iterative in nature. This design feature has followed through into the design of the escapED Framework in Output 4. Due to the constant need to trail and test the product with the end users, an iterative approach is an essential component of developing serious games. In Output 5 & 6, the authors work explored the use of problem-based learning combined with simulation gameplay approach to encourage learners to become more self-directed with their

			learning experience. The results showed promise in terms of developing vocational skills, but needs further development in developing student psychological preparation.
Chamberlain et al., 2013	• Connection of learning to the game task. • Task design streamlined.	Outputs 1-7 with particular emphasis on Outputs 1, 3 & 5.	Output 3 began to develop the research around connecting actual game tasks solidly with the learning task using the LO-GO approach. Further research needs to develop this out into ways educators can identify game objectives easily that could match up against developed LO's.
Hess & Gunter., 2013	• Management of resources • Consider psychological needs of competence and autonomy. • Clear guidance.	Outputs 1-7 with particular emphasis on Outputs 1, 2 & 4.	Hess & Gunter's work also identified the need to consider psychological needs with the design of serious games. The adaptation of key Intervention Mapping approaches in Output 1, 2 and 4, as part of the overall design process, present the first stages of using psychology planning methods within a games design discipline.
Moser et al., 2013	• Multidisciplinary team • Player-centred design • Active participation from the players in the design process • Requirements analysis.	Outputs 1-7 with particular emphasis on Outputs 1, 2 & 4.	Moser et al., identify in their work several key areas that were developed in Output 1 & 2, and that were carried through the remaining body of work. The use of multidiscipline experts and active input from the end users themselves in the form of participatory design, has been key to understanding the true needs of users during the design process.

As shown in Table 3, several key areas were consistent as areas for further study, including; guidance development, psychological needs considerations, connection of learning tasks to game-play and adequate facilitator support. The work developed in the Critical Review has gone some way to developing the research in these areas through the development of the Transdisciplinary Methodology and the escapED Framework. Future work will expand on these areas, particularly in the development of how assessment strategies can be mapped against learning and game objectives.

6. Contribution of Other Authors to Outputs

6.1 Overall Contribution Break Down

Table 4 Contribution Percentage of Work Breakdown

Description Output	Percentage of Work Contributed by Author	Comments
Output 1	35%	The contribution to the project and workload was in the creation of the application. This included the development of the design process, analysis of the theoretical frameworks and translation of theory into game practice.
Output 2	50%	All aspects of the theoretical and written development of the output was shared by the author and co-author.
Output 3	90%	The output was written by the author with contributions to sections from the co-authors.
Output 4	100%	The output was fully developed and written by the author.
Output 5	50%	The outputs activities were co-developed using the authors concept. The author was responsible for development and delivery of the activities, and contributed to the written output.
Output 6	85%	The output was mainly developed by the author with contributions from the co-authors to the development of the learning objectives, narrative and written output of the project.
Output 7	100%	The output was developed and delivered fully by the author, both in development of the concept and written/ practice output.

6.2 Output 1

The peer-reviewed Journal paper was led by Arnab, S., and contributed to by Brown, K., Clarke, S., Dunwell, I., Lim, T., Suttie, N., Louchart, S., Hendrix, M. & de Freitas, S., who were the main contributors to the research project on the technical delivery of the PR:EPARe game (except for Brown, who was principle investigator from SASH (Studies in Adolescent Sexual Health), a health and life sciences research centre at Coventry University). The journal which was revised continuously through the sharing of drafts between authors, was used to pull together the development approach and analysis of the PR:EPARe project. Clarke contributed as the principle designer on the game, and within the Journal was joint responsible (alongside Arnab) for reporting on the design and

development approach which utilises the Four-Dimensional Framework (4DF), Mechanics, Dynamics & Aesthetics (MDA) and Learning Mechanics-Game Mechanics (LM-GM) mapping approach that was implemented into the project. Clarke also contributed to the background, theory and structure of the journal. Brown, K (SASH) developed the change objectives, methods from the Intervention Mapping approach and the evaluation and discussion of the work which is documented in the journal.

6.3 Output 2

The peer-reviewed Journal paper was jointly written with Arnab, S., and presents a new trans-disciplinary model built from the design and development approach of the PR:EPARe project. Arnab and Clarke held joint responsibility for the development of the literature review, reporting of the project and the investigation into and the design of the overall concept of the Trans-disciplinary model. Arnab and Clarke worked in collaboration to pull together key workings and multi-disciplinary practices from the case study of the PR:EPARe project, and synthesise these findings to create a best practice approach to designing intervention-based serious games. Both authors were responsible for revising and resubmitting the paper following review.

6.4 Output 3

The peer-reviewed (EU Consortium) digital output of SimAULA was jointly created by Clarke, S., Lameras, P., Torrens, K., & Dixon, R. The serious game was funded and is a technical output in contribution to the EU project ISE (Inspiring Science Education). This digital game shows the development process and outcomes of the use of the Trans-disciplinary model. Within this piece of design-led research, the inclusion of the game-objective mapping approach was adopted alongside the standard approach of the LM-GM. Clarke's role was principle designer of the game, which included the consolidation of theory of Inquiry Based Learning (ISE) which was contributed by Lameras, application of the Trans-disciplinary methodology into the design development of the game, creation of stable and playable mechanics, and overseeing the products development up to a final Beta testing phase with the projects end users. Dixon was the lead programmer on the game, who was responsible for its technical realisation in the Unity engine and Torrens, produced the text flow files in the Chat Mapper program to be uploaded into the game.

Alongside the digital output, a peer-reviewed conference paper (ECGBL 2016) that was first authored by Clarke, is used to describe the development process further, particularly in relation to the expansion from the LM-GM mapping approach to include the LO-GO approach (Learning Objective to Game Objective mapping).

6.5 Output 4

The peer-reviewed Journal paper describes the development of the escapED Framework that developed on from the Trans-disciplinary model. Clarke was lead author and responsible for the concept and development of the escapED framework through an analysis of theory and practice from the entertainment games industry, and evidenced from insights gained at a pilot trial of the escapED project held at Coventry University. The journal is the extended article from a conference paper submitted to GALA 2016 (Games and Learning Alliance) in which the theory and process is described and in which five authors contributed Clarke, S., Peel, D., Arnab, S., Morini, L., Keegan, H. & Wood, O. Peel, who is an academic based at the University of Southampton, provides an analysis of his approach of using the escapED framework to create a game to be used for teaching research methods to University students. Based on the Trans-disciplinary model, Arnab helped to position the work from existing theory from Output 1 & 2, as well as contributing to the production and revision of the paper. Morini, Keegan and Wood helped to pilot the approach but did not contribute to the creation of the framework or the paper. Two peer-reviewed conference proceeding papers are also available and first authored by Clarke in relation to the escapED framework.

6.6 Output 5

Duncan was lead author for the peer-reviewed Journal paper and was responsible for the initial literature review around Problem Based Learning (PBL) and situating the theory and practice of sports science. Clarke brought her extensive experience of GBL creation and the concept and theoretical design of the curiosity box approach to produce the discussion of creating a gamified approach to a Sports Science Assessment at HE. Clarke took an existing module and its assessment (created by Duncan) and gamified this to create a unique approach, drawing on the methodology of the escapED framework and PBL that was supplied from Duncan. Clarke set up the physical and digital components for the gamified approach for the trial with a MSc Sports science cohort. Duncan and Tallis ran the student semi-structured interviews after the trial and conducted the analysis of the findings. Myers and Arnab, provided expertise via consultation when updated at key milestones of the project. Clarke was also responsible for contributing to the overall write up of the Journal in the areas around gamification and the methods section.

6.7 Output 6

The digital output (Output 6) was created by Clarke, S., Collins, B., & Flynn, D. The game was developed using the participatory approach of the Trans-disciplinary model with Coventry University Librarians

Collins & Flynn. Collins & Flynn contributed to the development of the overall aims, learning objectives and narrative development of the game. Clarke was responsible for the design, developing the learning objectives into game objectives, technical development and end user testing of the game. Clarke also developed and led the evaluation, and was supported by Collins in facilitating the pilot of the game with Coventry University students. Finally, Clarke is responsible for the ongoing analysis of evaluation, iteration of technical development work, based on student feedback and the writeup of further publications for dissemination of findings.

6.8 Output 7

The digital output (Output 7) was created solely by Clarke. Following a DBR approach, Clarke developed the concept utilising the Trans-disciplinary model alongside a Dungeons and Dragons game experience/ mechanics and realised them as a method for student self-reflection exercises. After trialling this as a pilot with a 2nd year undergraduate AddVantage+ module, the website was created as a digital version of the research based on the feedback of the students that undertook the pilot study. A peer-reviewed conference paper and a chapter featuring the Output in an Excellence case study book, which is first authored by Clarke, is also available alongside the digital Output.

7. Conclusions & Further Research

In the introduction to the critical overview, four main objectives were presented alongside the overall aim of the research in which to provide a presentation and discussion of best practice approaches to serious games and gamification design and development. These have to a large extent been realised, and continue to be worked upon and form the basis of new research projects. The portfolio of evidence and work contained in the thesis exhibits theory and literature surrounding an introduction to the philosophy of serious games, serious games design and development approaches, and the gap in the knowledge. An analysis of serious games design, intervention and entertainment games frameworks/ models, provided the theoretical underpinning of design best practices that was used in tandem with a design-based research methodology to develop the serious game PR:EPARe. The research conducted with PR:EPARe and its evaluation allowed for the development of a new multi-disciplined design approach the 'Trans-disciplinary Model', that combined best practices including those centred around participatory design from across the original four selected frameworks (4DF, IM, MDA, LM-GM). A need arose that the best practices put forward in the Trans-disciplinary model were to be adapted to flow with game/ gamification applications that were based in the live-action gaming genre. The adaptation was named as the escapED framework, and joins the Trans-disciplinary model as guidance to providers for best practice approaches to designing serious games and gamification applications. Both examples have been applied and dissected with discussions as to the use and adaptation of the methods that are presented in a real design project environment. Some best practices such as participatory design, learning mechanic to game mechanic mapping, needs assessments and iterative design have been found through using a design research-based methodology, to play a vital part in ensuring that end-learner needs and feedback are central to building better products. Simultaneously, the process of applying the Trans-disciplinary model and the escapED framework to real learning projects has also highlighted other practices in their guidance, where barriers such as time and attention such as in the case of Quality Assurance and Testing, need further emphasis in academic and practice-based study.

In Section 4.1 Methods, a discussion was drawn around the philosophical positioning of the work, specifically in that it adopted a Critical Realist perspective. Reflecting on the work that has made up the Critical Overview, the authors stance on Bhasker's theory that knowledge should be drawn from a holistic view of the world has been reinforced. As time has gone on, it has become more apparent to the author that there is no one set way of approaching or analysing a problem. As the world is changing it is perhaps even more appropriate now that we adopt a Critical Realist stance to understand the complicated nature between science and the social sciences. The work therein, has

evolved to utilise numerous methodologies that were perceived at the time to be appropriate for the needs of the work. The flexibility to move between different stances and methods has proved to be one of the most useful skills that the author has gained through the research, particularly in line with the discipline of GBL. Working with a wide range of educators, field specialists, psychologists, programmers and designers, one of the key insights to the design process, is that the trans-disciplinary approach as highlighted from Bhasker's work, has provided the flexibility required to move past discipline specific restrictions. New designers and practitioners to the field of GBL may wish to adopt a similar approach in that they become somewhat of a 'discipline translator' through willingness to accept multiple methodologies as best practice for the benefits of design.

A secondary observation in relation to the authors work and Bhasker's theory was how his stance that knowledge was everchanging and not a static commodity would ultimately prove to play more of a role in the summary of the research findings than originally perceived. When the author started the research, the knowledge that the work would be carried out in iterative cycles was a known factor, however, at the time the author believed there would be an end point in which the research frameworks were finished. On reflection of the work up to this point, the author believes that the frameworks will never be 'finished' in the original context that the author planned, but instead adapted and added to as she continues along her research journey reflecting a truly Critical Realist's approach.

And thirdly, from observing others work and adoption of the frameworks developed by the author and her co-workers, a belief has been gained that there is no one prescriptive way in which a framework should be utilised for the practice of GBL and gamification design. This was perhaps one of the more surprising insights gained from the critical review of the work, and came from observation of the way in which different practitioners adapted the frameworks for their own use. The authors original stance was that all elements of a proposed framework should be followed in order for a best practice approach to the design of a game. This has now changed since the beginning of the research, with a new outlook that a framework need not form a rigid and prescriptive practice to be adhered to, but instead provide insight into areas of consideration that can be drawn upon and used as required. This is much like Bhasker's view that the truth or falsity of scientific theories is a 'function of the judgment of scientists' (Hartwig, 2015). The ability to choose what is a 'best practice approach' for an individual should be placed upon those that are best suited to these decisions, those about to undertake the design journey. It is the view of the author that the frameworks within the Critical

Overview and any future endeavours be thought of as a guide in which others can develop their own best practice approach which suits their needs.

Further work on both the Trans-disciplinary model and the escapED framework continues to adapt and develop on the recommendations of best practice as are ongoing in their development in which both are applied and analysed with new projects internal and external to Coventry University. Following the successful completion of the work presented in the Prima Facie, three out of four of the projects are currently under iterative development using the DBR methodology, as further research endeavours. A description of the development plans is offered below.

- Output 5 is currently being developed to form further understanding around the different types of curiosity and how these can be applied to University learning environments. This is currently leading to talks of developing a simulation of work experience environments for final year undergraduate students who cannot be placed externally. A curiosity box game has also been developed as a prototype of a smaller experience that can be used in one teaching session.

- Output 6 is currently in the final analysis and write up stage of the evaluation. This is anticipated as a paper in an SJR: Q1/2 journal. The next stage for the game is scheduled with the consideration of the feedback gained from the evaluation to be included into the new version. A workshop to train teaching and learning staff in the use of the game engine RPG Maker is currently in development and expected to be ready for roll out early 2020.

- Output 7 is currently being developed with formal learning objectives. A review of the website and a new section which can track student attributes (character sheet mechanics) plans are currently being drawn up. A new workshop for teaching and learning staff has been created to help others implement D&D gamification strategies into their own practice.

Further work has recently been conducted on the Trans-disciplinary model with undergraduate students based at the University. Students were assigned control and intervention groups (with aid of the model and without aid of the model) and tasked to design a serious game to a brief. Semi-structured interviews were carried out with the students to assess acceptability, ease of use and perceived usefulness of the model. These results are currently being analysed and are expected to help form discussions about how other facilitators and practitioners use the model for design practice.

The escapED framework has been reworked into version 1.2 as seen in Figure 14. A workshop on how to use this version of the framework and how to develop simple educational escape rooms is currently in development to go some ways to addressing the need for different research dissemination tools.

The author recognises the body of work contained in the Prima Facie and the critical review, as an ongoing reflection of the development and growth that has been achieved as a practice-based researcher, and presents a research portfolio that is felt to be at the level of PhD equivalence. The critical review and the Prima Facie present sufficient evidence of knowledge and application of several research methods appropriate to the field. These methods include: literature reviews, surveys, one to one and group interviews with analysis (semi-structured and open), quantitative data analysis (Wilcoxon Signed Rank Test) and involvement in many different types of evaluation design and delivery in both leading and supporting role capacities.

The research provides significant evidence of knowledge in the general field of serious games and gamification and more specifically the multi-disciplined process of design considerations that have been taken from education, behavioural sciences and psychology and entertainment games design. The work presents originality of behalf of the author both in the development of practice-based outputs but through published works and recognised international awards in the field, and demonstrates the authors ability to synthesise existing theory and applicable research methodologies and apply these to deliver practice-based outputs for use with end-user stakeholders. These practices have been delivered for both internal projects and with large EU funded projects as part of the research activities.

The portfolio of evidence sets out to present a logical pathway that binds the research together, showing a flow of work that has achieved the following objectives (i) draw out key methodologies and frameworks used for aiding the design and development of SGs/ gamification (ii) synthesise these findings through a design-based research approach (iii) provide a reflection and amalgamate these findings to provide a multi-disciplined design process (iv) implement the design process in live learning environments and develop scope for future development, to put forward for the award of Doctor of Philosophy.

Finally, the author has learnt through their career and the building of this body of work, that research is never truly finished with. A project merely creates new opportunities to build and reflect upon what is already known. It is with this is mind that the author will take the developments gained from the

work presented and continue to ask, create and reflect upon our understanding of the field of serious games and gamification design and development.

8. References

Aken, J. E. V. (2004). Management research based on the paradigm of the design sciences: the quest for field-tested and grounded technological rules. *Journal of management studies*, *41*(2), 219-246.

Arnab, S., Brown, K., Clarke, S., Dunwell, I., Lim, T., Suttie, N., ... & De Freitas, S. (2013). The development approach of a pedagogically-driven serious game to support Relationship and Sex Education (RSE) within a classroom setting. *Computers & Education*, *69*, 15-30.

Arnab, S., & Clarke, S. (2017). Towards a trans-disciplinary methodology for a game-based intervention development process. *British journal of educational technology*, *48*(2), 279-312.

Arnab, S., Lim, T., Carvalho, M. B., Bellotti, F., De Freitas, S., Louchart, S., ... & De Gloria, A. (2015). Mapping learning and game mechanics for serious games analysis. *British Journal of Educational Technology*, *46*(2), 391-411.

Van Aken, J. E. (2005). Management research as a design science: Articulating the research products of mode 2 knowledge production in management. *British journal of management*, *16*(1), 19-36.

Alamri, A., Hossain, M. A., Hassan, M. M., Hossain, M. S., Alnuem, M. A., Ahmed, D. T., & El-Saddik, A. (2013). A cloud-based pervasive serious game framework to support obesity treatment. *Comput. Sci. Inf. Syst.*, *10*(3), 1229-1246.

Amory, A., & Seagram, R. (2003). Educational game models: conceptualization and evaluation: the practice of higher education. *South African Journal of Higher Education*, *17*(2), 206-217.

Archer, M. S. (1982). Introduction: Theorizing about the expansion of educational systems. *The sociology of educational expansion*, 3-64.

Archer, M. S. (1995). *Realist social theory: The morphogenetic approach*. Cambridge university press.

Archer, M., Bhaskar, R., Collier, A., Lawson, T., & Norrie, A. (2013). *Critical realism: Essential readings*. Routledge.

Archer et al. (2016) What Is Critical Realism? American Sociology Association, [online] http://www.asatheory.org/current-newsletter-online/what-is-critical-realism

Backlund, P., & Hendrix, M. (2013, September). Educational games-are they worth the effort? A literature survey of the effectiveness of serious games. In *2013 5th international conference on games and virtual worlds for serious applications (VS-GAMES)* (pp. 1-8). IEEE.

Bandura, A., & Walters, R. H. (1977). *Social learning theory*(Vol. 1). Englewood Cliffs, NJ: Prentice-hall.

Bandura, A. (2009). Social cognitive theory of mass communication. In *Media effects* (pp. 110-140). Routledge.

Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *The journal of the learning sciences*, *13*(1), 1-14.

Barab, S. (2014). Design-based research: A methodological toolkit for engineering change. In *The Cambridge Handbook of the Learning Sciences, Second Edition*. Cambridge University Press.

Baranowski, T., Buday, R., Thompson, D. I., & Baranowski, J. (2008). Playing for real: video games and stories for health-related behaviour change. *American journal of preventive medicine*, *34*(1), 74-82.

Bartholomew, L. K., Parcel, G. S., & Kok, G. (1998). Intervention mapping: a process for developing theory and evidence-based health education programs. *Health education & behaviour*, *25*(5), 545-563.

Bates, B., & LaMothe, A. (2001). *Game design: The art & business of creating games*. Prima Tech.

Berlyne, D. E. (1954). A theory of human curiosity. *British Journal of Psychology. General Section*, *45*(3), 180-191.

Berlyne, D. E. (1960). Conflict, arousal, and curiosity.

Bhaskar, R. (2013). *A realist theory of science*. Routledge.

Björk, S., & Holopainen, J. (2003). Describing Games-An Interaction-Centric Structural Framework. In *Level Up–CD-ROM Proceedings of Digital Games Research Conference 2003. Referred to www. play research. com/publications/2003/structural framework. pdf (ref. October the 25th*.

Björk, S., & Peitz, J. (2007). Understanding Pervasive Games through Gameplay Design Patterns. In *DiGRA Conference*.

Bloom, B. S. (1956). Taxonomy of educational objectives. Vol. 1: Cognitive domain. *New York: McKay*, 20-24.

Boud, D. (1985). *Problem-based learning in education for the professions*. Higher Education Research and Development Society of Australasia.

Bourgonjon, J., De Grove, F., De Smet, C., Van Looy, J., Soetaert, R., & Valcke, M. (2013). Acceptance of game-based learning by secondary school teachers. *Computers & Education*, *67*, 21-35.

Bourazeri, A., Bellamy-Wood, T., & Arnab, S. (2017, April). EnCity: A serious game for empowering young people with Down's syndrome. In *2017 IEEE 5th International Conference on Serious Games and Applications for Health (SeGAH)* (pp. 1-6). IEEE.

Boyle, E. A., Hainey, T., Connolly, T. M., Gray, G., Earp, J., Ott, M., ... & Pereira, J. (2016). An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. *Computers & Education*, *94*, 178-192.

Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The journal of the learning sciences*, *2*(2), 141-178.

Bruner, J. S. (1966). *Toward a theory of instruction* (Vol. 59). Harvard University Press.

Bryant, J., & Fondren, W. (2009). Psychological and communicological theories of learning and emotion underlying serious games. *Serious games: Mechanisms and effects*, 103-116.

Callaghan, M., Savin-Baden, M., McShane, N., & Eguiluz, A. G. (2015). Mapping learning and game mechanics for serious games analysis in engineering education. *IEEE Transactions on Emerging Topics in Computing*, *5*(1), 77-83.

Chamberlain, J., Fort, K., Kruschwitz, U., Lafourcade, M., & Poesio, M. (2013). Using games to create language resources: Successes and limitations of the approach. In *The People's Web Meets NLP* (pp. 3-44). Springer, Berlin, Heidelberg.

Clarke, S., Lameras, P., & Arnab, S. (2016, October). SimAULA: Creating Higher-Level Gamification Through Adoption of a Learning-Objective to Game-Objective Mapping Approach. In *European Conference on Games Based Learning* (p. 127). Academic Conferences International Limited.

Clarke, S., Peel, D. J., Arnab, S., Morini, L., Keegan, H., & Wood, O. (2017). EscapED: A framework for creating educational escape rooms and interactive games For higher/further education. *International Journal of Serious Games*, *4*(3), 73-86.

Clarke, S., Collins, B., Flynn, D., & Arnab, S. (2018, November). Gamifying the University Library: Using RPG Maker to Re-Design Library Induction and Online Services. In *European Conference on e-Learning* (pp. 721-XIV). Academic Conferences International Limited.

Clarke, S., Arnab, S., & Heywood, L. (2018). Bothersome Beasties (and how to deal with them!). In *The 4th e-Learning Excellence Awards: An Anthology of Case Histories 2018* (pp. 51-65). acpi.

Clarke, S., Arnab, S., Morini, L., & Heywood, L. (2018, December). Dungeons and Dragons as a Tool for Developing Student Self-reflection Skills. In *International Conference on Games and Learning Alliance* (pp. 101-109). Springer, Cham.

Cobb, P., Confrey, J., DiSessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational researcher*, *32*(1), 9-13.

Cochran-Smith, M., Barnatt, J., Friedman, A., & Pine, G. (2009). Inquiry on inquiry: Practitioner research and student learning. *Action in Teacher Education*, *31*(2), 17-32.

Cohen, E. L. (2014). What makes good games go viral? The role of technology use, efficacy, emotion and enjoyment in players' decision to share a prosocial digital game. *Computers in Human Behavior*, *33*, 321-329.

Cole, R., Purao, S., Rossi, M., & Sein, M. (2005). Being proactive: where action research meets design research. *ICIS 2005 Proceedings*, 27.

Collins, A. (1992). Toward a design science of education. In *New directions in educational technology* (pp. 15-22). Springer, Berlin, Heidelberg.

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: Theoretical and methodological issues. *The Journal of the learning sciences*, *13*(1), 15-42.

Connolly, T., Stansfield, M., & Hainey, T. (2009). Towards the development of a games-based learning evaluation framework. In *Games-based learning advancements for multi-sensory human computer interfaces: Techniques and effective practices* (pp. 251-273). IGI Global.

Csikszentmihalyi, M., & LeFevre, J. (1989). Optimal experience in work and leisure. *Journal of personality and social psychology*, *56*(5), 815.

Csikszentmihalyi, M. (1990). Flow: The Psychology of Optimal Experience: Finding Flow.

Day, H. I. (1982). Curiosity and the interested explorer. *Performance & Instruction*.

De Freitas, S., & Oliver, M. (2006). How can exploratory learning with games and simulations within the curriculum be most effectively evaluated? *Computers & education*, *46*(3), 249-264.

De Freitas, S., & Jarvis, S. (2009). Towards a development approach to serious games. In *Games-based learning advancements for multi-sensory human computer interfaces: Techniques and effective practices* (pp. 215-231). IGI Global.

De Lope, R. P., & Medina-Medina, N. (2017). A comprehensive taxonomy for serious games. *Journal of Educational Computing Research*, *55*(5), 629-672.

De Troyer, O., Van Broeckhoven, F., & Vlieghe, J. (2017). Linking serious game narratives with pedagogical theories and pedagogical design strategies. *Journal of Computing in Higher Education*, *29*(3), 549-573.

Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher*, *32*(1), 5-8.

Dewey, J. (1916). Education and democracy.

Dewey, J. (1997). *How we think*. Courier Corporation.

Driscoll, M. P., & Driscoll, M. P. (2005). Psychology of learning for instruction.

Duncan, M., Clarke, S., Myers, T., Tallis, J., & Arnab, S. (2018). A hybrid, gamified and mystery-driven approach for facilitating problem-based learning in a postgraduate strength and conditioning module. *Practice and Evidence of the Scholarship of Teaching and Learning in Higher Education*, *13*(1), 28-48.

Eason, L. P., & Linn, M. C. (1976). Evaluation of the effectiveness of participatory exhibits. *Curator: The Museum Journal*, *19*(1), 45-62.

Fleming, T. M., Bavin, L., Stasiak, K., Hermansson-Webb, E., Merry, S. N., Cheek, C., ... & Hetrick, S. (2017). Serious games and gamification for mental health: current status and promising directions. *Frontiers in psychiatry*, *7*, 215.

Fullerton, T. (2018). *Game design workshop: a playcentric approach to creating innovative games*. AK Peters/CRC Press.

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation & gaming*, *33*(4), 441-467.

Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment (CIE)*, *1*(1), 20-20.

Gee, J. P. (2011). Reflections on empirical evidence on games and learning. *Computer games and instruction*, *223232*.

Ghani, J. A. (1995). Flow in human computer interactions: test of a model. *Human factors in information systems: Emerging theoretical bases*, 291-311.

Giang, C., Chevalier, M., Negrini, L., Peleg, R., Bonnet, E., Piatti, A., & Mondada, F. Exploring Escape Games as a Teaching Tool in Educational Robotics.

Gleaves, A., Walker, C., & Grey, J. (2008). Using digital and paper diaries for assessment and learning purposes in higher education: a case of critical reflection or constrained compliance. *Assessment & Evaluation in Higher Education*, *33*(3), 219-231.

Göbel, S., Hardy, S., Wendel, V., Mehm, F., & Steinmetz, R. (2010, October). Serious games for health: personalized exergames. In *Proceedings of the 18th ACM international conference on Multimedia* (pp. 1663-1666). ACM.

Granic, I., Lobel, A., & Engels, R. C. (2014). The benefits of playing video games. *American psychologist*, *69*(1), 66.

Gunter, G. A., Campbell, L., Braga, J., Racila, M., & Souza, V. (2016). Using the RETAIN Model to evaluate mobile educational games for language learning. *Revista Brasileira de Linguística Aplicada*, *16*(2), 1-29.

Harteveld, C. (2010). Triadic game evaluation: A framework for assessing games with a serious purpose. In *Workshop of the ACM SIGCHI Symposium on Engineering Interactive Computing Systems*.

Hartwig, M. (Ed.). (2015). *Dictionary of critical realism*. Routledge.

Hess, T., & Gunter, G. (2013). Serious game-based and nongame-based online courses: Learning experiences and outcomes. *British Journal of Educational Technology*, *44*(3), 372-385.

Hiemstra, R. (2001). Uses and benefits of journal writing. *New directions for adult and continuing education*, *2001*(90), 19.

Hoth, S. R. (1978). National Museum of Natural History: The Discovery Room In B. Newsom (Ed.) The Art Museum as Educator.

Huitt, W. (2001). Motivation to learn: An overview. *Educational psychology interactive*, *12*.

Hume, D. (1902). An Enquiry Concerning Human Understanding, ed. LA Selby-Bigge. *Oxford, Clarendon Press*, *17771*, 155.

Hunicke, R., LeBlanc, M., & Zubek, R. (2004, July). MDA: A formal approach to game design and game research. In *Proceedings of the AAAI Workshop on Challenges in Game AI*(Vol. 4, No. 1, p. 1722).

Hutchinson, A. M., & Estabrooks, C. A. (2013). Educational theories. *Knowledge Translation in Health Care,* 298-307.

Imbellone, A., Botte, B., & Medaglia, C. M. (2015). Serious games for mobile devices: the intouch project case study. *International Journal of Serious Games*, *2*(1), 17-27.

Järvinen, P. (2007). Action research is similar to design science. *Quality & Quantity*, *41*(1), 37-54.

Jarvis, P. (1992). Reflective practice and nursing. *Nurse education today*, *12*(3), 174-181.

Kapp, K. (29011). Gamification vs. Serious Games -What's the difference? [Blog Post] Retrieved from http://karlkapp.com/gamification-vs-serious-games-whats-the-difference/

Ke, F. (2011). A qualitative meta-analysis of computer games as learning tools. In *Gaming and Simulations: Concepts, Methodologies, Tools and Applications* (pp. 1619-1665). IGI Global.

Kiili, K., & Lainema, T. (2008). Foundation for measuring engagement in educational games. *Journal of Interactive Learning Research*, *19*(3), 469-488.

Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *The Internet and higher education*, *8*(1), 13-24.

Kim, S., & Chang, M. (2010). Computer games for the math achievement of diverse students. *Journal of Educational Technology & Society*, *13*(3), 224-232.

Knight, J. K., & Wood, W. B. (2005). Teaching more by lecturing less. *Cell biology education*, *4*(4), 298-310.

Koivisto, J., & Hamari, J. (2019). The rise of motivational information systems: A review of gamification research. *International Journal of Information Management*, *45*, 191-210.

Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development*. FT press.

Koran, J. J., & Koran, M. L. (1983). The roles of attention and curiosity in museum learning. *Roundtable Reports*, *8*(2), 14-24.

Koster, R. (2013). *Theory of fun for game design*. " O'Reilly Media, Inc.".

Kriz, W. C., & Hense, J. U. (2006). Theory-oriented evaluation for the design of and research in gaming and simulation. *Simulation & Gaming*, *37*(2), 268-283.

Lameras, P., & Moumoutzis, N. (2015, November). Towards the gamification of inquiry-based flipped teaching of mathematics a conceptual analysis and framework. In *2015 International Conference on Interactive Mobile Communication Technologies and Learning (IMCL)* (pp. 343-347). IEEE.

Lee, J., & Kim, J. (2018). Method of app selection for healthcare providers based on consumer needs. *CIN: Computers, Informatics, Nursing*, *36*(1), 45-54.

Lieberman, D. A. (2006). What can we learn from playing interactive games. *Playing video games: Motives, responses, and consequences*, 379-397.

Lim, T., Carvalho, M. B., Bellotti, F., Arnab, S., De Freitas, S., Louchart, S., ... & De Gloria, A. (2015). The lm-gm framework for serious games analysis. *Retrieved October*, *3*, 2015.

Loftus, G. R., Loftus, E. F., & Loftus, E. F. (1983). *Mind at play: The psychology of video games* (Vol. 14). New York: Basic Books.

López-Pernas, S., Gordillo, A., Barra, E., & Quemada, J. (2019). Examining the Use of an Educational Escape Room for Teaching Programming in a Higher Education Setting. *IEEE Access*, *7*, 31723-31737.

Nesbit, P. L. (2012). The role of self-reflection, emotional management of feedback, and self-regulation processes in self-directed leadership development. *Human Resource Development Review*, *11*(2), 203-226.

Nicholson, S. (2015). Peeking behind the locked door: A survey of escape room facilities. *White Paper available online at http://scottnicholson. com/pubs/erfacwhite. pdf*.

Nicholson, S. (2018). Creating engaging escape rooms for the classroom. *Childhood Education*, *94*(1), 44-49.

Markey, K., Swanson, F., Leeder, C., Peters Jr, G. R., Jennings, B. J., St Jean, B., & Rosenberg, V. (2010). The benefits of integrating an information literacy skills game into academic coursework: A preliminary evaluation. *D-Lib Magazine*, *16*(7/8), 1-10.

Marne, B., Wisdom, J., Huynh-Kim-Bang, B., & Labat, J. M. (2012, September). The six facets of serious game design: a methodology enhanced by our design pattern library. In *European conference on technology enhanced learning* (pp. 208-221). Springer, Berlin, Heidelberg.

Maslow, A. (1968). Some educational implications of the humanistic psychologies. *Harvard Educational Review*, *38*(4), 685-696.

Mayer, I. (2012). Towards a comprehensive methodology for the research and evaluation of serious games. *Procedia Computer Science*, *15*, 233-247.

Mayer, I., Bekebrede, G., Harteveld, C., Warmelink, H., Zhou, Q., van Ruijven, T., ... & Wenzler, I. (2014). The research and evaluation of serious games: Toward a comprehensive methodology. *British Journal of Educational Technology*, *45*(3), 502-527.

McCandliss, B. D., Kalchman, M., & Bryant, P. (2003). Design experiments and laboratory approaches to learning: Steps toward collaborative exchange. *Educational Researcher*, *32*(1), 14-16.

McCrindle, A. R., & Christensen, C. A. (1995). The impact of learning journals on metacognitive and cognitive processes and learning performance. *Learning and instruction*, *5*(2), 167-185.

McKenna, P. E. (2017). *Embodied cognition and executive functioning: the effect of whole-body interaction on children's planning and inhibition* (Doctoral dissertation, Heriot-Watt University).

Moser, C., Tscheligi, M., Zaman, B., Vanden Abeele, V., Geurts, L., Vandewaetere, M., ... & Hofstätter, J. (2013, April). Let's talk about failures: why was the game for children not a success? In *CHI'13 Extended Abstracts on Human Factors in Computing Systems* (pp. 3199-3202). ACM.

Oliver, R., Reeves, T. C., & Herrington, J. A. (2005). Design research: A socially responsible approach to instructional technology research in higher education. *Journal of Computing in Higher Education*, *16*(2), 96-115.

Oppenheimer, F. (1970). Schools are not for sightseeing. *precollege science Smithsonian Institution*, *1*.

Oppenheimer, F. (1972). The Exploratorium: A playful museum combines perception and art in science education. *American Journal of Physics*, *40*(7), 978-984.

Oppenheimer, F. J., & Cole, K. C. (1974). The Exploratorium: A participatory museum. *Prospects*, *4*(1), 21-34.

Owen, N., Sugiyama, T., Eakin, E. E., Gardiner, P. A., Tremblay, M. S., & Sallis, J. F. (2011). Adults' sedentary behaviour: determinants and interventions. *American journal of preventive medicine*, *41*(2), 189-196.

Pagowsky, N. (2013). Test-Driving Purdue's Passport Gamification Platform for Library Instruction. *ACRL TechConnect Blog*.

Pandey, P., & Zimitat, C. (2007). Medical students' learning of anatomy: memorisation, understanding and visualisation. *Medical education*, *41*(1), 7-14.

Petridis, P., Dunwell, I., Panzoli, D., Arnab, S., Protopsaltis, A., Hendrix, M., & de Freitas, S. (2012). Game engines selection framework for high-fidelity serious applications. *International Journal of Interactive Worlds*, Article-ID.

Piaget, J. (1977). *The essential piaget* (Vol. 5076). Basic Books (AZ).

Prager, K. (2012). Understanding behaviour change.

Prensky, M. (2003). Digital game-based learning. *Computers in Entertainment (CIE)*, *1*(1), 21-21.

Proulx, J. N., Romero, M., & Arnab, S. (2017). Learning mechanics and game mechanics under the perspective of self-determination theory to foster motivation in digital game-based learning. *Simulation & Gaming*, *48*(1), 81-97.

Ramadan, R., & Widyani, Y. (2013, September). Game development life cycle guidelines. In *2013 International Conference on Advanced Computer Science and Information Systems (ICACSIS)* (pp. 95-100). IEEE.

Rieber, L. P., Smith, L., & Noah, D. (1998). The value of serious play. *EDUCATIONAL TECHNOLOGY-SADDLE BROOK NJ-*, *38*, 29-36.

Rogers, C. R. (1970). Freedom to learn. *Columbus, OH: Charles Merrill*.

Romme, A. G. L. (2003). Making a difference: Organization as design. *Organization science*, *14*(5), 558-573.

Santos, A. (2018). Instructional Strategies for Game-Based Learning. In *Gamification in Education: Breakthroughs in Research and Practice* (pp. 472-481). IGI Global.

Savin-Baden, M., & Callaghan, M. (2016). Designing Circuit Warz: Enhancing Teachers' And Students' Creativity through Problem-based Games-based Learning in the Computer Engineering Classroom. *The International Journal of Creativity and Problem Solving*, *26*(2), 81-104.

Sayer, A. (1999). *Realism and social science*. Sage.

Schell, J. (2014). *The Art of Game Design: A book of lenses*. AK Peters/CRC Press.

Schuler, D., & Namioka, A. (Eds.). (1993). *Participatory design: Principles and practices*. CRC Press.

Shavelson, R. J., Phillips, D. C., Towne, L., & Feuer, M. J. (2003). On the science of education design studies. *Educational researcher*, *32*(1), 25-28.

Shettel, H. H. (1973). Exhibits: Art form or educational medium. *Museum News*, *52*(1), 32-41.

Sitzmann, T. (2011). A meta-analytic examination of the instructional effectiveness of computer-based simulation games. *Personnel psychology*, *64*(2), 489-528.

Skadberg, Y. X., & Kimmel, J. R. (2004). Visitors' flow experience while browsing a Web site: its measurement, contributing factors and consequences. *Computers in human behaviour*, *20*(3), 403-422.

Skinner, B. F. (1990). *The behaviour of organisms: An experimental analysis*. BF Skinner Foundation.

Smith, M. K. (1999). The social/situational orientation to learning. *The encyclopaedia of informal education*.

Squire, K. D. (2008). Video game–based learning: An emerging paradigm for instruction. *Performance Improvement Quarterly*, *21*(2), 7-36.

Tang, S., & Hanneghan, M. (2010, September). A model-driven framework to support development of serious games for game-based learning. In *2010 Developments in E-Systems Engineering* (pp. 95-100). IEEE.

Thompson, D., Baranowski, T., Buday, R., Baranowski, J., Thompson, V., Jago, R., & Griffith, M. J. (2010). Serious video games for health: How behavioural science guided the development of a serious video game. *Simulation & gaming*, *41*(4), 587-606.

Ulicsak, M. (2010). *Games in education: serious games: A FutureLab literature review*. FutureLab.

Van den Akker, J., Gravemeijer, K., McKenney, S., & Nieveen, N. (Eds.). (2006). *Educational design research*. Routledge.

Virvou, M., Katsionis, G., & Manos, K. (2005). Combining software games with education: Evaluation of its educational effectiveness. *Journal of Educational Technology & Society*, *8*(2), 54-65.

Vogel, J. J., Vogel, D. S., Cannon-Bowers, J., Bowers, C. A., Muse, K., & Wright, M. (2006). Computer gaming and interactive simulations for learning: A meta-analysis. *Journal of Educational Computing Research*, *34*(3), 229-243.

Vygotsky, L. S. (1986). Thought and language-Revised edition.

Waller, A., Franklin, V., Pagliari, C., & Greene, S. (2006). Participatory design of a text message scheduling system to support young people with diabetes. *Health Informatics Journal*, *12*(4), 304-318.

Walsh, A., Edwards, A., & Hill, V. (2013). Games and Gamification for information literacy.

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational technology research and development*, *53*(4), 5-23.

Wang, R., DeMaria Jr, S., Goldberg, A., & Katz, D. (2016). A systematic review of serious games in training health care professionals. *Simulation in Healthcare*, *11*(1), 41-51.

Watson, J. B. (1913). Psychology as the behaviorist views it. *Psychological review*, *20*(2), 158.

Webster, J., Trevino, L. K., & Ryan, L. (1993). The dimensionality and correlates of flow in human-computer interactions. *Computers in human behaviour*, *9*(4), 411-426.

Wiemker, M., Elumir, E., & Clare, A. (2015). Escape room games. *Game Based Learning*, *55*.

Wilkinson, P. (2016). A brief history of serious games. In *Entertainment computing and serious games* (pp. 17-41). Springer, Cham.

Wilson, A. B., Higham, L., & Bhattacharjee, S. (2018). A means to foster STEM interest: A mystery room at Banksia Gardens Community Services.

Wittlin, A. S. (1970). *Museums: In search of a usable future*. the MIT Press.

Wouters, P., Van der Spek, E. D., & Van Oostendorp, H. (2009). Current practices in serious game research: A review from a learning outcomes perspective. In *Games-based learning advancements for multi-sensory human computer interfaces: techniques and effective practices* (pp. 232-250). IGI Global.

Wu, W. H., Hsiao, H. C., Wu, P. L., Lin, C. H., & Huang, S. H. (2012). Investigating the learning-theory foundations of game-based learning: a meta-analysis. *Journal of Computer Assisted Learning*, *28*(3), 265-279.

Yang, Y. T. C. (2012). Building virtual cities, inspiring intelligent citizens: Digital games for developing students' problem solving and learning motivation. *Computers & Education*, *59*(2), 365-377.

Yusoff, A., Crowder, R., Gilbert, L., & Wills, G. (2009, July). A conceptual framework for serious games. In *2009 Ninth IEEE International Conference on Advanced Learning Technologies*(pp. 21-23). IEEE.

Yusoff, A., Crowder, R., & Gilbert, L. (2010, March). Validation of serious games attributes using the technology acceptance model. In *2010 Second International Conference on Games and Virtual Worlds for Serious Applications* (pp. 45-51). IEEE.

Zepp, R. A. (2005). Teachers' perceptions on the roles on educational technology. *Journal of Educational Technology & Society*, *8*(2), 102-106.

Zolotaryova, I., & Plokha, O. (2016, February). Serious games: Evaluation of the learning outcomes. In *2016 13th International Conference on Modern Problems of Radio Engineering, Telecommunications and Computer Science (TCSET)* (pp. 858-862). IEEE.