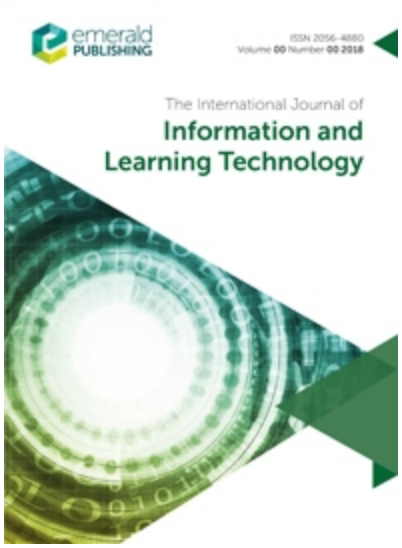

Developing a Game Design Framework to Embed Student Centered Learning.

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Developing a Game Design Framework to Embed Student Centered Learning.

Abstract

Purpose:

This paper presents the Student Centered Experience (SCE) Game Design Framework, which aims to guide the design of holistic Student Centered Digital Game Based Learning experiences which fully integrate all seven tenets of Student Centered Learning (SCL). The paper also rationalises the need for the framework and presents the steps taken in its development.

Method:

Initially the background areas of Student Centered Digital Game Based Learning and Digital Game Based Learning are examined and the need for a framework in digital educational games design, that has a focus on SCL, is then established. The rigorous and systematic Design Thinking process through which the framework was developed is then stepped through. The completed framework is then presented and each section detailed to explain its utilisation within the process of digital games design.

Findings:

The paper presents the completed SCE framework alongside a worked example of how it can be deployed in practise. Also included is guidance on the games designer and education practitioner roles at all stages of design, development and deployment, and how they may contribute their experience during the games design process to create high quality tools for learning.

Originality:

This paper presents a new game design framework integrating existing knowledge on Student Centered Learning and Digital Game Based Learning, which guides practitioners in the design of experiences that fully deliver the techniques of both areas.

Limitations:

While the SCE Framework presented is complete, the Framework is presented as a first version and will benefit from wider deployment and testing.

1. Introduction

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Student Centered Digital Game Based Learning (SCDGBL) is a promising area of educational research which seeks to deliver Student Centered Learning (SCL) techniques through the use of educational games, known as Digital Game Based Learning (DGBL), designed to engage students. Previous work (Coleman & Money, 2019) provides an overview of key concepts in SCL and DGBL, through their established interpretations in education literature. These are the seven tenets of SCL, as defined by Lea, Stephenson, and Troy (2003), summarised in Table 1, and the thirteen principles of high quality game design for DGBL, as described by Gee (2003); (2005) and categorised in Table 2. Previously established linkages between these concepts (Coleman & Money, 2019) are reproduced in Table 3 for easy reference. SCDGBL is an active research area with a number of existing games seeking to deliver a student centered experience (Barr, 2018; Hung, Sun, & Liu, 2018; Khamparia & Pandey, 2018; Wang, Chang, Hwang, & Chen, 2018).

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Table 1: Lea et al.'s seven tenets of Student Centered Learning

Table Adapted from Lea, Stephenson, and Troy (2003)

Tenet	Definition
Active Learning	Students learning through active involvement and experimentation rather than passive absorption of facts
Deep Learning and Understanding	Building in learning on a deeper level, giving students reasons to understand or care by relating or integrating learning to the student's own life or experiences.
Increased Responsibility and Accountability	Giving students a measure of control over their own learning, allowing them to take responsibility for actions or situations and with a safety net to help deal with success or failure
A *Sense of Autonomy*	Allowing students to engage with work without feeling they are monitored at every stage, and to make choices themselves that are or appear meaningful.
Teacher and Learner Interdependence	The relationship between students and teachers is important and flows both ways; students should feel they are directing their experience while learning from a teacher, who should look to students for guidance as to their progression speed, level of understanding and the nature of tasks.
Mutual Respect	The importance of students respecting each other as co-workers provides a grounding for collaboration, and for students to learn from and assist one another.
Reflexive Approach to Teaching and Learning	The ability for students and teachers to look back on work completed, evaluating not just how they achieved but lessons to be learned from their approach and future improvements.

Table 2: Gee's thirteen design principles for Digital Game Based Learning

Table Adapted from Gee (2003).

	Principle	
Learner Empowerment	P1: Co Design	
	P2: Customisation	
	P3: Player Identity	
	P4: Manipulation	
Problem Solving	P5: Ordered Problems	
	P6: Pleasantly Frustrating	
	P7: Cycles of Expertise	
	P8: Information Provision	
	P9: Fish Tank Learning	
	P10: Sandbox Learning	
	P11: Skills as Strategies	
Understanding	P12: Systems Thinking	
	P13: Meaning from Experience	

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Table 3: *Links between Digital Game-Based Learning Principles and Student Centered Learning tenets*

Source: Created by Author

Principle	SCL Relationships	Rationale for Linkage
P1: Co Design	SA, AL	This principle requires students to have a degree of autonomy necessary to make the choices that drive their in-game experience. Decision-making and the implementation of decisions within the game world are by nature active processes.
P2: Customisation	SA, RA, MR	That a player may make decisions about the way they play the game necessitates the player having the autonomy to make those decisions. A student making such decisions is encouraged to reflect upon these decision points, with a view to improving their gameplay and the learning obtained through it. Further opportunities to approach challenges in different ways are gained from the interaction with other students and therefore the ability to explore multi-student approaches.
P3: Player Identity	DL	Through taking on a role within the game, a player's interactions and experiences become less distant and more personal. Learning gained through these interactions may feel more practical and experiential.
P4: Manipulation	AL, DL	Learning through actions taken speaks to the core concept of Active Learning. The information gained from such actions becomes less something the student was told and more something they have discovered, and are given the opportunity to internalise themselves.
P5: Ordered Problems	SA	Effective implementation of ordered problems allows the student to hone their skills, including knowledge and understanding as they practice and progress at their own pace. This individual progression indirectly provides learners a sense of control.
P6: Pleasantly Frustrating	SA, IR	Surmounting an objective at the limit of a student's skill-based comfort zone provides a student a recognition of this personal achievement, which promotes autonomy. Such a well-placed objective makes a student aware they are capable of achieving it should they stretch their skills, inherently placing the responsibility to do so upon that student.
P7: Cycles of Expertise	RA	In adapting to a new challenge, the student is prompted to reflect upon the skill they have learned and consider ways in which it may be adapted. When encountering a new skill, the student is then aware that the skill will be expanded upon and is encouraged to consider how best to approach it.
P8: Information Provision	SA, ID, RA	Having information provided as students are about to or wish to use it allows them to implement it without seeking further explanation, thereby appearing to students as if they have solved the problem without help. Bringing teachers into the game world may allow teachers to take an active part in a student's activities on a similar level, without breaking student immersion. The ability to look back upon information gained and use that as revision tool and a tool by which to gauge progress fosters reflection.
P9: Fish Tank Learning	AL	The experimentation with concepts and mechanics is a clear implementation of Active Learning.
P10: Sandbox Learning	IR	Within a sandbox, the responsibility to experiment and learn falls upon the student, in these areas, students receive little or no prompting and are able to adopt an exploratory role and set challenges or discover boundaries for themselves.
P11: Skills as Strategies	AL, DL, SA	Practicing skills and implementing strategies requires the student to take an active role. That the learning forms a part of the strategy and progression of the game means the student is internalising this towards an immediate purpose, rather than learning for its own sake. The student individually coming up with a strategy based upon their learning engenders a sense of personal control.
P12: Systems Thinking	AL (Problem-Based Learning), DL	The skills and ideas being meaningful elements of the game world gives them deeper meaning to the student than surface level facts. For the skills and ideas to be meaningful elements that are learned implies strongly that the challenges a student faces requires the application of these skills.
P13: Meaning from Experience	DL, IR, SA	Associating learning with experience speaks to the core principles of Deep Learning and Understanding. The personal nature of the experience gained gives students a level of accountability for the choices made within that experience. This accountability prompts students to consider how they may have made alternative choices, promoting a sense of autonomy.

SCL tenet acronyms: Active Learning (AL), Deep Learning and Understanding (DL), Increased Responsibility and Accountability (IR), Sense of Autonomy (SA), Teacher and Learner Interdependence (ID), Mutual Respect (MR), Reflexive Approach to Teaching and Learning (RA)

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Despite active research in the area of SCDGBL, there is no games design framework and limited additional guidance on how to effectively integrate SCL within DGBL, to provide the necessary support for games design and education practitioners during the design process for SCDGBL experiences. It has been established that use of a games design framework can play a key role in the development of appropriate educational games that are effective learning tools (Kiili, 2005). Some researchers utilised existing games developed without an educational audience in mind (N. S. H. N. Ahmad, Wan, & Jiang, 2011; Barr, 2018; King, 2015; Watson, Mong, & Harris, 2011), or where a specific SCDGBL intervention was developed, there was often no mention of a design framework followed (Neville, Shelton, & McInnis, 2009; Owston, 2009; Sung & Hwang, 2013; Yang, 2015). This may explain why previous work (Coleman & Money, 2019) has identified that many existing educational games do not fully integrate all the tenets of SCL (Table 1). From this major gap in the literature, the end result is that learners may miss out on a number of the key benefits offered through traditional SCL techniques, particularly certain social components of SCL, such as peer learning within Active Learning, Mutual Respect, and Teacher and Learner Interdependence.

The development of a games design framework for DGBL offerings, with a specific focus upon SCL tenets (Table 1), could help to address this issue. An examination of existing game design frameworks, presented in the literature for use within educational and/or student-centered game design, was carried out. Suitability to deploy the tenets of SCL was identified for each framework, presented in Table 4. This demonstrates that the delivery of SCL tenets is not currently a key focus of any existing digital game design framework, highlighting another gap in the literature.

The development of an explicitly student-centered framework would enable practitioners to more easily design game mechanics that incorporate the full spectrum of SCDGBL principles, whilst also understanding the impact this will have on learner/player behaviour and enjoyment. This would bring numerous benefits to game designers, such as inclusion of tested and effective educational techniques (Gee, 2003, 2005; Lea et al., 2003) from the inception of the project, allowing these techniques to be tied more deeply into the game's fundamental mechanics, dynamics and aesthetics, creating a more seamless experience for learners. Learners would also benefit through the seamless blending of educational content with the game mechanics which would amplify the benefits of game-based learning, directly translating their mastery of the game into the intended transferable skills.

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Table 4: Comparison of Game Design Frameworks

Source: Created by Author

		Framework Details			SCL Tenets						
Author(s)	Paper Title	Educational Basis	Areas of Focus	Intended Audience	Active Learning (AL)	Deep Learning (DL)	Responsibility (IR)	Sense of Autonomy (SA)	Interdependence (ID)	Mutual Respect (MR)	Reflexive Approach (RA)
Aleven, Myers, Easterday, and Ogan (2010)	Toward a Framework for the Analysis and Design of Educational Games	Bloom	Establishing learning objectives as a guiding principle for educational game design work.	Educational design students	X	X		X			
Echeverría et al. (2011)	A framework for the design and integration of collaborative classroom games	Bloom, CMPG (CSCL)	Classroom-based multiplayer. Constraints of Tetrad elements by educational demands.	Educators/ Designers	X				X	X	
Hunicke, LeBlanc, and Zubek (2004)	MDA (Mechanics Dynamics Aesthetics)	N/A	How designed mechanics and implementation create fun. How to characterise and design for different aspects of fun.	Commercial Game Designers				X			
Moreno-Ger, Burgos, Martínez-Ortiz, Sierra, and Fernández-Manjón (2008)	Educational game design for online education	Constructivist	Modelling of games as Finite State Machines. Games adaptation and response to player actions.	Educators/ Designers	X		X	X			
Schell (2014)	The Art of Game Design: A book of lenses	N/A	The connection between different elements of games design. Methods of delivering story through games.	Commercial Game Designers				X			
Song and Zhang (2008)	EFM: A Model for Educational Game Design	ARCS (Motivation)	Maintaining player motivation and establishing Flow experience in learning environments.	Chinese Educators	X			X			
Winn (2009)	The design, play, and experience framework	Bloom	The interaction between Learning, Storytelling, Gameplay and User Experience.	Serious Games' developers	X	X					

1.1 Research Aim

The aims of this paper are twofold: First present a games design framework to support educators and games designers to create SCDGBL experiences for students, and second to present a worked example that shows how the presented framework can be deployed in practise.

Research Objectives

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1. Follow a systematic approach to develop the framework: Integrating key SCL and DGBL concepts together with established educational theory and games design techniques.
2. Provide practical guidance for the use of this framework by practitioners in fields of both education and games design.

The remainder of this paper focuses on the design and development of such a framework, henceforth referred to as the Student Centered Experience Framework, as it is designed for the creation of SCDGBL experiences. Section 2 documents the methods used to develop the Student Centered Experience Framework. Section 3 presents the resulting framework. The deployment of the framework within a typical development lifecycle is discussed in Section 4, with reference to the different roles of the games designer and education practitioner at each stage. Section 5 provides a walkthrough of an example of a digital game design that has been developed using the framework. Section 6 concludes this study and presents a call to action for practitioners to use the framework and to share experiences of deployment and evaluation.

2. Methods

The aim in developing the Student-Centered Experience Framework is to provide evidence-based guidance to games designers to assist in the creation of SCDGBL experiences for deployment within a range of situations.

This section is structured around the five stages of the Design Thinking Process, a systematic innovation and design process selected to guide the production of the framework. This process facilitates production of well-designed artefacts meeting end-user requirements from the outset (Roberts, Fisher, Trowbridge, & Bent, 2016). With its strong user-centric philosophy aligning well with the focus of Student-Centered Learning, Design Thinking has previously been deployed within the domain of education (Aflatoony, Wakkary, & Neustaedter, 2018; Ewin, Luck, Chugh, & Jarvis, 2017; Fabri, Andrews, & Pukki, 2016).

It can be argued that the current design challenge constitutes a wicked problem (Drechsler & Hevner, 2016) through its human-centred nature (the focus on SCL), the desire to design and develop an artefact that produces a collaborative learning experience, the need to meet specified learning outcomes within a curriculum framework, and the need to co-locate future deployment and evaluation of the designed artefact within a classroom, which is not considered to be a standardised setting (Devitt and Robbins, 2013). The solving of such

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Wicked Problems is a common grounds to deploy. It has been suggested that a Design Thinking approach can be complementary to DSR to boost the effectiveness of applying a DSR approach to address a wicked problem (Devitt & Robbins, 2013; Dolak, Uebernickel, & Brenner, 2013; Grobler & De Villiers, 2017; Rai, 2017).

The five stages of the Design Thinking Process, along with common pathways between them and activities undertaken at each stage in the current project, are shown in Figure 1 and stepped through below, with phases highlighted in ***bold italics*** and activities in *italics*. Each stage is approached initially linearly, before adopting an iterative approach to improvement.

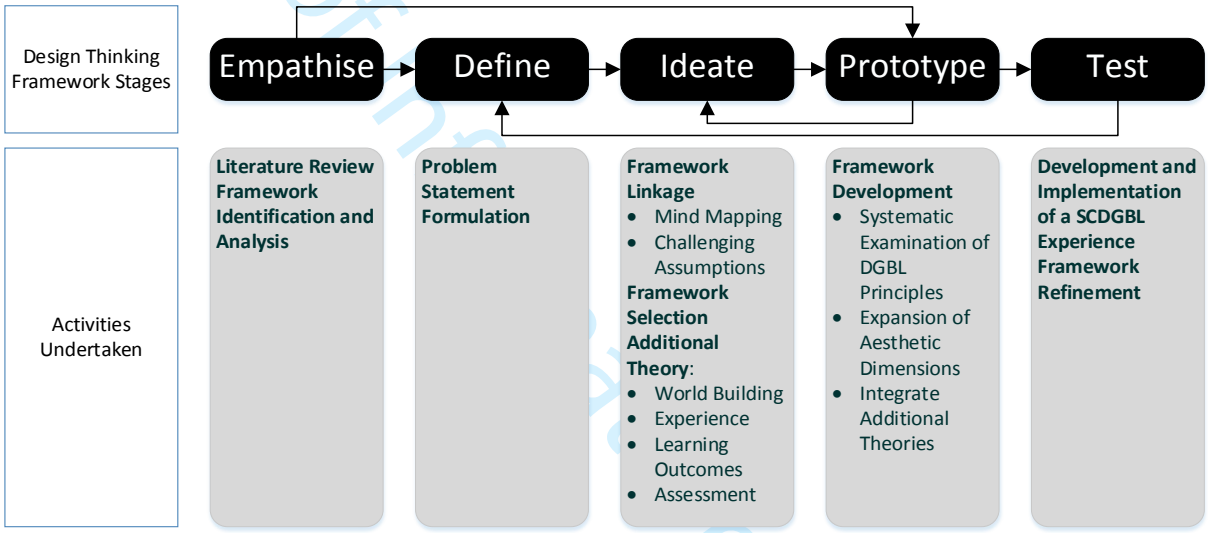

Figure 1: The Design Thinking process showing common routes between stages

Figure adapted from Roberts, Fisher, Trowbridge, & Bent (2016)

2.1 Empathise Phase

The first stage in Design Thinking is to ***Empathise***, involving research and taking on board the opinions of experts of the area and system users to gain an empathic understanding of needs within the area. Existing literature on DGBL experiences was explored (Coleman & Money, 2019) and existing game design frameworks that implemented SCL were identified and examined, to assess the extent to which tenets of SCL had been deployed, as shown in Table 4.

Despite the identified lack of key focus on SCL tenets within any given framework, some tenets of SCL are delivered through games (Coleman & Money, 2019). As existing game design frameworks function well for the creation of games, a SCDGBL framework should seek to build

upon this success to deliver in areas relating to SCL. To assist this endeavour, the integration of SCL tenets and DGBL principles for effective SCDGBL experiences has already been performed in previous work (Coleman & Money, 2019), as reproduced in Table 3. This forms an appropriate starting point to ensure comprehensive delivery of learning content in a fully student-centered manner.

2.2 Define Phase

The ***Define*** phase utilises knowledge and understanding gained in the ***Empathise*** phase to inform the creation of a problem statement for subsequent stages. It is customary to orient *Problem Statement Formulation* to be human-centric, aligning with the core ideal inherent within the term Student-Centered Learning. The following problem statement was formulated:

"To create a focused game design framework that integrates SCL tenets and DGBL principles into its foundations will help game designers to create cohesive and comprehensive SCDGBL experiences for learners to participate in."

2.3 Ideate phase

The ***Ideate*** phase seeks to address the problem statement from the ***Define*** phase, by utilising ideation techniques to identify possible solutions. Aspects of game design frameworks identified during the ***Empathise*** phase were mapped to SCL tenets (Table 1), and consequently the coupled DGBL principles (Table 2). Frameworks demonstrating the most potential for SCL tenet integration were further explored through use of mind mapping. From this work, it was identified that existing frameworks seeking to enable educational game development were often already complicated by the educational theory they sought to operationalise, which may at times conflict with that of Student Centered Learning. An ideal candidate framework may therefore focus solely on Game Design, providing an effective blank slate to mesh with the concept of SCDGBL.

For example, Aleven et al. (2010) explore the combination of Blooms taxonomy (an educational theory) with the Mechanics, Dynamics, and Aesthetics (MDA) game design framework (Hunicke et al., 2004), blending in a number of instructional principles. However, the list of 70+ principles drawn directly from four sources, which overlap and contradict in a number of areas, makes the framework difficult to comprehend and apply in a practical situation.

This phase resulted in a single game design framework being taken forward into the next phase: The MDA game design framework showed the most potential for linkage and integration of SCL tenets and was chosen as a basis due its flexibility and wide application within academic and game development areas.

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Without direct connection to pedagogical applications, selecting MDA allowed a clean introduction of these elements through SCL theory, but to support this introduction it was necessary to consider *Additional Theory* in the areas of both educational game design and student-centered course design. These additional theories are *World Building* and *Experience*, explored primarily as extensions of game design theory, and *Learning Outcomes* and *Assessment*, drawn primarily from the Student Centered Learning literature.

World Building covers the areas of Simulation, Role-Play and Story-driven play alongside other ways to build a world that engages the player (Wolf, 2014; Wouters, Van der Spek, & Van Oostendorp, 2009). Player *Experience* is the core consideration within game design, with other elements pushing towards this (Fullerton, 2018; Hagen, 2011); within educational games it remains a key factor but must share center stage with the educational concepts the game serves (Kiili, De Freitas, Arnab, & Lainema, 2012).

Learning Outcomes are a key aspect of learning, to provide students with the understanding of their goals and in turn empower students to seek those goals (McLaughlin et al., 2014; Wouters et al., 2009). *Appropriate Assessment* is given importance by several authors in SCL course design, with particular drive towards concepts such as ongoing practice taking the form of later assessments to ensure a student centered experience is maintained (Biggs & Tang, 2015; McLaughlin et al., 2014; Rust, O'Donovan, & Price, 2005).

At the end of the ***Ideate*** phase, the key contributors to a framework have been identified, bringing forward the existing understanding of SCDGBL along with key game-design concepts and understanding from the established MDA Framework, and additional theory related to both educational game and Student-Centered course design. This foundation can be taken forward to develop the initial prototype of the framework within the next stage.

2.4 Prototype Phase

Prototype forms the 4th phase in Design Thinking, where an initial version of the artefact is created through an iterative process. The new, Student-Centered Experience framework founded upon the selected MDA game design framework, that fully integrates SCL tenets and DGBL principles to provide a guide to designers seeking to create SCDGBL experiences. This initial prototype includes the foci identified within the *Ideate* stage, and to support and guide development, it was necessary to *Integrate Additional Theories* pertaining to educational game and Student-Centered course design, as identified during the *Ideate* phase. This balanced approach maintains the dual focus of developing a game which serves as an educational activity and must maintain effectiveness in both learning and fun.

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The construction of the framework was achieved in three steps. Firstly, the three lenses of the MDA framework (Mechanics, Dynamics, Aesthetics) were used to examine each DGBL principle. This process made clear which lens was the most appropriate for primary application to an individual principle, while in turn the implications of implementing that principle could be determined through the perspective of the remaining lenses. This guided the placement of each DGBL principle within the framework for the benefit of the designer, to capture the full impact of implementing each principle from the MDA perspective. Secondly, each DGBL principle was examined and its connection identified to one of the *Additional Theory* categories (Learning Outcomes, Assessment, World Building and Experience), to which it was assigned. This shows the primary goals that the implementation of each principle can serve. Lastly, the Aesthetic dimension of the MDA framework was expanded to introduce a Mastery dimension. Such expansion is intended and supported by the MDA framework as a method by which to recognise specific needs (Hunicke et al., 2004). The introduced Mastery dimension covers enjoyment of the game from demonstrating ability and/or control over the game, observed as an important source of enjoyment within digital games (Trepte & Reinecke, 2010) and further reinforced in other activities where participants are encouraged to seek improvement (Scanlan, Stein, & Ravizza, 1989).

2.5 Test Phase

Test is the final phase, where the artefact is deployed to establish its suitability, after which it is revised and further improved through repeating earlier phases. The process is not strictly linear, thus findings from testing can provide further background information to inform potential return to other phases of the process. The framework presented in this paper was applied to the development of an SCDGBL experience, presented in this paper as a worked example. This allows for observations regarding the framework's suitability to be made, and guidance to be created to support future usage of the framework. The empirical deployment and evaluation of such a SCDGBL experience, designed using the framework, will be presented in a future paper.

Following successful execution of the design thinking methodology, the Student Centered Experience Framework and a worked example of a SDGBL experience designed with the framework were outputs of this process, from the Prototype and Test phases respectively. The final iteration of the framework is presented in the next section.

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3. The Student Centered Experience Framework

The initial prototype is presented in Figure 2. This section steps through the framework, presenting each DGBL principle and its linked SCL tenets within the overarching design goal categories.

The Mechanics, Dynamics and Aesthetics lenses are represented at the top, drawn from the MDA games design framework selected during the Design Thinking process. Each row of the framework includes one DGBL Principle (rounded, grey box), and shows through which lens the DGBL principle is best viewed (denoted by the lens beneath which the Principle is presented), along with the implications of the DGBL principle when viewed through other lenses (pointed green box). The DGBL principles are organised under four overarching categories, derived during the Ideate component of the Design Thinking process. These represent goals in design: Learning Outcomes, Assessment, World Building and Experience. These categories, appearing left of the framework, offer guidance on which goals the effective implementation of a particular DGBL Principle most serves. Where a DGBL principle has implications within the Aesthetics lens, these are additionally expressed through the aesthetic dimensions identified in MDA research (yellow box), showing the types of engagement or fun that are most closely associated with realisation of that principle (Hunicke et al., 2004).

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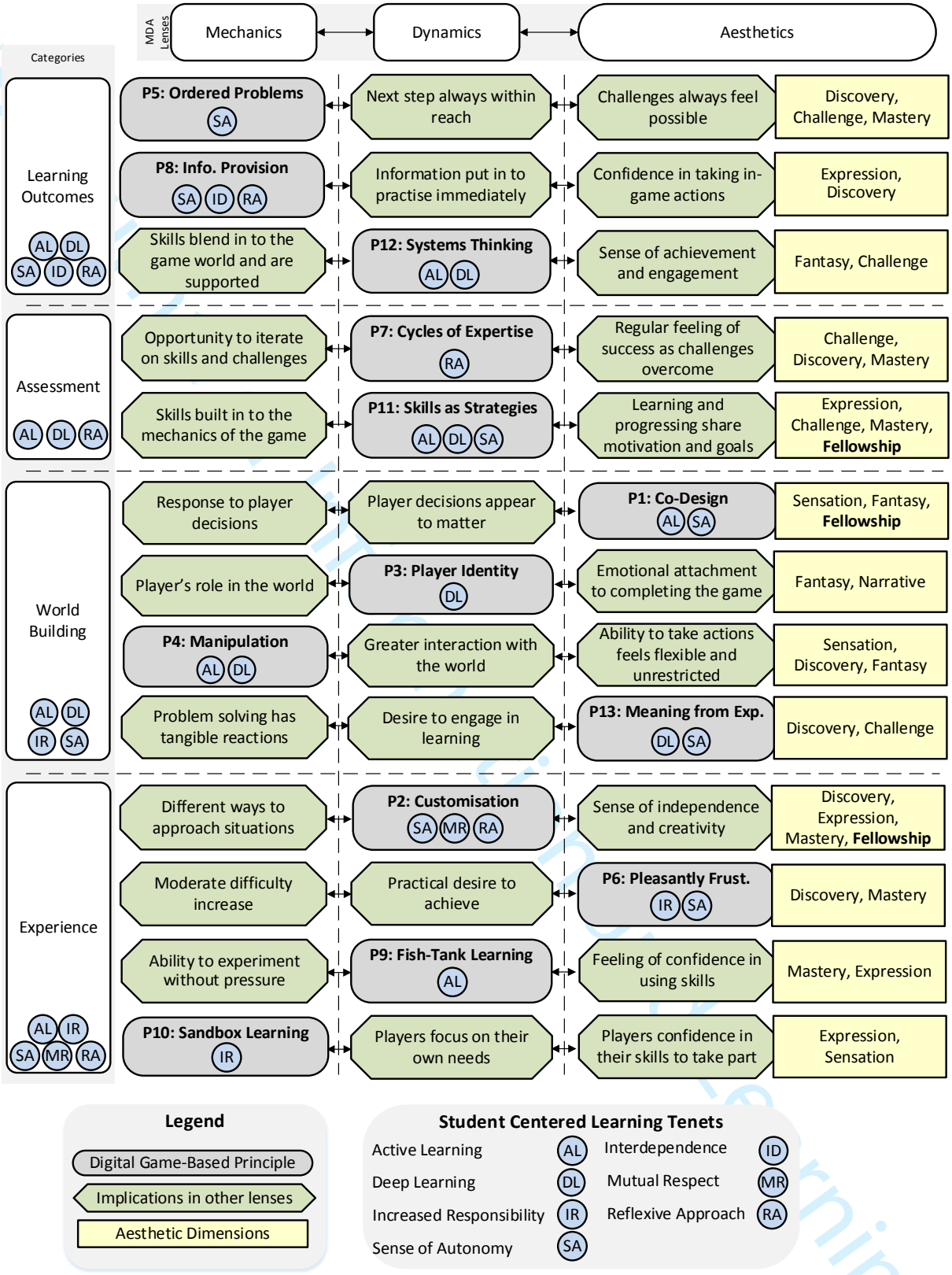

Figure 2: The Student Centered Experience Framework

Source: Created by Author

The tenets of Student Centered Learning (blue circles) are presented with their associated DGBL principles, as linked in Table 3. The SCL tenets are also displayed within the design

goal categories, to show which tenets may be integrated through implementation of that category's associated DGBL principles. Through this, it may be seen that appropriate deployment of DGBL principles provides an avenue by which all tenets of SCL may be integrated at the design stage for a given SCDGBL experience.

The SCE Framework is tightly focused around offering designers guidance on the ways to integrate SCL tenets into a serious game from an early stage, addressing the human-centric Problem Statement created during the Define phase of the Design Thinking process. By engaging with the elements of game design expressed above, a designer may understand the tenets as directly applied and also see the implied effects of that tenet in other areas, alongside expected player responses to an effective implementation. This fulfils the goal to inform and not prescribe the games design process, while basing this information on established and effective pedagogical theory.

3.1 Utilisation of the SCE Framework.

When designing a SCDGBL experience, a designer/practitioner may use the SCE framework as a guide towards the goal of a holistic deployment of Student Centered Learning. Each of the Principles of DGBL has been examined and its implications in alternate lenses identified, by identifying the principles a game seeks to implement, these implications can be used as a guide to the design needs in Mechanics/Dynamics and to the likely emotional responses in Aesthetics.

3.1.1. Learning Outcomes

P5: Ordered Problems falls within the Mechanics lens, being a design constraint upon the challenges offered to the player. Ordered Problems deals with the way in which learning challenges are set, which makes it a natural fit for the Learning Outcomes category. Successful implementation creates a situation for the player where the next step in their learning/playing is always within reach and therefore encouraging players to pursue that achievable next goal. This creates the Aesthetic dimensions of Discovery, as players learn further skills and explore their application in the world; of Challenge as the player is constantly offered the next step forwards and encouraged to reach for it; and of Mastery, as the player is able to later effortlessly complete tasks which were once found difficult.

P8: Information Provision sits within the Mechanics lens, the provision of information to the player being something the designer directly plans and controls. As the information provided and application of it are so closely connected to learning, this principle sits primarily under the Learning Outcomes category. Information Provision carries implications into the Dynamics lens where players will be encouraged to apply the information in the game as it is received, and will have access to the information they need without reliance on asking for help,

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increasing confidence. Carried into the Aesthetics lens, this offers Discovery as players learn new information and can use it to progress, along with Expression as players are able to experiment with the techniques they are taught and achieve success by using them.

P12: Systems Thinking is placed within the Dynamics lens as it is an emergent behaviour to be encouraged within players. As this principle deals primarily with the embedding of assessed skills into the activities undertaken, it has been placed under the Learning Outcomes category. Within the Mechanics lens, Systems Thinking can be through building of assessed skills into the game world as story or world-building concepts. In the Aesthetics lens, it encourages the dimensions of Fantasy, as the skills the player is exercising are a part of the make-believe world, along with Challenge as those skills are tested and the player strives to improve.

3.1.2. Assessment

P7: Cycles of Expertise fits in the Dynamics lens, being the activity of players practising and evolving skills over time to improve and adapt to new challenges. It is placed under the Assessment category as a further way to evaluate players' progress and assess their abilities within the game. Within the Mechanics lens this principle implies that the designer should provide opportunities for the player to iterate on the skills and challenges during mechanical and level design. Through the Aesthetics lens this principle can give rise to Challenge, Discovery and Mastery; Challenge as players are pushed to evolve these skills to overcome difficulties, Discovery as players explore the challenges and find out new ways to overcome them, and Mastery as players are able to demonstrate evolving skills to overcome challenges in different ways.

P11: Skills as Strategies also fits into the Dynamics lens, covering behaviour where players will deploy the different skills they have been taught in attempts to overcome difficulties and progress. This element was placed in the Assessment category as this skills deployment forms a key way to track assessment through games. To promote this behaviour, it is important in the Mechanics lens to ensure the desired learning skills are built into and supported by the mechanics of the game, giving players access to a range of options to deploy these skills as desired. Seen through the Aesthetics lens this implementation can promote the dimensions of Expression, as players are free to apply the skills in different ways as they attempt to progress, Challenge, as players are utilising the skills to try and overcome in-game difficulties, Fellowship as the skills of different players can be brought forward within a group or shared with other group members, and Mastery as players are able to use their skills in creative ways to overcome problems.

3.1.3. World Building

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P1: Co-Design deals with players' perceptions and experiences of their own impacts on the game, fitting directly within the Aesthetics Lens, relating to the kind of enjoyment players get from the game. This principle's connections to the player's gameplay decisions and within the branching story make it a clear fit under the category of World Building, and to the Aethetics dimensions of Sensation and Fantasy. The player options and abilities can be expanded through their interaction with others within the game, exploring the dimension of Fellowship. Within the Dynamics lens, players' decisions appearing to have significant impact on the way the game plays out will encourage this feeling within players that their activities matter. Viewed through the Mechanics lens, the responses to the player actions should be clear, and where players may make decisions, these are designed to take players down apparently different paths.

P3: Player Identity, the player being presented as a character or role within the game and given a connection to the world or story through this forms a natural fit for the Dynamics lens. The deep connections in this element to the story or background world elements makes it a clear fit to the World-Building category which deals with the world and story. The groundwork for this should be completed through the Mechanics lens, where the players' role and position should be set up and prepared. Looking to the Aesthetics lens, this principle can be used to encourage Fantasy, where players can feel more tightly connected to the world and the ongoing story, along with Narrative where the dramatic elements of a story can provide further emotional connections to the ongoing story elements.

P4: Manipulation addresses players' ability to act upon and engage with objects within the game world, most relevant to the Mechanics lens. The direct connections to the world created fit primarily under the World Building category. This gives rise in the Dynamics lens to greater incentive for players to engage with the world, exploring and experimenting with different interactive elements and using skills and abilities granted by the game. In the Aesthetics lens it promotes the dimensions of Sensation, where players are able to enjoy engaging with the game world; Discovery where players can look to find out more about the game world and about their skills through experimentation; and Fantasy as interacting with that world builds emotional connections.

P13: Meaning from Experience addresses player learning coming from activities they have performed, and being based around ideas with which they have a personal connection. The emotional connection established and deeper meaning conveyed make this element a strong fit for the World Building category. This emphasis on players' response and personal understanding makes it a fit for the Aesthetics lens, exploring the dimension of Discovery as players find out new things linked to the world, and of Challenge as they are asked to deploy

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skills in these activities are tested. To ensure players' learning comes from personal experiences, first those connections are built within the Mechanics lens, setting up the player to have the relevant experiences to learn from. With connections set, through the Dynamics lens players are given incentives to progress and learn, stimulating a desire to engage in the game and so the learning process. This engagement provides the experiences and embeds the learning within these.

3.1.4. Experience

P2: Customisation deals with players being able to choose their own methods of playing the same, placing it within the Dynamics lens as there are mechanics needed to support this type of gameplay. It is placed in the Experience category as it covers players' approaches to the gameplay and the decisions they will make during this. In the Mechanics lens players must have the ability to experiment and discover the ways they may approach the more challenging aspects of the game, while these challenging aspects should be built to be tackled in different ways where possible. The aesthetic dimensions associated with this include Discovery, as players different approaches allow them to identify new elements of the game world and of their learning, Expression, as players approach the game in different ways and can complete challenges in ways they feel are unique, Mastery as players can learn multiple different ways to accomplish problems and demonstrate their ability to do so in different ways, and Fellowship as players methods of playing offer different strengths and weaknesses to a group.

P6: Pleasantly Frustrating covers players' experiences during gameplay, particularly the emotions and responses engendered when confronted by tasks, a clear fit for the Aesthetics lens. Strongly related with players' feeling and drive, it fits best within the Experience category. Within the Mechanics lens, tasks are presented that appear on the edge of a player's ability through moderate difficulty increases to push player skills. This gives rise in Dynamics to encouraging players to stretch for achievements just out of reach, realising the principle when they grasp it, extending their comfort zone and leading to the next challenge. The Aesthetic Dimensions explored here are Discovery, as players are encouraged to learn in accessible steps to overcome obstacles, and Mastery, as players are able to demonstrate their increasing abilities and to see how much easier earlier challenges become.

P9: Fish-Tank Learning covers the ability of players to experiment with skills without significant risk; as it requires mechanical support it has been placed in the Dynamics lens. Dealing with the way players are able to approach parts of the game and how they may respond fits within the Experience category. Through the Mechanics lens, areas of the game must allow players to experiment without, or with limited pressure, particularly when new skills or abilities are introduced. Looking to the Aesthetics lens, benefits are offered in Mastery, as

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players feel they have understood or grasped a skill before being faced with difficult scenarios involving its use, and in Expression as players can freely apply the skill early on.

P10: Sandbox Learning is a specially designed area allowing freedom to practice and deploy skills and abilities with minimal risk and without a large degree of external pressure, this requires specific implementation and makes its placement within the Mechanics lens clear. Dealing with a gameplay method, this principle fits the Experience category. This creates the Dynamics of encouraging players to engage with a focus upon their own wants and needs in the game rather than a direction towards externally set goals. Through Aesthetics, players are likely to experience enjoyment through Expression as they develop, build or create according to their own desires, and through Sensation as the rewards for such play become the expansion of their own ability to play the game.

While the framework lays out the relationships between SCL tenets and DGBL principles, in order to deploy this in a practical games design situation, it is necessary to understand how practitioners in different positions, such as educators and games designers, may relate to the framework. To facilitate successful deployment, these roles will now be explored.

4. Deploying the SCE Framework

This deployment section aims to provide some guidance on how the framework may fit within a typical development lifecycle for a SCDGBL application, the role of teaching practitioners and game designers within each phase of the lifecycle, and how their interaction with the framework may inform each phase. This is theoretical guidance, as there is limited literature focusing on the interactions between games design and education practitioners. In some areas, this guidance remains general, as there is significant variance in the challenges that education practitioners face in the deployment of educational games by factors such as genre or subject area (Dimitriadou, Djafarova, Turetken, Verkuyl, & Ferworn, 2021).

The phases of software development may be concisely described as *Understanding*, *Design*, *Development*, *Testing*, *Deployment* and *Maintenance* (Mishra & Dubey, 2013). Table 5 summarises, at each stage in the software development life cycle, the ways in which the SCE framework may be used, in accordance with the roles of the games designer and teaching practitioner identified within each of those stages (M. Ahmad, 2022). This summary is represented as a flow diagram in Figure 3, which also shows key outputs at each stage in the cycle.

For the development of a SCDGBL experience, the SCE Framework has an integral role in the *Understanding* and *Designing* phases primarily, however work completed in these phases

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impacts throughout the lifecycle and an understanding of the SCE Framework may therefore guide and inform work completed at other times.

The SCE Framework may be read from left to right, as a designer would see it, or from right to left, as viewed by a player, and provides guidance as to how each principle may be viewed through different lenses. Throughout the lifecycle of a SCDGBL application, the SCE framework may be used as a guide to identify and explore what the application could or should be achieving and to understand how this may be achieved.

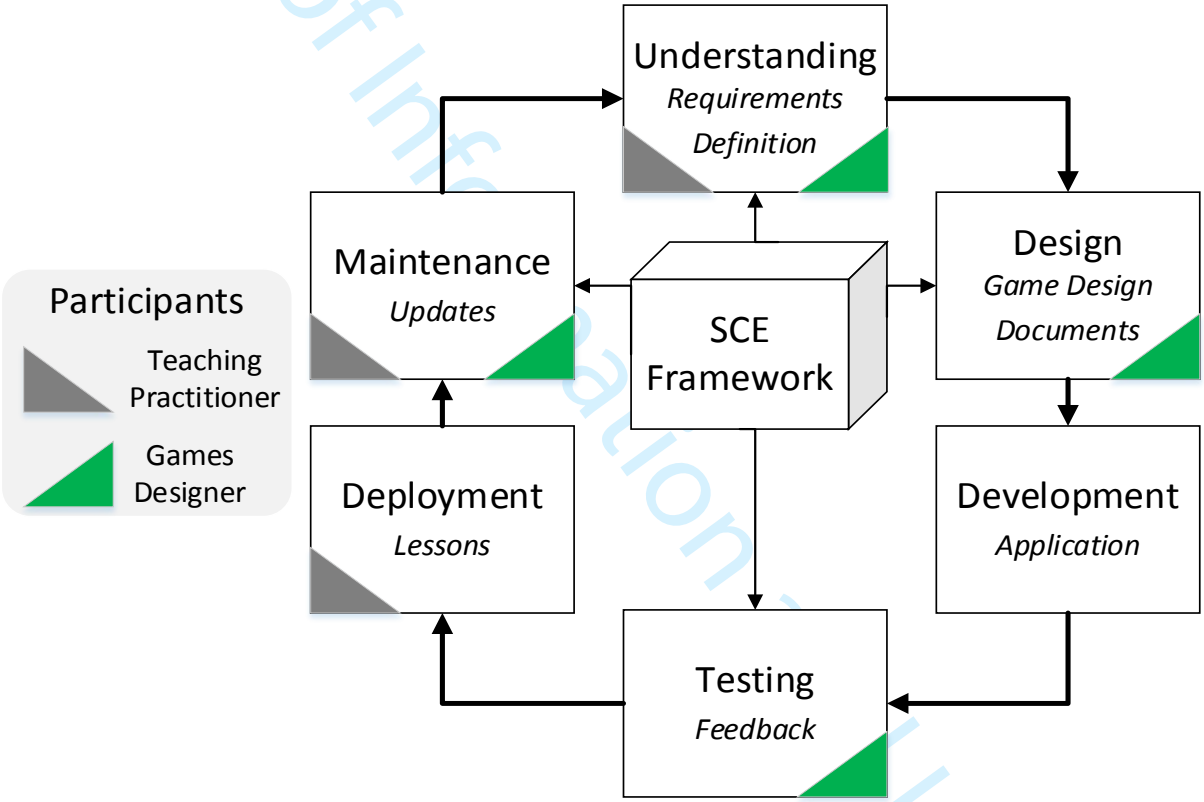

Figure 3: Software development utilising the SCE Framework, including key participants and outputs

Source: Created by Author

Table 5: The nature of the involvement of Games Designer and Teaching Practitioner in the software development cycle, and potential usages of the SCE Framework in each phase.

Source: Created by Author

Software Development Phase	SCE Framework Usage	Games Designer Role	Teaching Practitioner Role
Understanding	*Requirements Definition* informs deployment of DGBL principles within SCE overarching categories of Learning Outcomes and Assessment. Framework categories guide design choices in the type of game sought and presentation to players	Translate *Requirements Definition* into design: ▪ What sort of world will the players explore? ▪ How will the players experience the game and its learning?	Build *Requirements Definition*: ▪ Identify curricular goals for the project ▪ Identify the intended deployment environment ▪ Identify the nature of assessment
Design	Consider game design elements using the framework, identifying where a DGBL principle may be directly worked towards in the game's core Mechanics, where it may form derived activity in Dynamics and where it is primarily an emotional reaction or feeling to be created in Aesthetics.	*Game Design Documents* developed using the SCE Framework	Ensure curricular objectives and assessment criteria are integrated and linked to game mechanics and world building elements
Development & Testing	Determining successful integration of DGBL principles and associated SCL tenets into the created game. Guidance as to how integration may be viewed by players through its Aesthetics lens implications	Review *Feedback* to identify where integration of DGBL principles is meeting with success, and further revisions	-
Deployment	Assist practitioner in framing and setting up classwork, by prompting external activities building upon DGBL principles deployed and game aesthetics created.	-	Utilise the game as a teaching tool in *Lessons*
Maintenance	Utilised as in development and testing phases to understand where principles are meeting with success and target areas to improve	Make requested changes for development and redeployment	Respond to changes in curriculum or desired Learning Outcomes, through use of application tools or framing/delivery of lessons utilising the game

5. Worked example of SCE framework-informed game design: BuildLogic

Having introduced the SCE framework and its deployment, it is appropriate to demonstrate its application through a worked example. Presented, in brief, is an example SCDGBL experience, which aims to teach logic to secondary school or foundation level tertiary students, designed using the SCE framework. This is an output from the Test phase of the Design thinking process.

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The first section provides an overview of the program and how DGBL principles, and subsequently linked SCL tenets, have been integrated. An example is provided for each DGBL principle, grouped by overarching category, however, each principle may be utilised multiple times within a complete application. The second section showcases translation into game mechanics by walking through key elements of an example puzzle.

5.1 DGBL Principle Integration

BuildLogic is a modified Minecraft world. The focus was to create an educational game that can teach logic. The learning outcome was for students to understand and master the use of Boolean logic through practical experience. The SCE Framework guided the design and development of this experience from its foundational mechanics through to many specific level design features. It was developed as a multiplayer puzzle game with the logic skills needed to solve each puzzle, and eventually access a free-build area where entire logic circuits could be built from scratch with the in-game tools to achieve a goal, building directly into **P11: Skills as Strategies** and **P12: Systems Thinking**. The player perspective is first person with clear points to interact with in the world, **fulfilling P4: Manipulation**. An opportunity to familiarise oneself with the game controls and the game world is offered through a shared starting area, aligning with **P10: Sandbox Learning**. An overarching narrative and purpose to completing the puzzles, combined with the group-based play and each player having a key role in solving the puzzle, all help to provide a sense of **P3: Player Identity**. This increases the emotional impact of successful completion of puzzles. Strict timers and other high pressure mechanics were eschewed to enable **P9: Fishtank Learning**, through implementation of tutorial areas experienced by individual players so they could develop their understanding of individual concepts on their own terms before applying this understanding in a multiplayer setting.

As the puzzles were planned out, the skills required were staggered carefully to first introduce a new concept, such as a type of logic gate, which a player will immediately put into practice in a tutorial area, fulfilling **P8: Information Provision**. Progressing through the puzzles integrates more concepts each time, integrating **P5: Ordered Problems**, with later stages of the game containing multiple types of logic gate in combination. This resulted in a staged level-based design to create a reliable rhythm of concept introduction, pressure-free practice through multiple consolidation areas in-game to apply that concept, and finishing on a challenging puzzle. This rhythm is intended to build player comfort, by ensuring that players know what to expect, creating a cycle of expertise as the player discovers, is challenged by, and eventually masters each concept, per **P7: Cycles of Expertise**. While reliable, the difficulty of puzzles within this rhythm slowly increases, regularly asking players to ‘up their game’, this increase is guided by **P6: Pleasantly Frustrating**.

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Working through and completing these problems provides a challenging group experience wherein the use of taught concepts creates an emotional reward, embodying **P13: Meaning From Experience**. Individual puzzles were designed such that they could be considered from different angles, physically within the game and theoretically in the student's approach, allowing both individuals and groups to tackle these puzzles in a way that suits them, drawing from **P2: Customisation**. In order to enable **P1: Co-Design**, each player in a group was offered access to a different section of the puzzle, thereby meaning that every player's actions and decisions are relevant to identifying or achieving final solutions.

5.2 Mechanics Showcase

To demonstrate the in-game application of these concepts, an example puzzle is stepped through in the figures below to showcase key mechanics: a logic circuit that spans three player areas.

Figure 4: An aerial view, showing the three player areas and logic circuit connections between areas.

Source: Created by Author

Figure 4 shows an aerial view of the three player areas in-game and how they are connected. The goal of this puzzle is for each player to open the door in their area to progress to the next area. The next area has glass walls so players can see each other, but the puzzle area has opaque walls, thus players cannot see outside of their own area, necessitating communication.

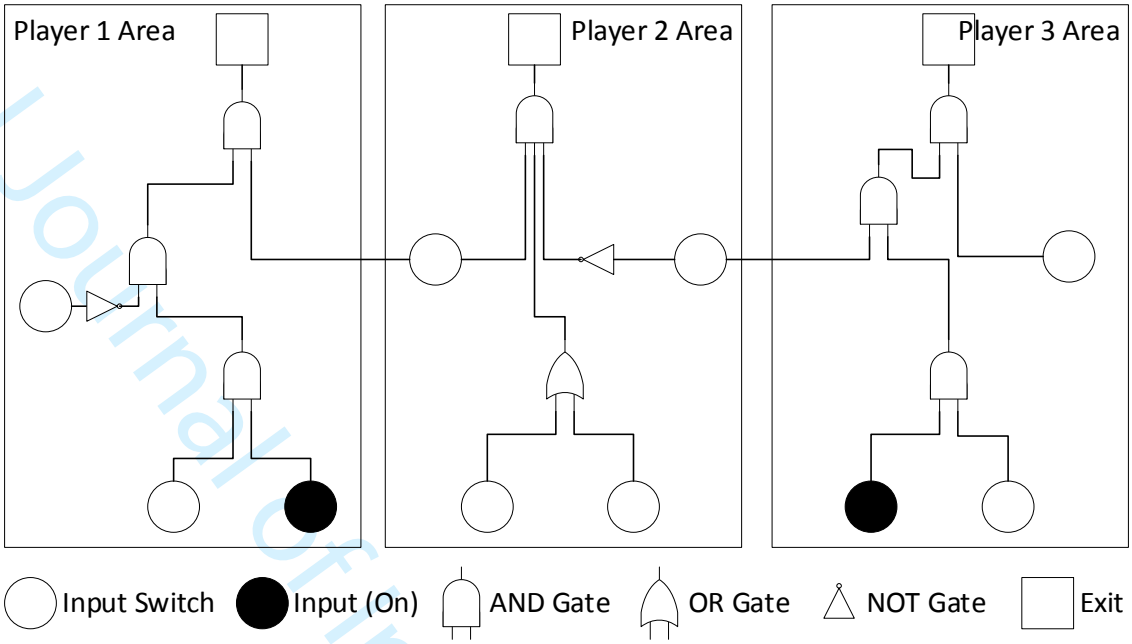

Figure 5: An example logic circuit crossing the three player areas. Correct activation of the input switches in each area enables the logic circuit requirements to be met to open the door to progress to the next area.

Source: Created by Author

Figure 5 shows the player areas as a logic circuit diagram. The three areas contain components that create a connected logic circuit. The puzzle requires each player to activate or deactivate inputs in their area to satisfy the requirements for the circuit to function, and achieve the goal (usually opening a door to the next area). This means all of the gates need to be correctly activated for all three players to progress to the next area, which is required for ongoing game progression.

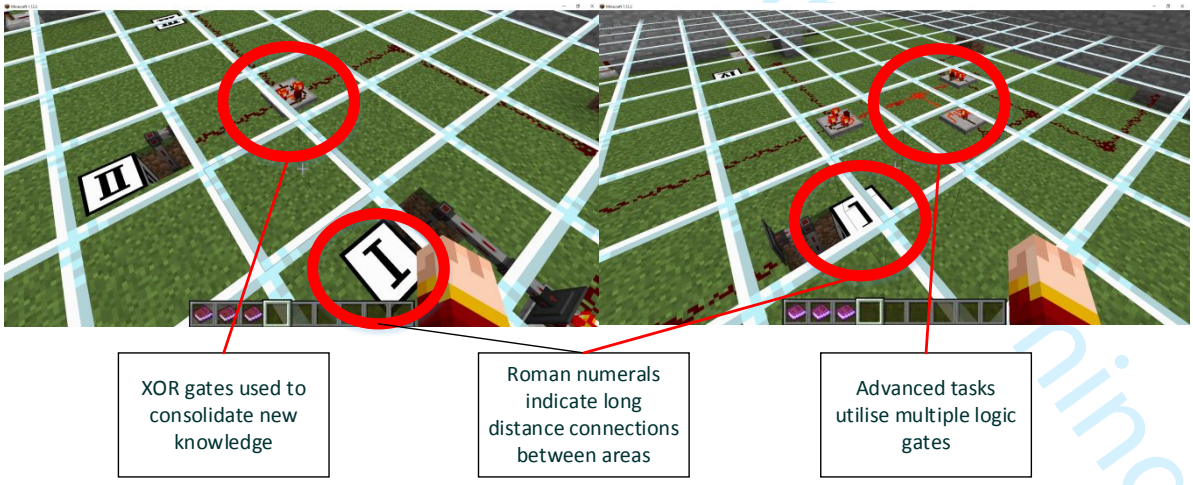

Figure 6: Viewpoints from Player 1 and Player 3, showing connections between areas and the need for players to communicate to solve the logic circuit together.

Source: Created by Author

Figure 6 shows the different player viewpoints and the need for communication between players about what they see. Logic circuits that travel to another player area are visible through the glass floor for identification of gate type, and labelled with Roman numerals to facilitate communication between players. Communication becomes even more crucial as the game progresses and puzzles increase in complexity, as multiple logic gates are used in sequence.

6. Conclusions

Through the examination of existing game design frameworks applied to educational games, it was established that the development of games that used Digital Game Based Learning as a vehicle for delivery of a Student Centered Learning experience did not have a strong structure. A lack of appropriate guidance was identified for practitioners to support the design of a holistic Student-Centered Learning experience that fully integrated all SCL tenets. Through the application of a systematic Design Thinking process, which identified the current state of the field and defined a student-centered problem statement to address through ideation and prototyping, the SCE framework was developed to provide that guidance. The SCE framework integrates SCL tenets, DGBL principles, and the MDA game design framework to direct practitioners on the implementation of the tenets of Student Centered Learning and enable them to identify the common implications of such implementations.

Strengths and limitations

The systematic approach to development and interdisciplinary integration of modern education, game design and game-based learning theories and principles can be considered key strengths of this work. While the SCE framework offers many strengths, it is important to acknowledge limitations: This is at present a theoretical framework, as is the deployment guidance, which is based on standard software development life cycles and limited literature exploring perceived roles of education and games design practitioners in the educational game design process. There is not yet a systematic deployment and evaluation to report. However, real-world testing is still ongoing, with further development, deployment and evaluation of BuildLogic, the worked example presented in Section 5, under way.

It is also important to emphasise that the SCE Framework is designed around collaboration between education and games design practitioners, therefore it is not intended for use by individual practitioners in isolation, absent a significant overlap of experience between the two areas. Lastly, the SCE framework is not a prescriptive framework and offers a large degree of

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freedom which may be daunting for first time users. The worked example, deployment guidance and detailed descriptions included within this paper seek to mitigate this.

Implications and future work

The SCE framework presents a reference for designers, educators and academics to examine the games they collaboratively create and use, and see avenues where SCL provision can be further developed, or where it may be supported with additional structure. With events of recent years having created considerable disruption to education systems worldwide, the SCE framework, alongside other innovations, offers an important tool in the design and delivery of collaborative education experiences which can be enjoyed remotely, thereby providing an additional layer of resilience to a well-designed curriculum in the face of future global disruption.

Present literature has identified opportunities to better integrate SCL into the game design process, and that there are benefits to the cooperation between educational and games design practitioners in this process. The SCE Framework as presented is ready for deployment and may offer a vehicle through which this cooperation may be put into practice. There is a need for empirical deployment and evaluation of the SCE framework to offer further support for the framework, and to support any further iterations and improvements within it that may be necessary. Such deployment and testing form the most pressing aspects of future work to be tackled. Alongside and following this deployment, fostering a community of practice around the framework, that provides additional understanding and guidance, will enable future development and support for practitioners and researchers.

To conclude the final stage of the Design Thinking process for the SCE framework, the use of the presented framework is encouraged by practitioners and researchers in the design and implementation of future SCDGBL learning experiences, and sharing of findings from their deployment and evaluation, as the authors will in future work.

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Conflict of Interest Statement

The authors declare no conflict of interest in the production of this work.

Ethics Statement

As a theoretical paper no ethics approvals were required for this research.

Data Access Statement

All the data generated in this study is presented within the manuscript and the authors encourage others to use and cite this game design framework.

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