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**AN EXPLORATORY STUDY: GAMES PROMOTING  
THE DEVELOPMENT OF VIRTUAL INQUIRY-BASED  
LEARNING COMMUNITY**

**LANLAN GAO**

A thesis submitted to the University of Huddersfield in partial fulfilment of the requirements  
for the degree of Doctor of Philosophy

The University of Huddersfield

September 2020

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## Abstract

The thesis summarises an exploratory study of digital games being used to promote the development of a virtual inquiry-based learning community (VILC). VILC has been shown to provide an important framework for enhancing students' problem-solving skills. However, little attention has been paid to the promotion of the value in social learning generated by VILC. There exists, a relationship between games and learning values, with learning value generated in social learning, and the use of games supporting social learning. To improve the development of the learning value of VILC, this thesis considers using digital games as specific communities providing the opportunity to create value. A value creation framework is utilised to evaluate social learning in games/communities. As the community of inquiry (COI) is related to the nature of knowledge construction in inquiry-based learning (IBL), VILC involves both COI and IBL. According to this, this research carries out investigations involving the use of game characteristics to support IBL and to promote learning values of COI.

The research onion had been utilised throughout the methodology of this thesis as an effective tool to help the organisation of the research and development of the research design according to the layers of the research onion (i.e. research philosophy, research methods, research strategies, time horizons, and data collection methods).

The first step of this research identifies game characteristics used in the game and game-based strategy that is designed to promote IBL. The analysis revealed that the game genre of role-playing games (RPG) is often used, given its high suitability to support IBL. A wide variety of game elements were used including storylines, interactive artefacts, gameplay-context coherence and task assessment mechanics. The study suggests that these game features can be designed to provide different levels of support to students, and structure for their learning progression according to different theoretical models and the creation of diverse environments to support making sense of knowledge in context.

The second step reviews activities of COI as the key link which connects COI and value creation. These activities were evaluated to explore related values generated by activities. The results showed that value creation was impacted by teaching presence (TP), social presence (SP) and cognitive presence (CP). In particular, reframing value was not positively promoted by COI. This result provides important evidence by which to explore the third step of this research.

The third step presents a model of game features promoting reframing value to clarify the relationship between digital RPGs and reframing value. The reliability of the model was evaluated by 39 experts according to their teaching experience. They gave a high score to

acknowledge the reliability of the model. The result of the factor analysis of 106 participants (teachers and students) was consistent with the model. This ensured the validity of the model. Participants of tests agreed that 10 game features such as multiple endings of the game, game stories, were inductively extracted from players' comments of RPGs. These features were oriented at promoting four criteria of reframing value (i.e. *promoting reflection, the change of evaluation, generating new assessments for other people and suggestions for community development*). The relationship between digital RPGs and reframing value can support reflection of multiple dimensions (i.e. four criteria of reframing value ) in the process of social learning, create related environments assisting students to understand the knowledge and provide a reference for related stakeholders (e.g. teacher educators) who can use the model to select or design games aiming at promoting reframing value. A guideline was attached in order to provide support to related users of the model.

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## List of abbreviations

AR	Augmented reality
ANOVA	Analysis of variance
CG	Control group
COI	Communities of inquiry
CP	Cognitive presence
CGWR	China games weight rank
DCENT	Digital Creativity Enhanced in Teacher Education
DEG	Digital education game
DGBL	Digital game-based learning
EG	Experimental group
FPS	First-person shooting
GBL	Game-based learning
GET	Game experience test
IBL	Inquiry-based learning
ICT	Information and communication technology

IT	Information technology
NPC	No-play character
PC	Personal computer
PR	Popularity rate
RPG	Role-playing game
RQ	Research question
RR	Response rate
SDT	Self-determination theory
SP	Social presence
STIMULATE	Science Training Immersive Modules for University Learning Around Teacher Education
TP	Teaching presence
VET	Virtual experience test
VLC	Virtual learning community
VILC	Virtual inquiry-based learning community

# **1 Introduction**

This chapter gives a brief introduction, including the research background, aims and objectives of the research and contributions of the research.

Games are playing an increasingly important role in education (e.g. Fabricatore et al., 2019; Bressler et al., 2021; Hwang and Chen, 2017; Erickson et al., 2021; Barr, 2017), especially by improving social learning (Bakhanova et al., 2020, Medema et al., 2016, Den Haan and Van der Voort, 2018).

There exists, a relationship between games and learning values, with learning value generated in social learning (Wenger et al., 2011), and the use of games supporting social learning (Bakhanova et al., 2020, Medema et al., 2016, Den Haan and Van der Voort, 2018).

Because the game is seen as a specific community where interaction can be generated (Bolter et al., 2000), a value creation framework i.e. Wenger et al.'s framework (2011) can evaluate social learning in games.

The virtual inquiry-based learning community (VILC) has been shown to be an important framework given that it enhances students' problem-solving skills (e.g. Eteokleous and Ktoridou, 2012; Setiani and MacKinnon, 2015; Chanprasitchai and Khlaisang, 2016; Suarez et al., 2016). As VILC is a specific type of community, it can highlight values that other communities can potentially create. However, little attention has been paid to how a

VILC can promote the value in social learning. Hence, the thesis investigates how digital games can be used to promote the development ,and improve the learning value, of VILC.

As the community of inquiry (COI) is related to the nature of knowledge construction in inquiry-based learning (IBL), VILC involves both COI and IBL. Utilising games to support IBL and COI presents considerable challenges in terms of the related issues of identifying game features and the extent to which they promote IBL and COI. This research will therefore carry out investigations involving the use of game characteristics to support IBL and to promote the learning values of COI. The research onion (Saunders et al., 2009) will be utilised throughout to explain the methodology of this thesis, providing an effective structure for this research, particularly through the layers of the research onion (i.e. research philosophy, research methods, research strategies, time horizons, and data collection methods).

## **1.1 Research background**

### **1.1.1 Games**

Both digital and non-digital games have been leveraged for over three decades to foster learning at all stages of formal education (e.g. Connolly et al., 201; Smith and Golding, 2018), in professional development contexts (e.g. Lamas et al., 2014; Bochennek et al., 2007; Fu et al., 2016), and in informal environments (e.g. Matijevic and Topolovcan, 2019; Bayeck, 2020). Research has amply theorised and demonstrated that games can effectively

enhance learners' motivation, engagement, and learning outcomes in multiple domains (Boyle et al., 2016, Mayer, 2019, Fabricatore et al., 2019, De Freitas, 2006, Bayeck, 2020).

### **1.1.2 Inquiry-based learning (IBL)**

Inquiry-based learning (IBL) is a student-centred pedagogical approach (Kember, 1997), in which students find the answers to problems through self-directed inquiry, driving their own learning (Prince and Felder, 2006). Students solve problems, build explanations and construct knowledge by actively exploring, observing, gathering and reflecting on information present in a rich and meaningful context (Barron and Darling-Hammond, 2008, Condcliffe et al., 2016, Kuhlthau et al., 2015). In contrast to traditional instructional learning, teachers play a guiding role, supporting students to develop their inquiry and critical thinking abilities so they can learn by themselves (Bennett, 2015). IBL is an iterative process wherein students must evaluate the strengths and weaknesses of their own results, determine their value and decide whether or not they should gather more information to elaborate on the problem being addressed. As a result, inquiry can be seen as a constant trial and error process. Research indicates that IBL can effectively support learning (Hwang et al., 2012, Lim, 2004, Pedaste et al., 2015), improving students' conceptual understanding (Gillies and Nichols, 2015, Wilson et al., 2010), and their higher-order thinking skills (Raes et al., 2012).

### **1.1.3 Community of inquiry (COI)**

The concept of Community Of Inquiry (COI) refers to a group of individuals collaboratively shared knowledge and technology, engaged in critical dialogue and

rethinking to construct personal meaning, and confirmed mutual understanding (Garrison et al., 1999). The COI theoretical framework supports the creation of online collaborative learning experiences. COI designs and evaluates virtual learning environments through reciprocal interaction of activities among multiple presences, such as Cognitive Presence (CP), Social Presence (SP), Teaching Presence (TP) (Garrison, 2011, Kozan and Richardson, 2014), Emotional Presence (EP) (Cleveland-Innes and Campbell, 2012, Stenbom et al., 2016a) and Learning Presence (LP) (Shea et al., 2013, Hayes et al., 2015).

#### **1.1.4 Virtual inquiry-based learning community (VILC)**

COI framework is related to the nature of knowledge construction in IBL (Suárez et al., 2016) and was first proposed by Garrison et al. (2011) based on the model of critical thinking and practical inquiry. Given the relationship between COI and IBL, the virtual inquiry-based learning community (VILC) integrates COI and IBL as a novel approach to learning (e.g. Eteokleous and Ktoridou, 2012; Setiani and MacKinnon, 2015; Chanprasitchai and Khlaisang, 2016; Suarez et al., 2016) to enhance students' question-solving skills (Chanprasitchai and Khlaisang, 2016) and co-create knowledge (Suarez et al., 2016). For example, integrating the IBL approach optimizes the design of activities in COI (Chanprasitchai and Khlaisang, 2016).

#### **1.1.5 Value creation**

Value creation refers to the values of social learning which occur through interaction and communication in communities and networks (Reed et al., 2010, Wenger et al., 2011). Social learning is seen as one of the most influential learning theories (e.g. behaviourism

and cognitivism) (Pinho et al., 2020) explaining human behaviour through using continuous interaction among cognition, behaviour and environmental influences (Bandura and Walters, 1977, Prestridge, 2019).

Given its nature, Wenger et al.'s (2011) value creation framework (e.g. creating immediate value, potential value, applied value, realized value and reframing value) represents a suitable tool to evaluate value creation. Social learning is seen as the practical process and results of value creation in the networks (van Amersfoort et al., 2012). In order to explore the nature of social learning (Wenger et al., 2011), the framework can be used as an effective way of seeing implicit learning outcomes (van Amersfoort et al., 2012). For example, the framework is utilised broadly to capture knowledge cocreation (Gidhagen et al., 2011) and understand what community members achieved from their participation (Dingyloudi and Strijbos, 2015). Hence, many studies reiterate the importance of Wenger et al.'s framework in the value evaluation of virtual communities and networks (e.g. van Amersfoort et al., 2012; Smith et al., 2017; Booth and Kellogg, 2015; Dingyloudi and Strijbos, 2015).

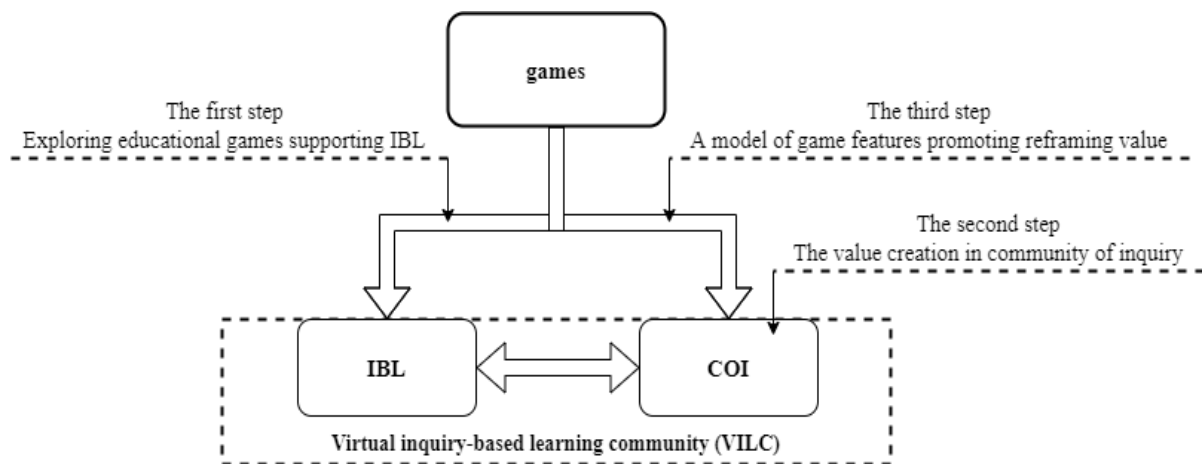
## **1.2 Aims and objectives**

The thesis aims to investigate an exploratory study that digital games are used to promote the development of a virtual inquiry-based learning community (VILC).

VILC has been shown to be an important framework given that it enhances students' problem-solving skills (e.g. Eteokleous and Ktoridou, 2012; Setiani and MacKinnon, 2015; Chanprasitchai and Khlaisang, 2016; Suarez et al., 2016). However, little attention has been paid to the promotion of social learning value through VILC. To improve the development of the learning value of VILC, this thesis considers digital games that are used as an educational strategy providing the opportunity to create value.

As the framework of Community Of Inquiry (COI) is related to the nature of knowledge construction in inquiry-based learning (IBL), VILC involves both COI and IBL. This research includes three steps involving the use of game characteristics to support IBL and promote the learning values of COI. This includes the following sub-research: exploring game characteristics supporting three core features of IBL (the first step of this research), investigating actual values created by COI and weaknesses generated during the process of value creation in COI (the second step of this research), and identifying game features that promote related value in order to rectify the weaknesses (the third step of this research), see Figure 1.1.





**Figure 1.1 The triangular relationship between games and VILC**

In order to achieve the aforementioned aim, the following sub-aims will be pursued:

- (1) To investigate how game features have been used to support the inquiry processes, and how game features may be related to impact on achievement and engagement

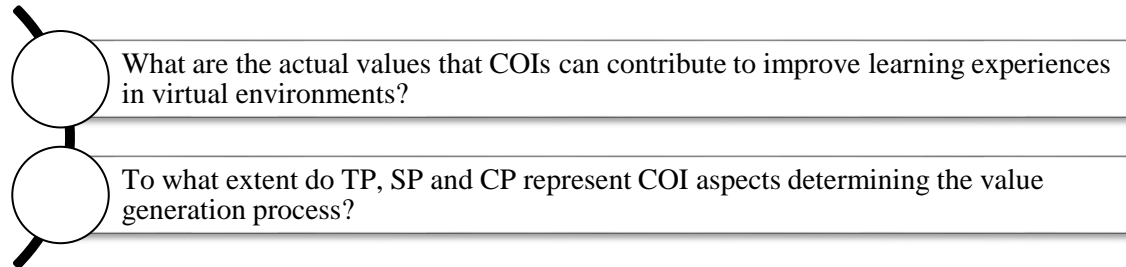
For this, the research questions require to be addressed:

- What are characteristics of a game-based IBL strategy?
- What game features have been used to support IBL?
- What aspects of IBL are being supported by game features?
- What are the reported impacts on students?

**Figure 1.2 The research questions of the first step**

- (2) To investigate the values created by COI and analyse the possible existing weaknesses from the perspective of value creation

For this, the research questions require to be addressed:

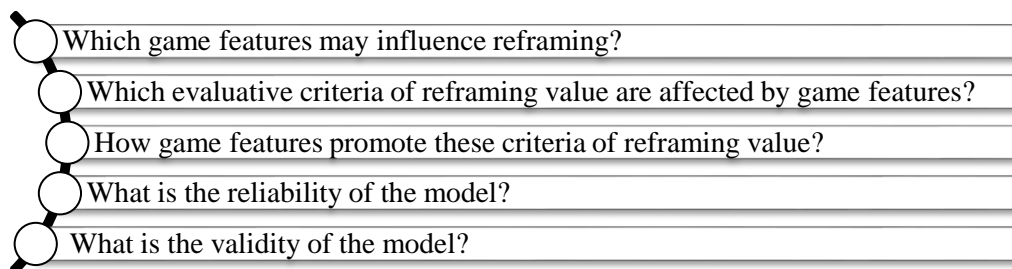


**Figure 1.3 The research questions of the second step**

**(3) To rectify the weaknesses generated by COI**

- (i) To establish an empirical model that describes the relationship between reframing value and game features, involving game features helped to deploy reframing functions, and the approaches
- (ii) To evaluate the model through the feedbacks of experts, teachers and students, in order to ascertain whether the identified features can help COI to generate reframing value as represented by them

For this, the research questions require to be addressed:



**Figure 1.4 The research questions of the third step**

## **1.3 Contributions to the knowledge**

The research work in this thesis includes the following contributions to knowledge:

### **1.3.1 Exploring serious games supporting IBL**

Several game features (e.g. storylines, interactive artefacts, gameplay-context coherence and task assessment mechanics) could be used to support inquiry processes. The study suggests that these game features can be designed to provide different levels of support to students, structure the learning progression according to different theoretical models and create diverse environments to support making sense of knowledge in context. Games present these intrinsic features (e.g. storylines, interactive artefacts) that can naturally support the core aspects of IBL: the provision of progressive and context-sensitive guidance, the hierarchical structure of the learning process and the creation of a meaningful environment to solve problems. This means that students who play IBL games can take active control of the pace of their progress, exert autonomy for decision-making and make timely observations regarding the relationships between actions, concepts and context. There is much space for these features to be explored and used by games aiming at supporting IBL.

### **1.3.2 The value creation in COI**

Community of Inquiry (COI) has become increasingly popular as an effective framework of social learning that promotes critical thinking and improves learning skills in online settings. The framework has been used to design and evaluate the interaction of virtual learning environments through multiple presences (teaching and social). However, little is

known about how COI contributes value by improving learning experiences in virtual environments and what determines the generation of this value. Through reviewing activities of COI that connect COI and value creation and evaluating these activities, this study found the related values created by COI and the extent to which Teaching Presence (TP), Social Presence (SP) and Cognitive Presence (CP) represent COI aspects determining the value generation process. Hence, this study can provide an important means to explore the nature of social learning; being utilised as an effective way of seeing implicit learning outcomes of COI; enabling stakeholders (e.g. participants of a virtual learning community, the organizations of a community and their sponsors) to achieve their expected outcomes; and optimizing the design of related activities to maximize learning value.

### **1.3.3 A model of game features promoting reframing value**

The second step of this research result showed that reframing value was not positively promoted by COI. Promoting reframing value is similar to promoting critical reflection, this research proposes that games are utilised as an educational strategy providing opportunities to create reframing value.

This study presents a model of using role-playing games (RPG) to promote reframing value in order to clarify the relationship between game features and four criteria of reframing value. This is the most important contribution because game designers, related educators and researchers who use games aiming at promoting reframing value or regard the need for a model to link games features with learning value will benefit. The relationship between digital RPGs and reframing value can support reflection of multiple dimensions (i.e. four

criteria of reframing value ) in the process of social learning, create related environments assisting students to understand the knowledge and provide a reference for selecting and designing games oriented at promoting reframing value. A guideline was attached in order to provide support to related users of the model.

## **1.4 Thesis structure**

With the aim that investigating games is used as a robust tool for promoting IBL and COI, this research discusses three aspects including exploring serious games supporting IBL, the value creation in communities of inquiry and a model of game features promoting reframing value. According to the three aspects of this research, the thesis is organized into six chapters and three appendixes to clarify research background, methodology, results, discussions and conclusions.

Chapter 1 gives a brief introduction, including the research background, aims and objectives of the research and the thesis structure.

Chapter 2 reviews the current literature to describe what has been done before and which research questions still need to be solved. The topic involves the theory backgrounds for using serious games supporting IBL, value creation in COI and constructing a model of using RPGs to promote reframing value.

Chapter 3 clarifies the research approaches. This includes related research processes, data capture, data analysis, sample size, calculation of inter-coder consistency and testing the reliability and validity for the model of using RPGs to promote reframing value.

Chapter 4 proposes related research results such as an overview of characteristics of a game-based IBL strategy; the actual values that COIs can contribute to improving learning

experiences in virtual environments; game features that may influence reframing value have been extracted.

Chapter 5 gives discussions. For example, the suitability of RPGs for supporting IBL; the importance of promoting reframing value; some special game features that only appear in stand-alone or online games to promote reframing value.

Chapter 6 presents an overall conclusion of this study and according to related limitations in current research proposes suggestions for future work.

The first appendix presents expanded research i.e. a few studies involve utilising IBL-serious games to support teacher training. This research, from a broader perspective, investigates the impact of serious games (SG) on teachers' professional development.

The other two appendixes include a form for the questions of the five-cycle value and questionnaires that test the reliability and validity of the model when using RPGs to promote reframing value.

## **1.5 Publications**

The work in this thesis has produced four papers, including three papers that have been published in related conference proceedings, and one paper (i.e. Construction of a Model that Uses Digital Role-playing Games Promoting Reframing Value) that is being reviewed by the *Journal of Educational Technology Research and Development*. At the end of this thesis (Publications section), the full publication list can be shown.



## **2 Literature review**

This chapter reviews the current literature to describe what has been done before and which research gaps still need to be addressed. The topic involves serious games, educational research in games and serious games, related research questions and theory backgrounds for the three steps of this study: using serious games supporting IBL, the value creation in COI and constructing a model of game features promoting reframing value.

### **2.1 Serious games**

Based on the research of Susi et al. (2007), serious games initiated from the "serious games initiative" in 2002 ([seriousgames.org](http://seriousgames.org)). "The Serious Games Initiative is focused on uses for games in exploring management and leadership challenges facing the public sector. Part of its overall charter is to help forge productive links between the electronic game industry and projects involving the use of games in education, training, health, and public policy" (Susi, et al., 2007 p.3, [seriousgames.org](http://seriousgames.org)).

With the term "serious game" becoming widely used, there seem to now be many different definitions available for the concept. For example, Susi et al. (2007) proposed that the definition of serious games (SG) should be studying the relationship between the game aspect and the application of gaming technology. They suggest that Serious games are adopted to game technology, process and design in solving problems faced by enterprises and other institutions. It can promote the transfer and cross-application of game development knowledge in some non-game markets (i.e training, sales) (Susi et al., 2007).

From the perspective of the application of SGs, the entertainment dimension (Michaud et al., 2008, Jantke, 2010, Zyda, 2005), the user's experience (De Freitas and Liarokapis, 2011, Arnab et al., 2011) and the combination of media (Lin et al., 2006, Arnab et al., 2011), Laamarti et al. (2014) all contribute to a definition of SGs: the SG becomes an application with three components (e.g. experience, entertainment, and multimedia). Jacobs (2021), considering the theoretical perspectives on player choice in SGs, therefore proposed that SGs can be seen as a form of promotional communication, media experience and technical innovations.

However, whilst there is no absolute agreement on a definition, most scholars agree on a core meaning when the primary purpose of SGs is within education (Bontchev et al., 2021), especially when applications from relevant areas such as game-based learning (Deterding et al., 2011, Plass et al., 2015) are included, rather than simply entertainment (Landers and gaming, 2014, Susi et al., 2007, Michael and Chen, 2005). Game-based learning products are therefore widely considered as a subcategory of SGs (Connolly et al., 2012, Hainey et al., 2016). This thesis similarly considers SGs through the conceptualisation of digital games/ game-based learning design, to consider how they promote behaviour change and/or the development of knowledge, skills and attitudes (Hainey et al., 2016, Connolly et al., 2012, De Lope and Medina-Medina, 2017).

### **2.1.1 Benefits of SGs and computer games in education**

Serious games represent an important asset in education, as there is rich evidence to show the benefits of SGs' use. For example, SGs can promote the development of transferrable

knowledge, skills and attitudes by engaging players in activities driven by meaning-making, and by setting scenarios that mirror real-world situations (Fabricatore et al., 2019). Bressler et al. (2021) indicate that mobile augmented reality games are an effective strategy that can provide benefits by supporting serious science learning. Hwang and Chen (2017) have utilised SGs to improve students' critical thinking and problem-solving. Furthermore, SGs have also been shown to successfully enhance teachers' professional development, facilitating the acquisition of domain-specific knowledge and skills (Johnson et al., 2021, Meletiou-Mavrotheris and Prodromou, 2016, Alyaz and Genc, 2016, Lamas et al., 2014) and fostering positive attitudes towards modern pedagogical approaches and tools such as game-based learning (Kennedy-Clark et al., 2011, Annetta et al., 2014).

In particular, SGs have been shown to have impacts on learners' motivation and engagement (Vrasidas and Solomou, 2013, C  zar-Guti  rrez and S  ez-L  pez, 2016, Lorenzini et al., 2015, Farrell and Moffat, 2014). According to Deci and Ryan's (2000) Self-Determination Theory (SDT) which summarises human motivation, the individual has innate tendencies toward psychological growth, which can be influenced by ability, autonomy, and relatedness. From this theoretical perspective, serious games are constructed to improve abilities through tasks, offer opportunities to enable player autonomy (Blumberg et al., 2013), and link with individual values that exist outside of the game environment (Ryan et al., 2006). Hence, motivation and engagement are closely linked to the development of SGs. Hookham and Nesbitt (2019), for example, have found that some potential evaluation approaches such as questionnaires, interviews, time and

performance on tasks can be effectively utilised to measure motivation and engagement in SGs.

Computer games can also provide other positive impacts on education. Many studies (i.e. Enochsson et al., 2004; Guy et al., 2005; Loparev et al., 2014; Erickson et al., 2021) have reported that playing computer games can promote the development of diverse learning skills such as spatial skills (Enochsson et al., 2004, Mitchell and Savill-Smith, 2004) and graduate skills (i.e. communication, adaptability and resourcefulness) (Barr, 2017). For example, the experience of playing with spatial models is provided by computer games to develop students' abilities for creation and design (Coyne, 2003, Guy et al., 2005). Thomas and Brown (2011) have advocated that a new learning experience can be afforded by digital games. They highlighted that in order for multiple methods of completing a task to be found, players are required to be adaptable through thriving on change and strategically handling game resources. Yet other advantages are pointed out by scholars such as Squire, 2008, Boyle et al., 2016, Mayer, 2019, Fabricatore et al., 2019, De Freitas, 2006 and Bayeck, 2020, who argue that games can effectively enhance learners' motivation, engagement, and learning outcomes.

Another potential benefit of games is in improving social learning (Bakhanova et al., 2020, Medema et al., 2016, Den Haan and Van der Voort, 2018). Since games have provided the necessary collaboration, and involve participatory stakeholders' (e.g. learners) communication, positive social learning achievements are created (Ampatzidou et al., 2018, Becu et al., 2017, Medema et al., 2016, Salvini et al., 2016). For example, the game

experience can promote the development of students' diverse learning skills (i.e. Enochsson et al., 2004; Guy et al., 2005; Loparev et al., 2014; Erickson et al., 2021) such as communication, adaptability and resourcefulness (Barr, 2017).

Other potential benefits of games include providing social spaces, social comparison/competition, and social interaction. Playing video games is seen to be a social activity according to Eklund (2015), as digital games (e.g. massively multiplayer online games) are usually social environments (Squire, 2008) that offer cooperation and competition (Fox et al., 2018) between the millions of players that are attracted by such games (Quandt et al., 2014). For instance, players utilise competitive scoring and they have the skills to help each other achieve success (Loparev et al., 2014). More specific impacts have also been reported, for example by Fox et al. (2018) who found a positive correlation between players' self-motivated and engaging in social comparison with other players. Several studies (e.g. Trepte et al., 2012; Cole and Griffiths, 2007) have also proposed that online and offline games promote social interaction involving the development of friendship, social capital and social support.

## **2.2 Exploring serious games supporting IBL**

IBL has been regarded as an approach of student-centred learning (Barron and Darling-Hammond, 2008, Condliffe et al., 2016, Kuhlthau et al., 2015), such as observations, investigations, concluding answers or explanations (NRC, 2000, Booven, 2015). Researchers indicated that IBL can effectively support learning (Pedaste et al., 2015, Hwang et al., 2012, Lim, 2004), such as improved students' conceptual understanding (Gillies and Nichols, 2015, Wilson et al., 2010) and their higher-order thinking (Raes et al., 2012). Kogan and Laursen (2014) demonstrated this by conducting an experiment on the comparison of student performance between non-IBL and IBL courses. The study showed that students who took the IBL program scored better than those who participated in non-IBL courses.

Many previous studies had proved that using information technology (IT) as a support in the process of IBL positively affected learning effectiveness (Kuhn et al., 2000, Hwang et al., 2012). It meant information-technology-assisted IBL provided students with the choice to develop their high-order abilities and engaged them with the learning performance of problem-solving (Oliver, 2008, Ucar and Trundle, 2011). Over the last decade, serious games as a part of IT, have been applied to support IBL for teaching and learning (San Chee et al., 2011, Sabourin et al., 2012, Kennedy-Clark et al., 2013, Kalz et al., 2014, Meesuk and Srisawasdi, 2014, Firssova et al., 2014, Dorji et al., 2015, Hwang and Chen, 2017, Srisawasdi et al., 2019). These research outcomes were not only discussed using serious games to promote students' problem-solving skill in IBL but also indicated that

serious games assist students to gain other achievements. For example, Sabthisin et al. (2012) improved the student's ability to collect information through tests of inquiry performance in a game-based learning environment.

Through systematical reviewing literature of the concept of engagement in serious games published from 1970 to 2015, Hookham and Nesbitt (2019) found that many studies (e.g. Adamo-Villani et al., 2013; Lorenzini et al., 2015; Farrell and Moffat, 2014) directly evaluated engagement in a serious game. However, Hookham and Nesbitt (2019) did not investigate whether or not these serious games were relevant to IBL. This means a research gap on how IBL-based serious games may be related to impacts on students' engagement needs to be addressed.

Hence, when using serious games to carry out IBL activities, it remains two challenges: a) to understand what games features were used to support IBL and how they have been designed to develop learning, b) to understand how IBL games may be related to impacts on students' achievement and engagement. In order to explain these questions, the literature overview has been utilised to analyse the relationship between serious games and IBL.

### **2.2.1 Three core characteristics of IBL**

There are three core characteristics of IBL that need to be present to support students' learning:

- 1) The structure of IBL

The literature agrees that IBL needs to be structured in stages in order to guide students in their inquiry process (Bybee et al., 2006, Pedaste et al., 2015, Quintana et al., 2004, Bell et al., 2010). Several possible structures have been proposed by the literature, based on different theoretical approaches. For example, Bell et al (2010) indicate that IBL should be structured in phases of question definition, data gathering, elaboration of explanations, creation of connections, and building of justifications. Pedaste et al (2015) identify different key phases: orientation, conceptualization, investigation, conclusion and discussion. Beyond their differences, they highlight that IBL should follow these stages in a flexible way, allowing students to move forward or go back to previous stages to elaborate coherent answers and sound conceptual explanations to the problems they need to solve. See Table 2.1.

**Table 2.1: The possible IBL structures have been proposed by scholars**

<b>Process (Bell T, 2010)</b>	<b>Phases (Pedaste et al., 2015)</b>
<b>Creating:</b> proposing interest question	<b>Orientation:</b> inspiring interest
<b>Obtaining:</b> using evidence to solve problems	<b>Conceptualization:</b> formulating hypotheses
<b>Explaining:</b> interpretation	<b>Investigation:</b> conducting a survey
<b>Connection:</b> communicating the information to the others collected in an investigation	<b>Conclusion:</b> concluding from the collected data
<b>Justification:</b> discussion	<b>Discussion:</b> including communication and reflecting

## 2) IBL environments



This means IBL should provide an internally coherent learning environment where students can perform learning actions by themselves (Wang et al., 2014). Moreover, some authors highlight that IBL should be situated in real-world environments (or virtual recreated versions), otherwise learning may not actually happen (Brown et al., 1989, Huang et al., 2014). Activities contextualised in real scenarios promote students linking their prior knowledge to the new one (Brown et al., 1989, Hwang et al., 2011). Studies have shown that IBL is promoted when students observe real phenomena and practice in a natural environment (Lee and Butler, 2003, Hwang et al., 2012, Oliver, 2008).

### 3) Guidance

Guidance is key in the whole process of IBL, however, the degree of guidance can vary according to students' abilities to self-direct their learning (see Table 2.2). Banchi and Bell (2008) indicate that teachers (or other supporting entities) need to guide students from level 1 (strong support to inquiry), progressively reducing the support until students are able to carry out inquiry processes in a more autonomous way (Level 4). However, even when students are able to guide themselves, the open inquiry is not likely to be successful unless students have a positive motivation (Yoon, 2012), which highlights the importance of guidance and support even when their inquiry skills seem more developed.

**Table 2.2: Four distinct levels of inquiry (Banchi and Bell, 2008)**

Level	Description
<b>1. Confirmation inquiry</b>	Teachers select a theme to teach, then promote questions that guide the student completing the activity to find the result. This method is very good for strengthening concept teaching, guiding students to learn to follow the

Level	Description
	procedure, collecting and recording data correctly, identifying and deepening their understanding.
<b>2. Structured inquiry</b>	Teachers provide the outline of the procedure and the starting questions, and students should develop an explanation of what they have found by evaluating and analysing the data collected.
<b>3. Guided inquiry</b>	Teachers provide students with research problems, but designing and carrying out the research is students' responsibility. Then, students share their findings with teachers and other students.
<b>4. Open/true inquiry</b>	Students develop the research question, define inquiry methods and carry out the inquiry process by themselves. Then, students share their findings with teachers and other students.

### 2.2.2 Game-based IBL

Due to their motivational potential and interactive nature, games have been proposed as a suitable format to support IBL (Meesuk and Srisawasdi, 2014, Firssova et al., 2014, Dorji et al., 2015, Hwang and Chen, 2017). Some game features may be particularly relevant to support IBL. Games can implicitly or explicitly provide problems and goals to achieve (Hwang et al., 2015, Firssova et al., 2014); an environment with resources and action possibilities that are meaningful to the problems to be solved (Hwang and Chen, 2017, Hwang et al., 2015); opportunities to actively explore, manipulate and build a comprehension of the inner workings of the game (Kennedy-Clark et al., 2013); and immediate feedback to correct errors, inform about performance and expand knowledge (Sabthisin et al., 2012). In addition, games can present specific rules and gameplay flow oriented to supporting players to understand what to do and when (San Chee et al., 2011). Furthermore, games can give players control over their actions and foster motivation by

presenting challenging tasks and providing relevant rewards (Lameras et al., 2014, Dorji et al., 2015).

### **2.2.3 Research question**

Despite the potential that games have to support IBL, little attention has been given to understand how game features have been used to support the inquiry processes, and how these may be related to impacts on achievement and engagement. The aim of this study to review the literature focused on IBL and games, to identify game features that have been used in games and gamified strategies designed to support IBL, and synthesise their impacts on students. The research questions are:

- (a) What are the characteristics of a game-based IBL strategy?
- (b) What game features have been used to support IBL?
- (c) What aspects of IBL are being supported by game features?
- (d) What are the reported impacts on students?

## **2.3 The value creation in COI**

According to Garrison et al. (1999), the concept of Community Of Inquiry (COI) refers to a group of individuals collaboratively engaged in critical dialogue and reflection to construct personal meaning, shared knowledge and confirm mutual understanding. The theoretical framework evaluates virtual learning environments through reciprocal interaction of activities among multiple presences, such as cognitive presence (CP), social presence (SP), teaching presence (TP) (Garrison, 2011, Kozan and Richardson, 2014), emotional presence (EP) (Cleveland-Innes and Campbell, 2012, Stenbom et al., 2016a) and learning presence (LP) (Shea et al., 2013, Hayes et al., 2015). The framework has been used broadly (Kozan and Richardson, 2014, Stenbom et al., 2016b) to enhance the effectiveness of online education research and practice (Kozan and Richardson, 2014), improve students' learning skills (Mikroyannidis et al., 2016, Secundo and Grippa, 2010), and promote critical thinking (Chanprasitchai and Khlaisang, 2016, Eteokleous and Ktoridou, 2012, Junus et al., 2017, Keles, 2018, Padilla and Kreider, 2018).

Value creation refers to the values generated by social learning, through interaction and communication in communities and networks (Reed et al., 2010, Wenger et al., 2011). Scholars indicate that social learning is one of the most influential learning theories (e.g. behaviourism and cognitivism) (Pinho et al., 2020). As it uses the continuous interaction among cognition, behaviour and environmental influences to explain human behaviour (Bandura and Walters, 1977, Prestridge, 2019). And given social learning includes

attention, memory and motivation, it is often used to bridge behaviourist learning theories and cognitive learning theories (Muro and Jeffrey, 2008).

The evaluation of learning values has an important meaning for social learning. This process can explore the nature of social learning (Wenger et al., 2011) and make related stakeholders of the value (e.g. participants of a virtual learning community, the organizations of a community and their sponsors) achieve desired outcomes (Smith et al., 2017). For example, managers are likely to be more interested in performance (value achieved) (Wenger et al., 2011).

Wenger et al.'s (2011) value creation framework represents a suitable tool to evaluate value creation in online environments. This framework indicates that learners' activities in Virtual Learning Communities (VLC) can create and achieve immediate value, potential value, applied value, realized value, and reframing value. In the framework of value creation, social learning is seen as the practical process and results of value creation in the networks (van Amersfoort et al., 2012). This means that the framework is an effective way of seeing implicit learning outcomes (van Amersfoort et al., 2012). For example, the framework is utilised broadly to capture knowledge cocreation (Gidhagen et al., 2011) and understand what community members achieved from their participation (Dingyloudi and Strijbos, 2015). Meanwhile, there is an emerging body of literature (e.g. van Amersfoort et al., 2012; Smith et al., 2017; Booth and Kellogg, 2015; Dingyloudi and Strijbos, 2015), reiterating the importance of Wenger et al.'s framework in the value evaluation of virtual

communities and networks. Hence, given its nature, this research uses Wenger et al.'s framework to construct an investigation.

As COI is a specific type of VLCs, it may be assumed that they create the values that have been identified as being created by VLCs. However, few studies have investigated the actual values that COIs can contribute to support learning experiences in virtual environments and the factors that determine the generation of these values. This research adopts a mixed content analysis (inductive and deductive) to investigate values generated in COI, in order to address such a gap.

### **2.3.1 Theory background**

#### **2.3.1.1 The presences of COI**

The literature agrees that TP, SP and CP are three original/ core presences of the COI framework (Chanprasitchai and Khlaisang, 2016, Garrison, 2011, Garrison et al., 1999, Shields, 2003). The three presences are used as a theoretical reference by this research. TP refers to key strategies that teachers can use to create a COI among learners (Bangert, 2008), and supports the design of activities in the virtual world (Burgess et al., 2010, Dalgarno and Lee, 2010, Pellas and Boumpa, 2017). SP provides social context and interaction to achieve knowledge (Pardales and Girod, 2006, Seixas, 1993), identify with and connect among participants in an online learning environment (Chanprasitchai and Khlaisang, 2016). According to Garrison et al. (2011), CP means to investigate the process of learners building meaning through discussion and reflection. The categories and indicators of the three presences are shown in Table 2.3.

**Table 2.3: COI categories and indicators (Chanprasitchai and Khlaisang, 2016, Shields, 2003)**

<b>Presences</b>	<b>Categories of activities</b>	<b>indicators</b>
<b>TP</b>	Design and organization	Setting environment and methods
	Promoting discourse	Shaping constructive communication
	Direct instruction	Focusing and resolving questions
<b>SP</b>	Individual/affective	Self-projection/expressing emotions
	Open communication	Learning circumstance/risk-free expression
	Group cohesion	Collaboration
<b>CP</b>	Triggering event	Sense of puzzlement
	Exploration	Information exchange
	Integration	Connecting ideas
	Resolution	Apply new ideas

### **2.3.1.2 A theory of five-cycle value creation**

In order to interpret the learning values, Wenger et al. (2011) propose a theory of five-cycle value creation that promotes and evaluates values in the community and a networked environment. The five values include immediate value, potential value, applied value, realized value and reframing value. See Table 2.4.

**Table 2.4: The theory of five-cycle value creation (Wenger et al., 2011)**

<b>Definition</b>	<b>Explanation</b>	<b>Example</b>
<b>Immediate value</b> Members' activities and interactions have value.	The interaction and communication among communities' members directly create immediate value.	Helping each other; meetings; dialogues; advice; a story be discussed; a project; a visit
<b>Potential value</b> The immediate value may not be shown immediately but is preserved as intellectual capital. This value is potential that is likely to achieve in the future.	The value does not appear immediately. It includes some forms of knowledge capital such as human capital, social capital, tangible capital, intangible capital, learning capital.	Looking at new perspectives of the problem, new ways to solve problems; inspiration, care, confidence, status reputation, mutual understanding, accompany, learning challenges among members; accessing to information, resources, tools; the reputation of the community; transformation of learning knowledge
<b>Applied value</b> The knowledge capital is used that requires adjustments to the capital and its application to specific situations.	The changes, or innovations of actions, practices, tools, methods, system, are due to the application of intellectual capital in different contexts.	Using the knowledge learned in the community Using the resources provided in the community to practice
<b>Realized value</b> It is not enough to adopt new practices or tools. Changing practice does not necessarily improve performance. Therefore, it is important to find out how the application of intellectual capital affects what is important to stakeholders.	Members are not satisfied with applications, new practices or tools and expect to practice new ideas or to use community resources in order to improve performance.	Achievements; comprehension; improvement of abilities
<b>Reframing value</b> Learning triggers a reflection for the definition of success. It includes re-engineering strategies and aims. When learners interact and share their knowledge, they can	When social learning leads to a rethinking of the definition of success, reshaping will be realized.	Definition of assessment criteria; suggestions for community development; self-reflection; new standards for learner's evaluation



<b>Definition</b>	<b>Explanation</b>	<b>Example</b>
recognise the quantity of their knowledge and assess the values themselves.		

According to the definition of reframing value, it is consistent with critical reflection. Scholars indicate that critical reflection means rethinking a person's choices, decisions and behaviours (Brookfield, 2015), to make people challenge and question the validity of a meaning or idea that is long taken for granted (Mezirow, 1990).

The five values represent the different desired outcomes of different stakeholders (Wenger et al., 2011). This means that different values may be important to different stakeholders. For example, a coordinator may be more focused on successful activities or the generation of outputs (immediate value and potential value) (Wenger et al., 2011).

In order to elaborate on possible consequences within the process of generating values, Wenger et al. (2011) set some key questions for every value (i.e. potential value: Was I getting new skills or knowledge?). See Appendix B. In this research, these questions are used as a reference for evaluating values. Learning is not a linear process of producing and applying knowledge. Wenger et al. (2011) propose that value creation interweaves into the process of learning. In other words, the cycle of value creation is also not a linear process. For example, every value can be analysed independently. When a five-cycle of value creation has finished, it does not mean the next cycle begins (Wenger et al., 2011).

### **2.3.2 Research question**

Wenger et al. (2011) indicate that the learning value of Virtual Learning Communities (VLC) stems from the ability which promotes learning. In other words, the development of learning values means the enhancement of the ability of learning. In order to promote the development of learning values, the primary research is to identify these actual values that COIs can contribute to support learning experiences in virtual environments and the factors that determine the generation of these values. For this, the following research questions (RQ) are addressed:

- 1) What are the actual values that COIs can contribute to improving learning experiences in virtual environments?
- 2) To what extent do TP, SP and CP represent COI aspects determining the value generation process?

## **2.4 A model of game features promoting reframing value**

### **2.4.1 Theory background for constructing the model**

The concept of reframing value is derived from the theory of value creation which was first developed by Wenger et al. (2011). They propose that reframing value triggers rethinking of the definition of success both for participants and for their environment, including multiple changes of reflection such as rethinking for methods, aims and values, and reshaping the new criteria of success (Wenger et al., 2011). The changes of reflection are one of the learning values, such as immediate value, potential value, applied value, realized value and reframing value, that are generated in social learning.

There exists, therefore, a relationship between games and learning values, with reframing value generated in social learning, and the use of games supporting social learning (Bakhanova et al., 2020, Medema et al., 2016, Den Haan and Van der Voort, 2018). This research proposes that games can be utilised as an educational strategy as they offer opportunities to create reframing value.

This research introduces the findings of a study clarifying the relationship between games and reframing value, based on Wenger et al.'s (2011) concept. It evaluates the reframing value of games within the context of role-playing games (RPG).

Since Wenger et al. (2011) suggested a framework of five-cycle value creation (immediate, potential, applied, realized and reframing values), the importance of this framework for evaluating values of social learning in communities has been reiterated by several authors

as part of an emerging body of literature (e.g. Van Amersfoort et al., 2012; Booth, 2015; Dingyloudi, 2015; Smith, 2017).

Social learning is used to explain human behaviour (Bandura and Walters, 1977, Prestridge, 2019) as one of the most popular learning theories (e.g. behaviourism and cognitivism) (Pinho et al., 2020). For Wenger et al. (2011)'s framework, social learning is seen as the actual process of generating values in the community (Van Amersfoort et al., 2012). This means that implicit learning outcomes, which include learning reflection, can be shown through the analysis of the five values (Van Amersfoort et al., 2012). Meanwhile, each value can be analysed independently (Wenger et al., 2011). Wenger et al.'s (2011) concept of reframing value was therefore adopted in this research as an appropriate indicator.

This research of the first step found that RPGs suit to support IBL given its nature. Tychsen (2006) proposes that RPGs are distinguished from other game genres through controlling the virtual characters with the use of storytelling in a fictional reality, this is consistent with the guidance of IBL. For example, Hwang, Chiu, and Chen (2015) use RPGs to explore the learning of financial knowledge. The storyline of the game guilds learners to enter Saving Island (game scene) to collect all the scrolls (game tools). Then they implement tasks in the Finances Bridge (game scene) following the storyline. Finally, learners achieve enough scores to participate in the competition in Investment Island (game scene) until the end of the game (Hwang et al., 2015).

Videogames offer a very rich ground for studies on virtual communities (VC) (Tardini and Cantoni, 2005) because the game is seen as a specific community where interaction can be generated (Bolter et al., 2000). According to Gee (2007), players have different identities when playing games (e.g. the real player, the virtual character). Tardini and Cantoni (2005) indicate that, based on the relationship between the real player's and the virtual character's identities, two different VCs can be constructed, namely the playing community and the player's community. In the playing community, for example, the virtual characters interact in the game's world with other characters or non-playing characters to complete tasks such as killing monsters. In the players' community, for instance, the interaction is generated between the real players who are interested in the same game (Newman, 2013).

The literature proposes that RPGs are broadly applied as one of the most popular game genres in multiple educational domains (Cheng et al., 2015, Hao and Lee, 2019, Jancic and Hus, 2018) to support science education (e.g. Wesselow and Stoll - Kleemann, 2018; Moreau et al., 2019; King, 2018), promote inquiry-based learning (IBL) (e.g. Hwang et al., 2015; Sabthisin et al., 2012; San Chee et al., 2011; Lameris et al., 2014; Kennedy-Clark et al., 2013) and develop language learning (e.g. Zhang et al., 2019; Kostikova et al., 2019; Cornillie et al., 2012; Yang and Quadir, 2018). This means that the popularity of RPGs can provide rich resources (e.g. feedback, comments and cases) for this research. Furthermore, scholars have highlighted that the slower game playing speed within RPGs provides more space and time to promote reflection (Squire and Barab, 2004).

As RPG game is a specific type of digital games, it can highlight values that any games can potentially create, and given the nature of this game genre and its popularity for education, RPGs are well-suited to the purpose of this investigation.

In particular, this study proposes that games can be used to promote reframing value. Promoting reframing value in education is important and yet there is a lack of empirical studies in related areas (from the perspective of games promoting critical reflection and generating learning value).

Promoting reframing value plays a significant role in education. The literature proposes that critical reflection means challenging and questioning the validity of ideas (Mezirow, 1990) and reflecting on the person's choices, decisions and behaviours (Brookfield, 2015). The core of critical reflection lies in "the idea of systematically and rigorously examining an idea, an experience, a problem, with an attitude of open-mindedness, whole-heartedness, curiosity, and responsibility" (Saric and Steh, 2017, p. 70-71). The definition of reframing value is consistent with critical reflection. Hence, it may be assumed that reframing value is as significant in education as critical reflection, which improves learning skills and problem-solving abilities. The studies show that learners reconstruct their pre-knowledge using critical reflection to improve learning skills (e.g. Brookfield, 2015; Lonka et al., 2001; Blatt et al., 2007; Mamede et al., 2008). Dewey (1933) proposed that reflective action is the active component of behavioural intervention, so reflective action is a useful tool to address difficult issues (Howard, 2003). However, this research mainly analyses the relationship between games and learning value. Reframing value highlights that it is a

learning value to show the changes of reflection, so the author considers how reframing value is promoted rather than critical reflection.

In addition, the perspective of stakeholders also highlights the importance of promoting reframing value. The reframing value in Wenger et al.'s (2011) study included the consideration of institutions/organizations and stakeholders in communities. For example, learners are the stakeholders of the reframing value because they focus on solving problems that occur in their study and when defining success (Wenger et al., 2011). When RPGs replace communities as the social environment which evaluates values, these institutions/organizations and stakeholders play specific roles (e.g. the participants of a game, the organizations of a game and their sponsors/developers) that can gain reframing value.

Many previous studies have shown that using games promotes critical reflection (e.g. Apperley and Beavis, 2011; 2013; Hsiao, 2007; Squire and Barab, 2004; Johnson and Mayer, 2010). For example, games as action-based projects provide the non-visual and non-textual elements of gameplay that can lead to critical reflection (Apperley and Beavis, 2011). Video games are utilised to simulate bias and inaccuracies in order to foster students' rethinking (Squire and Barab, 2004). Game experience scaffolds learning and offers instant feedback/reflection (Hamari et al., 2016). These studies from multiple perspectives such as gameplay, simulation and game experience analyse the effects of the use of games in promoting critical reflection.

Several studies consider games triggering accumulation which refers to the previous actions of players that are reflected in the current situation of the game (O Neil, 2007, Raessens and Goldstein, 2005, Vogel et al., 2006, Vorderer and Bryant, 2012). The accumulation can be explicit through some specific forms including game characteristics (e.g. points, badges). For example, points, badges, and leader boards are used to offer positive reinforcement, motivating a learner's performance (Skinner, 1965, Woolfolk, 1998) and enabling them to measure progression and feedback on behaviour (Gnauk et al., 2012) inspiring student self-efficacy (Bandura, 1982). This is likely to make students rethink learning content and values through their reflection in order to reshape themselves (Suls et al., 2002). This means that game features, to some extent, influence critical reflection. However, few studies have been carried out to investigate the way in which these features impact critical reflection.

Furthermore, little attention has been paid to analysing game features that support learning value. Although there are studies to discuss the value created by video games, the value involves the economic value of the games industry (Marchand and Hennig-Thurau, 2013, Gidhagen et al., 2011) not learning value. Hence, the research is important as it empirically explores how the game features can be related to reframing value and thus contributes to filling the lack of research in this area.

#### **2.4.1.1 Four criteria of reframing value**

Reframing value involves multiple changes of reflection, including rethinking for methods, aims and values, and reshaping the new criteria of success (Wenger et al., 2011). The



changes of reflection both for participants and for their environment are shown in Table 2.5.

**Table 2.5: The indicators for changes of reflection (Wenger et al., 2011)**

Typical indicators	Some potential sources
<b>Community aspirations</b>	New learning agenda New discussions about the value New horizon
<b>Assessment</b>	New indicators New evaluation process
<b>Relationship with stakeholders</b>	Different discussions with stakeholders New stakeholders' involvement New expectations
<b>Institutional change</b>	The new strategic trend that reflects the new situation understanding
<b>New frameworks</b>	New social, institutional, legal or political systems (appear or create)

According to the indicators for changes of reflection, Wenger et al. (2011) inductively split its assessment criteria into four functions: rethinking learning content and values through reflection, changing the processes and patterns of evaluation, reframing the assessment standard for other people, reshaping the new expectation of whole community development.

**Table 2.6: The assessment criteria of reframing value (Wenger et al., 2011)**

Criteria	Reflecting results on value creation: key questions
<b><i>Promoting reflection</i></b> (rethinking learning content and values through reflection)	Does the social learning process lead to a reflection on important issues? If this can change people' perspective of understanding important things?
<b><i>The change of evaluation</i></b> (changing the process and pattern of evaluation)	Does this mean that new standards and new indicators should be included in the assessment?

Criteria	Reflecting results on value creation: key questions
<i>Generating new assessments for other people</i> (reframing the assessment standard for other people)	How those people who have the right to decide standards of success are impacted by the new understanding?
<i>Suggestions for community development</i> (reshaping the new expectation of the whole community development)	Can the new understanding change into institutional change? Due to this new understanding, is there a new framework or system developed or created?

### 2.4.2 Research questions for constructing the model

In order to clarify the relationship between game features of RPG and the four criteria of reframing value, this study presents identifying game features and the way that these features promote reframing value. For this, the research investigated the following questions:

- (1) Which game features may influence reframing?
- (2) Which evaluative criteria of reframing value are affected by game features?
- (3) How game features promote these criteria of reframing value?

### 2.4.3 Theory background for the reliability of the model

An instrument was developed to refine the model of using game features promoting reframing value and capture experts' perceptions for the relationship between game features and criteria of reframing value. This instrument was designed according to the method of Moore and Benbasat (1991) since they propose that an instrument can measure diverse perceptions based on an individual adopts innovation of information technology

(IT). Many studies (e.g. Yılmaz and Olgan, 2020; Gyaurov et al., 2019; Zhang et al., 2011) utilise the instrument as a useful tool for measuring the adoption of study and diffusion of IT innovations (Moore and Benbasat, 1991).

Cronbach's alpha (Cronbach, 1951) was used to measure the reliability of questionnaires. the reliability of the scale depends on the value of Cronbach  $\alpha$  to judge, including  $\alpha$  is above 0.8 (very good),  $\alpha$  is above 0.7 (acceptable),  $\alpha$  is above 0.6 (should be revised) and  $\alpha$  is lower than 0.6 (needs to be redesigned) (Eisinga et al., 2013).

#### **2.4.4 Research questions for the reliability of the model**

In order to ensure the model of game features promoting reframing value is reliable, the problem needs to be solved: what is the reliability of the model?

#### **2.4.5 Theory background for the validity of the model**

This research designs a game experience test (GET) to evaluate normal RPGs participants interacted with in. The GET is built on Chertoff et al.'s (Chertoff et al., 2010) virtual experience test (VET). Since the VET has been presented by Chertoff et al. (2010), there is an emerging body of literature (e.g. Valkov and Flagge, 2017; Palomba, 2020; Turchet et al, 2012) indicating the effectiveness of the VET in the evaluation of virtual experience including digital games.

Such VET refers to a holistic method that measures virtual environment experiences integrating five dimensions sensory, relational, affective, cognitive and active (Chertoff et al., 2010). Every dimension involves related items and 24 items in total are evaluated by

the VET scale using a five-point Likert scale (from 1=strongly disagree to 5=strongly agree).

According to Chertoff et al. (2010), they propose the following explanations of the five dimensions: the sensory dimension regards the use of senses when interacting with the virtual environment. For example, “I found the visual display hardware to be of high quality” (Chertoff et al., 2010, p.106).

The cognitive dimension contains five heuristics, including the ability that the environment supports multiple solutions for the same task, the interest of perceived tasks, description of environmental rules, and the ability of task participation supported by the environment. For example, “I felt that the virtual environment allowed me to complete my task in several different ways” (Chertoff et al., 2010, p.106).

The emotional dimension focuses on the user's expected emotional impact on the scene and the environment conveys the desired emotion of users through dialogue, gestures, facial expressions and audio. For example, “I felt a variety of emotions while working on the environment's tasks” (Chertoff et al., 2010, p.106).

The relational dimension contains the expected level and quality of the interaction between the user and the agent in the environment. For example, “I think that the environment was able to support multiple human users at the same time” (Chertoff et al., 2010, p.106).

The active dimension involves the degree to which users see themselves as characters in the context, the expected level of reusing materials, and the level of narratives used. For

example, “I feel that I could construct a story about my actions in the environment” (Chertoff et al., 2010, p.106).

Nevertheless, this GET is only related to four dimensions relational, affective, cognitive and active since the main aim is not to explore the sensory content or the consistency of sensory information. Rather author is interested in emotions generated in the game, the judgment of the relationship between game features and criteria of reframing value, participants' perceived abilities to complete tasks and to understand the characters' behaviours or environments rules, and the assessment of proposed tasks.

#### **2.4.6 Research questions for the validity of the model**

In order to investigate the validity of the model, the research question is proposed: what is the validity of the model?

## **2.5 Theory background for the research design**

Saunders et al. (2003) suggest that a research process is like an "onion". When people before seeing the centre of the onion, many "onion skin" needs to be peeled off. From the outside to the inside, these "onion skins" represent respectively: research philosophy, research methods, research strategies, time horizons, and data collection methods.

Since Saunders et al. (2003) proposed the research onion, many studies (e.g. Sinha et al., 2018; Hayat et al., 2013; Fitrianto, 2020) have utilised it as an effective tool to help the organisation of the research and development of the research design according to the layers of the research onion (Melnikovas, 2018).

### **2.5.1 Positivism (research philosophy)**

Positivism is one of the research philosophies (e.g. scientific realism) in Saunders et al.'s (2003) "research onion". They indicate that positivism depends on social forces and the nature that can restrict people's opinions and behaviours to recognize the interpretations constructed by people in society or the individual subjective reality (Saunders et al., 2003).

According to Saunders et al. (2009), research using positivism philosophy means that the work with observable social reality can lead to credible data and the final product of such research can be a derivation of laws or rules (Remenyi et al., 1998).

### **2.5.2 Research methods**

Saunders et al. (2003) indicate that deduction and induction are the main research methods. They suggest that the deductive process is researchers designing a research strategy to

verify their hypothesis. The inductive method means that data analysis based on data collection and theoretical development.

### **2.5.3 Case study (research strategy)**

The layer of research strategy involves multiple methods of problem-solving such as case study (Saunders et al., 2003). Yin (2003) proposes that the case study approach refers to the experience that is used in a real environment to investigate current phenomena involving single and multiple case designs.

This study adopted the multiple-case study method given its nature and advantages. First of all, the strategy of case study is broader used to answer questions such as "what", "why", and "how to do" (Saunders et al., 2003, Yin, 2003). Since it can better explain the scope and the process of the study (Morris and Wood, 1991). Secondly, the multiple-case study approach usually provides rich sources in order to make the whole research is more convincing (Yin, 2003). Finally, various items such as literature and comments can be collected as research evidence (Yin, 1989).

## **2.6 Summary**

This chapter describes related theory backgrounds, including serious games, the importance of IBL for education, the definition of COI, value creation theory and the relationship between game features and critical reflection. Through reviewing these theory backgrounds, the thesis clarifies what has been done before and which research gaps still need to be addressed.



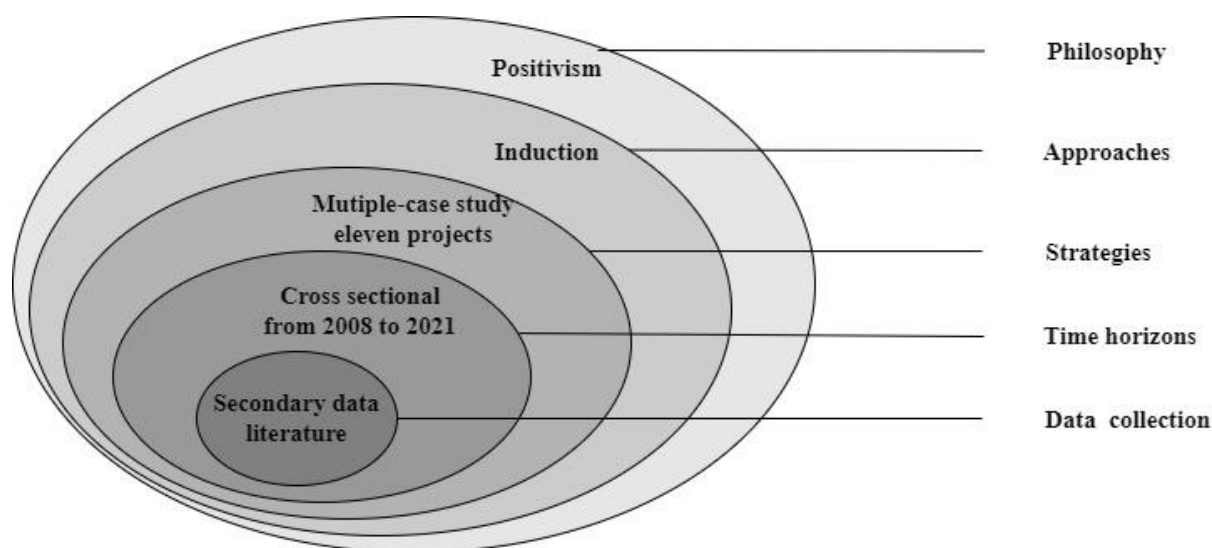
### **3 Methodology**

This chapter clarifies the research approaches. This includes related research process, data capture, data analysis, sample size, calculation of inter-coder consistency and testing the reliability and validity for the model of using role-playing games (RPG) to promote reframing value.

The research onion had been utilised throughout the methodology of this thesis as an effective tool to help the organisation of the research and development of the research design according to the layers of the research onion (i.e. research philosophy, research methods, research strategies, time horizons, and data collection methods).

#### **3.1 Exploring serious games supporting inquiry-based learning**

Sahay (2016) indicates that when a relationship is being studied, the philosophy of positivism generally is used by researchers. The first step of this study considered positivism as the research philosophy given the aim of the study was to explore the relationship between game characteristics and three core features of IBL. Game features and the three core characteristics of inquiry-based learning (IBL) were inductively extracted. According to Saunders et al. (2003), the research process was shown using the “*Research Onion*”:



**Figure 3.1 Methodology of exploring serious games supporting IBL adopted from Saunders' *Research Onion* (2003)**

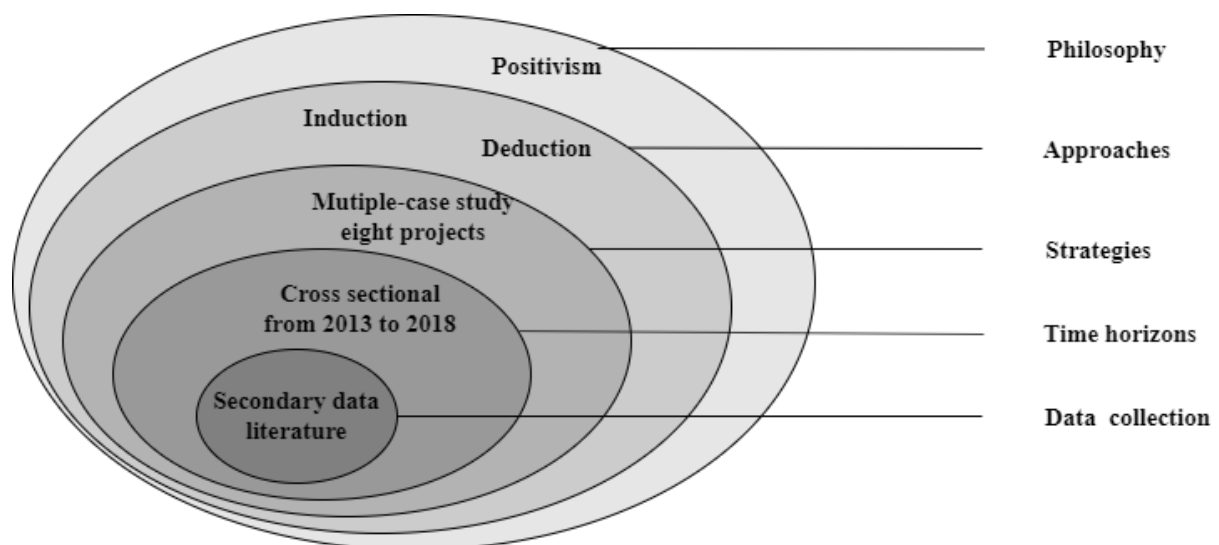
This study conducted a systematic database search using Summon (an integrated search engine that provides access to scholarly material across multiple databases and library collections, including Scopus, PsycARTICLES, sycCRITIQUES, and PsycINFO). Due to the lack of articles in this research field, the author looked for articles published between 2008 and 2021 using “\*nquiry-based learning” and “serious games” as keywords. The search yielded 108 papers, which were then screened by title and abstract to exclude non-pertinent documents.

Criteria for exclusion were: (a) addressing IBL or games separately; (b) presenting games and/or data presented in another publication (in these cases, only one was retained). Most papers did not discuss both aspects of IBL and educational games, and hence 91 papers were excluded. The remaining 17 papers were fully read, and 12 papers were selected for this review.

Data from the papers were extracted using a specially created form involving the method that game features support IBL and related evidence in projects reviewed. Game features were then described and analysed based on the function they had over the three core IBL features. The similar game features found in different games and game-based strategies were grouped in broader categories and general mechanisms supporting IBL were synthesised.

### 3.2 The value creation in communities of inquiry

The second step of this study investigated the relationship that actual values created by communities of inquiry (COI) and weaknesses generated during the process of value creation in COI. Positivism was considered as this research philosophy, as Sahay (2016) indicates that when a relationship is being studied, the philosophy of positivism generally is used by researchers. Activities of COI were collected using the inductive method. The values created by these activities adopted the deductive method that gave research problems and then solved them by analysing activities collected. Based on Saunders et al. (2003), the research process was drawn as follow:



**Figure 3.2 Methodology of the value creation in COI adopted from *Saunders' Research Onion* (2003)**

### **3.2.1 Data selection**

The literature reviewed came from Summon (an integrated search engine that provides access to scholarly material across multiple databases and library collections, including Scopus, PsycARTICLES, sycCRITIQUES, and PsycINFO). The keywords: ((community) AND ((virtual) OR (online))) AND (((inquiry) AND (COI)) OR ((enquiry) AND (COE))) were used within journal articles and conference proceeding. Because to gain the latest documents, this research chose papers published within 5 years currently. The articles had to be peer-reviewed, published between 2013 and 2018 and written in English, thus yielding 829 papers. This result was screened based on abstracts and titles to exclude irrelevant 770 articles. 59 papers were fully reviewed, 51 papers were excluded as they did not clarify the activities of communities. Eight papers were finally selected for this review.

### **3.2.2 Data analysis**

This investigation aimed to find the values in every activity described in COI. Mixed content analysis (deductive and inductive) was conducted according to Miles et al. (2014). The following codebook was edited using NVivo software (v 12 Pro). See Figure 3.3.

Name	Files	References
Chanprasitchai and Khlaisang(2016)	0	0
applied value	0	0
30 How is it different from my practice or life or background	0	0
CP	0	0
Exploration	1	1
Resolution	1	1
Triggering event	1	1
+ immediate value	0	0
+ potential value	0	0
+ realized value	0	0
+ reframing value	0	0
+ Eteokleous and Ktoridou(2012)	0	0
+ Junus et al.,(2017)	0	0
+ Keles. (2018)	0	0
+ Padilla & Kreider (2018)	0	0
+ Pellas & Boumpa (2017)	0	0
+ Setiani and MacKinnon(2015)	0	0
+ Wang, Y. et al. (2016)	0	0

**Figure 3.3 Codebook excerpt**

### 3.2.3 The process of coding

In the codebook, a theory of five-cycle value creation (immediate, potential, applied, realized and reframing values) was the main category. According to the key questions of main categories, three core presences (TP, SP, and CP) of COI and their indicators were deductively coded as subcategories. For example, coders needed to identify if these

activities of CP associated with the key question "Does the social learning process lead to a reflection on important issues?"

The descriptions of activities and their classification within presences of COI were analysed as manifest and latent contents in all cases. Manifest contents were directly collected as they were already clearly reported in these papers reviewed. For example, Eteokleous and Ktoridou (2012) directly recorded an activity in which students explored, investigated and discussed the concepts of the course. The coding of latent contents for the descriptions of activities (e.g. showing doubts/confusion, identifying and correcting misunderstandings of myself or others) (Junus et al., 2017) was inductively conducted, according to the action verbs described in each paper (e.g. "guide", "encourage" and "convey"). After this, these manifest and latent contents were required coders to specifically classify activities into presences of COI.

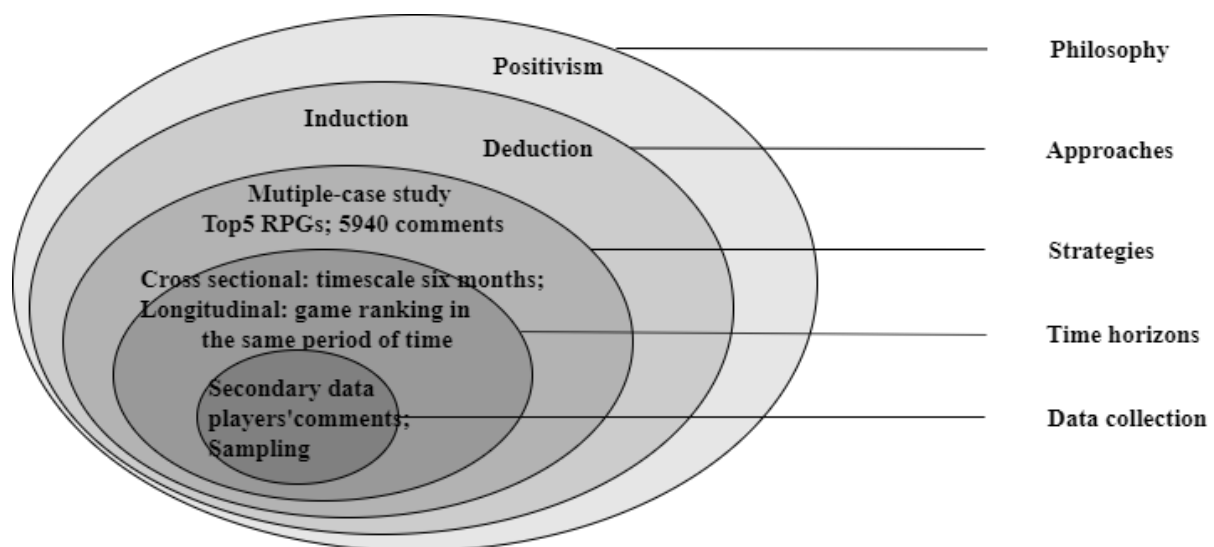
The coding schema was developed and refined through preliminary field testing before it was applied. The two coders (one was the thesis author, another was a PhD student) classified the same data units with subsequent comparison of their results. They negotiated with each other before the process of coding in order to ensure the consistency of information of 109 activities provided by them. They agreed that a high level of activity in the network often indicated a sign that something valuable was happening. Hence, if emoticons, photos, stickers and hyperlinks were used very frequently, then they could be considered valuable. In order to calculate the inter-coder reliability of this analysis, Cohen's kappa (90% estimates of the confident interval) statistic was used (Cohen, 1960), obtaining

kappa scores consistently equal to 0.86. This indicated a high level of agreement between coders (McHugh, 2012).



### 3.3 A model of game features promoting reframing value

The third step of this study aimed to extract game features that promote related value in order to rectify the weaknesses generated during the process of value creation in COI. This relationship between game features and reframing value was investigated, which meant that this research considered positivism was used as the research philosophy. This was consistent with Sahay (2016) who indicates that when a relationship is being studied, the philosophy of positivism generally is used by researchers. Game features were inductively identified and the model of game features promoting reframing value was presented utilising the deductive method. A “*Research Onion*” (Saunders et al., 2003) showed this research process.



**Figure 3.4 Methodology of the model adopted from *Saunders' Research Onion* (2003)**

### **3.3.1 Sample selection**

This study took two stages for sample selection. Firstly, RPGs were collected according to a specific ranking list. Secondly, game participants' comments were selected from these RPGs which were identified in the first stage.

RPGs were selected based on China games weight rank (CGWR) (CGWR is constructed by the company of *Sina*, which is the most authoritative, professional and fair game list in China. The list brings all the online game products tested and operated together in Europe, the United States, Japan, Korea and China. It has been divided into six major scores and several options for game information. It creates the most trusted platform for new game recommendations for Chinese players). The ranks of CGWR were published on August 13th, 2019 and the addresses were as follow. See Figure 3.5 and Figure 3.6.

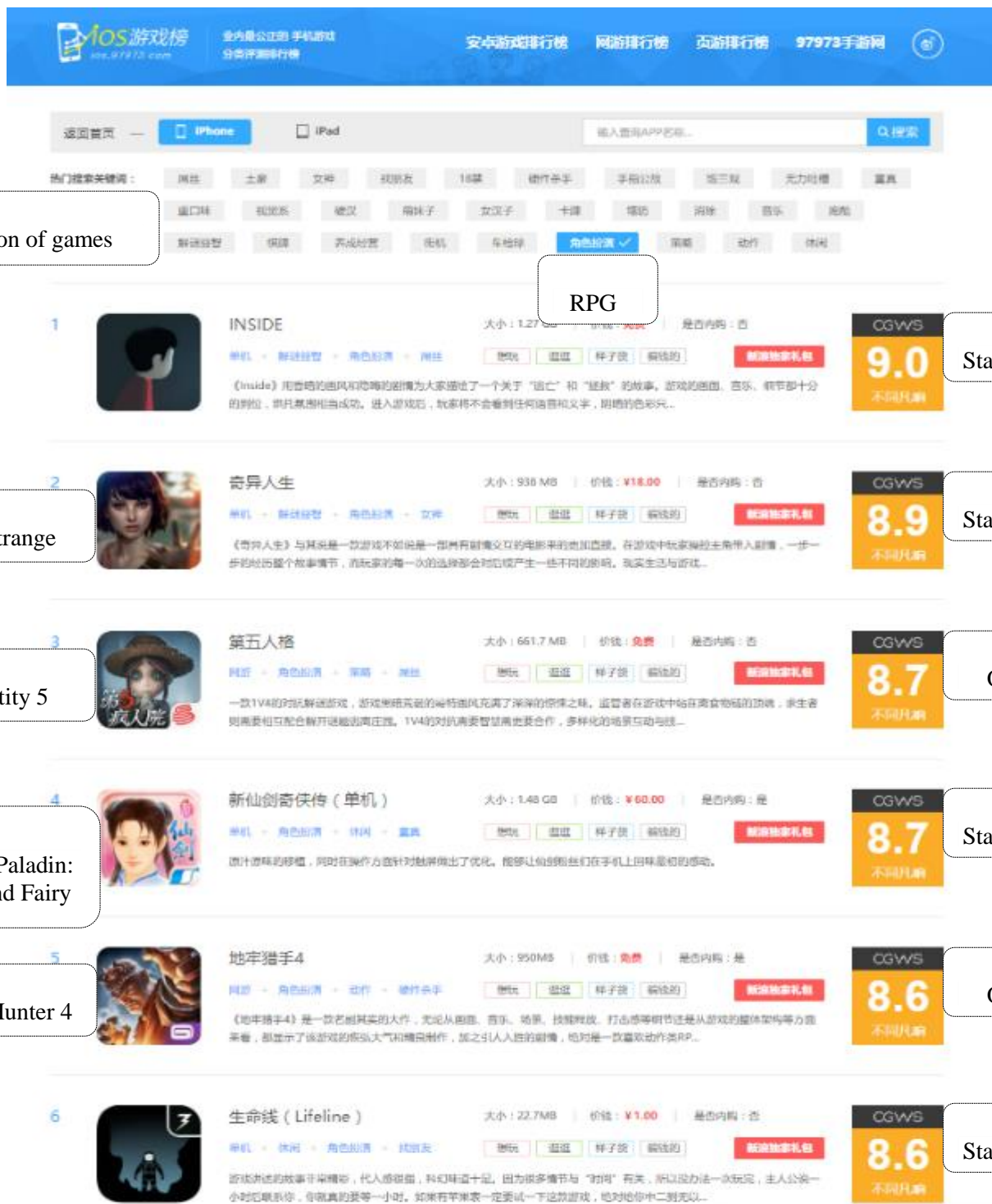
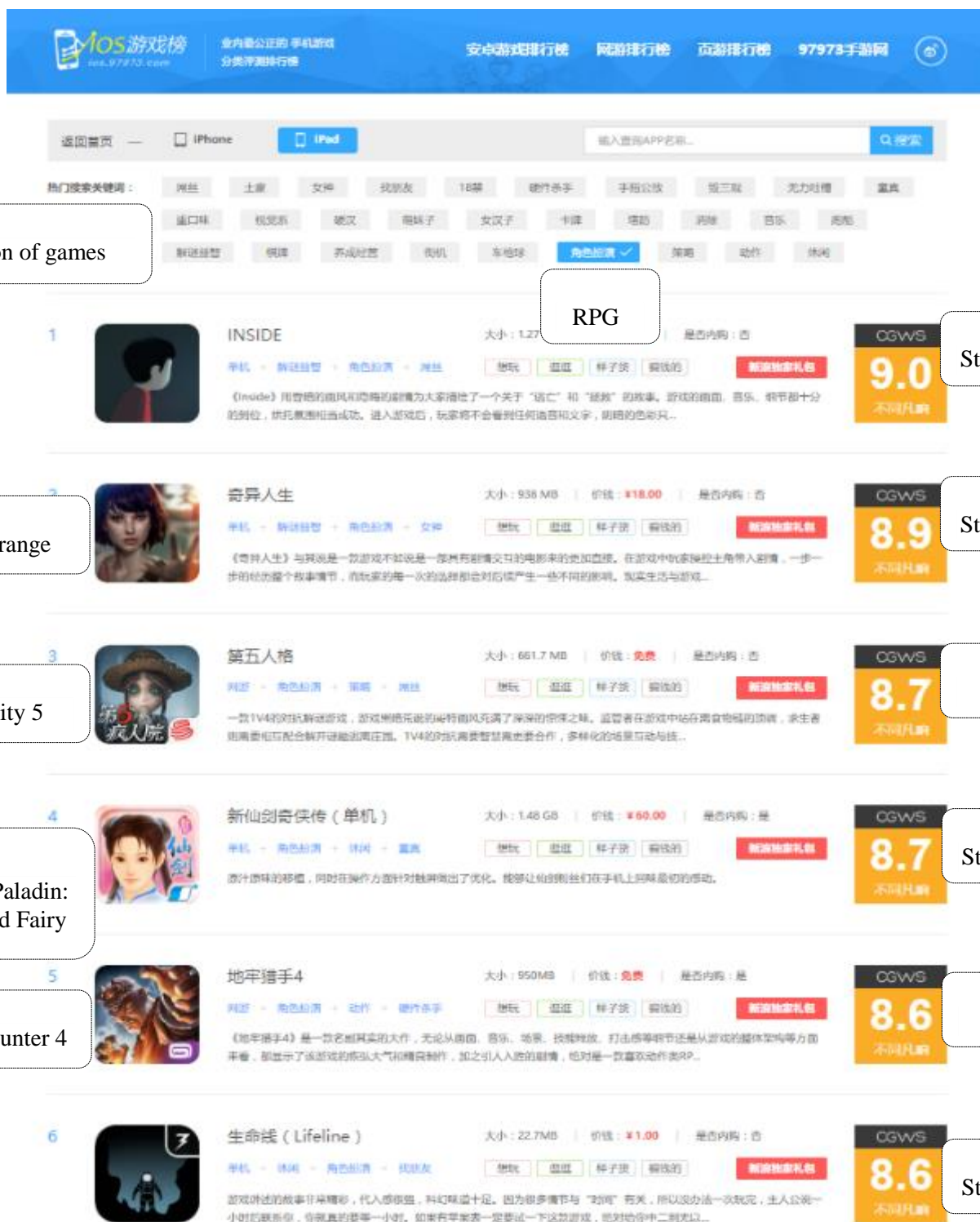


Figure 3.5 The rank of role-play games in CGWR for iPhone

([http://ios.97973.com/ios/hotlist?f=0\\_11\\_0\\_0\\_0&f2=0\\_0\\_11\\_0\\_0&platform=iphone](http://ios.97973.com/ios/hotlist?f=0_11_0_0_0&f2=0_0_11_0_0&platform=iphone))



**Figure 3.6 The rank of role-play games in CGWR for iPad**

([http://ios.97973.com/ios/hotlist?f=0\\_11\\_0\\_0\\_0&f2=0\\_0\\_11\\_0\\_0&platform=ipad](http://ios.97973.com/ios/hotlist?f=0_11_0_0_0&f2=0_0_11_0_0&platform=ipad))

The sample of RPGs was selected according to the following criteria: (1) to choose the game genre of RPG; (2) to choose the Top5 games in the grossing rank for iPhone operation system (IOS) (e.g. iPhone or iPad); (3) the Android market was excluded because it has not a uniformed and authoritative ranking platform in China.

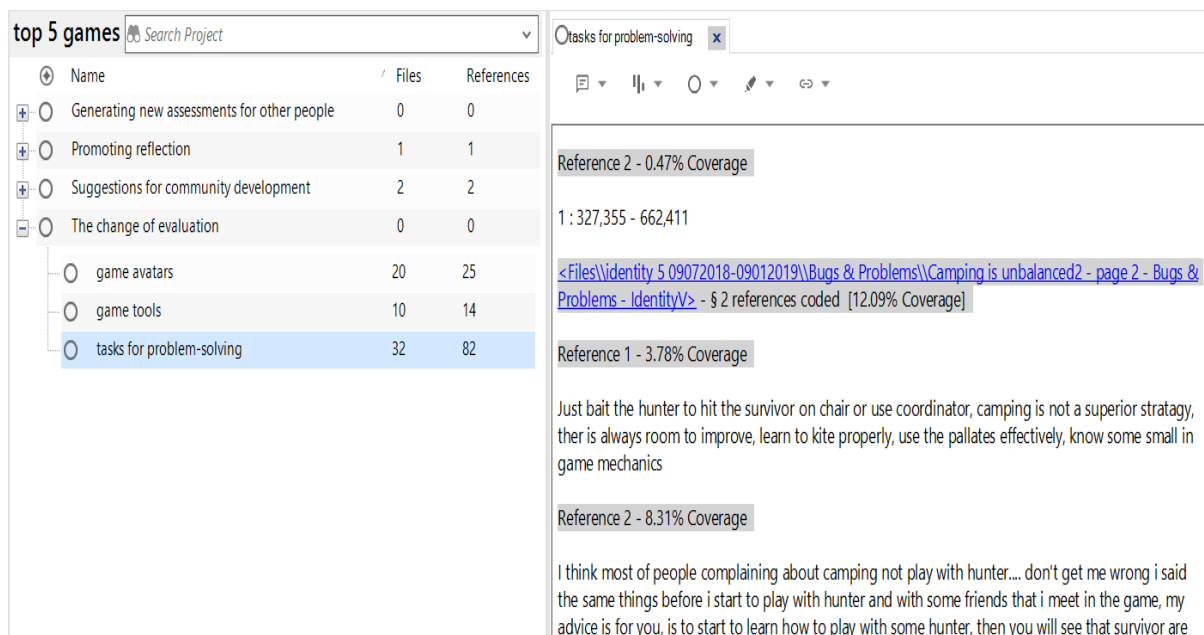
The comments were collected from the official website of the RPGs or the forum of Steam (Steam is one of the largest platforms which integrate digital products in the world. It enables players to purchase, download, discuss, upload and share games and software). The following criteria were used to select comments: (1) the theme of the comment was the unit of the sample; (2) comments came from Steam. However, players did not post comments in Steam that is why coders selected these comments from the official website. If the comments of the game were not to be found both in Steam and the official website, the game (e.g. *Hunter4*) was excluded; (3) the timescale for the comments was 6 months which started from the first theme posted in the forum of the game. For example, the first comment posted in the forum of *Lifeline* was March 9th, 2017, so the time was selected from March 9th, 2017 to September 9th, 2017; (4) due to different contents being posted for the same theme or different themes by the same participant, coders counted the number of comments and themes rather than counted the players' number. Finally, 1020 themes of players' comments were collected in total. See table 3.1.

**Table 3.1: The table for the details of participants' comments**

The top 5 games	The time scale	The number of the themes	The number of players' comments
<b>1. <i>Inside</i></b> This is an RPG game that focuses on solving puzzles on a black and white game screen. The player controls the little boy to walk, run, swim, climb, and use objects. When the player fails to quickly solve the puzzles (e.g. because of drowning underwater for too long) the boy controlled by the player will die.	12/06/2017-12/12/2017	45	2391
<b>2. <i>Life is strange</i></b> The protagonist of the game is Max. She finds that she has the ability to return to the past. This leads to a butterfly effect whenever she uses this ability. The game storyline is that Max foresees a storm will come, she must take responsibility to protect the town. Players' actions will affect the development of the story. The game allows and encourages players to use Max's ability (i.e. manipulating time) to reshape the plot.	30/01/2015-31/07/2015	28	879
<b>3. <i>Identity5</i></b> This is a massively multiplayer online role-playing game. The players control different game avatars and generate interaction in the game.	09/07/2018-09/01/2019	827	2036
<b>4. <i>Chinese Paladin: Sword and Fairy</i></b> The game is designed based on incorporating elements of martial, magic and fantasy. According to the setting of the storyline, the player controls the characters to complete diverse tasks (e.g. finding lost items).	19/09/2017-19/03/2018	98	523
<b>5. <i>Lifeline</i></b> As the spacecraft crashed, astronaut Taylor was trapped on a strange planet. The players help Taylor solve various problems using real-time communication with him in the game (e.g. messages). And players can choose the branch of the plot to guide Taylor's adventure.	09/03/2017-09/09/2017	22	111

### 3.3.2 Data analysis

This study used a mixed content analysis (quantitative and qualitative) to analyse 5940 comments of players. These comments were coded with the NVivo software (v 12 Pro), full codebook available upon request from the corresponding author. See Figure 3.7.



**Figure 3.7 Codebook excerpt (the number of the themes was collected in Files; the number of players' comments was collected in References)**

The four criteria of reframing value (e.g. promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people) were coded as the main category of the codebook. Coders needed to extract game features and identify if the game features associated with these criteria according to the comments which involved evidence of reframing.

The two coders (one was the thesis author, another was a PhD student) classified the same data units with subsequent comparison of their results. Specifically, two coders independently coded to extract reframing content in all comments, based on whether the comments provide evidence of the reframing process firstly. The data included (1) evidence of effected reframing (players directly posted their opinions without discussion with other players); (2) evidence of stimulated reframing (players were triggered by other players' comments to present their ideas).

Secondly, these reframing comments were classified according to the criteria of reframing value. Because the reframing value was evaluated in RPGs, some potential descriptions were considered based on the assessment criteria of reframing value (Wenger et al. 2011): (1) promoting reflection -rethinking game content and values through reflection; (2) the change of evaluation -changing the gameplay processes and patterns/presenting new game strategies that help players to win or solve problems; (3) generating new assessments for other people -proposing the assessment standard (e.g. players directly posted their opinions regarding characters' behaviours; players changed their opinions regarding characters' behaviours) for different identities with playing games (Gee 2007) including self, teammates, enemies and other players; (4) suggestions for community development-reshaping the new expectation of the whole game development, which means that game players provide suggestions (e.g. revising game design/errors/modes) to game developers.

Finally, game features were extracted qualitatively from the comments which involved evidence of reframing. The two coders through negotiation before the process of coding



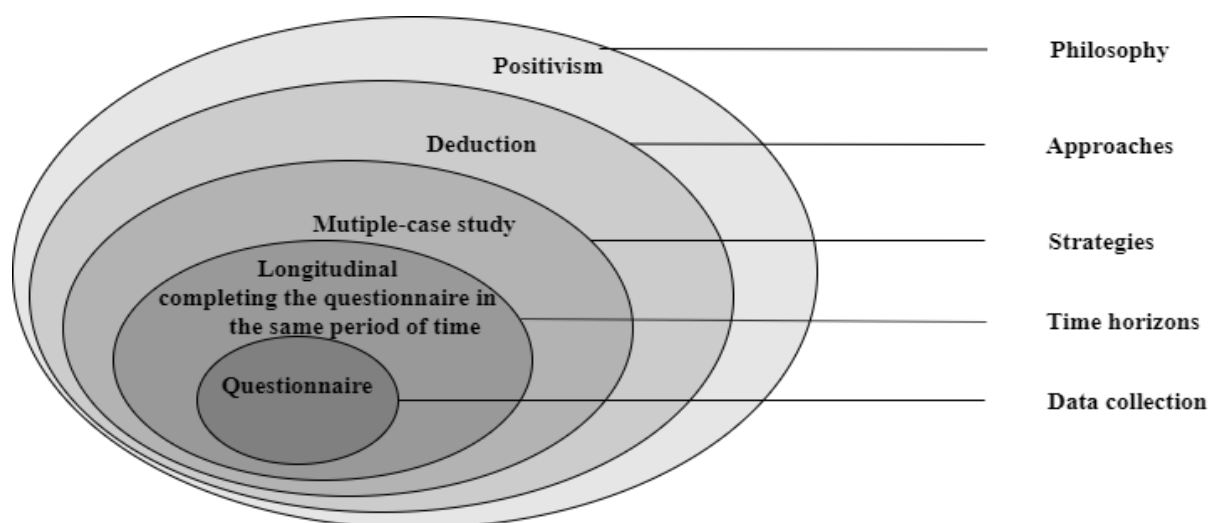
confirmed the consistency of information. For example, they agreed that players proposed game strategies that involved suggestions to game developers or other players. According to this, coders needed to negotiate whether these game strategies (e.g. the application of the game tools, revising game time) were proposed regarding game developers or other players. This study obtained a high level of agreement ( $\kappa=0.85$ ) between coders (McHugh, 2012) utilising Cohen's (1960) kappa statistic ( 90% estimates of the confident interval).

The model used a specially created form that described strategies of game features promoting the four evaluative criteria of reframing value (e.g. *promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people*).

### **3.3.3 An instrument for evaluating the reliability of the model**

Based on Saunders et al. (2009), research using positivism philosophy means that the work with observable social reality can lead to credible data. This research considered positivism as research philosophy given the aim was to measure the reliability of the model (i.e. credible data) through analysing the questionnaire completed by related experts according to their game-teaching experience (i.e. the work with observable social reality). This process of measurement used the deductive method that the high score evaluated by 39 experts confirmed the model was reliable.

According to Saunders et al.'s (2003) *Research Onion*, the research process was designed.



**Figure 3.8 Methodology for measuring the reliability of the model adopted from Saunders' *Research Onion* (2003)**

An instrument was developed to refine the model of using game features promoting reframing value and capture experts' perceptions for the relationship between game features and criteria of reframing value. This instrument was designed according to the method of Moore and Benbasat (1991) since they propose that an instrument can measure diverse perceptions based on an individual adopts innovation of information technology (IT). This instrument consists of three stages: generation of the instrument items; categories for the organisation of items; instrument testing.

The aim of the first stage was to confirm the clarity of game features as created items. Two game-analysis experts who were familiar with the theoretical background of games assessed these definitions of game features. They conceptually pilot tested these game features with kinds of RPGs in order to refine the definitions of game features. For example,

“attractive” is a highly subjective word, the concept of “attractive game stories” was not objective. The experts suggested that when defining game features should be as objective as possible. After this, the author defined the game feature as “game stories” in order to exclude the ambiguity of the game feature.

The objective of the second stage was to classify the game features confirmed. The four criteria of reframing value were instrument scales in order to evaluate the game features: “if players rethink the game content to lead to a reflection on important issues or change people’s understanding for important things”, “if players reframe the assessment standard for other people”, “if players reshape the new expectation of the whole community development” and “if players change the process and pattern of evaluation via the game experience”.

The third stage was to reword 10 game features according to instrument scales to a questionnaire form for evaluation. For example, in the criteria for “change of evaluation,” it is investigated “if players change the process and pattern of evaluation via the game experience” by: (1) game avatars; (2) the game design of particular style; (3) tasks for problem-solving; (4) game tools. The promotion of reframing value was assessed via a single item on a five-point liker scale (1: “strongly disagree; 5: “strongly agree”).

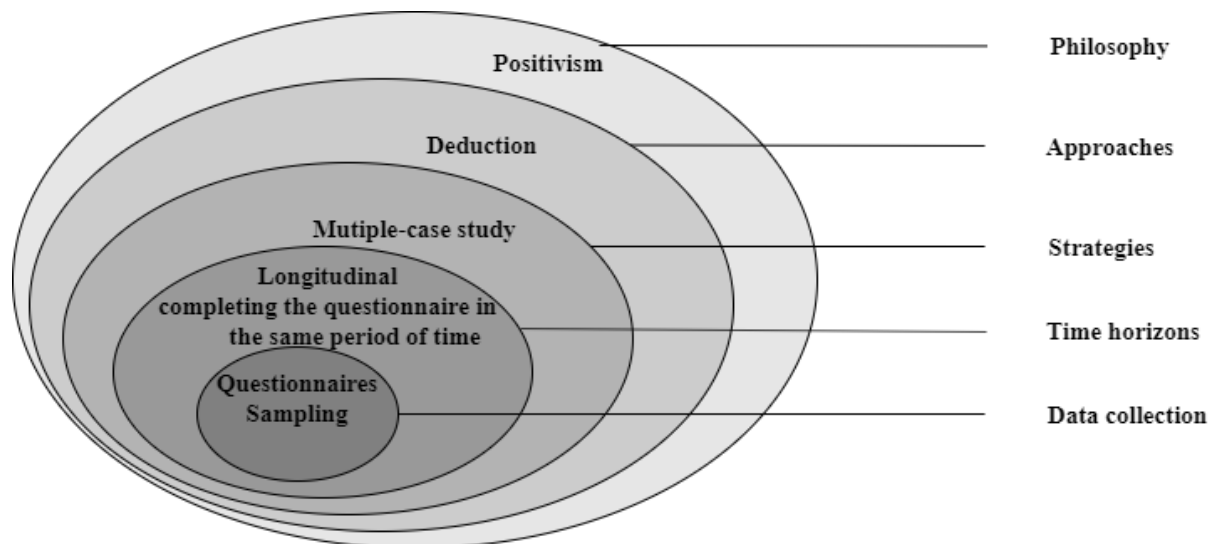
The expert evaluation was conducted to assess the reliability of the analysis instrument. According to Gay and Diehl (1992), at least 30 subjects are required as an acceptable number of respondents in correlational research. So 39 game-teaching experts coming from

China participated in the test independently. All testers were familiar with critical reflection theory and the underpinning model. These experts according to their game -teaching experience completed the online questionnaire. The full Chinese version is available from the address: <https://www.wjx.cn/jq/54588262.aspx>. The English version is listed in Appendix C.1.

Cronbach's alpha (Cronbach, 1951, Eisinga et al., 2013) was used to measure the reliability of the questionnaire, obtaining Cronbach  $\alpha=0.940$ . This meant that the reliability was high (Eisinga et al., 2013).

### 3.3.4 The validity of the model

The following “Research Onion” showed the research process.



**Figure 3.9 Methodology for measuring the validity of the model adopted from Saunders' Research Onion (2003)**

Based on Saunders et al. (2009), research using positivism philosophy means that the work with observable social reality can lead to credible data. This research considered positivism as research philosophy given the aim was to measure the validity of the model (i.e. credible data) through analysing related questionnaires completed by the testers after playing a specific game (i.e. the work with observable social reality).

#### **3.3.4.1 Game sample**

The three RPGs (*Chinese Paladin: Sword and Fairy 3*, *Limbo* and *World of Warcraft*) were collected to conduct this investigation, given the nature of these games and their popularity.

*Chinese Paladin: Sword and Fairy 3* is a stand-alone RPG game developed by *Dayu* Company. It was published in China in 2003. This game won the most popular RPG game in China voted by players. The game story is designed based on Chinese martial arts. Players control the character to attend events and fight monsters, completing a series of tasks.

*Limbo* is an RPG game developed by *Playdead Studios*. So far, the game has won more than 100 game awards, such as the best download game (*GameInformer*). The player controls a little boy in the game to seek peace on the edge of hell.

*World of Warcraft* is a multiplayer online RPG game produced by *Blizzard* Company. According to the statistics of China's office web in January 2020, about 900,000 people log in to the game in a single day. The plot of the real-time strategy game "*Warcraft*" was

utilised as the historical background of this game. Players play a specific character (i.e. Magician and elf) to explore, adventure, and complete tasks in this virtual world.

#### **3.3.4.2 Sample size and participants**

The sample size of factor analysis was determined according to Gorsuch's (1983) suggestion that the required number of participants is obtained using the total numbers of items being multiplied to 5. This method which uses a subject-to-item ratio of 5:1 to construct validity in the sample size is preferred by many studies (e.g. Alsubaie et al.,2020; Bunz et al.,2020; Diao et al.,2020).

The testers (106) coming from China were divided into three groups (34 participants evaluated 5 items in *Chinese Paladin: Sword and Fairy 3*, 37 participants evaluated 7 items in *Limbo* and 35 participants evaluated 5 items in *World of Warcraft*). Three tutors managed testers' participation in order to ensure testers completing related questionnaires after playing a specific game for three days. The three groups were composed respectively of 19 teachers and 15 students, 20 teachers and 17 students, 18 teachers and 17 students. These testers were selected randomly, some usually played digital games and some did not play.

The questionnaires included these items: (1) participants' status (teacher or student). (2) If the related game features were covered by the game testing. (3) 17 items were utilised involving four dimensions, relational (i.e. "I thought that the rank system of the game was able to support multiple players at the same time"), affective (i.e. "I felt a sense of responsibility in controlling roles' destiny while working on the options of multiple-endings of the game"), cognitive (i.e. "I felt that game tools allowed me to complete my

task in several new strategies of matching”) and active (i.e. “I believed that I was the game avatar I was controlling”). (4) What the extent to game features supporting criterion of reframing value is. This used a five-point liker scale (1: “strongly disagree; 5: “strongly agree”) and there is an “other” point that needs evaluators to provide their other attitudes to explain how the specific feature could be improved. The full Chinese version is available from the address: <https://www.wjx.cn/report/63422586.aspx>. The English vision is listed in Appendix C.2.

This evaluation used Cronbach's alpha (Cronbach, 1951) to measure the reliability of three questionnaires, Cronbach  $\alpha$  equals to 0.892 (5 items, *Chinese Paladin: Sword and Fairy 3*), 0.919 (7 items, *Limbo*) and 0.905 (5 items, *World of Warcraft*), respectively. The reliability of the three questionnaires was robust (Eisinga et al., 2013).

Furthermore, due to the difference in the testers’ status (e.g. teacher and student), this thesis author considered that assess differences between teachers and students mentioned with respect to promoting reflection. the Multifactor Analysis of Variance (ANOVA) was used to measure the major influence across variables between teachers and students on the consent of game features.

### **3.4 Summary**

This chapter describes the research methods. All studies used positivism as the research philosophy because research data could be obtained by observable social reality (i.e. IBL-based games, activities of COI).

For exploring serious games supporting IBL, this step presents a literature review that aims at determining the game features utilised in the game and the gamification strategy designed to promote IBL and their effects on students' achievement. Through a systematic database search, 12 studies were included in the review. An inductive method was utilised to extract game features of IBL-based games.

The second step of this research analysed eight papers to review activities of COI as the key link which connects COI and value creation. This investigation used a mixed-method (inductive and deductive) to analyse data.

The third step of this research proposes a model to clarify the relationship between digital RPGs and reframing value. According to 5940 comments of players, coders constructed the coding book and inductively extracted RPG game features. After this, questionnaires were used as investigation tools to test the reliability and validity of the model of game features promoting reframing value. The deductive method was utilised in the process of measuring reliability and validity, respectively.



## **4 Research results**

This chapter proposes related research results such as an overview of characteristics of a game-based inquiry-based learning strategy; the actual values that communities of inquiry (COI) can contribute to improving learning experiences in virtual environments; game features that may influence reframing value have been extracted.

These research results are given according to related research questions mentioned before one by one.

### **4.1 Exploring serious games supporting inquiry-based learning**

#### **4.1.1 What are the characteristics of a game-based inquiry-based learning strategy?**

The study found that serious games reported by 12 papers had some certain similarities. For example, all of the papers discussed the participants' characteristics, most papers mentioned the arrangement of game time and the type of game. Therefore, the participants in games, playing game time and the game genres as three characteristics of game-based inquiry-based learning strategy were proposed in Table 2.3.

Most studies (n=9) concerned with the use of serious games support inquiry-based learning (IBL) of students. However, only a few studies (n=3) reported that IBL serious games promoted teacher training.

Regarding this issue, this has a work expanded in Appendix A that from the perspective of empirical studies, explore the feasibility of serious games applied supporting teachers' professional development.

Most articles reviewed indicated that students involved aged six to eighteen including primary schools and secondary schools. Only one paper discussed the field of higher education. See Table 4.1.

**Table 4.1: Characteristics of a game-based IBL strategy**

	Study	Characteristics of game-based IBL strategy		
		Participants in games	Playing game time	Game genres
1	Hwang, Chiu, and Chen (2015)	P, 6th-grade students	120 minutes in classroom	RPG
2	Lameras and Moumoutzis (2015)	P,S,H	out of classroom	not reported
3	Hwang and Chen (2017)	P, 6th-grade students	3 weeks for 4 periods per week in classroom	adventure game
4	Kennedy-Clark, Galstaun, and Anderson(2013)	T	2 hours in classroom	RPG
5	Kalz M et al. (2014)	S, 8th grade students	5 weeks for 2 and 4 hours a week in classroom	not reported
6	Meesuk and Srisawasdi (2014)	S, Study 1: 12th-grade students P, Study 2: 10th-grade students	study1 20 minutes; study2 not reported in classroom	shooting game
7	Sabthisin et al. (2012)	S, 8th grade students	55 minutes in classroom	RPG
8	Chee et al. (2011)	S	twice a week during 4 weeks and 6 sessions	RPG

	Study	Characteristics of game-based IBL strategy		
		Participants in games	Playing game time	Game genres
			for each session 120 minutes in classroom	
9	Lameras et al. (2014)	T	not reported	RPG
10	Firssova et al. (2014)	S, 8th grade students	5 weeks for 2 and 4 hthiss per week in classroom	not reported
11	Dorji,Panjaburee and Srisawasdi(2015)	S, 10th grade students	not reported	strategy game
12	Okada et al. (2019)	T	not reported	Augmented reality (AR)
P: primary, S: secondary, T: teacher, H: higher education				

This research found that there was mixed evidence for the arrangement of playing game time. Some were periodical, which was consistent with the stage structure of IBL, others were arranged as an intact time. For instance, Kalz M et al. (2014) arranged the playing time into five weeks between two to four hours per week. When the first week ended, learners just completed a part process of IBL. Sabthisin et al. (2012) suggested that the playing game time was 55 minutes. Most studies (n=8) showed that the time was spent in a formal classroom rather than out of the classroom.

A variety of game genres were used including strategy, role-playing, and shooting (Wolf, 2001), but RPG was discussed in most studies (n=4) reviewed.

#### **4.1.2 What game features have been used to support IBL?**

This analysis identified thirteen game features supporting different aspects of IBL (Table 2.4). Half of the games and game-like activities included six or more features. The lowest number of game features was found in Lamerias and Moumoutzis (2015) and Kalz et al. (2014), which included two features each, while the highest number of features supporting IBL was present in the games by Hwang, Chiu and Cheng (2015) (nine features), Hwang and Chen (2017) and Sabthisin et al (2012) (eight features each).

The most used game features found in the different games and game-based activities were the use of a game context mirroring real-world contexts (n=9), and coherent game environment with specific rules, artefacts, potential goals and action possibilities (n=8). The least used game features were contextualised feedback (n=1), task assessment mechanics (n=1), and non-linear exploration of information (n=3).

#### **4.1.3 What aspects of IBL are being supported by game features?**

Most game features found in this review were oriented at supporting one (n=5) or two (n=6) core aspects of IBL. For example, game tips and scoring systems were aimed primarily at providing guidance, while interactive artefacts and contextualised feedback were used to support guidance and the creation of a meaningful environment. Only two game features, namely storyline and structured game tasks, were used to support the three core characteristics of IBL.

#### **4.1.3.1 Game features**

**(1) Game tips** (Hints given by the game at certain points which like some dialogues with virtual characters). For example, energy-consuming graphs show the ratio of the energy consumption of various household appliances and the formula “your saving=income-cost of energy” is used to prompt students (Dorji et al., 2015).

**(2) Scoring system** (The game report students’ scores or achievement, which students can check). For example, students choosing the way to save money can decide their score to be increase or decrease, which stimulates their inquiry by the feedback of the scores (Hwang et al., 2015).

**(3) Storyline** (Central compelling storyline linking several gaming tasks which may coexist with specific inner stories for separate tasks). For example, the outer storyline is to participate in a competition for winning a villa. Students are guided to participate in three gaming steps, where they follow the gaming inner storylines, to learn the relationships between the prizes and risks of different ways of investment (Hwang et al., 2015).

**(4) Interactive artefacts** (Different materials, icons, and objects in the environment with which the player can perform actions). For example, the blue shield provides hints as to what to look for or where to look for information (Hwang and Chen, 2017).

**(5) Structured game tasks** (Series of goal-oriented tasks presenting a structured organisation of steps to complete them). For example, one of six tasks provides sea

knowledge to students' learning, where is designed involving some questions and prompts of real sea creatures (Hwang and Chen, 2017).

**(6) Contextualised feedback** (Information given to the player regarding his/her performance with is meaningful to gameplay or game context). For example, in a microbiology scenario, a camp nurse reviews the diagnosis worksheet elaborated by students (Sabourin et al., 2012).

**(7) Nonlinear exploration of information** (Completion of tasks is done through iterative and non-consecutive processes). For example, students can gather data using different strategies and methods that serve to fill in, correct and update information in diagnosis worksheets and laboratory tests (Sabourin et al., 2012).

**(8) Gameplay-context coherence** (A real-like or fictitious game environment with specific rules, related artefacts and action possibilities, which convey internally coherent meanings). For example, a virtual medieval background is built in a game to help learners conduct detective activity (Kennedy-Clark et al., 2013).

**(9) Task assessment mechanics** (Evaluation system is provided for students to test skills and/or knowledge understanding). For example, two tests were used in the game to evaluate the students' achieving process and assist to review previous learning concepts (Hwang and Chen, 2017).

**(10) Multiple weapons** (Choice among weapons to attack monsters or produce specific impacts or results). For example, students' weapons have different ammunitions to help them escape from the lab (San Chee et al., 2011).

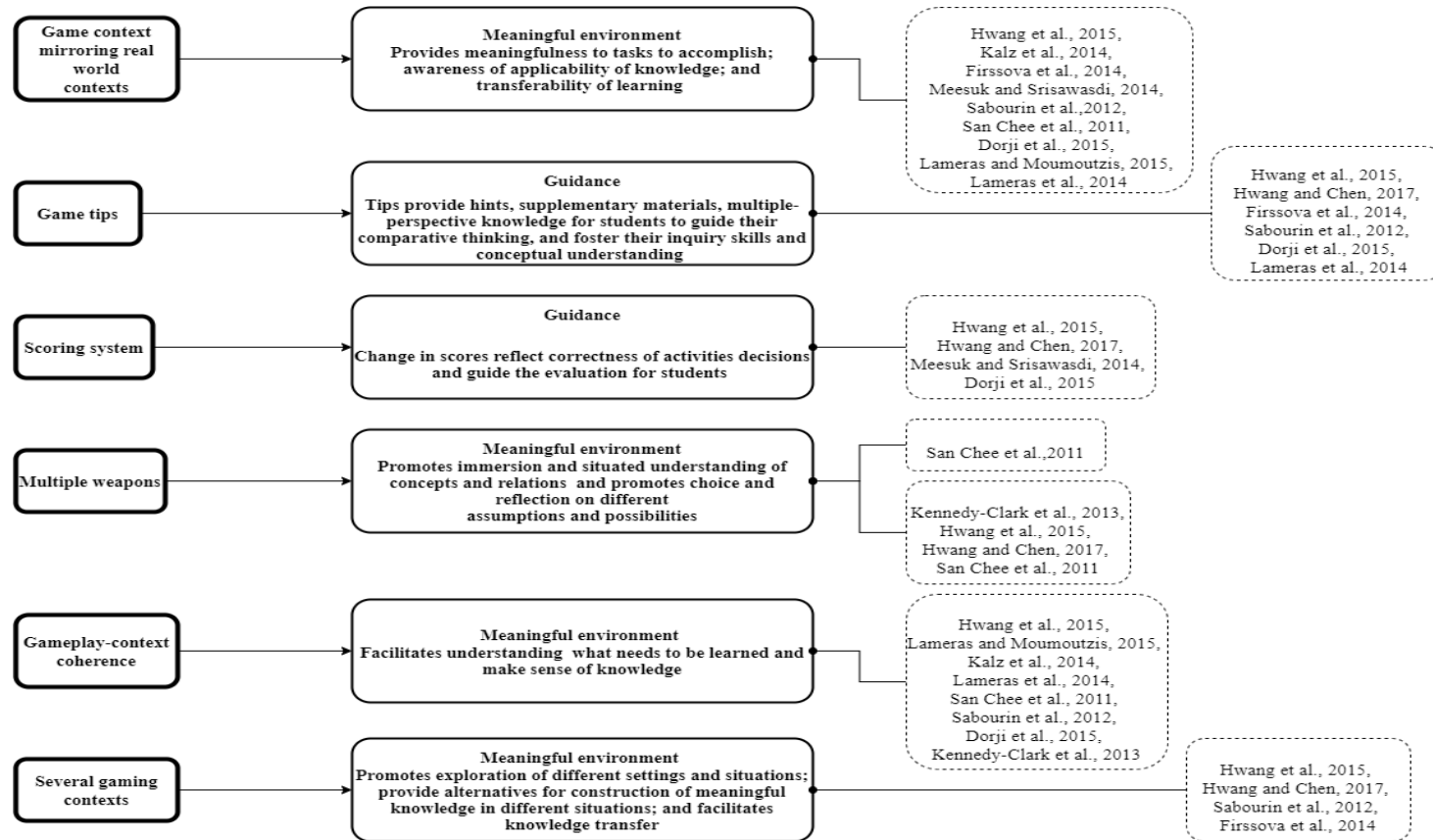
**(11) Several gaming contexts** (Different scenes and situations where students' actions take place). For example, students can shift between two gaming contexts of real school and virtual scenario via swiping their QR code (Hwang and Chen, 2017).

**(12) Game context mirroring real-world contexts** (Situations in the game simulate the real world). For example, piggy bank and Financial Institution are designed in the game to show the real world (Hwang et al., 2015).

**(13) Student assumes a role coherent with the game context** (Students control player token through role-playing). For example, the student plays the role of a young man who needs to choose among different ways to invest his family's money, exploring different types of financial investments (Hwang et al., 2015).

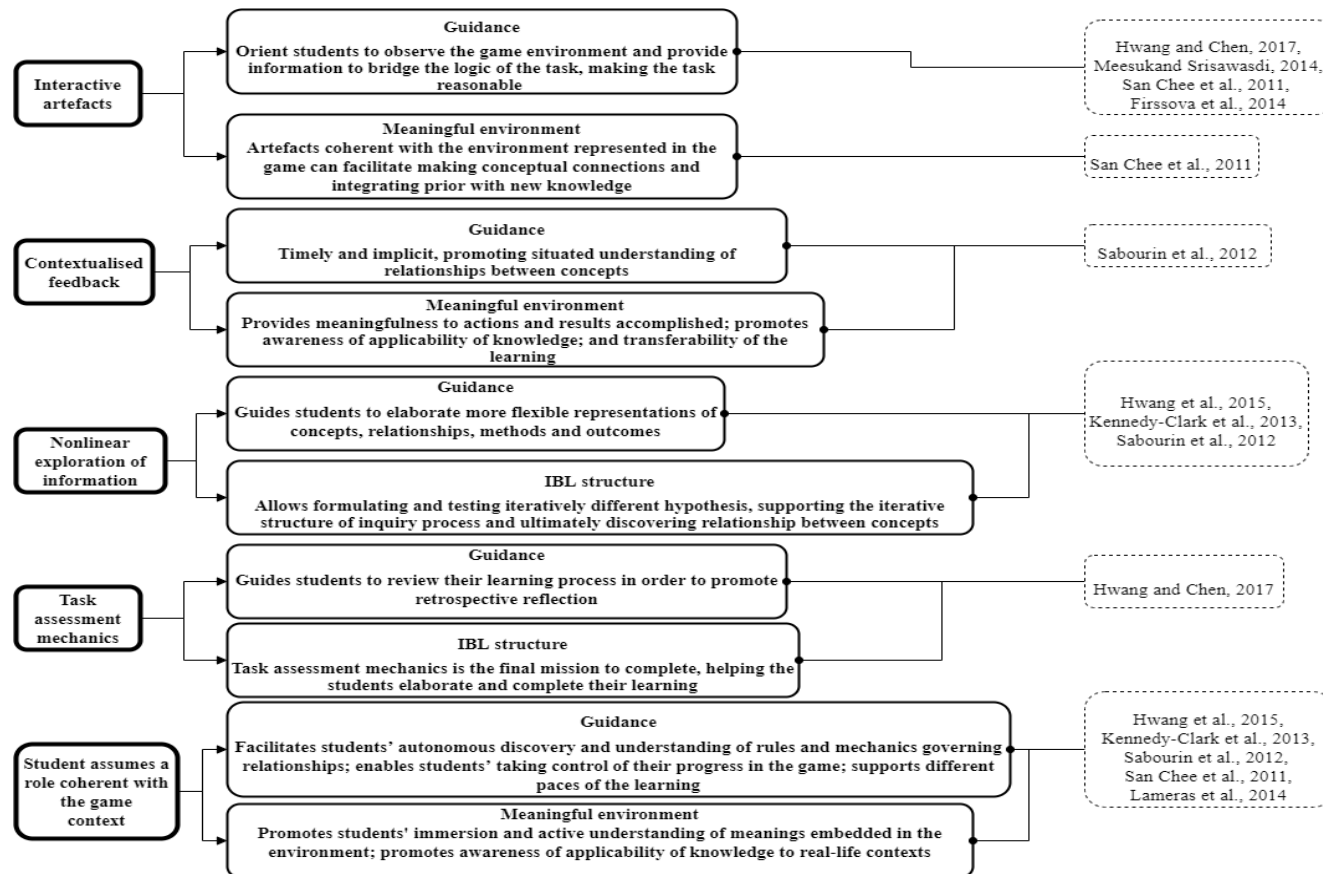
#### **4.1.3.2 Game features support the core IBL characteristics**

IBL-supporting functions of each game feature are described in the following figures.

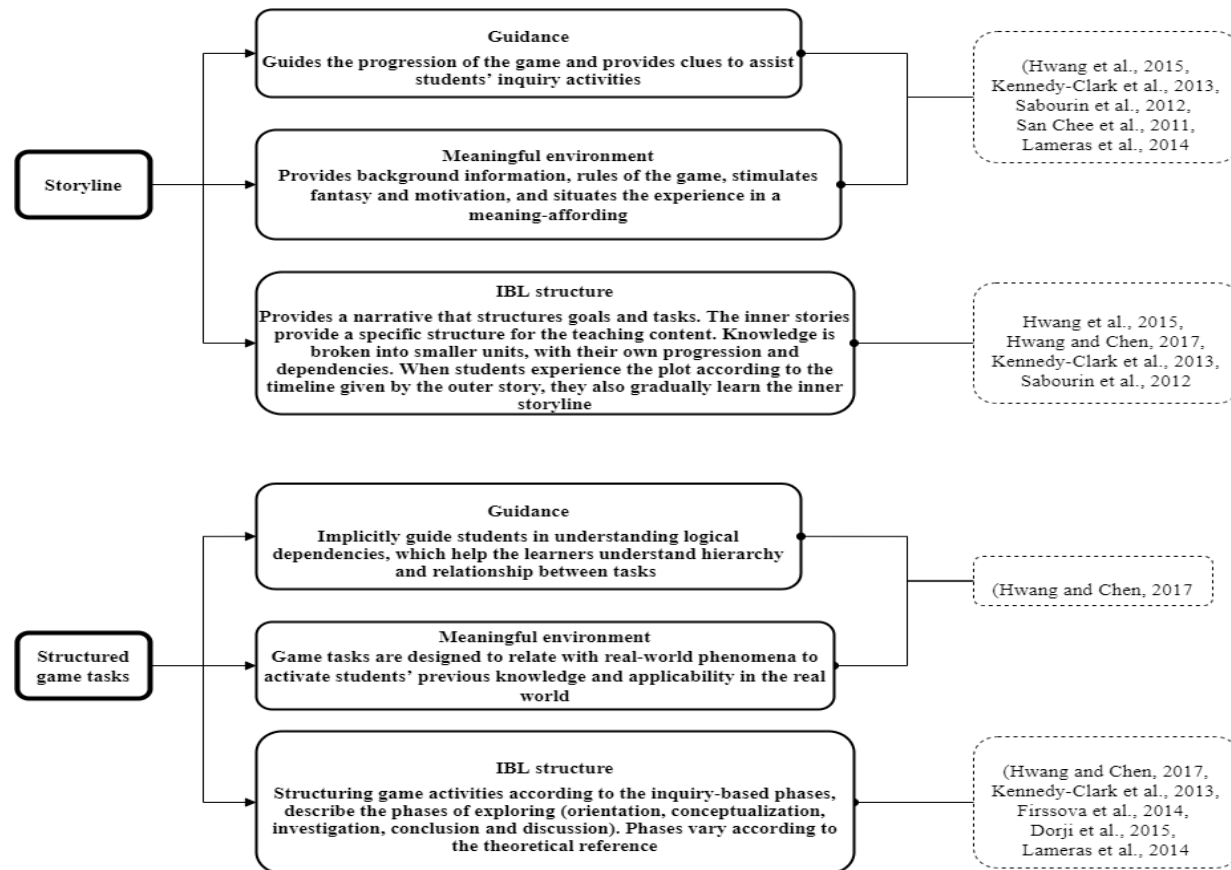


**Figure 4.1 Game features supporting one core IBL characteristic**





**Figure 4.2 Game features supporting two core IBL characteristics**



**Figure 4.3 Game features supporting three core IBL characteristics**

#### **4.1.4 What are the reported impacts on students?**

Only seven studies measured impacts on students. Positive impacts on achievement were reported in all of them, either in terms of conceptual learning or information-seeking strategies. For example, Kalz et al. (2014) found significant knowledge improvement in secondary students who used an IBL-based game to learn about energy consumption. Sabthisin et al. (2012) observed that 8<sup>th</sup>-grade students displayed more effective problem-solving strategies while playing a microbiology IBL-supporting game, although knowledge improvement was correlated to data collection behaviours performed before playing. Six of the seven studies measuring knowledge improvements found significant impacts compared to pre-tests or control groups in school-age students.

Mixed evidence was found regarding the impacts of IBL supporting games and game-like strategies on engagement. Hwang and Chen (2017), Hwang, Chiu, and Chen (2015) and Meesuk et al. (2014) found medium-size impacts on intrinsic motivation when students played IBL-supporting games, but Kalz et al. (2014) and Firssova et al. (2014) observed no significant effects on triggering or maintaining motivation. See Table 4.2.

**Table 4.2: The impacts of serious games used on IBL**

<b>Study</b>	<b>impact: engagement</b>	<b>impact: achievement</b>	<b>impact: other</b>	<b>impact on</b>
	<b>How did using games benefit learners' motivation</b>	<b>How did using games benefit learners' achievement</b>	<b>which others benefit games generate</b>	
Hwang, Chiu, and Chen (2015)	* Small effects of computer games IBL on motivation	* Medium effects in financial knowledge in comparison to the group with conventional IBL activities (non -computer games IBL)* Large effects in students with an active learning style	*Medium effects on flow in comparison to the group with conventional IBL activities (non-computer games IBL)*Small effect on satisfaction in comparison to conventional IBL activities	6th-grade students
Hwang and Chen (2017)	* Medium size effects regarding intrinsic motivation for learning of control group (CG); no difference in extrinsic motivation between groups	*Statistically significant results. The medium effects in students' performance in the game group than students in the traditional inquiry group (eta2= 0.110, corresponding to a medium effect size)	*Students explore more high-frequency activities of seeking help in games than in conventional IBL and promote participation in learning activities. Experimental group (EG) students performed more help-seeking actions than CG* EG students performed more field observation, comparison and data search behaviours* EG High relationship between the provision of clues and field observation* EG students prefer to look more information about the task after the solution was submitted (probably revealing a tendency to confirm	6th-grade students

<b>Study</b>	<b>impact: engagement</b>	<b>impact: achievement</b>	<b>impact: other</b>	<b>impact on</b>
	<b>How did using games benefit learners' motivation</b>	<b>How did using games benefit learners' achievement</b>	<b>which others benefit games generate</b>	
			success in the solution)* CG performed read more supplementary material to find a solution* EG interacted more with the real world to find a solution and assess success* CG presented more Trial-error behaviours	
Kennedy-Clark, Galstaun , and Anderson (2013)	not reported	*Participants were fairly consistent between the pre-and post-tests for an understanding of these terms: gameplay, understanding of serious games and the virtual world	*Significant shifts of teachers' response from negative in the pre-test to positive in post-test, including the use of information and communication technologies (ICT), is enhanced the change of teachers' attitudes toward games, and teachers' selection for games in the classroom*For current game was used and preferred games, the result showed that men played the most common games which are first-person shooting games (FPS) and RPGs, However, females played phone applications*The chi-square test revealed that between gender and frequency of playing the game there	teachers

Study	impact: engagement	impact: achievement	impact: other	impact on
	How did using games benefit learners' motivation	How did using games benefit learners' achievement	which others benefit games generate	
			was no statistically significant correlation ( $\chi^2 = 7.744$ , $p = .021$ )	
Kalz M et al. (2014)	*Did not impact on using games to inquiry motivate students to be interested in topics that they are not interested in	*Significant effects in using games promote knowledge acquisition*Students with low prior knowledge benefitted the greatest. However, effect sizes seem small (not calculated)	not reported	8th grade students
Meesuk and Srisawasdi (2014)	*Students' science motivation in SAGOI class is more change than their SAGOI learning experience* Statistically significant results (the data of eta2 correspond to a medium effect size). *Medium effects in intrinsic motivation (eta2= 0.10), self-determination (eta2= 0.25), self-efficacy(eta2=0.21), and career motivation(eta2=0.15) impact on the increase of science motivation, which is different from the control group and the experimental group participating with the learning instruction	not reported	*Research 1 points out that using the IE War game have effects in influencing students' flow, satisfaction and enjoyment. However, effect sizes are not calculated	Study 1 12th grade students Study 2 10th-grade students

Study	impact: engagement	impact: achievement	impact: other	impact on
	How did using games benefit learners' motivation	How did using games benefit learners' achievement	which others benefit games generate	
Sabthisin et al. (2012)	not reported	*The increased data collection behaviour prior to attempting to resolve a problem is associated with a more effective problem resolution. Students spend less time and have fewer total attempts than students who did not participate in information gathering before solving the problem*The behaviour of collecting information before the problem is solved, which will not lead to better learning benefits for students	not reported	8th grade students
Chee et al. (2011)	not reported	*The summary chemical separation task of the game group is superior to the control group in separation effect measurement and chemical concept understanding	not reported	students
Firssova et al (2014)	The use of games does not consistently maintain student motivation	not reported	*Using the scenario of the game make students experience the "usefulness" of game tasks	8th grade students
Dorji,Panjaburee and Srisawasdi (2015)	not reported	*Significant effects in promoting the learning performance of conceptual knowledge through play RES-battle ( $\eta^2=13.887$ , corresponding to a significant effect size)*Medium effects in learning gain of students ( $0.3<\eta^2=0.47<0.7$ , corresponding to a medium effect size)*	not reported	10th grade students

<b>Study</b>	<b>impact: engagement</b>	<b>impact: achievement</b>	<b>impact: other</b>	<b>impact on</b>
	<b>How did using games benefit learners' motivation</b>	<b>How did using games benefit learners' achievement</b>	<b>which others benefit games generate</b>	
		having a high degree of recognition and satisfaction using RES-battle serious games to improve their conceptual knowledge		



## 4.2 The value creation in communities of inquiry

The eight papers discussed activities of COI improving the development of learning in medical education, teachers' skills, course practising, civic education, learning strategy and semi-synchronous language exchange. Four papers particularly described that the contexts of activities were formal learning environments (see Table 4.3).

**Table 4.3: Activities of COI**

<b>Study</b>	<b>Activities of COI</b>	<b>Setting where activities were accessible</b>
Wang, Y. et al.(2016)	Using WeChat as a communication tool of COI to study two languages (Mandarin Chinese and English)	not reported
Chanprasitchai and Khlaisang (2016)	Solving traditional medicine problems	not reported
Eteokleous and Ktoridou (2012)	Using Google applications to study systems of management information	formal (classroom)
Junus et al. (2017)	Interacting and communicating to practice students' learning strategies	not reported
Keles (2018)	Using Facebook completed community services practices	formal (classroom)
Padilla and Kreider (2018)	Studying clinical practice management	formal (classroom)
Pellas and Boumpa (2017)	Interacting and communicating to study a foreign language	not reported
Setiani and MacKinnon (2015)	Studying civic education course	formal (classroom)

These activities mainly oriented to sharing documents and information, learning the experience of each other, guiding, helping and supporting each other, learning knowledge together, inspiring changes, and providing new types of development chances. For example,

Eteokleous and Ktoridou (2012) indicate that teachers provide convenient and direct guidance to set up communication and interaction between teachers and students.

#### **4.2.1 The actual values that COIs can contribute to improving learning experiences in virtual environments (answering research question RQ1)**

This review found that immediate, potential, applied, realized and reframing values were promoted by the activities of COI. Most activities generated three or more types of value. The lowest number of types of the value was found in Keles (2018) (two types of value), while the highest number of types of the value was presented in the activities by Chanprasitchai and Khlaisang (2016) (five types).

In particular, immediate value and potential value were frequently promoted with positive outcomes. During students' exploration, for example, they would be likely to gain new knowledge, based on evaluating the topic, planning their methods of learning and constructing meaning. This leads to promoting potential value (Padilla and Kreider, 2018).

However, only one activity that promoted reframing value was reported in these papers reviewed. Chanprasitchai and Khlaisang (2016) indicate that students positively discuss experts' advice for further clarification to propose solutions for clinical problems, which could trigger students' reflection with connecting their ideas.

Furthermore, some similar types of activities generated the same value. For example, teachers check students' WeChat messages every day and replied on time (Wang et al., 2016). Teachers provide links to learning resources and gave feedback (Junus et al., 2017).

These activities generate similar interactions (e.g. teachers' help and feedback for students) to promote immediate value.

The same activity helped to generate more than one value. For instance, students could freely explain their opinions and openly communicate with peers using their virtual avatars or interactive text or voice communication (Chanprasitchai and Khlaisang, 2016). For this activity, students interacted with each other, which not only create immediate value but also likely to gain something new (e.g. strategies, knowledge) from other persons through their communication to create potential value.

Some unappropriated activities were likely to lead to passive effects. Keles (2018) describes that during the implementation process of COI, some activities did not create value and even brought negative effects. For example, some participants very rarely show their feelings of anger or shyness and never share content with the Facebook group, which is not useful for communication and interaction. The quantity of content was more focused on by participants than the quality of content and use the method of 'copy and paste' posts to increase the number of comments. This is not beneficial for sharing information and also wastes teachers' time.

#### **4.2.2 TP, SP and CP represent COI aspects determining the value generation process (answering RQ2)**

This review indicated that most activities of TP promoted immediate value, especially its categories of promoting discourse (n=22) and direct instruction (n=16). For instance, to shape constructive communication (promoting discourse), from different perspectives,

teachers initiate and guide the weekly topics to promote the discussion of the topics and ensure the continuity and frequency of the comments within groups (Keles, 2018). This is likely to attract students' interest so that promote immediate value.

Most activities of SP promoted immediate and potential values. Open communication (n=13) positively generated immediate value. This is consistent with Wenger et al. (2011) who propose that interactions or communications can generate immediate value in online communities. For example, the students used the online tools to express their opinions freely, participate in the course discussion and frequently communicate with their peers or other participants (Eteokleous and Ktoridou, 2012).

The activities of CP promoted three or more values. For example, the resolution of CP helped to promote potential, applied and realized values. Junus et al.(2017) discuss that Identify owns or others' misconception and correct them. These activities could improve the ability to achieve important aims for self or other stakeholders. Hence, it promoted realized value. However, some values were significantly promoted by specific activities, including triggering event (n=5) promoting immediate value, exploration (n=9) supporting potential value, integration (n=4) and resolution (n=4) generating applied value. See Table 4.4.

**Table 4.4: The statistics form that the appearing numbers of activities in three presences**

presences	categories	Numbers of activities				
		immediate value	potential value	applied value	realized value	reframing value
<b>TP</b>	Design and organization	4	1	0	0	0
	Promoting discthisse	22	0	0	0	0
	Direct instruction	16	0	0	0	0
<b>SP</b>	Individual/affective	7	2	0	0	0
	Open communication	13	3	0	0	0
	Group cohesion	9	4	0	0	0
<b>CP</b>	Triggering event	5	2	0	0	0
	Exploration	4	9	6	2	0
	Integration	2	1	4	1	1
	Resolution	0	2	4	1	0

### **4.3 A model of game features promoting reframing value**

#### **4.3.1 Which game features may influence reframing?**

Ten game features were identified including multiple endings of the game, tasks with emotional experience, a real no-play character (NPC) image, the game design of particular style, game stories, game avatars, tasks for problem-solving, the rank system of the game, game tools and game mode.

In order to extract game features, an inductive method was used to analyse the comments which were selected based on evidence of reframing. For example, “game story” was extracted as a game feature in light of these comments: “.....While reading the journal entries of the survivor who is stuck in the manor and witnessed someone leaving, it describes that on a certain day after the rain they receive a note to go to the dining room.....” (*Identity5*); “.....also in Before the storm we can see that Max was very worried about parting with Chloe and they promised to call each other.....all the more after the death of Chloe (leading character in the game)'s father, Max knew how bad Chloe feels.....” (*Life is strange*).

#### **4.3.2 Which evaluative criteria of reframing value are affected by game features?**

##### **4.3.2.1 The relationship between game features and criteria of reframing value**

###### **(1) Multiple endings of the game**

Multiple endings of the game allow players to choose what they want to get and why. Players presented their opinions according to different endings, stimulating more

discussions and reflecting on themselves. For example, players would consider the advantages and disadvantages of the different endings to decide which one was they want. The game *Life is strange* has two different endings, involving protecting the town Arcadia Bay or rescuing Chloe's life. Players post and discuss their comments to explain the reasons for choosing one option.

Multiple endings of the game support *promoting reflection*.

i) *Inside* (Stand-alone): when players experienced one of the endings, they reflected through discussion on the meanings that antagonistic characters (e.g. the dogs, the masks and the mermaid) appeared in the game.

ii) *Life is strange* (Stand-alone): the different endings of Chloe' life inspired the reflection of the player who decides which game ending is better for Chloe.

## **(2) Tasks with emotional experience**

When players in the game complete the tasks involving emotional experience such as friendship, love, betrayal, and adventure in a constantly changing virtual world, they are likely to get emotional satisfaction to trigger rethinking. For example, in the game *Life is strange*, a player presents comments to discuss the friendship of the two characters (Max and Chloe). This leads to players' various ideas. For example, players suggest that people tend to forget childhood friends and move on with their lives or others suggest that children's world cannot be understood by adults.

Tasks with emotional experience support *promoting reflection*.

i) *Inside* (Stand-alone): the task inspired the player's empathy to rethink the reason that causes the chickens to starve to death.

ii) *Life is strange* (Stand-alone): the experience of the player's love in the task triggered his rethinking for love with his personal experience in the real world.

*Identity 5* (Online): the player could not rescue his teammate in a task, which made him feel bad and presented his reflection about the importance of friendship.

### **(3) A real NPC image**

When players interact with an NPC who is close to a real social character, this will trigger players to evaluate the virtual NPC. For instance, David (NPC) is created by the game (*Life is strange*) as a retired soldier. Through understanding his background, the players assess his personality and consider David can be a good step-dad for Chloe if he learns to put his ego aside and genuinely care about her as a person.

A real NPC image support *promoting reflection*.

i) *Life is strange* (Stand-alone): the players proposed that Warren (NPC) was a good man and Nathan (NPC)'s behaviour needed to receive punishments. As Warren and Nathan have been looked real people, the players used moral regulations of real-world to reflect the two NPC's behaviours.

### **(4) The game design of particular style**



The game design of particular style involves the themes of the game, details of design, music and voices. These could impact players' thoughts that reflect the game or living meaning or design issues. For example, in the game *Inside*, players used the poems to interpret the theme of the game and tried to set up the relationship between a poem and the game. This meant that they reconsidered game contents and meaning. From the perspective of details of design, players always wanted to know the function of a strange box in the game. They spent many months exploring a reasonable explanation for the function of the box. The players were curious about the voices from the secret room where the barn was full of pigs. In the game *Life is strange*, the players listened to the music of the game to consider the relationship between lyrics and their lives.

The game design of particular style supports *promoting reflection*.

i) *Inside* (Stand-alone): the players found the huddle scene was a funny design detail, they openly discussed if its design supported the plots.

ii) *Life is strange* (Stand-alone): most characters in this game are female, which made some players seriously consider if this game was designed based on a feminist theme.

The game design of particular style promotes *suggestions for community development*.

i) *Identity5* (Online): according to the player's observation, he suggested that the developer revised the distance between hunters and survivors (details of design). He thought that would be a chance to save the survivor who was camping.

ii) *Chinese Paladin: Sword and Fairy* (Stand-alone): through comparing the animation effects (details of design) of entering battles between old and new versions, the players found that the animation in the new version was unappropriated. They suggested that the developer revised the new version.

iii) *Inside* (Stand-alone): a player suggested that an error of the scene should be revised as the scene disappeared sometimes.

iv) *Life is strange* (Stand-alone): the player reflected that the application (e.g. the theme diversity of games such as the theme of females was applied in mainstream video games) was an innovation. He suggested that the publisher explored more similar applications in related games.

## **(5) Game stories**

A game story can attract players' attention, including whether or not the game has rich and colourful plots, good characters and humorous narrative construction. When players play a good game, their feelings are similar to experiencing good movies or art, which is likely to trigger players' curiosity to further divergent thinking. When players feel unsatisfied with the game story, they want to change it. For example, for *Identity5* players rewrote the story themselves or gave some suggestions to developers. The game story should make players feel that the game required their participation to solve problems. For example, a friend has been kidnapped or a family reputation has been threatened. These situations need players to think about the ways of problem-solving (*Life is strange*).

Game stories support *promoting reflection*.

i) *Identity5* (Online): players attracted by the game story gathered some evidence and reread game content in order to present their theory that proved Gardner (the game character) actually was the hidden killer.

ii) *Inside* (Stand-alone): the player through analysing some details of the game story generated the theory that the last place in the game could be a real place, this meant it was not a fantasied product of the boy. It was used to explain some illogical situations such as why the huddle starts to laugh when you try breaking the wooden wall at the end.

iii) *Life is strange* (Stand-alone): the game story mainly described the relationship among multiple females such as friendship and love, which made players reflect if the game theme was designed from the perspective of females.

iv) *Lifeline* (Stand-alone): the player reflected the life rule that risks and rewards are both existences through considering the story about how to keep Taylor (game character) alive yet progress forward.

Game stories promote *suggestions for community development*.

i) *Life is strange* (Stand-alone): because the player was attracted by the emotional story of the game, he reflected kinship can come in many forms, such as a strong friendship could be looked equalling to kinship. Then players suggested writing more emotional plots for Max (game character).

ii) *Identity5* (Online): the player was extremely intrigued by the story of survivors and hunters. He wondered what the story would discover next. Hence, he suggested designing a story scenario where the player plays the detective to find clues as to what the game is about and who started it.

## **(6) Game avatars**

Game avatars have original skills and personalities, which would lead to players' reflections. This includes revising skills, proposing the new strategies of the skills' matching and giving suggestions for creating new characters. For example, in the game *Identity5*, a player suggested revising the Joker's (game avatar) original skill which was weak in the player's opinion. Another player suggests creating a new character in order to make the game more interesting (*Identity5*).

In addition, game avatars were controlled by the players. The behaviours of the game avatars, to some extent, decide players' behaviours. These avatars impact each other as partners or enemies, which is likely to lead to players' reflections on avatars' performances. For example, a player of *Identity5* suggested that the survivors (avatars) needed to work together properly, which could ensure the success of teamwork.

Game avatars promote *suggestions for community development*.

i) *Identity5* (Online): the player used some evidence to prove that hunters' skills were more powerful than survivors'. They rethought the way of revising game avatar' skills to suggest

the developer would give survivors more time to do something rather than escape from hunters.

ii) *Life is strange* (stand-alone): the player considered that Max didn't call Chloe and stopped all communications with her after moving to Seattle. This did not correspond to the personality of Max (game avatar). Hence, he suggested the developer needed to address the issue that enables game avatars' personality was consistent with reasonable people's personality in real life.

Game avatars promote *the change of evaluation*.

i) *Identity5* (Online): the player through multiple tests suggested a new strategy that at the beginning of the battle, the hunter (game avatar)'s tentacle summon (skill) can be used to enhance a normal attack of the hunter.

Game avatars promote *generating new assessments for other people*.

i) *Identity5* (Online): the player through rethinking the skills of these survivors who controlled by other players showed his new assessment for these survivors: survivors should have more options themselves to decide the victory of the battle rather than relying on other teammates' abilities.

ii) *Life is strange* (stand-alone): the player thought Chloe (game avatar) was gay before, but after playing the game he changed his idea that from the perspective of bisexual to assess Chloe' behaviours.

## **(7) Tasks for problem-solving**

Tasks for problem-solving mean players faced challenges such as intellectual challenges and annoying pitfalls. Players need to consider various methods in order to solve these problems. At this more abstract level, players use existing resources and information to determine the best course of action. For example, when players encounter more powerful monsters, they need to constantly master and reflect on new skills or different strategies in order to ensure their win (e.g. *Identity5*, players decided how to organise the marching order in order to guarantee their survival in case of a surprise attack).

Tasks for problem-solving promote *suggestions for community development*.

i) *Identity5* (Online): in order to stop campers from camping (the mission), some players suggested the developer added more players.

Tasks for problem-solving promote *the change of evaluation*.

i) *Inside* (Stand-alone): a player tried to deactivate some orbs to glow the left bulb (new method) in order to make the secret elevator becomes accessible.

ii) *Identity5* (Online): for solving the task that how to deal with camping hunters, a player presented many new strategies, such as a normal survivor used his or her body to block the escaped one; a specific skill was used to hit the hunter into a wall from a distance; nurses and coordinators (other avatars) were selected as teammates.

iii) *Chinese Paladin: Sword and Fairy* (Stand-alone): the player utilised the wine and roasted meat to synthesize gold silkworm (new strategy), which could receive the achievement of earning much money (task).

#### **(8) The rank system of the game**

The rank system of the game involved game outcome and pairing. Players' attentions for game outcome and pairing was likely to lead to their rethinking. For example, in *Identity5*, one player reflected that the counting of game points based on the players' skills rather than the performance of the whole team.

The rank system of the game promote *suggestions for community development*.

i) *Identity5* (Online): the player suggested that prohibited this pairing of duplicate character selection (e.g. two coordinators' combination and two perfumers' combination) in order to ensure the fairness of battles.

#### **(9) Game tools**

The application of game tools shows players' new strategies, which improve characters' skills. For example, in *Identity5* players put down a blue music box in the middle of the battle area to delay hunters' movement and slow down the speed of the attack. This method was found through players' multiple tests in the game.

Game tools support *promoting reflection*.

i) *Inside* (Stand-alone): the player through the use of the shockwave (game tool) in the game divergently thought how to use the decibel scale to measure voice.

Game tools promote *suggestions for community development*.

i) *Identity5* (Online): players expected to win the battle with more rate, then they suggested that add first aid kits (game tool) somewhere on every map in order to increase the chance of survivors' self-healing.

Game tools promote *the change of evaluation*.

i) *Inside* (Stand-alone): the players utilised the same vertical box in different situations (ledges or the roof of buildings) to help them complete difficult jump or movement.

ii) *Identity5* (Online): the player recommended using broken windows (game tool) with every single character, and also tide turner (game tool) to increase the escape time.

iii) *Chinese Paladin: Sword and Fairy* (Stand-alone): in order to improve fast the ranks of the character, players advised new strategies for problem-solving, such as using transmission gear (game tool) or using the special brush (game tool) to assist the battles.

## **(10) Game mode**

Game mode refers to game rules and functions. Players will give suggestions that revise or optimise game mode. For instance, a player wanted to revise the game rule that allowed participants to play against real people after 15 competitions. This is because player thought



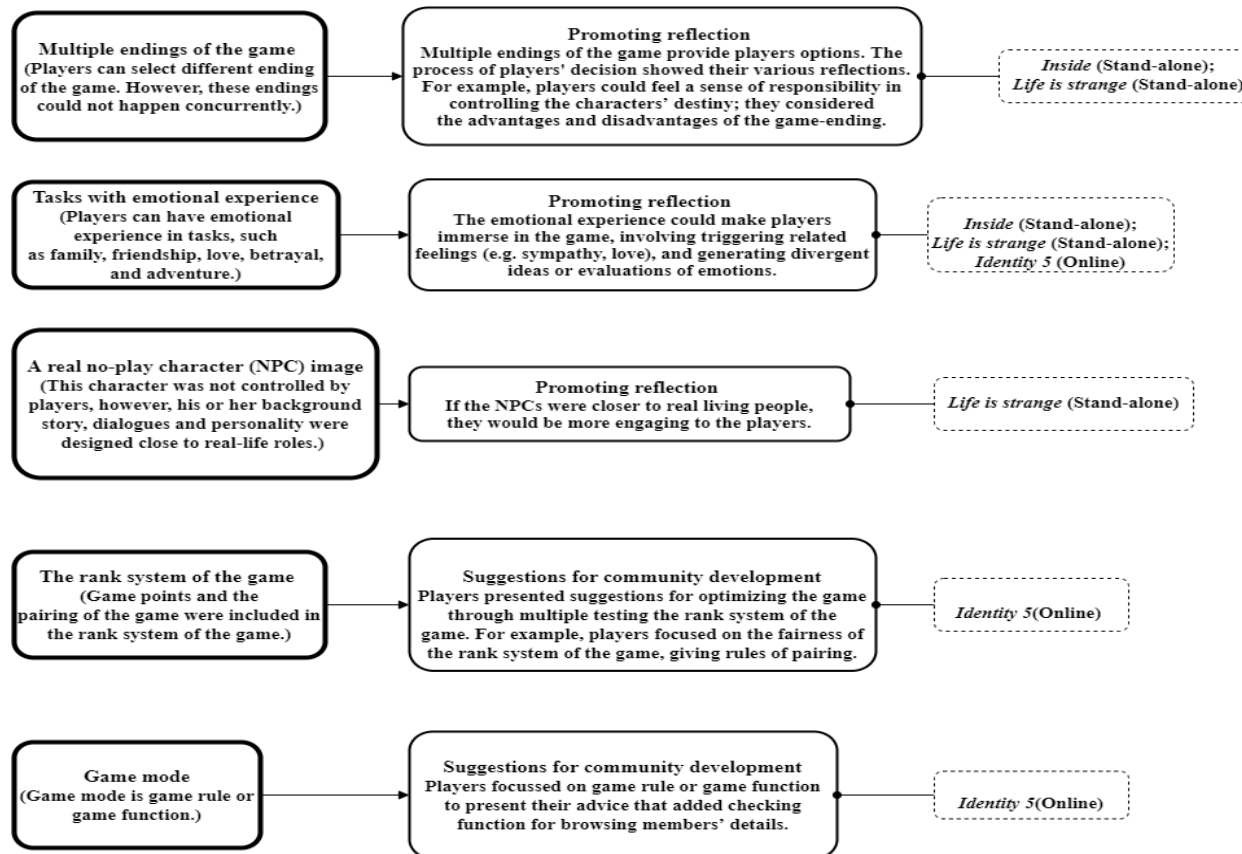
that they could not learn concrete skills by playing with/against robot mates or enemies (*Identity 5*).

Game mode promotes *suggestions for community development*.

i) *Identity5* (Online): in order to more understand other friends, a player suggested that add a function to check another player who has the most owned characters and what character he or she used.

#### **4.3.3 How game features promote these criteria of reframing value?**

The following figures systematised the question.



**Figure 4.4 The model of game features promoting one criterion of reframing value**

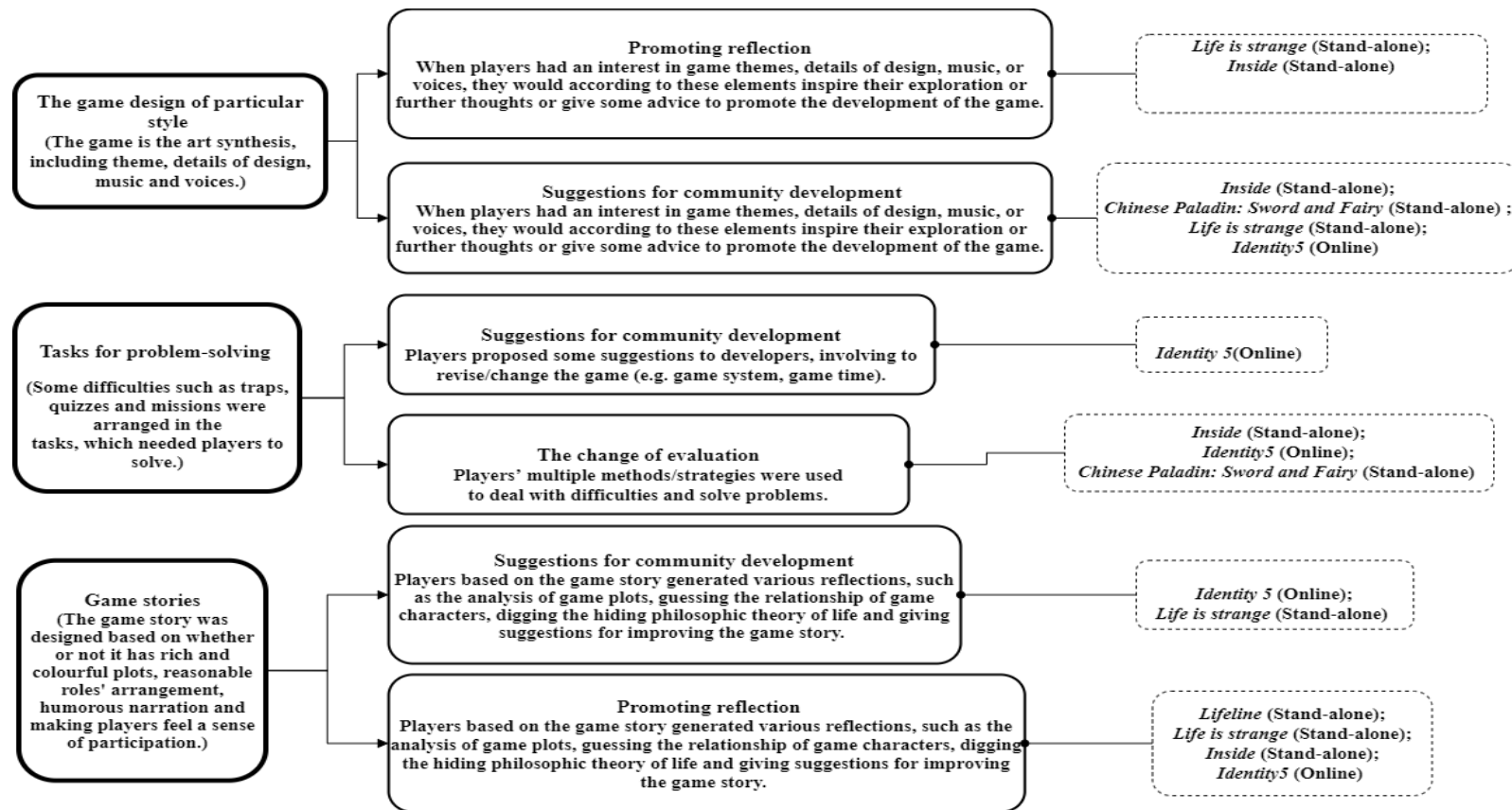


Figure 4.5 The model of game features promoting two criteria of reframing value

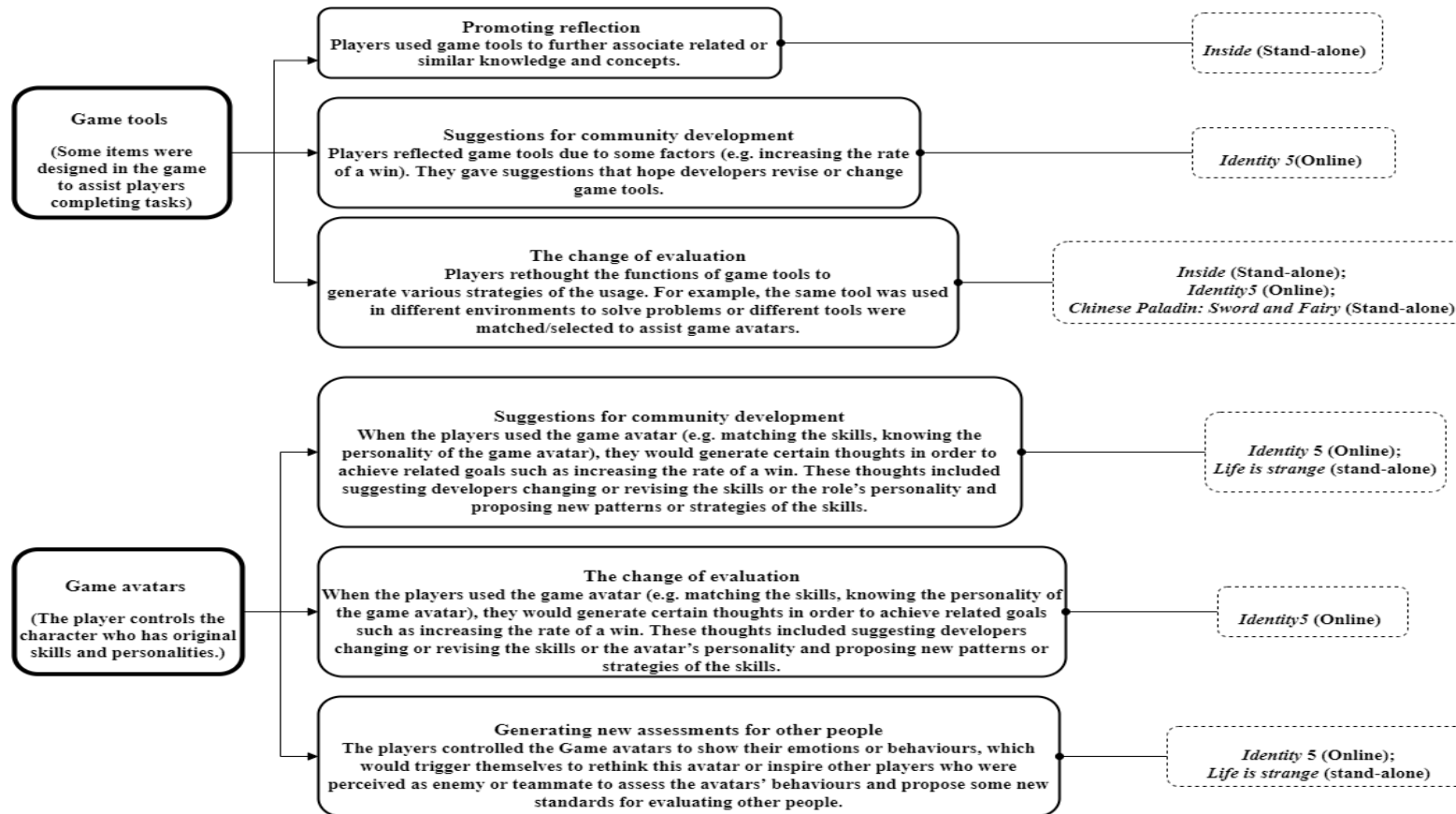


Figure 4.6 The model of game features promoting three criteria of reframing value

Most game features supported *suggestions for community development* (n=6) and *promoting reflection* (n=7). The 3 game features (game stories, game tools and game avatars) broadly promoted reframing value, including *suggestions for community development*, *promoting reflection* and *the change of evaluation*. The Top 5 games cover a range of game features. The lowest number was found in Lifeline (n=1), while the highest numbers were in Identity5 (n=6) and Life is strange (n=8).

Some game features showed positive effects on promoting reframing value. For example, two game features (the game design of particular style and game stories) supported *promoting reflection*. *Suggestions for community development* was most impacted by game avatars and *the change of evaluation* was most impacted by tasks for problem-solving and game avatars.

*Generating new assessments for other people* was only promoted by game avatars. This meant that game features had little impact on this criterion of reframing value. See Figure 4.7.

top 5 games				
	Name	Files	References	
[-]	Generating new assessments for other people		0	0
	game avatars		13	22
[-]	Promoting reflection		1	1
	a real no-play character (NPC) image		5	19
	game stories		16	43
	game tools		1	5
	multiple- endings of the game		2	2
	Tasks with emotional experience		4	6
	The game design of particular style		23	93
[-]	Suggestions for community development		2	2
	game avatars		50	75
	game mode		7	9
	game stories		3	3
	game tools		6	7
	task for problem-solving		5	5
	The game design of particular style		8	14
	the rank system of the game		6	6
[-]	The change of evaluation		0	0
	game avatars		20	25
	game tools		10	14
	tasks for problem-solving		32	82

**Figure 4.7 The relationship between game features and reframing value**

#### **4.3.4 An instrument for evaluating the reliability of the model**

##### **4.3.4.1 The reliability of the model**

The reliability of the model was shown through the feedback of 39 experts' agreement. The average percentage of "agree" and "strongly agree" for game features promoting reframing value was 87.6%, which meant experts acknowledged the 10 game features could promote reframing value. See Table 4.5.

**Table 4.5: Participants' feedback**

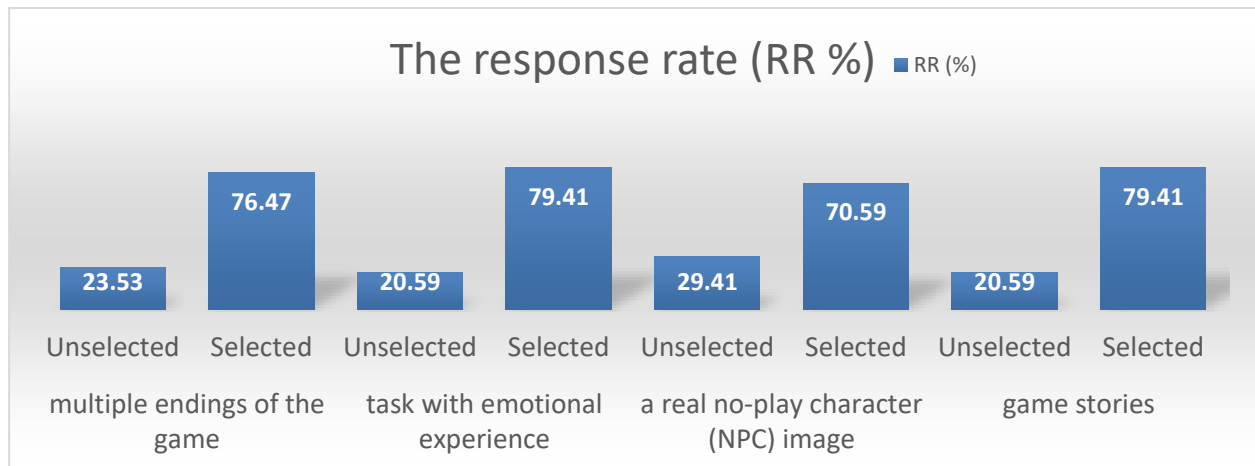
Criteria of reframing value and involved game features	game feature	Percentage (%) of agree + strongly agree
<i>Promoting reflection</i>	a real NPC image	84.6
	game stories	94.9
	multiple endings of the game	89.8
	the game design of particular style	89.8
	tasks with emotional experience	89.7
	game tools	76.9
<i>Generating new assessments for other people</i>	game avatars	79.5
<i>Suggestions for community development</i>	game stories	96.6
	game avatars	79.5
	game mode	97.1
	the game design of particular style	89.7
	tasks for problem-solving	92.3
	game tools	79.5
	the rank system of the game	87.2
<i>The change of evaluation</i>	game avatars	89.7
	Tasks for problem-solving	89.7
	game tools	82.1

### 4.3.5 The validity of the model

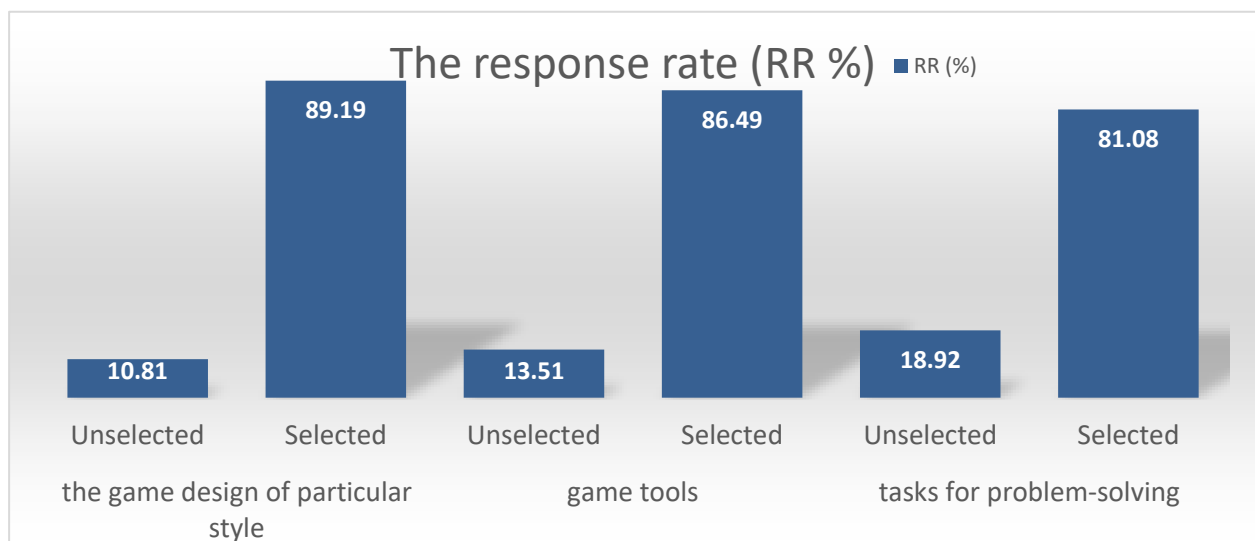
#### 4.3.5.1 The related game features

From the perspective of the response rate (RR), most participants agreed on the following facts: *Chinese Paladin: Sword and Fairy 3* covered 4 game features, including multiple endings of the game RR=76.47%, task with emotional experience RR=79.41%, a real NPC image RR=70.59% and game stories RR=79.41%, Figure 4.8; *Limbo* covered three game features, including the game design of particular style RR=89.19%, game tools RR=86.49% and tasks for problem-solving RR=81.08%, Figure 4.9; *World of Warcraft* covered three game features,

including game avatars RR=74.29%, the rank system of the game RR=82.86% and game mode RR=88.57%, Figure 4.10.

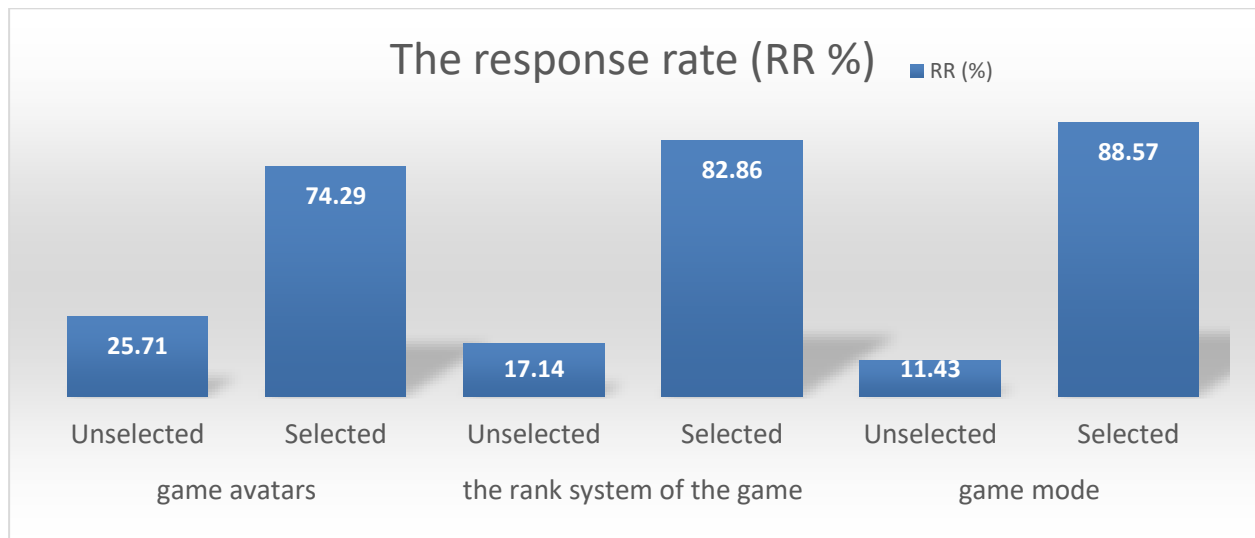


**Figure 4.8** The frequency of the response (*Chinese Paladin: Sword and Fairy 3*)



**Figure 4.9** The frequency of the response (*Limbo*)





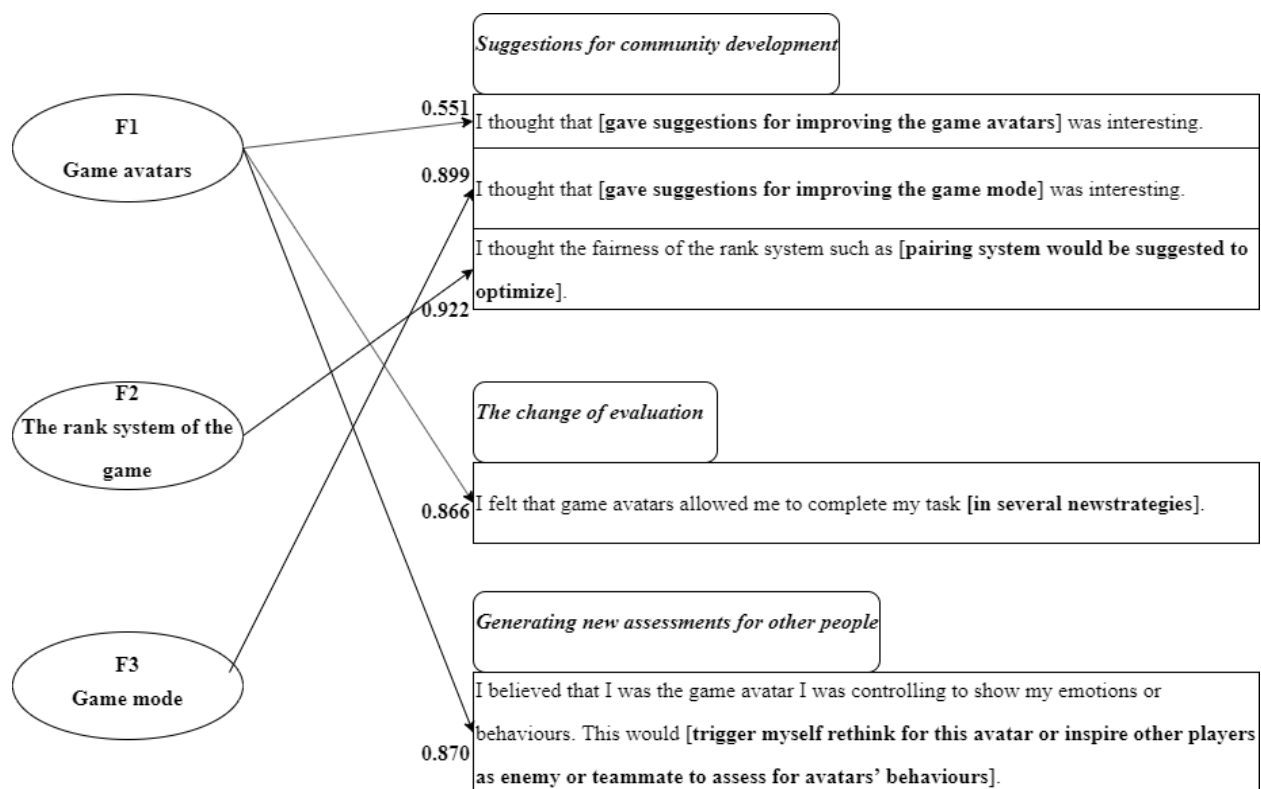
**Figure 4.10 The frequency of the response (*World of Warcraft*)**

The relationship between game features and four criteria of reframing value (answering RQ: what is the validity of the model)

The following results showed that 10 game features have strong associations with four criteria of reframing value. This was consistent with this model of game features promoting reframing value.

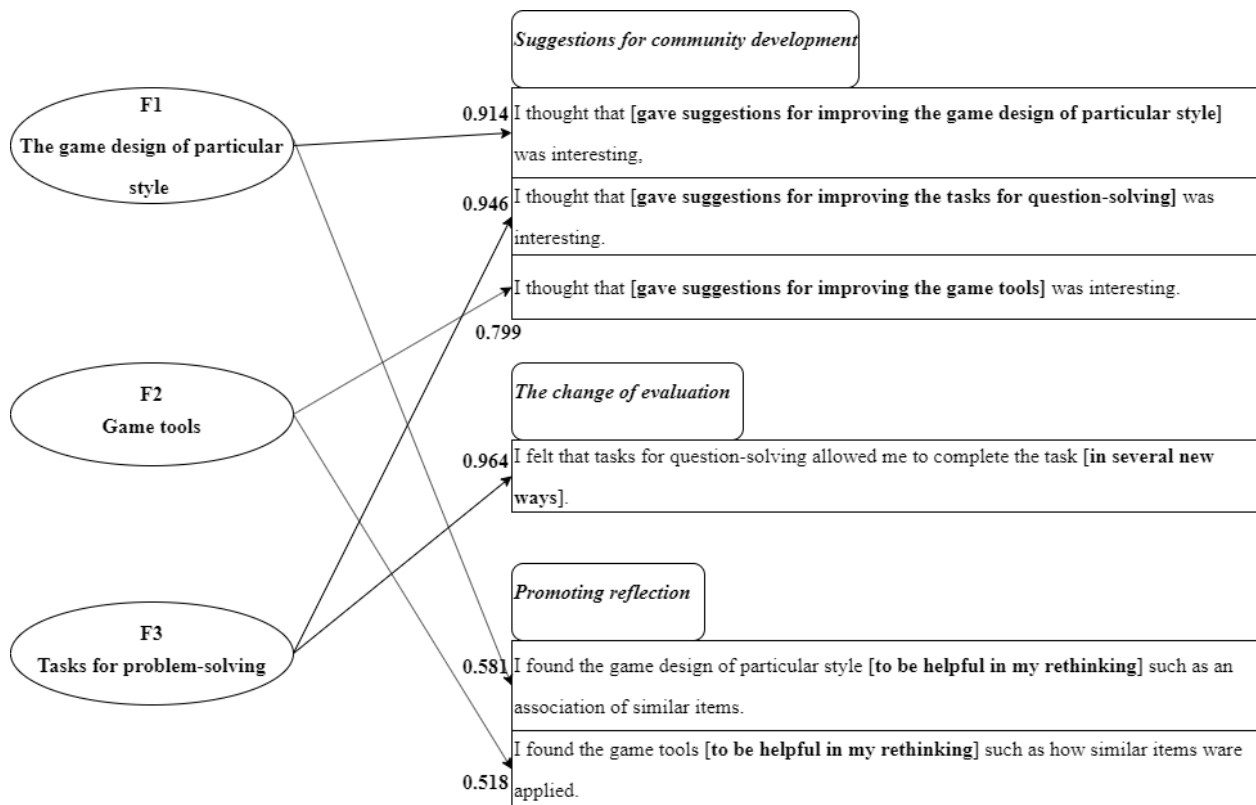
The factor analysis was performed for the three investigations respectively. the KMO measure of sampling adequacy (0.814 *World of Warcraft*, 0.722 *limbo*, 0.843 *Chinese Paladin: Sword and Fairy 3*) was high and Bartlett's Test of Sphericity ( $p < 0.05$ ) respectively reached statistical significance (Kaiser, 1958, Bratt and Fagerström, 2020).

For the factor analysis of the game experience test (GET) (*World of Warcraft*), three factors (game avatars, the rank system of the game and game mode) were extracted and the cumulative explanation of variance after rotation was high (93.89%) (Kaiser, 1958). This meant that three factors promote related criteria of reframing value. The indicators included game avatars promote *suggestions for community development* (0.846 common variances), *the change of evaluation* (0.948 common variances) and *generating new assessments for other people* (0.949 common variances); the rank system of the game promote *suggestions for community development* (0.955 common variances); game mode promotes *suggestions for community development* (0.997 common variances). See Figure 4.11.



**Figure 4.11 Factor analysis (factor loading) with varimax rotation of measures of the relationship between game features and criteria of reframing value (*World of Warcraft*)**

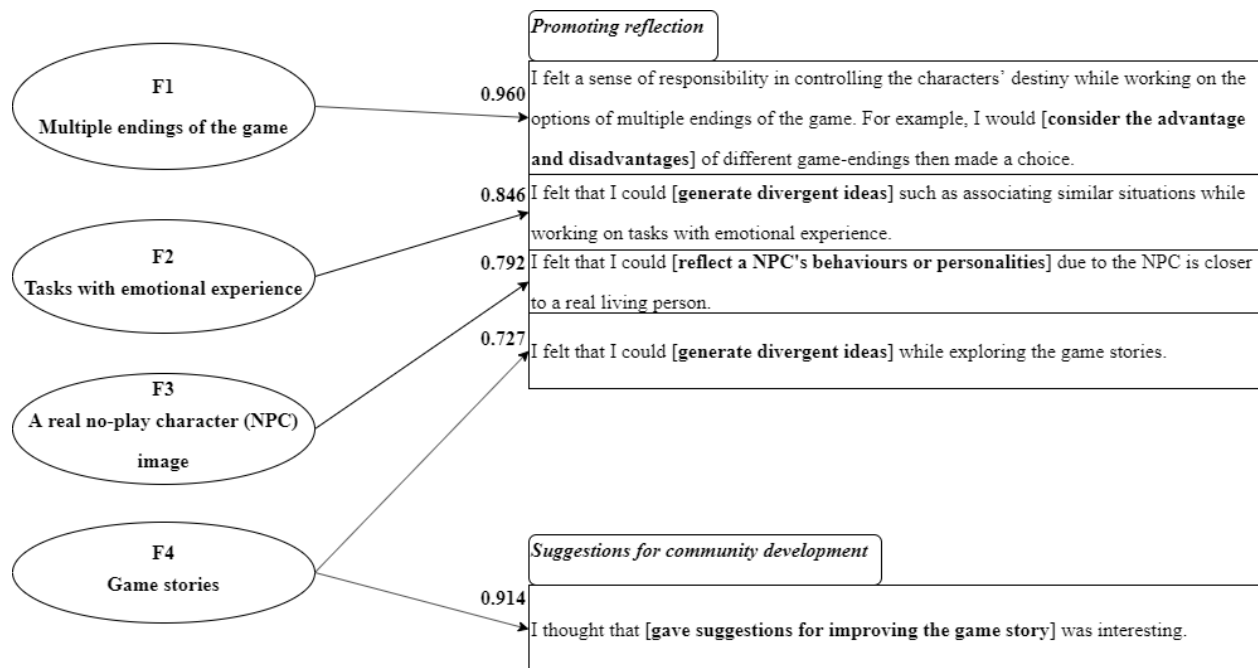
The cumulative explanation of variance after rotation was 90.69% in the factor analysis of GET (*Limbo*). Three factors (the game design of particular style, game tools and tasks for problem-solving) extracted have strongly correlated with related criteria of reframing value. The indicators included the game design of particular style supports *promoting reflection* (0.581 common variances) and promotes *suggestions for community development* (0.914 common variances); game tools support *promoting reflection* (0.957 common variances) and *suggestions for community development* (0.964 common variances); tasks for problem-solving promote *suggestions for community development* (0.946 common variances) and *the change of evaluation* (0.964 common variances). The loading on the factor (game tools) promoting the change of evaluation was low (less than 0.400). According to Sass (2010), the factor loading did not represent the primary factor (game tools). However, comparing responses of participants was utilised to further check the validity of game tools promoting *the change of evaluation*. The result showed that the percentage of "agree" and "strongly agree" for game tools promoting *the change of evaluation* was 89.19%. See Figure 4.12.



**Figure 4.12 Factor analysis (factor loading) with varimax rotation of measures of the relationship between game features and criteria of reframing value (*Limbo*)**

Four factors were extracted (multiple- endings of the game, tasks with emotional experience, a real NPC image and game stories) in the factor analysis of GET (*Chinese Paladin: Sword and Fairy 3*). The cumulative explanation of variance after rotation was 97.10%. The indicators included multiple endings of the game support *promoting reflection* (0.960 common variances); tasks with emotional experience support *promoting reflection* (0.846 common variances); a real NPC character image support *promoting reflection* (0.993 common

variances); game stories support *promoting reflection* (0.727 common variances) and *suggestions for community development* (0.914 common variances). See Figure 4.13.



**Figure 4.13 Factor analysis (factor loading) with varimax rotation of measures of the relationship between game features and criteria of reframing value (*Chinese Paladin: Sword and Fairy 3*)**

Furthermore, this research did not analyse participants' suggestion that improves the game feature to promote reframing value. Only one participant in the questionnaires gave suggestions.

In addition, the Multifactor Analysis of Variance (ANOVA) was used to measure the major influence across variables between teachers and students on the consent of game features. The testers (106) coming from China were divided into three groups (34 participants evaluated 5 items in *Chinese Paladin: Sword and Fairy 3*, 37 participants evaluated 7 items in *Limbo* and

35 participants evaluated 5 items in World of Warcraft). The three groups were composed respectively of 19 teachers and 15 students, 20 teachers and 17 students, 18 teachers and 17 students. These testers were selected randomly, some usually played digital games and some did not play.

For *Limbo*, there was a statistically significant difference ( $p < 0.05$ ) between teachers and students, involving tasks with emotional experience promoting the change of evaluation, Table 4.6.

**Table 4.6: *Limbo*- Results of One-way ANOVA Analysis**

Game feature	Criteria of reframing value and involved game features	(Mean±Std. Deviation)		F	p
		teacher(n=20)	student(n=17)		
The game design of particular style	<i>Promoting reflection</i>	4.40±0.60	4.35±1.00	0.031	0.860
	<i>Suggestions for community development</i>	4.30±0.86	4.29±1.05	0.000	0.985
Game tools	<i>Promoting reflection</i>	4.40±0.88	4.41±1.00	0.001	0.970
	<i>Suggestions for community development</i>	4.65±0.67	4.18±1.13	2.485	0.124
	<i>The change of evaluation</i>	4.60±0.60	4.06±1.39	2.496	0.123
Tasks for problem-solving	<i>Suggestions for community development</i>	4.60±0.50	4.12±1.05	3.316	0.077
	<i>The change of evaluation</i>	4.75±0.44	4.29±0.69	5.926	0.020
p<0.05, there was a statistically significant difference.					

For *World of Warcraft* and *Chinese Paladin: Sword and Fairy 3* the results ( $p > 0.1$ ) illustrated that there was not a statistically significant difference, see Table 4.7,4.8.

**Table 4.7: World of Warcraft- Results of One-way ANOVA Analysis**

Game feature	Criteria of reframing value and involved game features	(Mean±Std. Deviation)		F	p
		teacher(n=18)	student(n=17)		
Game avatars	<i>Suggestions for community development</i>	4.50±0.71	4.47±1.28	0.007	0.933
	<i>The change of evaluation</i>	4.67±0.49	4.29±1.05	1.860	0.182
	<i>Generating new assessments for other people</i>	4.78±0.43	4.35±1.11	2.265	0.142
The rank system of the game	<i>Suggestions for community development</i>	4.61±0.50	4.24±1.56	0.940	0.339
Game mode	<i>Suggestions for community development</i>	4.22±1.00	4.41±1.06	0.294	0.591
p>0.1, there was not a statistically significant difference.					

**Table 4.8: Chinese Paladin: Sword and Fairy 3- Results of One-way ANOVA Analysis**

Game feature	Criteria of reframing value and involved game features	(Mean±Std. Deviation)		F	p
		teacher(n=19)	student(n=15)		
Multiple endings of the game	<i>Promoting reflection</i>	4.53±0.96	4.40±0.99	0.141	0.710
Tasks with emotional experience	<i>Promoting reflection</i>	4.42±1.30	4.00±1.13	0.978	0.330
A real NPC image	<i>Generating new assessments for other people</i>	4.05±1.08	3.80±1.26	0.395	0.534
Game stories	<i>Suggestions for community development</i>	4.53±0.84	4.00±1.13	2.417	0.130
	<i>Promoting reflection</i>	4.53±0.51	4.07±1.16	2.394	0.132
p>0.1, there was not a statistically significant difference.					

## 4.4 Summary

This chapter describes the research results. For exploring serious games supporting IBL, the results revealed that a wide variety of game elements were used including storylines, interactive artefacts, gameplay-context coherence and task assessment mechanics. These elements were mainly oriented at supporting three core features of IBL.

For value creation in COI, the results showed that value creation was really impacted by TP, SP and CP. The process of creating values was not linear. Most activities of TP promoted immediate value. Immediate and potential values were positively promoted by most activities of SP. The activities of CP have specifically promoted three or more values. Reframing value was not positively promoted by COI.

For constructing a model of game features promoting reframing value, the results showed that both the reliability and validity of the model were high. Participants of tests agreed that 10 game features were extracted such as multiple endings of the game, game stories, the task with emotional experience, game avatars and game tools. These features were oriented at promoting four criteria of reframing value (e.g. *promoting reflection, the change of evaluation, generating new assessments for other people and suggestions for community development*).



## **5 Discussion**

This chapter gives related discussions. For example, the suitability of role-playing games for supporting inquiry-based learning (IBL); the importance of promoting reframing value; some special game features that only appear in stand-alone or online games to promote reframing value.

### **5.1 Exploring serious games supporting IBL**

IBL serious games can be used in formal education (e.g. classroom). This research proposed that playing game time was spent in the classroom in most studies reviewed (n=8). This is consistent in many kinds of literature that serious games were broadly applied in formal education (Beavis et al., 2012, Gee, 2007, Steinkuehler, 2010, Arnab et al., 2012).

RPGs suit to support IBL given its nature. This study indicated that most projects reported used RPG as their game genre. Tychsen (2006) proposed that RPGs are distinguished from other game genres through controlling the virtual characters with the use of storytelling in a fictional reality, this is consistent with the guidance of IBL. For example, Hwang et al. (2015) use RPGs to explore the learning of financial knowledge. The storyline of the game guides learners to enter Saving Island (game scene) to collect all the scrolls (game tools). Then they implement tasks in the Finances Bridge (game scene) following the storyline. Finally, learners achieve enough scores to participate in the competition in Investment Island (game scene) until the end of the game (Hwang et al., 2015).

The diversity of game genres in IBL contexts is an option for multi-dimensional solutions (e.g. one solution for multiple questions or multiple solutions for one question). For example, on one hand, using RPGs solve biology questions (Sabourin et al., 2012) or study chemical knowledge (San Chee et al., 2011). On another hand, San Chee et al. (2011) allow learners to explore chemical knowledge using RPGs, but Meesuk and Srisawasdi (2014) chose the shooting game.

This review indicates that there is wide variability in how games incorporate game features to support IBL. Some of the reviewed games included six or more game features that supported two or all defining attributes of IBL, while others used two or three game features in what seemed to be more gamified learning activities in fully structured games.

The stage-based but flexible structure of IBL was mainly supported by the use of storylines, structures game tasks, and the possibility to explore information in a non-linear way. Storylines provided a narrative that structures goals and tasks in a logical way. In this way, concepts and processes were broken into smaller units, with their own progression and dependencies, but maintaining coherence with the general story. In addition, several games activities presented a goal-oriented task structure consistent with IBL stages, structuring game actions and knowledge in an incremental way, despite being designed following different IBL theoretical models. For example, in Hwang et al. (2015), the game's storyline provided a general frame to contextualise financial knowledge. Tasks were organised so students explored simple concepts (e.g. savings) before tackling more complex ones (e.g. investments). San Chee et al (2011) used a game following a 6-stage model of inquiry (question identification, hypothesis

formulation, investigation, analysis, synthesis, and evaluation), in which each level had a specific task with goals and learning activities. Completing a level meant completing a stage of inquiry, which likely promoted students' progressive understanding of complex concepts and fostered their sense of mastery and feeling gratified. Interestingly, only a reduced number of games supported the cyclic and multi-directional nature of the inquiry, allowing students to explore information and activities in a non-linear manner. IBL has been conceptualised as a process developed in loops within and between stages (Pedaste et al., 2015), which can generate different inquiry cycles. These findings suggest that game features have been designed primarily to structure the stages of the inquiry process as a sequenced set of steps, and less oriented at providing students with the opportunities to create their own pathways and inquiry cycles.

This is consistent with these findings regarding how game features supported the guidance that student need when participating in IBL activities. This analysis revealed that games used several game features such as game tips and/or interactive artefacts to guide completing tasks to advance to the following stage of the learning process. Furthermore, in five games it was necessary to complete the previous task before the next one was unlocked, which evidenced that games were designed to guide students through stages in an orderly and sequenced manner. This suggests that game features have primarily been used in games to provide stronger forms of guidance which may be classified in level 1 (confirmatory) and level 2 (structured) according to Banchi and Bell (2008) categorisation.

In terms of the meaningful environment key to IBL, these findings indicate that game features like storylines, coherence in of the meaning of the context, gameplay actions and player roles, and contextualised feedback, were designed to create a game environment that promotes immersion, fosters the construction of situated knowledge, the integration of prior and new knowledge, and the applicability of knowledge in different environments.

Most studies recreated game scenarios that mirrored real-world contexts or dynamics. These game designers seem to have taken the approach of simulations when moving into game design. On one hand, integrating games and simulations has a positive impact on learning goals (Vlachopoulos and Makri, 2017). On the other hand, games things do not have to be realistic to be effective. As National Research Council (2011) showed that when games and simulations were compared that there would be more positive results from the game rather than from the simulation because if the simulation was not 100% accurate to the real-life (i.e. introducing an element of error) then the negative transfer of learning would take place (Novick, 1988). Furthermore, Mimicking authentic environments has been considered one essential aspect for IBL (Brown et al., 1989, Huang et al., 2014), to enable the exploration and application of knowledge in contexts that will facilitate transferability of learning and develop problem-solving skills.

According to the literature, students' achievement of understanding knowledge and problem-solving strategies showed positive results while them playing an IBL-supporting game. The author suggests that when constructing knowledge and carrying out problem- solving, adopt serious games to apply IBL is a good approach. Furthermore, some research (i.e. Hwang, et

al., 2015, Hwang and Chen, 2017, Kalz M et al., 2014, Meesuk and Srisawasdi, 2014, Firssova et al., 2014) focuses on the motivation of students, mixed results were found regarding the impacts on engagement. However, the author could not find the regularity involving the engagement impacts of serious games support IBL.

## 5.2 The value creation in communities of inquiry

### 5.2.1 Discussion

The activities of communities of inquiry (COI) collected positively relevant with some questions of value creation. See Table 5.1.

**Table 5.1: The activities of COI involving some questions of value creation**

<b>The five values</b>	<b>reflecting questions of value creation</b>
<b>Immediate value</b>	What happened/were the important things? Is it interesting/attractive? Who did I contact or have established with whom?
<b>Potential value</b>	Do I believe they are enough to ask them for help and am I not feeling so isolated?
<b>Applied value</b>	How is it different from my practice/life/background?
<b>Realized value</b>	Am I more successful?
<b>Reframing value</b>	Does the social learning process led to a reflection on important issues?

Most activities met one or three questions of values, there is much room for improvement as activities seem to address a few questions. For example, every value includes multiple questions to reflect, according to these questions the content of activities can be redesigned, which is likely to develop more values.

Most values can be created by activities of COI in a formal learning environment where TP, SP and CP positively affected immediate and potential values, see Table 5.2. However, this result cannot explain if a formal learning environment is a precondition for generate values. Further research will focus on the relationship between values and the learning environment in the future.

**Table 5.2: The values and formal learning environment**

Formal learning environment	<b>Immediate value</b>	SP	Group cohesion	Keles (2018) Setiani and MacKinnon (2015) Eteokleous and Ktoridou (2012)
			Open communication	Padilla and Kreider (2018) Eteokleous and Ktoridou (2012)
			Individual or affective	Eteokleous and Ktoridou (2012)
		TP	Promoting discourse	Keles (2018) Setiani and MacKinnon (2015) Padilla and Kreider (2018)
			Direct instruction	Keles (2018) Padilla and Kreider (2018)
			Design and organization	Padilla and Kreider (2018) Eteokleous and Ktoridou (2012)
		CP	Triggering event	Setiani and MacKinnon (2015) Padilla and Kreider (2018)
	<b>Potential value</b>	SP	Group cohesion	Keles (2018) Eteokleous and Ktoridou (2012)
			Open communication	Eteokleous and Ktoridou (2012)
			Individual or affective	Eteokleous and Ktoridou (2012)
		TP	Design and organization	Eteokleous and Ktoridou (2012)
		CP	Exploration	Setiani and MacKinnon (2015) Padilla and Kreider (2018)
			Triggering event	Eteokleous and Ktoridou (2012)
	<b>Applied value</b>	CP	Integration	Setiani and MacKinnon (2015) Eteokleous and Ktoridou (2012)
			Resolution	Eteokleous and Ktoridou (2012)
			Exploration	Padilla and Kreider (2018) Eteokleous and Ktoridou (2012)
	<b>Realized value</b>	CP	Integration	Eteokleous and Ktoridou (2012)
			Resolution	Eteokleous and Ktoridou (2012)
			Exploration	Eteokleous and Ktoridou (2012)

### **5.2.2 The importance of promoting reframing value**

This research found that reframing value was not positively promoted. Given the characteristic that every value can be analysed independently, the author proposed to consider the importance of promoting reframing value.

Firstly, promoting reframing value is similar to promoting critical reflection that can improve learners' skills (e.g. Brookfield, 2015; Lonka et al., 2001; Blatt et al., 2007; Mamede et al., 2008) playing an important role in education. For example, Wenger et al. (2011) indicate that through communication in communities, learners not only contribute their experience but get new knowledge from others. This may be trigger reconsidering old knowledge construction of learners to carry out their self-development.

Furthermore, from the perspective of stakeholders, they expected to promote reframing value. For example, students who were the stakeholder of reframing value care more about addressing issues that happen in their practice and defining success (Wenger et al., 2011). In other words, students are likely to be more focused on the development of reframing value.

Generally, educational strategies could provide opportunities to promote reframing value, many studies indicate that some educational strategies include games (e.g. Apperley and Beavis, 2011; 2013; Hsiao, 2007; Squire and Barab, 2004). For example, games (e.g. role-playing, adventure, simulation ) provide a slower pace to proceed so that more space and time are offered to reflect (Squire and Barab, 2004).



### 5.3 A model of game features promoting reframing value

This study indicates that there is wide variability in how game features promote criteria of reframing value. Some criteria include one or three game features that supported two or three criteria, while others used mixed game features (e.g. some supported two or three criteria, others supported one).

This research could not find a clear association between game features. However, some identified game features are consistently oriented at supporting the same criterion of reframing value. For example, tasks with emotional experience, game avatars and game stories together impact on *promoting reflection*. A player's comment was collected: "when it comes to Max being gay or straight, I am thinking as what others are saying, she might be interested in both but has yet had the chance to explore it, which she will likely get with her interactions with Chloe, which I admit is a bad influence, but Max is also good for her, there have been many real-life people that have had bad habits, smoking drinking, drugs and when they meet someone, they could be just friends or more and their presence and friendship or whatever it is, allows him to be transformed into something better for them. That is what likely will happen here with Max and Chloe" (*Life is strange*). This comment shows that the tasks involving love and friendship emotional experience (Max and Chloe) increasingly impact the player to post his ideas about the sexual orientation of game avatars (Max). Furthermore, the player explains his opinion (Max being bisexual) based on the interaction of Max and Chloe (the game story) and his own reflections on the real world (e.g. some people could be influenced by people they

care for). Hence, in this example, the three features (tasks with emotional experience, game avatars and game stories) concurrently support the reframing value (*promoting reflection*).

Some factors which are not game features also trigger players' rethinking involving promoting *suggestions for community development* and *promoting reflection*. For example, players suggested that the developer used only one English name for the game *Chinese Paladin: Sword and Fairy*. This could assist customers to recognize the game on different game platforms (*suggestions for community development*). The whole game experience of *Identity5* makes the player feel confident. He/she rethinks personal value to share the experience with people who are in the same community (*promoting reflection*).

Some special game features only appear in stand-alone or online games to promote reframing value. This means that the game classification is likely, to some extent, to impact reframing value. For instance, multiple endings of the game appear in stand-alone RPGs, which positively influence reframing value (*promoting reflection*). The rank system of the game and game mode appears in online RPGs to promote reframing value (*suggestions for community development*).

### **5.3.1 An instrument for evaluating the reliability of the model**

#### **5.3.1.1 The limitations of this instrument**

The result suggests that the instrument would be an effective tool for examining the potential that game features elicit the creation of reframing value. However, this instrument which evaluates the reliability of the model is only at an exploratory stage.

## **5.4 Summary**

The chapter gives diverse discussions including:

1) limitations of this study, and what could be done to address this. For example, the samples of games selected were limited from the IOS system. The author needs samples of games collected from broader game markets such as the markets of the IOS system and the android system; 2) relevance of the findings to inform practice. For instance, based on these findings, games could be used as an educational tactic to enhance reframing value; 3) how these findings can inform future research. For example, reframing value did not be promoted by COI, the author proposes that consider the importance to promote reframing value.

## **6 Conclusions and Future work**

This chapter presents an overall conclusion of this study and according to related limitations in current research proposes suggestions for future work.

### **6.1 Conclusions**

Games are playing an increasingly important role in education (e.g. Fabricatore et al., 2019; Bressler et al., 2021; Hwang and Chen, 2017; Erickson et al., 2021; Barr, 2017). Literature indicated that both theories and demonstration have shown that games in multiple domains can effectively strengthen learners' motivation, engagement (Squire, 2008, Mayer, 2019, Fabricatore et al., 2019, De Freitas, 2006, Bayeck, 2020) and critical reflection (Apperley and Beavis, 2011, Apperley and Beavis, 2013, Hsiao, 2007, Squire and Barab, 2004). In particular, the use of digital games and game-based activities can positively impact social learning (Bakhanova et al., 2020, Medema et al., 2016, Den Haan and Van der Voort, 2018).

The thesis aims to investigate an exploratory study that digital games are used to promote the development of a virtual inquiry-based learning community (VILC). VILC has been proved that is an important framework given that it enhances students' problem-solving skills (e.g. Eteokleous and Ktoridou, 2012; Setiani and MacKinnon, 2015; Chanprasitchai and Khlaisang, 2016; Suarez et al., 2016). However, little attention has been paid that promotes the value in social learning generated by VILC.

There exists, a relationship between games and learning values, with learning value generated in social learning, and the use of games supporting social learning (Bakhanova et al., 2020, Medema et al., 2016, Den Haan and Van der Voort, 2018). This thesis proposes that in order to improve the development of the learning value of VILC, digital games are used as specific communities (Bolter et al., 2000) as they offer opportunities to create value. A value creation framework i.e. Wenger et al.'s framework (2011) is utilised to evaluate social learning in games or communities. As the community of inquiry (COI) is related to the nature of knowledge construction in inquiry-based learning (IBL), VILC involves both COI and IBL. Utilising games to support inquiry-based learning (IBL) and communities of inquiry (COI) considerably challenges the related issues that identifying game features and the extent to which they promote IBL and COI. According to this, this research carries out investigations involving the use of game characteristics to support IBL and promote learning values of COI. Meanwhile, the research onion (Saunders et al., 2009) had been utilised throughout the methodology of this thesis as an effective tool to help the organisation of this research and development of the research design according to the layers of the research onion (i.e. research philosophy, research methods, research strategies, time horizons, and data collection methods). The research conclusions finished in the thesis are showed as follows.

### **6.1.1 Exploring serious games supporting IBL**

The first step of this research presented a review to analysing the characteristics of a game-based IBL strategy, determining the game features utilised in the games and the gamification strategies designed to promote IBL and their effects on students. The results revealed that the

game genre of RPG is used given the high suitability to support IBL. A few studies involve utilising IBL-serious games to support teacher training. Several game features can be used to support inquiry processes, including storylines, interactive artefacts, gameplay-context coherence and task assessment mechanics. From the perspective of game impacting IBL, positive impacts were identified both in terms of conceptual learning and information seeking strategies, but mixed evidence regarding the impacts on engagement was shown. This study suggests that these game features can be designed to provide different levels of support to students, structure the learning progression according to different theoretical models and create diverse environments to support making sense of knowledge in context. Games present intrinsic features that can naturally support the core aspects of IBL: students can take active control of the pace of their progress, exert autonomy for decision-making and timely observe the relationships between actions, concepts and context. There is much space for these features to be explored and used by games aiming at supporting IBL.

### **6.1.2 The value creation in COI**

In order to clarify why games are used to support COI and how to promote COI, a systematic synthesis is firstly proposed for the investigation of value creation in COI, and the extent to which TP, SP and CP represent COI aspects determining the value generation process. The results of the second step showed that the activities of COI mainly generated immediate, potential and applied values and value creation was really impacted by teaching, social and cognitive presences. For example, most activities of TP promoted immediate value, especially its categories of promoting discourse and direct instruction. Most activities of SP promoted

immediate and potential values. Open communication positively generated immediate value. The activities of CP promoted three or more values. In summary, this study can provide an important mean to explore the nature of social learning; be utilised as an effective way of seeing implicit learning outcomes of COI; make stakeholders (e.g. participants of a virtual learning community, the organizations of a community and their sponsors) achieve their expected outcomes; optimize the design of related activities to maximize learning value.

Meanwhile, the research result revealed that reframing value was not positively promoted by COI. Due to the fact that promoting reframing value is similar to promoting critical reflection, this research proposes that games are utilised as an effective educational strategy providing opportunities to create reframing value.

### **6.1.3 A model of game features promoting reframing value**

The third step of this research constructs a model in order to identify which game features can support generating reframing value and how they promote reframing value. RPGs are used as context games given that it is highly suitable to support IBL and popularity of applying education. Ten game features were qualitatively extracted, including multiple endings of the game, tasks with emotional experience, a real no-play character image, the game design of particular style, game stories, game avatars, tasks for problem-solving, the rank system of the game, game tools and game mode. This model bridged game features of RPG and four criteria of reframing value, which will benefit game designers, related educators and researchers who use games aiming at promoting reframing value or regard the need for a model to link games features with learning value. The relationship between digital RPGs and reframing value can

support reflection of multiple dimensions (i.e. four criteria of reframing value ) in the process of social learning, create related environments assisting students to understand the knowledge and provide a reference for selecting and designing games oriented at promoting critical reflection. A guideline was attached in order to provide support to related users of the model.



## **6.2 Future work**

In this thesis, games have been investigated as a robust tool to support IBL and COI. However, some limitations still exist in the current work. For example, the top 5 RPGs which were collected come from the IOS system, this brings some limitations. The author needs samples of games collected from broader game markets such as the markets of the IOS system and android system.

Further research to address the issues which find within research processes (i.e. a few studies involve utilising IBL-serious games to support teacher training). This research from a broader perspective investigates the impacts of serious games (SG) on teachers' professional development. The author has finished some studies, including investigating what contexts SGs have been used for teacher education, what types of games have been used for teacher education and what impacts SGs can have on teachers' professional development. However, the author plans to study associations between impacts, characteristics of the participants and game types/features, as this could more robustly inform the planning and evaluation of game-based teacher education, by allowing to identify these game features suitable to promote desirable effects in a specific target population.

## **Publications**

### **Refereed Conference Papers**

Gao, L., Fabricatore, C. and Lopez, M.X., 2019, September. Game Features in Inquiry Game-based Learning Strategies: A Systematic Synthesis. In 13th European Conference on Games Based Learning (pp. 854-862). Academic Conferences and Publishing International. The content of this paper involves the first step of my research.

Gao, L., Fabricatore, C. and Lopez, M.X., 2020, September. Feasibility of Using Serious Games for Teachers' Professional Development: A Review of the Current Literature. In 14th European Conference on Games Based Learning (pp. 701-710). Academic Conferences and Publishing International. The content of this paper addresses the new issue (e.g. only a few studies involve utilising IBL-serious games to support teacher training) which find within research processes.

Gao, L., Ward, R., Fabricatore, C. and Lopez, M.X., 2021, January. The Value Creation in Communities of Inquiry. In 2020 International Joint Conference on Information, Media and Engineering (IJCIME) (accepted). IEEE. The content of this paper involves the second step of my research.

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## **Appendix A Feasibility of Using Serious Games for Teachers' Professional Development**

As the result aforementioned (Chapter 4.1) that few studies involve utilising inquiry-based learning (IBL)-serious games to support teacher training, the author hopes from a broader perspective to find out the evidence of empirical studies that how serious games impact teachers' professional development. This research was carried out as follows.

### **A.1 Introduction**

Both digital and non-digital games have been leveraged for over three decades to foster learning at all stages of formal education (e.g. Connolly et al., 2012; Smith and Golding, 2018), in professional development contexts (e.g. Bochennek et al., 2007; Fu, Hainey and Baxter, 2016), and in informal environments (e.g. Matijevic and Topolovcan, 2019; Ruzic-baf et al, 2016). Research has amply theorised and demonstrated that games can effectively enhance learners' motivation, engagement, and learning outcomes in multiple domains (Squire, 2008, Boyle et al., 2016, Mayer, 2019, Fabricatore et al., 2019, De Freitas, 2006, Bayeck, 2020).

Teachers' professional development represents a particularly relevant scenario for the application of learning-oriented games. The modern role of teachers requires adapting to changing and increasingly complex contexts and demands and involves responsibilities that transcend the mere act of conveying information to students and assessing their coursework. Nowadays, teachers have to leverage pedagogical, technological, domain and context

knowledge in order to (i) prepare, convey and deploy appropriate contents and resources in learning environments (Graham, 2011, Harris et al., 2009, Galstaun et al., 2011, Hu and Fyfe, 2010), and (ii) guide students so that they can actively and autonomously construct knowledge (Biggs, 1996). These complex responsibilities require teachers to continuously develop, update and integrate knowledge, skills and attitudes relevant to tackle the scenarios that they face. This in turn requires novel teacher training approaches and tools (Webb and Cox, 2004, Kennedy-Clark et al., 2011).

Games represent an important asset in this context, as they can promote the development of transferrable knowledge, skills and attitudes by engaging players in activities driven by meaning-making, and set in scenarios mirroring real-world situations (Fabricatore et al., 2019). Indeed, games have been successfully leveraged to enhance teachers' professional development, facilitating the acquisition of domain-specific knowledge and skills (Meletiou-Mavrotheris and Prodromou, 2016, Alyaz and Genc, 2016, Lameris et al., 2014), increasing their motivation and engagement (Vrasidas and Solomou, 2013, Cózar-Gutiérrez and Sáez-López, 2016), and fostering positive attitudes towards modern pedagogical approaches and tools such as game-based learning (Kennedy-Clark et al., 2011, Annetta et al., 2014). However, to this knowledge, there is no systematic synthesis of evidence on the impacts of games in teacher education. This review addresses such a gap, aiming to better understand how serious games (SGs) can be used to enhance teachers' professional development of teachers' professional development, and with what effects. To this end, this review addressed the following questions:

- (a) In what contexts have SGs been used for teacher education?
- (b) What types of games have been used for teacher education?
- (c) What impacts can SGs have on teachers' professional development?



## A.2 Method

### A.2.1 Study selection

This review focussed on empirical studies reporting the effects of the use of SGs in teacher education. SGs were conceptualised as digital games designed to promote behaviour change and/or the development of knowledge, skills and attitudes (Hailey et al., 2016, Connolly et al., 2012, De Lope and Medina-Medina, 2017). The author considered game-based learning products as forms of serious games, given that game-based learning is usually synonymised with or used as a subcategory of serious games (Connolly et al., 2012, Hailey et al., 2016).

Studies for inclusion in this review were identified through a systematic database search in Scopus, using the following query: (teacher AND (training OR (professional AND development))) AND ((serious AND games) OR (learning AND games) OR (game-based AND learning) OR (digital AND game-based)). Searches were performed in title, abstract or keywords. The author looked for the journal or conference articles, written in English, and published between 2010 and 2020. Automatic lemmatisation was used to ensure the inclusion of relevant variants of keywords (e.g. including “games” automatically triggered the search for “game”). The search yielded a total of 471 articles. Titles and abstracts were screened by two reviewers, to identify duplicate and non-pertinent documents. As a result, 400 articles were excluded. Titles, abstract and full bodies of the remaining 71 articles were then reviewed, to identify studies for final review. Articles were excluded if they met any

of the following criteria: (i) not reporting on applications of digital SGs (as defined above) in teacher education; (ii) not reporting qualitative or quantitative outcomes/impacts; (iii) focussed on interventions and/or data already covered in other selected articles. As a result, 63 articles were excluded, and 8 were kept for full analysis.

#### A.2.2 Data analysis

Two researchers independently reviewed and coded the selected articles, extracting data using specially-created forms. In order to address RQ1, articles were coded through a deductive approach (Miles et al., 2014), identifying the description, purpose and country of the game-based teacher education intervention, the settings in which SGs were available to play, and key characteristics of the involved participants. To address RQ2, articles were analysed through an inductive coding process (Miles et al., 2014), focussing information describing the SGs used, and identifying key types of: (i) educational contents conveyed through SGs; (ii) hardware platforms on which SGs were used; and (iii) gameplay features, including roles impersonated by players, learning-conducive tasks involved in the game, settings in which gameplay unfolded, and virtual representations of players in the game space. RQ3 was addressed through further inductive coding, analysing information concerning ascertained impacts that game-based interventions had on teacher education.

Both manifest and latent contents were analysed in all cases. Latent contents concerning game genres were coded based on Herz' (1997) taxonomy of games. Coding of latent contents was subjected to inter-coder reliability testing through Cohen's kappa (Cohen,

1960), obtaining kappa scores consistently equal to 0.88. This indicated a high level of agreement between coders (McHugh, 2012). Disagreements were resolved through discussion to consensus.

## A.3 Findings

### A.3.1 Contexts of use of SGs

Table A.1 systematises the findings addressing Q1. The reviewed studies were mainly conducted in European countries (n=6). Only two studies were carried out before 2014. Most of the studies (n=5) used games only in formal teacher education settings (classrooms). In most cases (n=3) studies were focused on science education. Most studies targeted exclusively prospective teachers (n=5). All studies reportedly involved young people (n=4). The SGs involved mainly role-playing (n=6) and simulation (n=7) gameplay and contextualisation aspects. In most cases (n=6) SGs were used aiming at improving specific teachers' skills and knowledge, with a particular focus on classroom management capabilities (n=3). In all these cases, players acted as virtual teachers in simulated formal education environments (e.g. virtual classrooms) and interacted with virtual students (AI agents).

**Table A.1: Context of use of SGs**

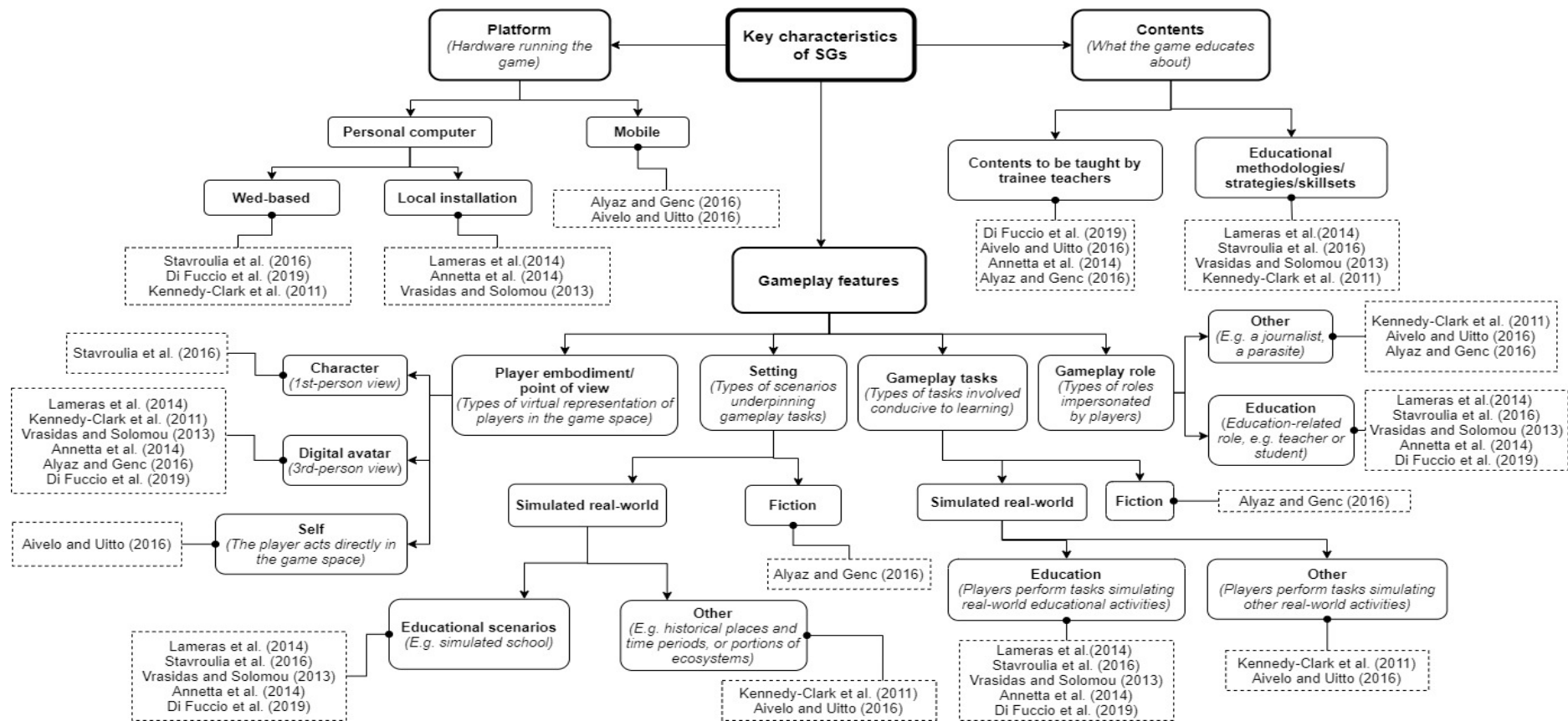
Study	Description of the game-based teacher education intervention	Purpose of the educational intervention	Country	Setting where the game was accessible	Characteristics of participants			
					Age	Gender	Subject area	Status
Di Fuccio et al. (2019)	Role-playing SG simulating real-world classroom environment developed and used within the DoCENT (Digital Creativity Enhanced in Teacher education) training programme. Game facing players/teachers with realistic situations requiring them to interact with virtual students (AI agents).	Enhance teachers' ability to apply digital creativity strategies in schools.	Europe	not reported	not reported	not reported	Not reported	pre-service
Alyaz and Genc (2016)	Adventure SG "A Mysterious Mission" set in a fictional context used as a scenario-based training environment.	Improve teachers' language skills.	Turkey	formal (classroom); informal	22.33 average	88% female, 12% male	German language	pre-service
Aivelo and Uitto (2016)	Augmented reality (AR) simulation SG "Parasite Race" set in a fictional context, used as a scenario-based training environment.	Promote exploration of how AR may facilitate the learning of conceptual models.	Finland	formal (classroom)	mostly young	86% female, 14% male	Biology	in-service
Stavroulia et al. (2016)	Role-playing SG "SimSchool" simulating real-world classroom environment. Game facing players/teachers with realistic situations, requiring them to interact with virtual students (AI agents).	Enhance teachers' classroom management capabilities (strategies to support and motivate students).	Greece	formal (classroom)	97.3% 18 to 30	42.7% female, 57.3% male	Not reported	pre-service

Study	Description of the game-based teacher education intervention	Purpose of the educational intervention	Country	Setting where the game was accessible	Characteristics of participants			
					Age	Gender	Subject area	Status
Lameras et al. (2014)	Role-playing SG "SimAULA" simulating real-world classroom environment. Game facing players/teachers with realistic situations, requiring them to interact with virtual students (AI agents). Training adopted an inquiry-based learning approach.	Enhance teachers' classroom management and lesson planning capabilities.	Europe	not reported	not reported	not reported	Science education	in-service and pre-service
Annetta et al. (2014)	Role-playing SG STIMULATE (Science Training Immersive Modules for University Learning Around Teacher Education) simulating science laboratory problem scenarios, used as a course for teacher preparation.	Advancing teachers' preparation and development in laboratory safety.	USA	formal (classroom)	not reported	35% female, 64% male	Science education	pre-service
Vrasidas and Solomou(2013)	Online role-playing gaming environment Quest Atlantis used to engage teachers in the evaluation and improvement of simulated classroom situations.	Promote the exploration of the potential of games for education, and reflection on practices from experience.	Cyprus	formal (classroom)	not reported	100% female	Not reported	in-service
Kennedy-Clark et al. (2011)	Teachers participated in a game-based inquiry learning process which included playing a role-playing SG and assessing other online SGs and virtual worlds.	Developing skills in using and evaluating game-based learning resources in secondary science education.	Austria	formal (classroom)	24.4 average	61% female, 39% male	Science education	pre-service

### A.3.2 Key characteristics of SGs involved in the reviewed studies

Figure A.1 illustrates the key game features identified to address Q2.

Most SGs (n=6) adopted a 3rd-person view to show a “physical” representation of the player in the game space. Educational game contents involved in equal measure contents that trainee teachers would have to teach in the future (n=4), and educational methodologies/strategies/skillsets to enhance their practice (n=4). Studies were generally conducted using different approaches regarding the learning environment. Some directly used virtual game environments. For example, on Alyaz and Genc (2016) a detective story as a fantasy setting of learning was provided to teachers where people were kidnapped for a secret project and rescued. Others, real scenarios blended with SGs, which meant the settings of games simulated realistic approximations of the environment to support teachers' learning (n=7). Especially, these games tended to use simulated school as the setting (n=5). Most papers (n=5) reviewed reported respectively that players had to perform tasks simulating real-world educational activities and assumed an education-related role (e.g. teacher or student). Most (n=6) games required a PC to be run. Among these, three required internet connectivity. Only two games ran on mobile platforms. One of them (Aivelo and Uitto, 2016) adopted augmented-reality and location-based mechanics, thus aligning with current trends in mobile gaming.



**Figure A.1 Key characteristics of SGs demonstrated effectiveness in mediating teacher education**



### A.3.3 Impacts of SGs

Table A.2 systematises the findings concerning impacts on teachers' professional development (Q3). Three key types of effects were identified: knowledge development; attitudes and others. The studies of Lamas et al. (2014) and Di Fuccio et al. (2019) did not report impacts. Hence, they were excluded from Table 2. Most studies reported quantitative measurements of impact. Vrasidas and Solomou (2013) reported qualitative outcomes. Only four studies reported knowledge development outcomes. However, mixed evidence was found regarding the impacts of SGs on teachers- knowledge development. Kennedy-Clark et al. (2011) showed that knowledge achievement did not change, via comparison of the pre-and post-tests within the game intervention. Alyaz and Genc (2016) and Annetta et al. (2014) observed significant effects on knowledge development through the intervention of SGs. From the perspective of attitudes, most studies reported positive impacts, such the perceiving SGs as useful tools for learning (Alyaz and Genc, 2016, Vrasidas and Solomou, 2013, Aivelo and Uitto, 2016), or positive shift of attitudes towards adopting technology in the classroom (Kennedy-Clark et al., 2011). Only one study reported other types of impacts (Kennedy-Clark et al., 2011).

**Table A.2: Impacts of SGs**

Study	Types of Impact (measurement)		
	Knowledge development	Attitudes	Others
Alyaz and Genc (2016)	(1) The game expanded teachers' professional vocabulary (paired-samples t-test showed a pre-post increase in words, $t(59) = 18.41$ , $p < 0.01$ ). (2) Learning achievement in the game is affected by age (ANOVA F-test, $F = 6.48$ , $p < 0.05$ ). (3) Gender, game preferences and language priming do not affect teachers' learning (ANOVA F-test, $F = 6.48$ , $p > 0.05$ ).	Most teachers believed that digital games are useful for learning foreign languages (86.7%, by frequencies of survey responses).	Not reported
Stavroulia et al. (2016)	not reported	(1) Simulated classroom environment generates both positive and negative real-time emotions similar to those experienced in real-world settings. (2) Most frequently-felt positive emotions (by frequencies of survey responses in quartile four): interest (95.2%); excitement (90.4%), motivation (92.3%) and satisfaction (90.4%). (3) Most frequently negative emotions (by frequencies of survey responses in quartile four): fatigue (94.2%); inability to deal with situation (83.6%); nervousness (77.6%). (4) Feelings experienced were not affected by genre ( $\chi^2 = 2.652$ , $df = 1$ , asymptotic $p$ -value = 0.103).	Not reported
Aivelo and Uitto (2016)	not reported	(1) Teachers provided suggestions to enhance the game	Not reported

Study	Types of Impact (measurement)		
	Knowledge development	Attitudes	Others
		<p>(2) Key attitudes broadly supported by teachers (based on analysis of themes emerging from group interviews, and individual support to these):</p> <p>(2.1) Positive attitudes toward the game, including the outdoor setting and the educational game contents</p> <p>(2.2) Dissatisfaction with the technical issues</p> <p>(2.3) Need for guidance on how to play the game</p>	
Annetta et al. (2014)	<p>(1) Self-perceived development of chemistry safety knowledge (pre-post questionnaire responses; Shapiro–Wilk W test, <math>W = .907</math>, <math>p = .059</math>, <math>M = 5.06</math>, <math>SD = 1.84</math>).</p> <p>(2) Self-perceived development of emergency response skills (pre-post questionnaire responses; Shapiro–Wilk W test: <math>W = .94</math>, <math>p = .124</math>, <math>M = 5.81</math>, <math>SD = 1.93</math>).</p> <p>(3) Gender affects self-perceived development of safety assessment skills (ANOVA F-Test, <math>MFemales = 3.95</math>, <math>SDFemales = 1.46</math>, <math>MMales = 6.09</math>, <math>SDMales = 1.64</math>, <math>F(8, 30) = 11.54</math>, <math>p = .002</math>, <math>n2 = 0.27</math> (large)).</p> <p>(4) Factors not affecting self-perceived development of safety assessment skills: ethnicity (ANOVA F-Test, <math>M = 4.68</math>, <math>SD = .94</math>, <math>F(4,30) = 0.356</math>, <math>p = 0.837</math>); years in school (ANOVA F-Test, <math>M = 1.29</math>, <math>SD = .46</math>, <math>F(1,30) = .048</math>, <math>p = .828</math>); major (ANOVA F-Test, <math>M = 1.54</math>, <math>.50</math>, <math>F(1,30) = .314</math>, <math>p = .581</math>); and experience (ANOVA F-Test, <math>M = 4.87</math>, <math>SD = 2.92</math>, <math>F(1,30) = 2.94</math>, <math>p = .101</math>)</p>	Most teachers endorsed mixed-mode video games integrating different game types (e.g. sport, first-person shooter) centred on social components, which similarly to what most SGs do (61.29%, by frequency of survey responses).	Not reported

Study	Types of Impact (measurement)		
	Knowledge development	Attitudes	Others
Vrasidas and Solomon (2013)	<p>(1) Self-perceived development of knowledge on student motivation and strategies to enhance it.</p> <p>(2) Self-perceived improvement of readiness to deal with future motivation-related situations.</p> <p>(3) Self-perceived development of other knowledge and skills, such as navigation.</p> <p>(All the above stemming from qualitative content analysis of teachers' propositions)</p>	<p>(1) Identified learning affordances offered by online game environments: interaction, collaboration, authentic problem-solving, role-playing, immersion, learner-centred; and instructor support.</p> <p>(2) Identified learning hindrances generated by online environments: complexity in integrating game-acquired knowledge in the curriculum; understanding ability; time pressure; learning contents distributed across game space and other resources.</p> <p>(3) Knowledge acquisition enhanced by games, compared to other media (e.g. books, articles, web pages, etc.).</p> <p>(4) Appropriateness of games to promote situated learning and effective understanding of information. (All the above stemming from qualitative content analysis of teachers' propositions)</p>	Not reported
Kennedy-Clark et al. (2011)	<p>(1) Participants were fairly consistent between the pre-and post-tests for the understanding of knowledge of serious games(e.g. defining a virtual world).</p> <p>(2) Teachers could effectively choose and utilise games as a teaching tool in the classroom (pre-test 52.9%, post-test 83.3%, by frequency of survey responses).</p>	Teachers showed a positive shift towards using games in the classroom (pre-test 38.5%, post-test 86.7%, by frequency of survey responses)	There was no significant correlation between gender and frequency of playing game (the test: $p = .021$ ).

## A.4 Discussion

### A.4.1 Viable outcomes of serious game-based teacher education

The author proposes in Figure A.2 a model of teacher education outcomes that is viable to obtain through the use of SGs, based on the evidence that the author analysed and summarized in table 8.2.

This model can be useful to inform the planning and evaluation of teachers' education. For example, targeting specific impacts (e.g. developing specific attitudes, skills or knowledge), and involving teachers in user-centred design processes to anticipate likely impacts (e.g. identify possible issues and unforeseen learning benefits). By the same token, such a model could be used to plan the adoption of games in teacher education programmes. For example, by facilitating the identification of benefits that games could promote in a specific context, and then selecting and adopting games presenting features that could promote such benefits.

### A.4.2 Trends and limitations emerging from the reviewed studies

The scarcity of empirical studies investigating the impacts of games on teachers' training through qualitative and quantitative methods is a key limitation that should be addressed. Based on this review, the author suggests that more empirical studies should be conducted to investigate the impacts of SGs in teacher training. Furthermore, there is a far larger number of empirical studies investigating the impacts of the use of SGs on other types of students according to these previous reviews (e.g. Hung et al., 2018, Perttula et al., 2017, Hwang et al.,

2012). The author proposed that this disparity should be pondered and addressed. After all, both teachers and students are key entities of pedagogical systems that require support and development.

Most studies (n=7) included in this review did not investigate associations between the effects of the use of SGs and the demographics of the participants. However, according to these findings, younger teacher trainees seem more likely to accept games as an effective tool to use. This is consistent with previous studies (Shaffer, 2006, Van Eck, 2006) which indicated that Serious Games and game-based learning may be more suitable to engage younger learners.

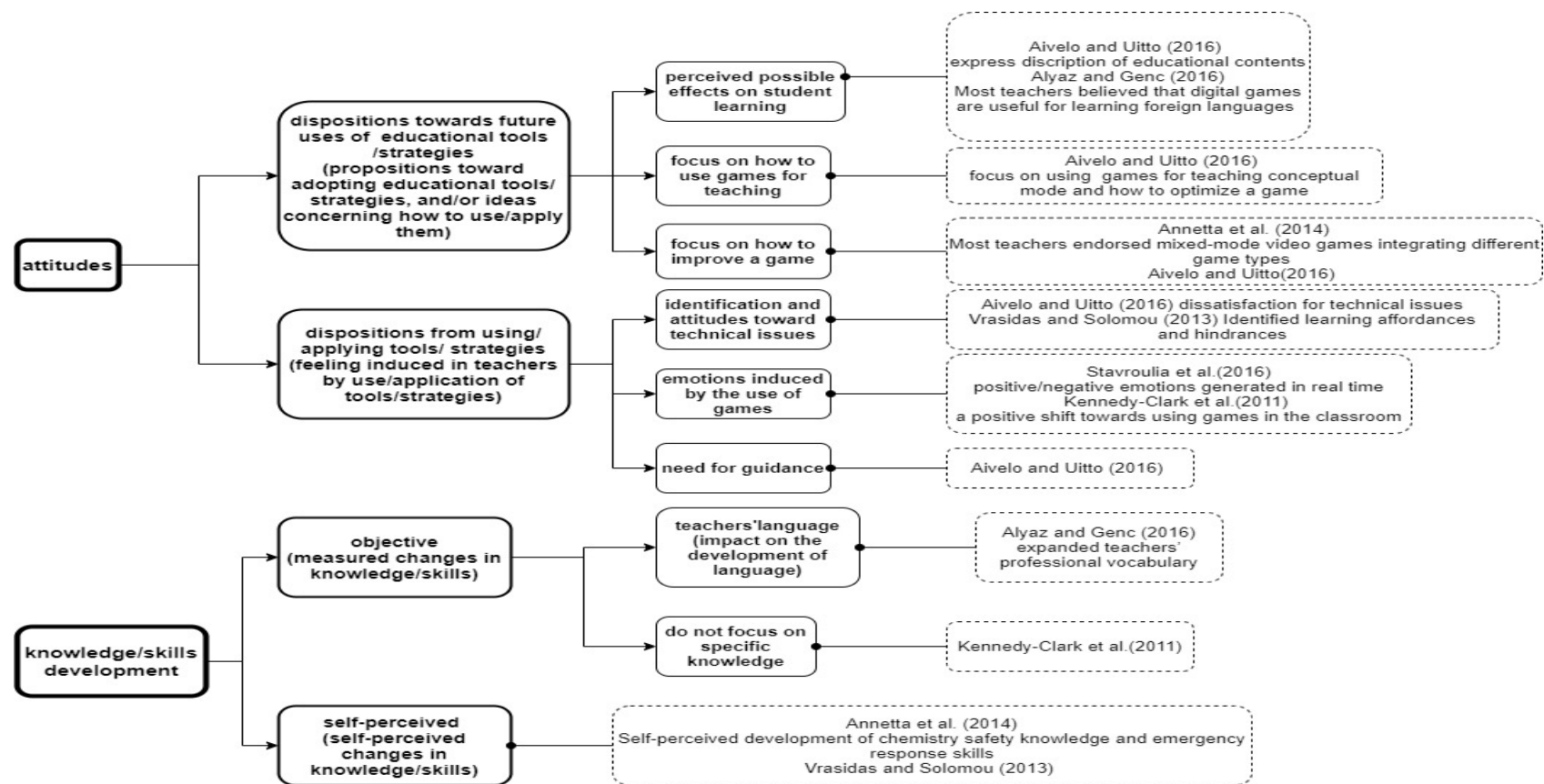


Figure A.2 A model of SGs-mediated teacher education outcomes

These findings suggest that future research may focus on the extent to which games should be leveraged to promote teachers' learning "anytime, anywhere". Most studies (n=6) implemented games within in a formal educational context, rather than promoting the voluntarily use of games outside classes. A good game might motivate people to use it - and consequently, learn through it - even if players are not "required" to do so (Crowston and Prestopnik, 2013). Hence, there may be interesting potentialities that might remain unexploited if SGs are not available outside formal training/educational sessions.

Furthermore, the platform of games can affect the learning experience (Klopfer and Squire, 2008, Squire et al., 2002). For example, a mobile game might be easier and more frequently used than a PC game. However, most projects (n=6) in this review reported using PC games. This should be further investigated in the future, exploring which platforms SGs should be designed in order to maximise the possibility of using and learning through them. This could be done, for example, involving teachers in participatory design processes. In addition, the author suggested that it would be good if researchers provided a rationale underpinning the choice of the technological platform, in relation to the characteristics of the target audience, the desired context of use, and the learning outcomes pursued.

#### A.4.3 Limitations of this review and trajectories for future studies

A limitation of this study is that it used Scopus as the only search database. Expanding searches to other databases, and/or adopting broader search criteria will be done in the future to further develop this review, hoping to increase the number of digital game-based interventions



reviewed. The author also plans to use more comprehensive strings in order to include interventions using non-digital games appropriately. For example, Petersen et al. (2011) used non-digital games for training pre-teachers to raise awareness of HIV/AIDS. Investigating these cases is crucial to achieve a more comprehensive analysis of broader analysis of game-mediated learning in the context of teacher education. After all, the notion of SGs was originally conceived for non-digital games (De Lope and Medina-Medina, 2017). Finally, the author plans to study associations between impacts, characteristics of the participants and game types/features, as this could more robustly inform the planning and evaluation of game-based teacher education, by allowing to identify these game features suitable to promote desirable effects in a specific target population.

## A.5 Summary

This chapter is a work expended, the aim is to explore the viability of serious games as an effective tool for teacher training. For this, the author searched existing literature regarding serious games and teacher training between 2010 and 2020 in the Scopus database. Articles were included in the review if they reported any impacts on teachers, such as in their knowledge and skills, their motivations, perceptions and attitudes. Results revealed that: (1) most studies were conducted using different approaches regarding the learning environment (e.g. some use virtual game environments, others real scenarios blended with serious games) to support teachers' learning; (2) most studies report that the use of serious games could support teachers' preparation, especially the development of planning skills and strategies; (3) there are only a few studies that focus on teacher knowledge development; (4) research was mainly conducted in European countries; (5) most games are targeted to prospective teachers. In general, findings suggest that serious game can be good tools to promote teachers' professional development, but future research should explore which game characteristics are more suitable and effective for specific training aims and different teacher characteristics.

## Appendix B The questions of the five-cycle value

**Table B.1: The value creation of the five-cycle (Wenger et al., 2011)**

value creation	explanation	examples	questions
Immediate value (activities and interactions)	The interaction and communication of communities' members can create value.	Help each other; meetings; dialogues; advice; a story be discussed; a project; a visit	1) What happened and experienced?
			2) What happened/were the important things?
			3) How many people participate?
			4) What was the quality of mutual participation?
			5) Is it interesting/attractive?
			6) How were the activities related to me?
			7) Who did I contact with or have established with whom?
			8) Which relationships have the greatest impact on my own progress?
Potential value (knowledge capital)	Some values do not appear immediately. This includes knowledge capital that is acquired	Look at new perspectives of the problem, new ways to solve problems; inspiration, care,	9) What happened to all these activities?
			10) How has my attendance changed me?
			11) Was I getting new skills or knowledge?
			12) Was I aware of this knowledge or my opinion has changed?

value creation	explanation	examples	questions
	and used when needed. The form of knowledge capital: human capital; social capital; tangible capital; intangible capital; learning capital	Confidence, status reputation, mutual understanding, accompany, learning challenges among members; access to information, resources, tools; reputation of the community; transformation of learning knowledge	13) Did you have more inspiration through your work? 14) Was I confident in my practical ability? 15) How has my attendance changed my social relationships? 16) To new people what access I gain? 17) Do I know them enough that what they can do to my learning? 18) Do I believe they are enough to ask them for help? 19) Am I not feeling so isolated? 20) Did I gain a reputation from my engagement? 21) What access to materials has my attendance given me? 22) Do I have new instruments, means or processes? 23) Can I have documents or sthisces of information that I do not have access to? 24) What situation has the community gained? 25) Is recognition of this expertise changed by the community? 26) Did we get a new voice through group learning? 27) How has my attendance transformed my idea of learning? 28) Can I see learning opportunities I haven't seen before? 29) Do I have the opportunity to convene a practice or online community to serve learning that I have never seen before?
Applied value changes in practice)	The changes, or innovations of actions, practices, tools, methods, system, are due to the application of intellectual capital in different contexts.	Use the knowledge learned in the community or the resources provided to practice	30) How is it different from my practice/life/background? 31) Where do I use community/network products? 32) Where do I use my acquired skills? 33) When do I use community/network connections with completing tasks? 34) Can I attract other people to pursue the cause that I care about? 35) When and how do I use documents or tools produced or accessed by the community? 36) How to implement an idea? At what level - personality, unit, organization?

value creation	explanation	examples	questions
Realized value (performance improvement)	Members are not satisfied with applications, new practices or tools and expect to practice new ideas or use community resources to improve performance	Achievements; comprehension; ability improvement	<p>37) Does it make any difference to my ability to achieve important functions for me or other stakeholders?</p> <p>38) What aspects of my behaviour influence my participation in the community/network?</p> <p>39) Am I saving time or implementing to gain some new?</p> <p>40) Am I more successful? How about it?</p> <p>41) What is the impact of the implementation of an idea?</p> <p>42) Does this affect some of the indicators used to evaluate activities?</p> <p>43) Because of my attendance, what achievements can my team achieve in the community/network?</p>
Reframing value (redefining success)	When social learning leads to a rethinking of the definition of success, reshaping will be realized	Definition of assessment criteria; suggestions for community development; self-reflection; new standards for learner evaluation	<p>44) If it has changed the understanding and definition of important things that I or other stakeholders have?</p> <p>45) Does the social learning process led to a reflection on important issues?</p> <p>46) If this has changed people understanding of important things?</p> <p>47) Does this mean that new standards and new indicators should be included in the assessment?</p> <p>48) How those people who have the right to decide standards of success are impacted by this new understanding?</p> <p>49) Can the new understanding change into institutional change?</p> <p>50) Due to this new understanding, is there a new framework or system developed or created?</p>

## Appendix C Questionnaires

### C.1 A questionnaire for testing the reliability of the model

**Table C.1: A form for testing the reliability of the model**

Investigation introduction: This investigation aim was to exam game features influencing reflection to promote reframing value generated by the community of inquiry(COI). The investigation is based on a model of game features promoting reframing value. The model driven by value-making is based on integrating perspectives from reframing value theory and COI theory.					
Criteria of reframing value and involved game features	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
	1	2	3	4	5
<i>Promoting reflection</i> If players rethink the game content leads to a reflection on important issues or changed people understanding of important things:					
A real no-play character (NPC) image					
Game stories					
Multiple endings of the game					
The game design of particular style					
Tasks with emotional experience					
Game tools					
Generating new assessments for other people If players reframe the assessment standard for other people:					

Investigation introduction: This investigation aim was to exam game features influencing reflection to promote reframing value generated by the community of inquiry(COI). The investigation is based on a model of game features promoting reframing value. The model driven by value-making is based on integrating perspectives from reframing value theory and COI theory.					
Criteria of reframing value and involved game features	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
	1	2	3	4	5
Game avatars					
Suggestions for community development if players reshape the new expectation of the whole community development:					
Game stories					
Game avatars					
Game mode					
The game design of particular style					
Tasks for problem-solving					
Game tools					
The rank system of the game					
The change of evaluation If players change the process and pattern of evaluation via the game experience:					
The game design of particular style					
Tasks for problem-solving					

## C.2 The questionnaires for testing the validity of the model

**Table C.2: The questionnaires for the game experience test (*Chinese Paladin: Sword and Fairy 3*)**

<p>1.What is your status: teacher ( ) or student ( )</p> <p>Multiple choice question</p> <p>2. If the game covers the following game features:</p> <p>Multiple endings of the game (Y/N)</p> <p>Task with emotional experience (Y/N)</p> <p>A real no-play character (NPC) image (Y/N)</p> <p>Single choice question</p> <p>3. I felt a sense of responsibility in controlling roles' destiny while working on the options of multiple- endings of the game. For example, I would consider the advantage and disadvantages of different game-endings then made a choice. ( )</p> <p>A. Strongly disagree (1 point)</p> <p>B. Disagree (2 points )</p> <p>C. Undecided (3 points)</p> <p>D. Agree (4 points)</p> <p>E. Strongly agree (5 points)</p> <p>F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?_____ (0 point)</p> <p>4. I felt that I could generate divergent ideas such as associating similar situations while working on tasks with emotional experience. ( )</p> <p>A. Strongly disagree (1 point)</p> <p>B. Disagree (2 points )</p> <p>C. Undecided (3 points)</p>
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D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)

5. I felt that I could reflect an NPC's behaviours or personalities due to the NPC is closer to a real living person. ( )

A. Strongly disagree (1 point)

B. Disagree (2 points )

C. Undecided (3 points)

D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)

6. I felt that I could generate divergent ideas while exploring the game stories. For example, the game story would stimulate my curiosity to explore more details including the analysis of game plots, guessing the relationship of game characters, digging the hiding philosophic theory of life. ( )

A. Strongly disagree (1 point)

B. Disagree (2 points )

C. Undecided (3 points)

D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)

7. I thought that gave suggestions for improving the game story was interesting. ( )

A. Strongly disagree (1 point)

B. Disagree (2 points )

C. Undecided (3 points)

D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)

**Table C.3: The questionnaires for the game experience test (*Limbo*)**

1.What is your status: teacher ( ) or student ( )

Multiple choice question

2. If the game covers the following game features:

The game design of particular style (Y/N)

Game tools (Y/N)

Tasks for problem-solving (Y/N)

Single choice question

3. I found the game design of particular style (theme, details of design, music and voices) to be helpful in my rethinking such as an association of similar items. ( )

A. Strongly disagree (1 point)

B. Disagree (2 points )

C. Undecided (3 points)

D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)

4. I found the game tools to be helpful in my rethinking such as how similar items were applied. ( )

A. Strongly disagree (1 point)

B. Disagree (2 points )

C. Undecided (3 points)

D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)

5. I thought that gave suggestions for improving the game design of particular style was interesting, including revising theme, details of design, music and voices. ( )

A. Strongly disagree (1 point)

B. Disagree (2 points )

C. Undecided (3 points)

D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)

6. I thought that gave suggestions for improving the game tools was interesting. For example, I suggested that enhance aid kits in order to win the battle easier. ( )

A. Strongly disagree (1 point)

B. Disagree (2 points )

C. Undecided (3 points)

D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)

7. I thought that gave suggestions for improving the tasks for question-solving was interesting. For example, I wanted to complete the task easier hence I gave some suggestions to decrease the difficulty of tasks. ( )

A. Strongly disagree (1 point)

B. Disagree (2 points )

C. Undecided (3 points)

D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)

8. I felt that game tools allowed me to complete my task in several new strategies of matching. ( )

A. Strongly disagree (1 point)

B. Disagree (2 points )

C. Undecided (3 points)

D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)

9. I felt that tasks for question-solving allowed me to complete the task in several new ways. ( )

A. Strongly disagree (1 point)

B. Disagree (2 points )

C. Undecided (3 points)

D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)

**Table C.4: The questionnaires for the game experience test (*World of Warcraft*)**

1.What is your status: teacher ( ) or student ( )

Multiple choice question

2. If the game covers the following game features:

Game avatars (Y/N)

The rank system of the game (Y/N)

Game mode (Y/N)

Single choice question

3. I thought that gave suggestions for improving the game avatars was interesting. For example, the skills and personalities of game avatars sometimes directly impacted the quality of the game entertainment and art, which inspired me to suggest developers changing or revising the skills or the avatar's personality. ( )

A. Strongly disagree (1 point)

B. Disagree (2 points )

C. Undecided (3 points)

D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)

4. I thought that the rank system of the game was able to support multiple players at the same time. Hence, the fairness of the rank system such as the pairing system would be suggested to optimize. ( )

A. Strongly disagree (1 point)

B. Disagree (2 points )

C. Undecided (3 points)

D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)

5. I thought that gave suggestions for improving the game mode was interesting. For example, I would present advice such as adding a checking function for browsing members' details in order to know teammates better. ( )

A. Strongly disagree (1 point)

B. Disagree (2 points )

C. Undecided (3 points)

D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)

6. I felt that game avatar allowed me to complete my task in several new strategies such as the skills matching could be appropriately utilised to enhance avatars' ability. ( )

A. Strongly disagree (1 point)

B. Disagree (2 points )

C. Undecided (3 points)

D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)

7. I believed that I was the game avatar I was controlling to show my emotions or behaviours. This would trigger my rethink for this avatar or inspire other players as enemy or teammate to assess for avatars' behaviours. ( )

A. Strongly disagree (1 point)

B. Disagree (2 points )

C. Undecided (3 points)

D. Agree (4 points)

E. Strongly agree (5 points)

F. Other (0 point). How could this feature be improved in order to support refreshing value (promoting reflection, suggestions for community development, the change of evaluation and generating new assessments for other people)?\_\_\_\_\_ (0 point)