Essential features of serious games design in higher education: Linking learning attributes to game mechanics

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Abstract

This paper consolidates evidence and material from a range of specialist and disciplinary fields to provide an evidence-based review and synthesis on the design and use of serious games in higher education. Search terms identified 165 papers reporting conceptual and empirical evidence on how learning attributes and game mechanics may be planned, designed, and implemented by university teachers interested in using games, which are integrated into lesson plans and orchestrated as part of a learning sequence at any scale. The findings outline the potential of classifying the links between learning attributes and game mechanics as a means to scaffold teachers' understanding of how to perpetuate learning in optimal ways whilst enhancing the in-game learning experience. The findings of this paper provide a foundation for describing methods, frames, and discourse around experiences of design and use of serious games, linked to methodological limitations and recommendations for further research in this area.

Practitioner Notes

What is already known about this topic

- Serious game design is a relatively new discipline that couples learning design with game features. A key characteristic of this approach is grounded in educational need and theory, rather than a focus purely on entertainment. Under this approach, a common method for designing serious games involves the creation of learning strategies, content and principles for the purpose of enhancing the student's learning experience.
- There are no pedagogically driven strategies that take into account how learning attributes are interlinked to game elements for balancing learning with play. This is due to a limited evidence base of comparative evaluations assessing differing game designs against a single pedagogical model, or vice versa. This often leads practitioners seeking to introduce games into classroom with difficulties identifying what defines a game or how design should be enacted in a way that encompasses particular learning interventions.
- Qualitative research methodologies have not been utilised as often for discerning how people experience, understand and use serious games for teaching and learning in higher education.

What this paper adds

- This paper presents the foundation of a taxonomy linking learning and game attributes along

with teacher roles, aiming to encourage the cross-fertilisation and further integration of evidence on serious game design. The initial findings provide insight for practitioners on elements common to games and serious games, and how these link to particular learning design strategies that may afford pedagogically-rich games.

- It informs development in the design and use of serious games to support teaching and learning in higher education. Given the key role of practitioners in the development of a wide range of serious games, due to the iterative and participatory methods frequently adopted, it offers insight into game elements and mechanics, allowing practitioners to easily relate to how learning activities, outcomes, feedback and roles may vary and visualised in relation to what needs to be learned out of playing the game.
- The paper also identifies gaps in the evidence base and avenues for future research. Through this a practitioner can gain insight into the current unknowns in the area, and relate their experience of introducing games in the classroom to the current evidence base.

Implications for practice and/or policy

- The taxonomy informs serious game/instructional designers, game developers, academics and students about how learning elements (e.g. learning activities, learning outcomes, feedback and assessment) can be represented in games. We advocate dialogue between teachers and serious game designers, for improving the process of amalgamating learning with fun; and whilst the idea of using digital games is relatively new, teachers have a wealth of experience introducing learning features in games to be used into their classroom activities which frequently set out undocumented.
- It aids the delineation of game attributes and associated game categories for characterising games based on primary purpose and use. Planning and designing teaching and learning in a game and teacher's associated role in guiding the in-game learning process is a consistent challenge and this paper seeks to provide a foundation by which this process can be undertaken in an informed and conscious manner.
- The findings of the review act as the point of departure for creating a research agenda for understanding disjunctions between espoused and enacted personal theories of using serious games through qualitative methodologies.

Introduction

Serious Games (SGs) design is a relatively new discipline that couples learning design with game mechanics and logic (de Freitas, 2006; Hainley 2006; Westera et al., 2008). Design for SGs involves the creation of learning activities that may use the whole game or entail a gaming element (e.g. leader boards, virtual currencies, in-game hints) for the purpose of transforming the student's learning experience. Arguments against SGs have centred upon lack of empirical evidence in support of their efficacy; and the fact that appropriate research methodologies have not been enacted as yet for discerning how people understand and use SGs for teaching and learning in higher education (Mayer 2012; Connolly 2012).

However, there are studies in the UK and US respectively that have demonstrated positive results in large sample groups (see for example Dunwell et al., 2014; Hertzog et al., 2014; Kato et al., 2008). Research evidence stresses the lack of commonly accepted pedagogically-driven strategies to afford game mechanisms and suggest that an inclusive model that takes into account pedagogy and teaching strategy, aligned to game activity and assessment is necessary for balancing play features with pedagogical aspects. This argument stems from an important observation that learning is a

constructive process, which encompasses aspects of collaborative learning in which knowledge creation emerges through discussion and negotiation between individuals and groups.

With these perspectives, this paper draws together evidence and material from a range of specialist and disciplinary fields to offer a critical review and synthesis of the design and use of SGs in higher education.

Current literature on the field of SGs is inconclusive as regards the provision of a comprehensive analytical structure on SGs design, due to several complications. Firstly, drawing on both game and learning attributes essential for creating an engaging, immersive and transferable learning experience to the student. Secondly, serious game development has a broad remit, covering the large-budget; repurposable, digital solutions aimed at wide markets, the role of the teacher in guiding learning via games seemed to be fuzzy and unclear and may lead to confusion during the design stage, and finally, a lack of comparative evidence, with games often assessed only in terms of their individual successes or failures, makes it difficult to ascertain whether success or failure was due to a specific design choice or omission.

The consequent scarcity of this evidence has an immediate implication when seeking to approach educational game design theory from a basis of sound teaching and learning strategies, principles and pedagogies. Despite these drawbacks, the increasing investment in serious gaming is leading to the emergence of studies seeking to address these issues with digital games frequently seen as a means for providing intrinsically motivating and inclusive learning experiences.

This study draws upon a corpus of items selected from this emerging evidence base and representing key themes around the topic, offering pointers, recommendations, and scaffolding mechanisms for educational game design and development which seeks to balance learning principles and features with the engagement and motivation stimulated by gaming.

The paper connects with wider strands of research on SGs in higher education, including work on learning design (Beetham, 2008) game mechanics (Charsky, 2010; Juul 2005; Fabricatore, 2007) and linking game attributes to learning (Bedwell et al., 2012; Arnab et al., 2015; Amory 2007), educational design for games (Gunter 2006; Gonzalez et al., 2014; Hainey et al., 2011; Hirumi et al., 2010) engagement and motivation (Boyle et al., 2011; Boyle et al., 2012; Hainley et al., 2006). It is carried out with three main aims:

1. To inform development in the design and use of SGs to support teaching and learning in higher education.
2. To contribute to the cross-fertilisation and further integration of evidence on SGs design with particular focus on mapping learning elements to game attributes.
3. To identify gaps in the evidence base and avenues for future research.

In line with the main aims, this paper is structured into the following sections: the overarching methodology that frames the study contemplating on search design and implementation, analysis and synthesis, the results from the study grouped in themes, discussion and conclusion.

Methodology

The review was informed by the following research questions: (1) how is the use of games for teaching and learning conceptualised, theorised, modelled and researched? (2) what are the essential features of SGs in higher education? (3) how do learning attributes match game elements as means to optimise SGs design and the student learning experience? The review of evidence in this report is based on the process of search, retrieval, appraisal, extraction, synthesis and interpretation of relevant literature in the public domain. The search and review process is illustrated in Figure 1.

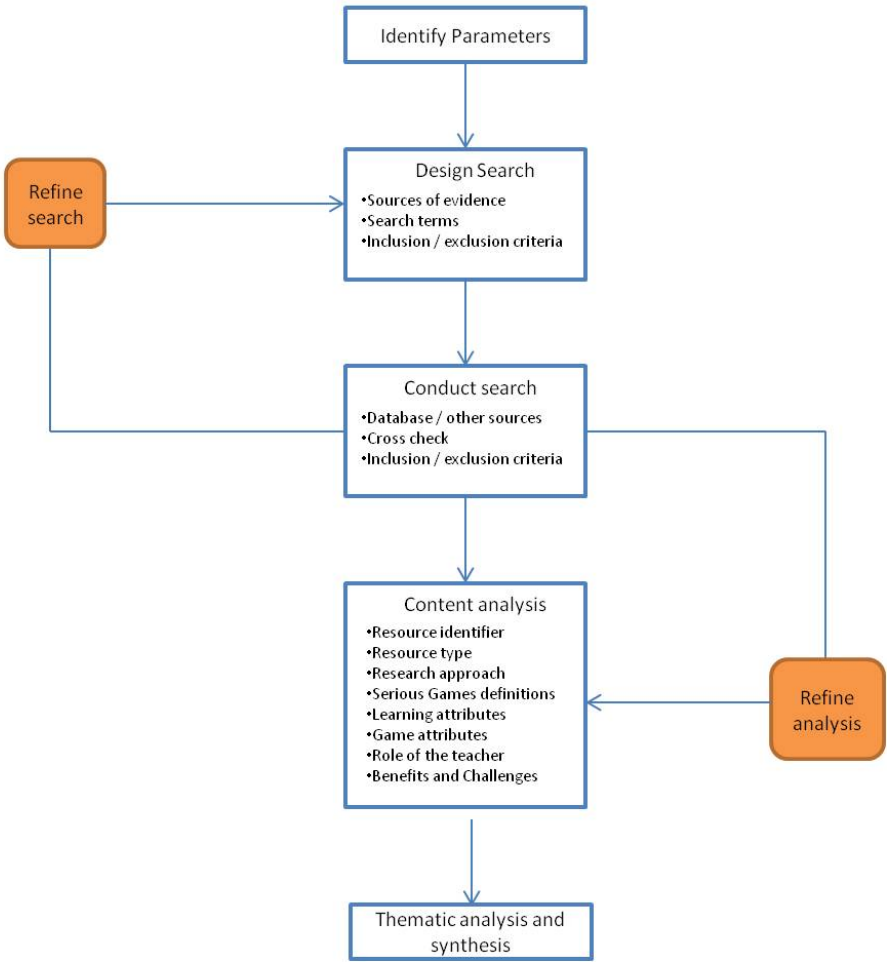

Figure 1: Methodology process

A range of sources predominantly including journal articles, conference papers, book chapters, reports and policy documents are identified and used for creating a corpus of 165 items (see Table 1). The database searches were conducted in winter-summer 2014 with some key items added in winter 2015. The key items added in winter 2015 were as part of the iterative search and retrieval process followed by the methodology process in Figure 1 and included only new items without updating the entire corpus. This is not perceived as a methodological limitation as only key items have been included omnipresent to the literature evidence.

Type of Resource	Number of Resources
Journal papers	123
Conference papers	20
Book chapters	15
Policy reports	2
Other (reports, web etc.)	5
Total items in corpus	165

Table 1: Type of sources and total number of items in corpus

Databases searched and search terms

The search was conducted via a number of bibliographic databases such as: EBSCO: academic search complete, business source complete, communication and mass media complete, library information science and Technology abstracts, Science Direct via Scopus, and British Educational Index (BEI). Google Scholar is used as the key search engine. Open access search engines are used in congruence such as CORE, BASE and COPAC, which allowed keywords and semantic search for open access to 'deep web' sources, which are ignored by commercial search engines (see Table 2). These databases have been selected on the premise of selecting both key publications included in reputable databases such as BEI and Scopus whilst to complement key papers with papers that might potentially be more challenging to find hence indexed in other databases. Normally using Boolean and Proximity search the term(s) "serious games" OR "serious games design" OR "game-based learning" OR "serious games" AND "learning attributes" OR "engagement" OR "motivation" OR "enjoyment" OR "learning outcomes" OR "teacher roles" OR "assessment" OR "collaboration" OR "game mechanics" OR "game attributes" OR "rules/goals" OR" challenge/surprise" OR "rewards" OR "game hints/feedback/progress indicators". The search terms are selected (a) on the basis of addressing the research questions accurately and (b) for aligning relevant aspects of game design to the researcher's lines of research trajectories, experiences and expertise.

Inclusion and exclusion criteria

Items relating to investigating games for teacher's training and professional development across different academic disciplines were included. Serious games developments with strong emphasis on behavioural change as means to persuade conceptual or attitudinal change were included. Detailed technical descriptions of developing SGs without any kind of empirical evidence or conceptual analysis of using SGs at any scale were excluded.

Database	Number of papers in search	Number of papers meeting inclusion criteria
EBSCO	5215	34
Science Direct	5974	80
BEI	1230	28
CORE	7315	11
BASE	3235	10
COPAC	79	2
Total	23048	165

Table 2: Total number of papers identified from database and total number of papers included in corpus

To summarise, items were included in the review corpus if:

- The term serious game(s) or close synonyms such as 'game-based learning', 'games for teaching and learning' 'educational games' at the level of title and/or abstract were included.
- Game design with focus on learning/educational design as means to improve learning was reported.
- Game design with focus on learning/educational design as means to support and guide university teachers to design, develop, share and re-use SGs were reported.
- Game design with focus on learning/educational design enacted in HE was included.
- Linking learning attributes to game attributes was reported.
- Learning design as discipline linked with games was reported
- Items were published between 2002-2014 with the exception of key papers and selected prior items.

Research design

Figure 2 depicts the number of papers in relation to the research design approach used for collecting and analysing data. Results showed that the overarching approach to research SGs is quantitative 120 (60.6%) utilised randomised control trials 50 (41.6%), survey designs 35 (29.1%) with open questions 2 (5.7%) and 25 (71.4%) with closed questions. The remaining 35 (29.1%) papers were quasi experimental. Qualitative methodologies for understanding experiences of using SGs were only 45 (27.2%), with 20 (44.4%) general content analysis with a predefined interview guide and 5 (25%) with an open-ended questionnaire. 25 (55.5%) papers were literature reviews out of which 3 papers (12%) were systematic literature reviews and 22 papers (88%) were evidence based. It is clear that qualitative study designs for understanding practitioners' experiences of using games for learning is under-utilised in the current evidence-base in terms of understanding the qualitatively different ways of experiencing games.

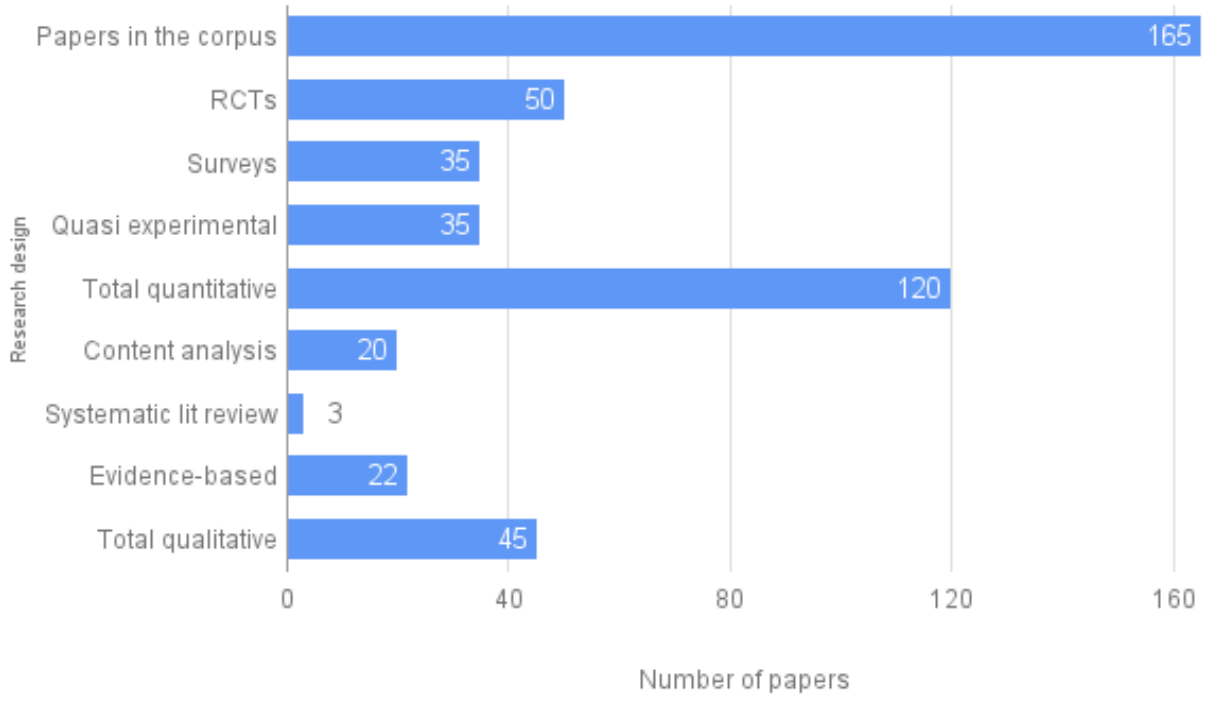

Figure 2: Papers in the corpus by study design

Data analysis

A coding scheme has been developed in order to code papers. The coding scheme is based on: paper resource identifier; resource type; research approach; Serious Game (SG) definitions; genres of SGs; educational features; SG frameworks; role of teacher; behavioural factors; game mechanics; benefits and challenges; key findings. The design of each study was coded according to how empirical data were approached: either quantitatively or qualitatively. The coding framework is presented in Table 3.

Themes	**Description**	**Code**
Resource identifier	Title, author, date of publication	RI
Resource type	Research report, journal article, conference paper, policy document, book chapter	RT
Research approach and methods	RCT; quasi-experimental, Survey, ANOVA grounded theory, qualitative	RA
SGs definitions	What serious games means? Different conceptualisations of serious games including games designed for knowledge or skill acquisition or training.	SGD
Learning attributes	Learning attributes used like in-game learning activities; assessment, feedback, learning outcomes.	LA
Game attributes	Game attributes like levels, game hints, scores, game narration; extrinsic and intrinsic rewards; avatars; dialogues; rules, challenges, collaboration; competition.	GA
Role of the teacher	What is the role of the teacher in using games? Designer, co-player, use of existing games in own context; facilitator, transmit information and knowledge, assessor.	RoT
Benefits and challenges	Beliefs towards the level of effectiveness / or not in the use of serious games in HE. Aspects such as motivation and engagement, enabling research practices or constraints are identified and discussed.	BC

Table 3: Coding framework

The coding scheme has been pre-tested by analysing 11 papers to calibrate coding effectiveness in relation to the research questions. Codes such learning attributes and game mechanics have been identified to delineate how learning and play will co-exist within a game in a balanced way. The learning attributes code identified relevant processes and practices enacted in the classroom, such as learning outcomes, assessment and feedback and learning activities. The game attributes code perpetuated relevancy with fun gaming elements such as levels, victory conditions, missions, game goals puzzles, timers grouped to emerging categories. The research approach and methods code allowed the correlation of various research methodologies with the game's evaluation purpose (i.e. whether it had to do with the evaluation of the actual game -mostly statistical tests) or the player's experience of playing the game (qualitatively different ways of experiencing the use of games). SGs definitions allowed preconceiving the plethora of different ways of usage identified in the literature and understanding disjunctions between espoused theories (i.e. conceptions) and theories in use (actions). The role of the teacher code illuminated the variation in what the teacher is doing before, during and after playing the game. The perceived teacher's role in turn informs, the chosen learning activities, game elements and learning outcomes (see Figure 1).

Results

Serious Games Definitions

There is variation in the literature in the ways of understanding the theoretical and practical dimensions of experiencing a serious game. Dempsey et al. (1996) defined SGs in terms of encompassing essential characteristics such as competition and goals, rules, challenging activities, choices and fantasy elements. Zyda characterises a serious game as a "mental contest, played with a computer according to certain rules, that uses entertainment to further government or corporate training and education [...] (2005, p.26). Zyda differentiates between an entertaining game and a serious game from their main overarching principles. SGs are more complex artefacts, as their design involves not just a story, art and software development. SGs need to encompass rigorous pedagogical strategies that discern learning theory, teaching and learning approaches, assessment and feedback (Cornillie et al., 2012; Orvis et al., 2008; Sawyer 2007). These additions make a game appropriate for educational purposes (Yusoff, 2009; van der Spek, 2011; Raybourn 2014). The design, art, software and pedagogy teams work together to produce a finished product (Zyda, 2005), perceived as the result of a systematic, conscious and consistent application of a game design process (Gentile et al., 2014; Harteveld et al., 2010; Hess and Gunter, 2013). The pedagogy and story should be aligned together to form a balance between the fun and learning features (Csikszentmihalyi, 1990) in order for spurring motivation and engagement to delineate the distinctive features of an educational game and thereby spurring in-game learning activities, content acquisition, feedback, assessment and reflection (Gutner 2008; Neville, 2010; Manusos, 2013) in the context of a particular academic domain (see Figure 3).

SGs in Higher Education are used in conjunction to acquiring knowledge and skills applied to a particular discipline, module or educational topic. The interactive, participatory and engaging features of games (Blanco et al., 2012) and their problem-solving orientation (de Freitas, 2006) led to the assumption that games could be used for enhancing learning and teaching across different academic territories (Giannakos, 2013).

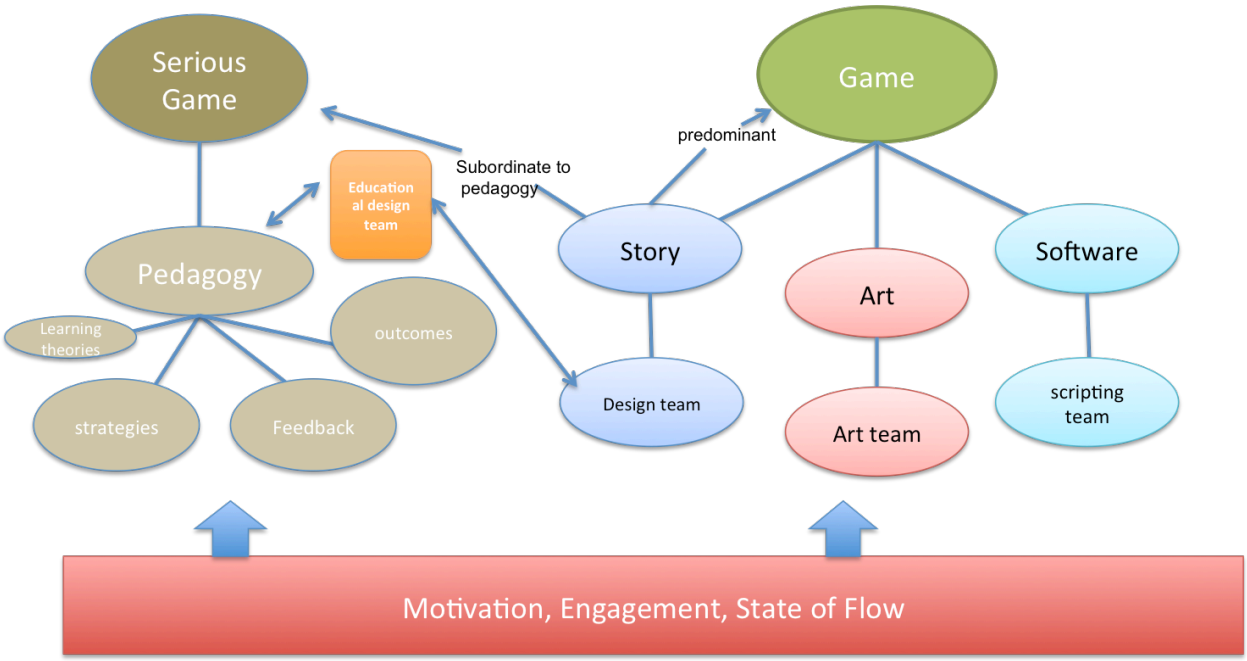

Figure 3: Conceptions of serious games design (adapted from Zyda 2005)

Two conceptual dimensions have been suggested (e.g. Gunter, 2006; Hainey, 2011) to link the entertainment aspect with the learning features of the game. The first is *motivation* and the second is *attention.* Induce motivation to the learner to repeatedly consume content (playing the same level more than one time to achieve learning outcomes or improve performance). Introduce new rich mediated content along with exploratory in-game learning activities that allow students to retain their attention and expand their knowledge beyond the intended learning outcome set out by the teacher.

Benefits and challenges

Possibilities to increase the quality of the learning experience in games have been a subject of a debate in the current evidence base (Charsky 2010; Hong et al., 2009; Kazimoglu 2012). There is inconclusive evidence in responding to the research questions: Are SGs an effective means of enhancing the student learning experience in universities? What are the advancements sought to bring into the teaching and learning practice in conjunction to current methods? Studies of e-learning environments tend to focus on the sociocultural context in relation to how university teachers and students understand and use tools for learning. Thus, from a sociotechnical perspective, research on educational technology, sought to investigate primary affordances of technological tools (Laurillard, 2003) and how these map to personal teaching and learning experiences (Conole et al., 2004). Such empirical research has not been instantiated in terms of understanding the merits of using a game for consolidating and assimilating learning content (Kebritchi, 2008). Connolly et al (2014) carried out a systematic meta-analysis review on SGs and presented evidence that a SGs contribution to effective learning was not strong.

Motivation and engagement seem to be primary factors argued by proponents of the uptake of games (Connolly et al 2014; Boyle et al., 2012; Erhel and Jamet, 2013) in conjunction with the diversity of debates with regards to their educational value. For example, Vos et al. (2011) conducted a study on student motivation and deep learning strategy use with 235 students. One group of students created their own memory game while another group played an existing memory game. The results suggested that student motivation significantly increased especially for the student group that constructed their own game. Intrinsic motivation was highlighted as an important variation that can be enhanced through construction. Through games, students increased their curiosity and overall interest levels by participating in contextual learning activities meaningful to them. By situating learning into context (Lave and Wenger 1991), games twin content with playful elements for providing intrinsic motivation at a higher level compared to traditional academic teaching and learning.

Learning attributes

Studies on how SGs may improve the teaching and learning process have focused on certain approaches to learning and teaching as well as on instructional strategies that facilitate learning in games. In games, it is not uncommon for students to use games in a playful way with little attention on the learning aspect (Connolly et al., 2012), bringing to the fore serendipitous or incidental learning where students learn without insinuating a learning goal (Erhel and Jamet 2013). Evaluating the effects of learning using SGs may provide empirical evidence on mapping game elements to learning (Harteveld et al., 2010; Hess et al., 2010; Hirumi et al., 2010). Learning attributes such as learning activities, learning outcomes, assessment and feedback and teacher roles are further decomposed as to provide a framework for linking learning with play.

Learning activities

Learning activities in games drive the learning outcomes set out by the teacher, curriculum or instructional designer. The outputs of some activities are used as inputs to others resulting in game flows that can be adapted while the student is executing the learning activity. A game-based learning

activity, as distinct from game content, is the central concern of work within the game-based learning design, which has historical roots in the wider field of instructional design (McLean and Scott, 2011). Following Goodyear (2002), it is helpful to establish a distinction of in-game *learning task* and *learning activity*, but in line with common practice in the literature the terms 'tasks' and 'activities' are used as synonyms. In essence tasks assigned by the teacher are transformed into learning activities enacted by the student. For this study, the design of in-game learning activities is a situated action – that is triggered from the game's objectives and each game sub-level goals created by teachers in specific contexts of practice.

Type of learning activity	**Source**
Information Transmission (teacher-led) • Lecture / lecture notes / slides • Memorising concepts • Labelling diagrams and concepts • Exampling • Incomplete statements • Lecture summary • Listening	Beetham 2008; Laurillard 2002; Gutner 2008
Individual (teacher and student-directed) activities • Web-quest (information search and retrieval) • Exercise solving • Carrying out scientific experiments • Reflection • Simulations • Modelling • Role playing • Inquiry (pose questions) • Determining evidence • Analysing evidence • Formulating evidence • Connect explanations to knowledge	Crawford, 1999; Bybee 2008, Kleemans, 2011; Lacasa, 2008; Gee, 2002
Collaborative (teacher and student-directed) activities • Brainstorming • Group projects • Group web-quests • Rank and report • Group of students posing questions to each other • Group simulations • Pair-problem solving • Group data gathering • Group data analysis • Group reflection	Dillenbourg 1999; Anjewierden 2011; Bell et al., 2010 Gijlers et al., 2009
Discussion and argumentation activities (Reflective teacher and student-led) • Guided discussions (discussion topic provided by teacher) • Open discussions (discussion topic provided by students) • Choices: data on events and several choices for students to make comments • Debates (justifying explanations)	Dillenbourg 1999; Dominguez, 2013, Laurillard, 2002; Beetham, 2008; Jarvinen, 2008

Table 4: Types and sub-types of learning activities used in games

Beetham defines learning activity as a *"specific interaction of students with others using specific tools and resources, orientated towards specific outcomes"* (2008 p.28). Contextualising and applying this definition to SGs design should discern a meaning such as: *a specific interaction of students with others or [individually] using specific game mechanics and dynamics, orientated towards specific outcomes.* In games, learning activities encompass mental elements (e.g. to explore the notion of gravity by visiting different virtual planets), game elements (e.g. narrative, resources, a scoring mechanism) and physical elements (e.g. a scientific tool, a computer or a laboratory). In Table 4, learning activities are grouped based on the nature of the activity (e.g. information transmission, individual, collaborative, discussion & argumentation) to inform the scope and nature of the activities that afford specific learning processes within a game.

Learning outcomes

In addition to categorising learning activities that may be enacted in games, it is important to think about learning outcomes mapped to such activities. The most important categorization used for this scoping study is Bloom's taxonomy of learning outcomes. It is perceived that by mapping Bloom's taxonomy to game attributes will provide a broad framework that attempts to achieve an abstract generalisation of learning outcomes that games might incorporate. Hainley and Henderson (2006) contests that games have variable outcomes permeated, for example, in the form of a game journal (Dunwell et al., 2015), at the start, during or at the end of each level. Combining these principles on game outcomes effects to the player, Bloom's taxonomy sought to closely align with game features and models allowing games to be fun, enclosing an array of learning purposes helping to understand better how knowledge is gained.

Bloom classified learning into three domains: cognitive, affective and psychomotor. For this study, the focus is on the cognitive domain (Table 6) as it refers to the knowledge structures relevant to perceiving games as artefacts for linking knowledge-oriented activities with cognitive outcomes. Bloom defined the 'cognitive domain' as a student's intellectual level that is what a student knows and how they organise ideas, opinions and thoughts. The cognitive domain connects with in-game activities that advances learning and knowledge and are integrated throughout in-game learning experiences. Skills and outcomes, therefore, are organised using a continuum from fragmented to cohesive (Ellis et al., 2006) categories of outcomes designed to increase student's knowledge based on student's knowledge levels. Bloom's taxonomy consists of 6 categories designed to scaffold teachers' effort to link learning activities with learning outcomes.

Category	**Outcome**
Remembering	Learner can memorise and recall information
Understanding	Learner can comprehend, explain and predict.
Applying	Learner can use information and solve problems
Analysis	Learner can analyse data patterns or concepts and findings can be discerned to prior evidence
Evaluating	Learner can compare and make justifiable judgements about the value of ideas, methodologies or products
Creating	Learner can design, build, invent, plan or produce original knowledge and transferring it to new contexts for making a contribution to the society

Table 5: Bloom's classification of learning outcomes

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Feedback

In-game meaningful feedback is key for helping students to achieve the embedded learning goals and also for encouraging students to reflect on misconceptions and transfer learning to new contexts (Swanson et al., 2011). Gaved et al (2013) define feedback as responses to a learner's performance against criteria of quality; and Feedback Progress Indicators (FPIs) as responses indicating the current position of a student within a larger activity related to time. Jones et al (2014) developed the SCAMP framework (Social, Cognitive, Affective, Motivational for reviewing Progress) shown in Table 6. *Social feedback* is embedded in game mechanics that indicate learning activity from student's interactions with: Non Player Characters (NPCs), peers or teachers involved in playing simultaneously the game. Example includes 'liking a game progress'. *Cognitive feedback* focuses on the formation of cognitive patterns. Examples include formative feedback provided by the system focusing on correcting knowledge misconceptions and accuracy of understanding. Affective feedback is about attitudes and moods, feelings and emotions. Game rewards tor enhancing motivation such as in game gifts such as extra characters, apparels and objects may increase student's confidence, lack of anxiety and tolerance of level failures. Motivational feedback in games should aim to create situations that trigger students' curiosity to start playing the game (i.e. *motivation*) and then it should maintain student's curiosity, intention to learn, attention and involvement by balancing fun (game mechanics) with learning (learning elements) to achieve *engagement.* Progress feedback in games captures and analyses the increasing competency of the students towards mastery which enables the performance of in-game learning tasks and the transfer of the knowledge gained to realistic contexts.

Type of FPI	***Example in games***	***Game mechanics***
Social	'liking' gaming progress through an in-game discussion mechanics	Visual feedback (emoticons), discussion thread
Cognitive	Selecting the correct choice out of an in-game dialogue script	Prompts; in-game hint; assessment tool; game levels, gaining/loosing lives
Affect	Avatar visual indicators in terms of solving correctly or not a puzzle	Scoring, achievement
Motivational	Winning currency for finishing the treasure hunt mini-game Winning XP points for passing a games level	Experience points, game levels; lives/virtual currencies to be used for buying game items from an online inventory;
Progress	Game journal; goal progress in the form of visual feedback; level badges to highlight learning mastery.	Progress bar, achievements, dashboards; assessment tool

Table 6: The SCRUM model contextualised for inducing FPIs in serious games

Contextualising the application of FPIs in games (Table 6), the most common representation of feedback is through (1) progress bars (2) in-game hints, (3) scoring (4) achievements, (5) experience points, (6) virtual currencies (7) prompts; (8) assessment tools and (9) dashboards. The use of 'achievements' to recognise players' activities within the game helps to scaffold learning activities, monitor progress, and provide direct feedback. Supports are also embedded into the game primarily within easier levels which are typically played first, advancing on to more ill-defined and complex levels as mastery is gained. Vygotsky's notion of the Zone of Proximal Development (ZPD) is applied here when the player is becoming more experienced in playing the game and thereby feedback is fading. Other FPIs can be achieved through the use of graphics, such as navigation maps, which can scaffold player's cognitive load while playing the game.

Teacher roles

From a game design perspective, features that necessitate careful planning of teacher's different role types need to be approached from balancing learning and fun is presented in Table 7. In games, the teacher provides support and guidance in case of student's inability to proceed to the next level and thereby suggests actions in relation to student's game practices. Teachers try to influence gaming paths by making explicit the rules of the game, objectives and learning outcomes and also provide game-play directions on how these game objectives can be achieved devouring a more *active* role. Teachers may also observe student's actions during game play as to not interrupt student's immersive experience in the game undertaking a more *passive* role (Bellotti et al., 2012). There are assumptions that the degree to which an active or passive role permeated by a teacher in game-based learning is influenced by the genre and level of game's difficulty (Hanghoj and Brund, 2013). It is reasonable to assume that the design affordances of the game especially learning features are designed and balanced with the game mechanics and overall game-play difficulty influences the type of role enacted by the teacher.

Type of role	**Example**
Designer	• Genre of game and difficulty should be aligned with the specific role permeated to the teacher spanning from an active to a more passive role. • Designing experiences, materials and sources of information in conjunction to game-play and methods of conveying content via the game. • Designing in-game tutorials on how the learning content, virtual instruments and overall game play including rules, dynamics and mechanics are instantiated within the game context. • Design for collaborative opportunities and dialogic game-play
Player	• Engage in actual playing individually or collaboratively with the students the game for scaffolding students' efforts to play and learn. • To act as a best practice example in terms of what is the optimal way to play and learn via the game.
Facilitator	• Asking questions that encourage students to transfer learning originated from the game to learning applied in real-world situations. • Engaging students via in-game discussion mechanics or in-game hints on how to evidence their ideas or answer their questions through game play evidence or curated content in the game (i.e. content mushed-in from external

	resources) • Provide guidance and support for solving learning problems and progress to next game levels.
Motivator	• Use KPIs as means to motivate and reward students to learn existing knowledge and transfer knowledge to new game or non-game settings.
Evaluator	• Asking pre- and post- gaming questions to elicit understandings on what students do during the game (role of the evaluator with focus on formative assessment) • Including measurable and quantifiable metrics for assessing students' performance in the game (role of the evaluator with focus on summative assessment).

Table 7: Types of teacher role in designing and playing games

It is apparent from the types or roles that a teacher enacts in a gaming context that roles switches from one of conveying content and information via the game to, guiding and facilitating the learning process by designing game learning activities that focus on student engagement, motivation and assessment. The teacher inputs to the process in such a way as to allow game play to flow naturally with learning content discerning a feeling of learning naturally without any disruptions from the game space or game design inconsistencies. There is a need for the teacher to be aware of and responsive to potential frustration of the students in the face of game activity that may be complex and ill defined. The idea that a teacher may support and encourage the student to think reflectively the actions, behaviours and cognitive patterns in the game is essential.

Game attributes

Game attributes have been broadly understood as a way to summarise game rules (Lundgren and Bjork 2003) - but it is still unclear as to whether only rules define game mechanics or encompass sub-features used in game design to form an actual game. Rouse (2005) approaches game attributes from an overall user-game design perspective in terms of *"investigating what the player is doing in the game, how it is done, and how this leads to a memorable and compelling [learning] and game experience"* (2005, p. 310). Fabricatore (2007) gives a computational-based abstraction in terms of inputs and outputs and gameplay: *"[...] proper tools for game-play, atomic-rule based interactive subsystems capable of receiving an input and reacting by receiving an output"* (2007, p. 6). Decomposing this definition, it is perceived that a game may consist of several attributes, and an attribute may be part of many games (Lundgren and Bjork, 2003). Cook (2005) interpreted game attributes from an educational perspective giving emphasis to feedback properties while acknowledging the relations between player's rules and attributes.

Games as rules

The rules of a game provide the context in terms of the challenges, goals and actions and how these are formalised in relation to game design. In that sense, rules may be characterised as constraints that limit the actions of the player (Charsky 2010). Playing a serious game is an activity of improving content knowledge, skills and competencies in order to achieve learning outcomes. Games are structured in two ways comprising rules and challenges for learners: through *emergence* and *progression*. Juul (2005) argues that *emergence* is a game structure, where a game is specified as a small number of rules that combine large numbers of game variations for which the players must

design strategies to handle. Such type of games includes strategy, action and board games. *Progression* – is where the player has to perform a predefined set of actions in order to complete the game. The game designer has control over the sequence of the events, and therefore games with strong *storytelling* features are dominant as progression games. Although, there are game rules that can be influenced or changed by player's actions (Charsky 2010).

Goals and choices

There is common understanding in the research evidence-base that games should be goal directed, competitive and designed within a framework of rules, choices and feedback to enable teachers and students to monitor progress towards the goal. Goals should be communicated by game attributes such as a score mechanism or a puzzle to resolve, which in turn adds a competitive factor and a player's decision informed by a specific choice. For example, van der Spek et al., (2011) described the *code red: triage* serious game as permeating specific goals, teaching the player to perform triages. These goals are achieved through specific choices that need to be taken by the player. Choices in games refer to the number of decisions a player has before and during game play (Hannafin and Peck 1988), and a game is a series of interesting choices (Juul 2005). An interesting choice is mentally challenging, strategic rather than skill-oriented.

Tasks, activities and challenges

It is prevalent from the findings of this study that learning enhancement and performance improvement stems from learning that originates out of task completion (Bedwell, 2012; Gunter et al., 2006; Huang, 2011; Kebritchi et al., 2008; Lacasa et al., 2008). During a serious game, the player needs to separate task-relevant from task-redundant information (Juul 2005) and determine the inherent complexity of game tasks. An overarching task of the player is to familiarise with the rules, controls and logic of each level for adjusting game-play. For example van der Spek et al (2011) argue that in the domain of a crisis management game where information is redundant, players have to make decisions to discern information that is relevant to them; and allow them to make connections from information that is irrelevant to the task and overall mission.

Category	**Game Attribute**
Rules	scoring, moving, timers levels, progress bars, 'game instructions including victory conditions
Goals and Choices	Game journal, missions, objective cards, storytelling, nested dialogues, puzzles, NPCs / avatars
Tasks/ challenges	NPC-based task description, progress bars; multiple choices to select, major tasks, branch tasks, puzzles, research points, study, requirements
Collaboration and competition	Role-playing, community collaboration, epic meaning, bonuses, contest, scoring, timers, coins, inventories, leader boards, communal discovery
Feedback / assessment	Game hints, NPCs, game levels, gaining/loosing lives, progress bars, dashboards; lives/virtual currencies to be used for buying game items from an online inventory; progress trees

Table 8: Game categories and associated game attributes

Table 8 classifies the games categories with relevant attributes. An attempt is made to map overarching gaming categories discerned to game attributes that may be used to afford the instantiation of game attributes with focus on educational practice. For example, rules may be realised through scoring, timers or game instructions as to direct students on what needs to be achieved during the game thus to sufficiently explain the purposes and ways of playing and learning. From a research

perspective, there is no comprehensive taxonomy that classifies game attributes with initial categories as to specifically depict how these elements can be translated into actual processes in SGs.

Mapping learning attributes to game attributes

Table 9 links primary leaning attributes (i.e. learning activities in Table 4) with game attributes (Table 8), learning outcomes (Table 5), feedback /assessment (Table 6) and teacher roles (Table 7) based on the findings of the review study. An attempt is made to provide a more holistic interpretation of learning attributes and how these may be translated to game attributes by encompassing key aspects of the learning process such as outcomes, feedback and assessment and teacher roles. It is perceived that there is no hierarchical orientation or progressive development for applying this classification to a serious game of any scale. Rather it is developed as a research instrument that provides guidance and support of related activities, game mechanisms, outcomes, feedback and roles teachers may enact when designing SGs for learning and teaching. The classification contributes to the advancement of research in the field of game and learning affordances by analysing and relating them to feedback and progress indicators and teacher roles. University teachers, game and instructional designers will be able to design and implement particular learning activities in the context of appropriating what the teacher does' in conjunction to designing outcomes, feedback and assessment.

Learning Attribute	**Game Attribute**	**Outcomes**	**Feedback/ Assessment**	**Teacher Roles**
Information transmission (teacher-led)	task description; multiple choices to select, content description, challenge repetition, scoring	Remembering	Progress; affect Summative	Designer/ evaluator
Individual (teacher and student led)	Game journal, missions, objective cards, storytelling, dialogues, puzzles, branch tasks, research points, study requirements, game levels,	Understanding, applying, analysis	Motivational; Progress, affect Formative and/or summative	Player, Facilitator, Designer, motivator, evaluator
Collaborative (teacher and student led)	Role-playing, community collaboration, epic meaning, bonuses, contest, scoring, timers, coins, inventories, leader boards, communal discovery; game levels	Applying, analysis, evaluating, creating	Motivational, social Formative and/or summative	Player, facilitator, motivator
Discussion and argumentation (Reflection)	Nested dialogues, NPC interaction, in-game chats; game levels, research track, maps; progress tress	Evaluating, understanding, analysis	Motivational, affect, social Formative	Motivator, evaluator, facilitator

Table 9: Linking learning and game attributes, outcomes, feedback and roles

The classification may be used by academics, instructional and game designers, game practitioners or game science researchers, who intend to plan, design and develop a serious game or a SGs authoring environment for delivering a particular topic or lesson at any scale. It may be perceived as a guiding tool for designing in-game learning activities, feedback and assessment in the form of game rules linked to associated learning outcomes. For example, a teacher may start the game design process initially by forming an intended learning outcome (Ellis, 2006; Gunter, 2008). Then a learning attribute could be created (such as an individual or collaborative learning activity). A combination of more than one attributes may be also enacted, blending an individual activity with a collaborative activity or a discussion and argumentation with information transmission. The game design classification is perceived as a non-linear open-ended design process where the designer my combine different learning outcomes with a diverse array of learning and game attributes, feedback and teacher roles. Once the learning outcomes have been established and the learning attributes (i.e. type of activity) have been identified (e.g. information transmission) and aligned to the game attribute (solve all mini puzzles and finish level 1), types of assessment for every type of activity may be formulated considering how this may be visualised in the game.

Discussion

The current review focused on how learning design features and game properties can be planned, designed and implemented by university teachers interested in using games for teaching and learning in higher education. The large number of papers (165) identified using associated search terms confirmed that there are qualitatively different ways of conceptualising and approaching the design and use of SGs for academic teaching and learning. The majority of these papers showed that the integration of learning elements into the design of a game creates misconceptions, discrepancies and uncertainty in terms of how learning activities, feedback and assessment may be designed and applied in a game. The role of the teacher in guiding learning via games seemed to be fuzzy and unclear and may lead to confusion during the design stage, game play and after the end of the game. It is central that the way teachers interact and facilitate students' efforts to construct in-game learning experiences to be carefully thought and planned at the design stage. This will highlight the proffered scaffolds, guidance and support akin to the curriculum design proliferated during a conventional course (Yussoff et al., 2009; Wouters et al., 2013).

The inclusion criteria identified 165 papers providing empirical evidence and conceptual assumptions concerning specific learning activities that could be linked with game elements (Erhel and Jamet 2013; Gross, 2007; Gunter 2006), feedback and progress indicators (Cornillie et al., 2012; Gaved et al., 2013) and teacher's roles in designing and facilitating game play (Hanghoj and Brund 2013; Bellotti et al., 2013). Papers that described game attributes that afforded enjoyment, motivation and fun were diverse in terms of describing the plethora of ways that enjoyment, engagement and fun could be instantiated in different types of games. However, very few papers provided a framework that twins learning with game elements either from a theoretical / abstract level or stemming out from empirical evidence.

This lack of evidence may resonate from inconclusive attempts to decompose instances of learning attributes (e.g. information transmission, individual, collaborative etc.) and linking them to overarching game categories (rules, goals and choices, tasks, collaboration, feedback and assessment) for propagating balance between learning and enjoyment and attain a state of flow (Csikszentmihalyi, 1990). The emerging categories of game attributes may represent shared mental models (Bedwell et al., 2012) and varied ways of combining learning elements with game components (Westera et al., 2008). This review study attempted to provide a learning-game attribute taxonomy derived from a comprehensive analysis of both learning elements and game mechanics grouped to categories,

encompassing a collection of learning and game elements to be used in designing a game for teaching and learning purposes. It is perceived that the taxonomy will help instructional designers and game developers to better discern particular types of learning outcomes with game elements. It is essential therefore for teachers to understand the effects of game mechanics to learning outcomes and vice-versa as to enable the design of in-game learning activities, instantiated with specific game attributes leading to intended outcomes. A recommendation of this review would be for game authoring environments to introduce visual representation drag and drop learning attributes and in-game authoring scaffolds on how these may be linked to game mechanics and dynamics. To instantiate such modality at an operational level, would entail future research on carrying out empirical associations between particular learning features and game mechanics for optimising serious game's authoring and game play. It would also be beneficial, contemplating that SGs design is an emerging field, to establish a comprehensive and common vocabulary for describing common game-based concepts and design features. This will pave the way to designing an architecture for integrating SGs in lesson plans (designed through learning design authoring environments e.g. LAMS) as part of a learning sequence orchestrated at any scale, easily shared, re-used or repurposed.

The development of categories that link not only the learning experience with the game element, but also the perceived role of the teacher is imperative to the advancement of the field; without delineating what the teacher is doing in terms of facilitating the design or student's learning effort during or after the game may be complex or controversial to revealing a learning pattern concomitant to a game experience. Similarly, the way feedback is designed and realised in the game-play is key for characterising the purpose of learning. How feedback affects learning in games? Are there different types of feedback delivered to students in different game instances? How social, cognitive, affect, motivational and progress feedback can be visualised? (Via prompts, game hints, avatars etc); or why do we need to design feedback that motivates and engages students? Such design-level questions should be considered during the design stage based on the in-game: student's involvement (level of motivation, engagement and enthusiasm), learning experience (identifying the process of what happens when the in-game learning process is going well / not going well; the extent to which students feel that their learning needs have been met by overall game design and game play; and in-game learning outcomes in terms of identifying if there are improvement in learning after playing the game. This is congruent with measuring the effectiveness of the game intervention by correlating data from a conventional practice as evidenced from a number Randomised Controlled Trials (RCTs) studies identified in the study. However, when evaluating the student learning experience during or after playing the game, it is useful to use or combine quantitative approaches with qualitative ones especially when investigating factors that require deeper understandings and richer descriptions of what a game needs to contemplate (eg. types of learning activities based on student's learning style, types of learning outcomes, feedback diversity) when designing a serious game as means to tailor in-game learning with student's different ways of learning (Soflano et al., 2015; Hwang et al., 2012). Indeed adaptability and adaptivity in games should be further researched for investigating the differences in learning effectiveness compared to other traditional modes of learning.

It is axiomatic therefore to use qualitative research methodologies to elicit qualitatively different ways of designing and using games for academic teaching and learning from the teacher and student perspective. The results from this study show that 50 papers utilised RCTs and surveys whereas 20 papers used generic content analysis. Given the current challenge to identify how individual people experience, teach and learn through games and the meaning discerned to how game attributes delineate different types of learning, feedback and outcomes, a recommendation of this review would be to use qualitative studies informed by overall study design in order to investigate not only engagement and motivation (eg. Connolly, 2012; Boyle et al., 2012) but also types of learning

activities, variation in outcomes, differences in cognitive patterns, ways of feedback visualisation and application.

Limitations

The current review has a number of limitations. As with all reviews it was limited by the search terms used, the journals included, the databases searched and the coding scheme applied to carry out the analysis. It would be insightful for future research, the taxonomy to be empirically validated as means to understand differences in academics' experiences of using games for learning and teaching for attempting to distinguish different learning attributes and how these are translated to game elements. Identifying variation of using specific learning activities with game mechanics associated with roles and assessment as experienced by academics would help on understanding conceptions of, and approaches to, designing SGs in higher education. It would also be interesting to delineate connections between game genres, learning/gaming attributes, assessment and roles (Mayer 2012). Limitation of such investigations would be on the basis of generalising learning activities and game attributes to different games content, rules and goals, level of students, discipline, game genres, and approaches to teaching and learning in different contexts of use.

Conclusions

The review study has analysed, presented and discussed findings on how learning features and game properties can be planned, designed and implemented by university teachers interested in using games for teaching and learning in higher education The review offers one possible point of departure for providing guidance and support to university teachers, instructional and game designers to design, plan and use SGs for a topic or entire module. It also contributes on introducing the concept of learning design as an overarching modality in game's design architecture; it adopts a bottom-up, multi-component analysis approach of heterogeneous set of data for categorizing learning activities, learning outcomes, feedback progress indicators and teacher's roles; it discerns game attributes grouped to categories such as rules, goals and choices, challenges, collaboration and competition, feedback and assessment and it attempts to match learning and gaming attributes, outcomes, types of feedback and assessment and teacher roles as means to discern possible learning instantiations though game attributes in optimal ways and thereby enhancing the in-game learning experience.

The investigation of the SGs design literature revealed notable interest to providing guidance and support in designing and using games for university teaching and learning. It has also shown that teachers and practitioners alike are overwhelmed by the plethora of design choices and level of complexity entailed in integrating, combining and balancing learning with game features. Design elements surrounding the notion of in-game learning activities, feedback progress indicators, assessment, learning outcomes and teacher roles have yet to be adequately researched by providing empirical evidence on how such features can be incorporated into SGs adhered to the need of creating games that are adaptive to linking prior knowledge to new understandings, application of what the student knows, and student's learning styles. (Soflano, 2015; Hwang et al., 2012).

Drawing on the review's outcomes, it is clear that more qualitative research is needed, towards understanding the essential features of SGs design and consistently aligning them in a way that teachers and practitioners will be able to delineate and balance learning with fun. It is also essential to understand variation in ways of theorising and using specific learning modalities with game attributes that address content specific processes and teaching strategies conducive to particular academic disciplines as to contextualise games for use in disciplines that require certain ways of learning and knowing (e.g. science, social sciences, and humanities). This will pave the way for identifying an

inclusive hierarchy for describing ways, frames and discourses of experiencing the phenomenon and contextualising it in particular academic tribes and territories.

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