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RESEARCH ARTICLE

Designing and integrating purposeful learning in game play: a systematic review

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Abstract Via a systematic review of the literature on learning games, this article presents a systematic discussion on the design of intrinsic integration of domain-specific learning in game mechanics and game world design. A total of 69 articles ultimately met the inclusion criteria and were coded for the literature synthesis. Exemplary learning games cited in the articles reviewed and developed by credible institutions were also analyzed. The cumulative findings and propositions of the game-based learning-play integration have been extracted and synthesized into five salient themes to clarify *what, how, where,* and *when* learning and content are embedded in and activated by gameplay. These themes highlight: (a) the types of game-based learning action—prior-knowledge activation and novel-knowledge acquisition, (b) the modes in which learning actions are integrated in game actions—representation, simulation, and contextualization, (c) the blended learning spaces contrived by game mechanics and the game world, (d) the occurrence of meta-reflective and iterative learning moments during game play, and (e) the multifaceted in-game learning support (or scaffolding). Future directions for the design and research of learning integration in digital games are then proposed.

Keywords Game-based learning · Educational game design · Intrinsic fantasy · Learning-play integration

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Introduction

For the past 2 decades, researchers have designed and examined a variety of digital games for learning purposes (e.g., Barab et al. 2005; Clark et al. 2014; Cooper 2014; Dede 2005; Klopfer et al. 2009; Shute et al. 2013; Andersen et al. 2011; Squire 2003). Their efforts provided good cases exemplifying the design of learning games. The recent meta-analysis on the effectiveness of digital games for learning indicated that digital games, compared with non-game instruction conditions, have a moderate to strong effect on cognitive learning outcomes (Clark et al. 2014). The analysis findings, in agreement with prior research (Ke 2008; Young et al. 2012), also underscored the significant moderator effect of design features in game mechanics, visual, and narratives on the affordances of games for learning. Yet the account of what, how, where, and when domain-specific learning is integrated into gameplay during the game design process remains murky, in spite of the plethora of research on the topic.

Games in general can be defined as organized play that is structured by a set of rules and an obstacle-tackling goal (Klopfer et al. 2009; Schell 2014; Suits 1978). A common skepticism on using computer games for learning is that students may be distracted by the play part, thus not achieving the learning goals (Miller et al. 1999). The challenge is to integrate learning into core game elements while not violating or corrupting what is enjoyable about games (Garris et al. 2002). An earlier effort to address this challenge is the proposition of designing *endogenous or intrinsic fantasy*—the attainment of an integral and continuing relationship between gameplay and the content to be learned (Habgood and Ainsworth 2011; Ke 2008; Malone and Lepper 1987; Squire 2003; Kafai 1995). Particularly, it is argued that the extent to which the content is intrinsic to the game mechanics (i.e., game rules and actions) will influence the game's learning effectiveness (Richards et al. 2013). Nevertheless, empirical and theoretical research examining the design of an intrinsic integration between learning and gameplay is still limited and sporadic (Habgood et al. 2005; Habgood and Ainsworth 2011).

Via a systematic review of the literature on digital games for learning purposes, this paper aims to synthesize learning-game design heuristics regarding an intrinsic integration of purposeful and domain-specific learning in gameplay. The overarching research question to be addressed is: What are the aggregate findings and propositions on designing learning-play integration in digital learning games? The specific questions include: What type of game-based learning actions were emphasized in prior research? In which game design elements was content learning embedded? When or under what supportive contexts would game-based learning moments occur?

Conceptualizing game play, learning, and learning games

Play and learning in games

The role of imaginative and social play in fostering language development and hence a child's understanding of the external world and cognitive development has been examined for decades (e.g., Piaget 1962; Vygotsky 1978). Game play is now a ubiquitous part of youth's lives, with 97 % of teens in United States playing video games daily (Lenhart et al. 2008). Game play is essentially a process of learning, in which players interact with the game to learn rules and play strategies, then adapt and improve play skills to make progress in the game (Lindley and Sennersten 2008). Research suggest that game play has positive cognitive, motivational, emotional, and social effects (Granic et al. 2014). Specifically, game play has been found to be associated with enhanced spatial skills (Green and Bavelier 2012), problem solving skills (Cooper 2014), and persistence (Shute et al. 2013).

Via a multimodal representation and visualization of information, simulated problem solving, and instant feedback, games can provide an immersive and authentic context for experimentation and situated understanding, hence act as rich primers for active learning (Barab et al. 2005; Clark et al. 2011, 2014; Gee 2004; Squire 2003). Yet research on the learning effectiveness of games is still inconclusive. Rather, it is found that the effectiveness of games for learning purposes depends on the nature of learning to be fostered, the game's attributes, and how it is used in the teaching or learning process (Clark et al. 2011, 2014; Hays 2005; Ke 2008; Ota and DuPaul 2002; Vogel et al. 2006).

There are two types of learning to be fostered by the games. One focuses on the skills that are "often to the exclusion of traditional academic subject matter" (Klopfer et al. 2009, p. 1) and domain generic, such as computational thinking, media literacy, and system thinking (e.g., Denner et al. 2012; Steinkuehler 2008; Shute and Ke 2012). The other concentrates on domain-specific learning in educational or training settings (Clark et al. 2014). These two compose the continuum of game-based learning and are not mutually exclusive. The paper focuses on the games that aim to promote domain-specific content learning.

The ways to which games are used in the teaching and learning processes varied. A game may act as the micro-world to embody a situated practice or epistemic experience (Shaffer 2006), as the interactive, multimodal representation of conceptual knowledge (Habgood and Ainsworth 2011), as a simplified simulation of a complex system to encourage scientific discovery learning (Barab et al. 2005; Cooper 2014), or as an authoring tool to support constructionism-oriented learning processes (Ke 2014). Correspondingly, game-based cognitive activities may involve acquisition of novel understanding and skills (Sedig 2008), and/or application (i.e., retention and transfer) of the previously-learned knowledge (Clark et al. 2011).

Learning games

According to Klopfer et al. (2009), a learning game is the one that targets the acquisition of knowledge as its own end and foster cognition that is either generally useful (e.g., *Lumosity* games) or useful within an academic context (p. 21). A learning game has also been defined as an activity structure in which players use a body of knowledge or set of skills as resources in competitive play (DeVries and Edwards 1973). A learning game is supposed to provide structured and immersive problem-solving experiences that enable the development of both knowledge and 'ways of knowing' to be transferred to the situations outside of the original context of gaming or learning (Gee 2004; Shaffer 2006). Serious games, games that express and inspire underlying epistemic frames, values, and beliefs (Shaffer 2006) to foster informal learning, can be considered as a school of learning games.

Learning games can be categorized based on the type of learning integrated. For example, Ito (2008) categorized learning games into three genres: Educational games (i.e., games that privilege the drill-and-practice of an academic subject), entertainment games (i.e., games that privilege narrative and play, with domain-generic, incidental learning as a side effect), and construction games (e.g., *SimCity*). Ito's (2008) game categorization tended to equate educational games to drills and practices that only convey an extrinsic integration of play and learning (e.g., answering a cut-screen of multiple-choice questions

Table 1 Genres of learning games classified via core mechanics and narrative design

Game type	Core mechanics	Narrative
Casual puzzle game	Logic and thought during puzzle solving	• Environmental storytelling: Maybe • Backdrop story or mission: Maybe • Localized narrative: No • Open-ended: No
Action	Quick thinking and reflexes (e.g., in jumping, shooting)	• Environmental storytelling: Yes • Backdrop story or mission: Maybe • Localized narrative: No • Open-ended: No
Adventure	Long-term obstacle overcoming, involving constant exploration, item collection, and puzzle solving	• Environmental storytelling: Yes • Backdrop story or mission: Yes • Localized narrative: Maybe • Open-ended: No
Strategy	Strategic deployment via system thinking and planning	• Environmental storytelling: Yes • Backdrop story or mission: Yes • Localized narrative: Maybe • Open-ended: No
Role-playing	Interacting with characters, information collection, and decision making	• Environmental storytelling: Yes • Backdrop story or mission: Yes • Localized narrative: Yes • Open-ended: Maybe
Simulation	Interacting with and discovering an underlying, simulated model or system	• Environmental storytelling: Yes • Backdrop story or mission: Maybe • Localized narrative: No • Open-ended: No
Construction	Design, build, and resource management	• Environmental storytelling: Yes • Backdrop story or mission: Maybe • Localized narrative: No • Open-ended: Yes

during play), in comparison with the "thinking games" that intrinsically integrate play and learning to be intellectually engaging. Such a supposition may not comply with the recent development of learning games. Drill and practice signify only a function of the game in the educational context. A thinking game can also be used for the practice of existing knowledge rather than delivering or representing the novel information.

In agreement with Klopfer et al. (2009) and Habgood and Ainsworth (2011), this article characterizes a learning game mainly by the type of gameplay involved, and the way and the extent to which content or learning is integrated into the gameplay. The next section provides the definition of the construct of gameplay in terms of two main components—game mechanics (i.e. gameplay rules and actions) and the game narrative (i.e., game-world design, comprising scenarios, the storyline, and/or characters).

Game mechanics, narrative, and corresponding genres of learning games

The construct of gameplay can be described in two layers: the "ludus" or game mechanics layer that involves rules and actions, and the narrative layer that comprises the setting, plot, and/or characters (Ang 2006; Frasca and Gonzalo 1999). It is agreed that gameplay lies in the meaningful interplay between the two layers, though research is inconclusive as to whether game design is more the design of experience (Salen and Zimmerman 2004) or a narrative architecture (Jenkins 2002).

According to Järvinen (2008) and Sicart (2008), the game mechanic is an activity structure that consists of rules and the actions afforded to players by those rules. Rules are designed or established to determine the conduct and standard for both play behaviors and the winning/losing state. These rules lead to the creation of player strategies and means with which the player can interact with game elements to "influence the game state towards the attainment of a goal" (Järvinen 2008, p.255). The game mechanic can also be understood as "a compound activity composed of a suite of actions" (Salen and Zimmerman 2004, p. 316). The essential activity that players repeatedly perform and directly apply to achieve the end-game state is usually described as a *core mechanic* (Sicart 2008).

Not all games tell a story, and hence the narrative layer may not be a defining feature for certain games of which the representation of the narrative is simplistic and even tokenized. But many games do have narrative aspirations, or at least tap into the player's memory of previous narrative experiences (Jenkins 2002). According to Jenkins (2002), narrative can be integrated into the game as: (a) a broadly defined goal (e.g., a backdrop plot or an adventure mission), (b) a localized incident or plot developed in game level(s), and (c) a sandbox or an open-ended game world that allows players to define their own goals or stories via authoring- or construction-based play. A game can convey storytelling and create an immersive narrative experience via the "spatiality" or the game world, in which the story element is infused into a space that a player navigates through and interacts with.

Conceptualizing the genre of a learning game by its gameplay characteristics (i.e., the game mechanic and narrative aspects) will help us to delineate its design profile and better evaluate how learning is integrated in gameplay. Table 1 presents the gameplay-based learning-game genres that emerged from the literature and exemplary games reviewed. It should be noted that this genre categorization is not aimed to be prescriptive or exhaustive, and a single learning game may belong to multiple genres at once.

Summary

The types of learning to be fostered by gameplay varied in whether the acquired cognitive skills and performance emphasize 'domain-specific knowledge' (i.e., purposefully learned information inside an educational context, Tricot and Sweller 2014). Whether the primacy is to acquire novel or practice prior domain-specific information, enabling knowledge-based cognitive performance without interrupting gameplay is the core design challenge for learning games and hence the focus issue to be examined. Analyzing learning games via the innate components of gameplay design—game mechanics and narrative structure—will facilitate a design-centered examination of *what, how, where*, and *when* domain-specific learning is intrinsically integrated into and activated by core game elements.

Method

Search procedure and inclusion criteria

A systematic review was conducted with the multidisciplinary literature on the design of learning games, using the keywords of "game-based learning," "learning games," "serious games," and "educational games." The selection criteria were specified as: (1) Content relevance—studies and conceptual papers that examined or described *the design and development* (vs. only evaluating the effectiveness) of *digital* games for *purposeful*, *domain-specific* learning, (2) year of publication within 2000–2014, and (3) English, refereed research publications or research reports. The literature search was comprehensive within the data pool consisting of computerized bibliographic databases (i.e., ERIC, Academic Search Complete, PsycInfo, JSTOR, Dissertation Abstracts, and ACM), major education and technology journals (e.g., journals listed in the science and social sciences citation indexes and official journals of major educational and learning technology research associations), refereed conference proceedings (e.g., conferences of major academic or research associations), and the reference lists of several reviews.

The initial online searches of the aforementioned data pool identified 249 articles (using the subject term of game-based learning), 1684 articles (for learning games), 289 articles (for serious games), and 963 articles (for educational games). The primary researcher and the other two coders read the references and abstracts separately and congregated selection decisions. After removing the duplicates and reading the abstract, 275 articles were retained for screening at the full text level. Of these articles, 120 articles met the preliminary selection criteria. Among them, 37 articles examined game-supportive school culture, pedagogy (i.e., game-extended learning contexts), or conventional learning activities with gamification elements (e.g., badges). Another 14 articles reviewed general design challenges, theoretical underpinnings, the production procedure (e.g., interdisciplinary collaboration and participatory design), or evaluation criteria, without examining actual design solutions or features of learning games. These articles, though informing the development of analytical framework and acting as a meaningful context for the interpretation of the findings, were not included in the coding. In the end, 69 articles were coded and included in the final literature synthesis.

Coding procedure

When conducting the literature search and initial content coding, the researcher paid special attention to the articles that would establish preliminary components of an analytical framework and guide the later comparative and categorical aggregation analyses. An initial coding framework or matrix was then developed to categorize articles based on the research purpose, methods, the targeted learning and learners, game genres used, game design features (e.g., how content and learning were integrated into the gameplay design), the implementation setting, and key findings. This coding matrix was refined as the analysis process proceeds, and overlapped with the processes of coding the articles and placing them into categories. Using the constant comparative method (Strauss and Corbin 1990), the data coded from each article/study were constantly compared to drive the revision of the coding matrix, the reanalysis of studies, and new insights. The consistency and rigor of analyses and results were achieved by using three coders for peer examination and inter-rater checking during the coding process (Creswell 1998). One coder coded all articles independently; the other two coders divided the articles and coded their shares separately. After formal reviews and discussion on differences among the coding sets, coders reached a 100 % agreement on the final coding results.

Exemplary learning games in the articles reviewed and developed by credible institutions were also analyzed to further examine the typical design approaches of the learning-play integration. The game analysis approach (Aarseth 2003) comprised both document analysis of the design report and direct game play. Salient themes on the design of intrinsic integration between learning and gameplay were extracted and corroborated with the literature review findings.

Results

Prior research on learning games has generally agreed that learning occurs only when play experience connect to intellectual content. Scholars have frequently proposed an *intrinsic integration* of game fantasy (i.e., gameplay) and learning elements, referring to an *interdependent* relationship between a game's play and the instructional content being presented (Habgood and Ainsworth 2011; Kafai 1995; Ke 2008; Malone and Lepper 1987; Richards et al. 2013; Squire 2003). It is believed that games with intrinsic learning integration is more educational and intrinsically motivating than those with extrinsic integration—the games in which the skill or content to be used/learned has a weak connection with the curiosity and challenge elements, and can be easily swapped without influencing gameplay.

Nevertheless, the current review found that empirical research systematically explaining or purposefully examining the design of learning integration in games is lacking. Of the 69 articles coded (please refer to Supplementary Table), only eight purposefully examined the design heuristics for learning-play integration (i.e., Dickey 2007; Barab et al. 2009, 2010; Blakesley 2013; Boyan and Sherry 2011; Habgood and Ainsworth 2011; Perry et al. 2014; Plass et al. 2012). In five studies (e.g., DeShazo et al. 2010; Howard-Jones and Demetriou 2009; Infante et al. 2010; Ronimus et al. 2014; Zapata-Rivera et al. 2009), games portrayed an extrinsic association between learning and play, in which players basically answered knowledge questions to earn game tokens or progresses. Other articles, among secondary findings, informed discrete design strategies for the learning-play integration.

Five salient themes have emerged from the review to synthesize empirical findings and data-driven theoretical propositions in prior research on the design of learning-play integration in digital games. The five themes, addressing the research questions as to *what, how, where,* and *when* learning and content are embedded in and activated by gameplay, clarify: (a) the types of game-based learning action—prior-knowledge activation and novel-knowledge acquisition, (b) the modes in which learning actions are integrated in game actions—representation, simulation, and contextualization, (c) the blended learning spaces contrived by game mechanics and the game world, (d) the occurrence of meta-reflective and iterative learning moments during game play, and (e) the multifaceted in-game learning support (or scaffolding). The report on each theme, with the support of exemplary studies and an analysis of relevant game design perspectives and strategies, is provided below. For a theory-driven, operational description of every theme, theoretical frameworks and research that are reviewed, not directly related to the research questions, but provide a meaningful lens for the illustration and interpretation of each theme were also cited.

Theme 1: Designing game-based learning as knowledge activation and acquisition

In the articles reviewed, games were used for domain-specific learning in varied academic disciplines, ranging from science, math, engineering, business administration, political science, to reading and language. Game-based learning setting depicted in the articles coded were more for curriculum-oriented formal education ($n = 35$) than informal learning or training ($n = 15$), with very few targeting both settings ($n = 3$) and others not specifying a learning setting. The targeted types of learning outcome varied from declarative knowledge (e.g., factual information collection, $n = 10$), concept comprehension ($n = 22$), to procedural knowledge and problem solving ($n = 18$) and unspecified, content learning in general ($n = 19$).

Prior research frequently designed and used learning games as a practice tool for activating pre-taught knowledge and a supplement to conventional instruction. In-game learning actions were designed as prior knowledge *activation* in excess of novel knowledge *acquisition*. Many learning games employed an investigative inquiry or a problem-solving task as a meaningful context for players' application of prior knowledge, which then prompted players to review the task-oriented content via a "background" content object (e.g., the Help function). For example, in the 3D adventure game "Elektra" (Schrader and Bastiaens 2012a, b), learners got to solve a series of puzzles by retrieving the conceptual knowledge of light refraction. They received both written hints from an in-game pedagogical agent and an on-learner-demand, hyperlinked reference book. The study on Elektra found that the experience of virtual presence in the 3D adventure led to better retention and comprehension of the embedded, background knowledge. Certain inquiry-based science learning games highlighted knowledge collection (or acquisition). For instance, in the virtual-world game Quest Atlantis (Barab et al. 2009, 2010), learners were challenged with scientific inquiries and had to collect information from both offline, conventional library resources and in-game hints from non-player agents and background content objects (e.g., a scroll or a graph). The design of the aforementioned games, notably, emphasized self-regulated activation and exploration of *background knowledge*, whether presented explicitly (e.g., in a formal book) or tacitly (e.g., via informal feedback/cue from an agent). The study by Barab et al. (2009) indicated that QA-game-based learning, in comparison with textbook-based learning, better promoted standardized test and performance task performance. The observation on the prevalent design of background knowledge in game actions is consistent with the argument of Wainess et al. (2011) that current learning games highlights activation and acquisition of the "background" information during puzzle solving, in comparison with illustrative instruction situated in "presentation" content objects (objects that proactively represent information as part of gameplay).

Only a few studies designed and examined games as a novel-knowledge presentation tool and a stand-alone counterpart of instruction (e.g., Lester et al. 2014; Liu et al. 2013; Sedig 2008; Toprac 2009; Wu 2009). In the Super Tangrams game by Sedig (2008), middle-school students learned transformation geometry concepts through solving visual (Chinese Tangrams) puzzles—transforming and moving a set of seven two-dimensional geometric figures together into a larger shape. Math concepts, such as angle and line of reflection, were actively represented via both pictorial and symbolic forms, and then processed via transformation interactions (e.g., translation, rotation, or reflection). The in-game illustrative "presentation" objects (e.g., figures, visual scaffolds during game play), focusing on a versatile and transitional representation of knowledge, making conceptual understanding as an innate action of gaming. The evaluation study with 58 6th-grade students reported that participants found the game-based learning process engaging and exhibited significant improvement in the knowledge test of transformation geometry concepts (Sedig 2008).

Theme 2: Learning integration via representation, simulation, or contextualization

An overarching proposition in the prior research on learning-play integration can be synthesized as the attainment of a *blended balance* between gameplay and learning. The blended balance comprises not only a learner-adaptive *dosage* of domain-specific learning in play, but also an *intrinsic integration* between domain-specific learning and play.

Klopfer and Squire (2008), Klopfer et al. (2009) proposed that learning-game designers should seek elements that are "fundamentally game-like" in an academic discipline, and make game players involved in what is fundamentally engaging about the subject, thus enabling them to "partake in those pleasures of the discipline that motivates its expert practitioners" (p. 32). Those engaging elements, according to the epistemic game perspective of Shaffer (2006), will not "sweeten" the content but actively represent meaningful interactions between the player and the epistemic frames of the target subject matter—a structured collection of skills (or activities), understanding, values, and identity that characterize the epistemology of the discipline. Such a perspective is consistent with the proposition of Barab et al. (2009, 2010) that the learning game, as a playable fiction, should provide players with positionality (e.g., a professional role), legitimacy in content engagement (e.g., procedural and conceptual content application required by game quests), and consequentiality in a meaningful context (e.g., play actions causing experiential or projective change of the game world).

Sustaining the aforementioned perspectives on game-based learning (or content) engagement, three salient approaches of *intrinsic* learning-play integration were found in the literature—*representation*, *simulation*, and *contextualization*. *Conceptual representation*—designing game objects and object-centered interactions as the active embodiment of the focus concepts—was an underscored design principle in multiple articles coded (n = 11). For example, in the math puzzle games "Refraction" and "Save Patch" created by the Center of Game Science at University of Washington (Andersen et al. 2011; O'Rourke et al. 2014; O'Neil et al. 2014), the concepts of a unit fraction and its relation with the whole number were represented as separate coils to be added to energize a whole trampoline, or a laser beam to be split into fraction pieces. Conceptual representation is achieved via the meaning-making association between an abstract concept and illustrative game objects (e.g., a coil-composite trampoline and a laser beam), and mapping learning actions onto game actions (e.g., the analogy between fraction calculation and laser splitting plus coil adding). Conceptual-representation-oriented learning integration was found in multiple recent math and science games (e.g., Andersen et al. 2011; O'Neil et al. 2014; Lester et al. 2014; Pareto et al. 2012; Plass et al. 2012). Positive findings on engagement and learning were generally reported by studies of those games.

Simulating a scientific problem or a complex system is another main mechanism of the game-based learning-play integration in the previous studies (n = 23). Scholars frequently described game play as an iterative process of problem solving, discovery learning, or inductive reasoning—comprising hypothesis development, probe manipulation, output interpretation, hypothesis modification or generalization, and re-probe (e.g., Aldrich 2009; Garris et al. 2002; Gee 2004). Correspondingly, learning games were constructed by extending an interactive simulation with a reward structure, a setting, and a plot-driven goal. For example, Cooper (2014) designed "Foldit"—an online scientific discovery game—by converting the simulated protein structure problem to 3D jigsaw puzzles and adding game scoring structures (i.e., ranking-oriented competition and collaboration) to a molecular simulation of proteins. Empirical research evidenced that Foldit players were able to solve complex science problems via game-based scientific discovery learning (Cooper et al. 2010). In the study of Li et al. (2013), a sandbox game called "Train B&P" simulated a professional, engineering task to enable learning by doing and making. Players got to construct a railway model and design the transportation behaviors of the trains by applying newly-learned algorithmic thinking that was partially acquired through processing system feedback and partially learned from out-of-game instructions. Other science games (e.g., Adams et al. 2012; D'Angelo Cynthia 2010; Koenig 2008; Lazarou 2011; Martinez-Hernandez 2012; Schrader and Bastiaens 2012a, b; Sedig 2008; Shute et al. 2013; Williams et al. 2007) augmented (or "gamified") the natural or mechanical system simulation with a backdrop scenery, a character, and a meaningful goal. For instance, Haugom et al. (2007) examined a puzzle game that simulated a mechanical system to train on nonlinear control theory. The main game action was to guide a duck (the character) to get through a maze by adjusting the input values of multiple system variables to create the path through the maze. Similar design mechanism was also adopted by another engineering game made by Münz et al. (2007), with the character of duck changed into a submarine. Empirical research suggested that using those system-simulation-based educational games in lecturing motivated learning and improved conceptual understanding for students (Münz et al. 2007).

Contextualization, encompassing an adventure-themed mission, game characters, and/or a 3D immersive game world, was frequently employed to increase the pertinence and fascination of content representation and simulated problem-solving for players (e.g., Barab et al. 2009, 2010; Leemkuil and de Jong 2012; Koenig 2008; n = 14). For example, students were challenged to select planets in the solar systems for 6 species of alien in the 3D adventure role-playing game "Alien Rescue III" (Liu et al. 2013). The in-game scientific inquiry, along with the embedded notebook, databases, and data collection probes, replicated the learning actions and tools of a conventional space science lab at middle school. Then the backdrop story (presented via an introductory video), game characters, and the 3D fictive game world added the elements of fantasy and role-play to such an inquiry. The study by Liu et al. (2013) reported that sixth graders' science knowledge improved after using the game, and probes and learning about aliens were two elements deemed most fun by learners. In comparison, a non-desirable dissection between the learning task and the game's play/fantasy element was intermittently observed in prior research. In certain cases (e.g., DeShazo et al. 2010; Howard-Jones and Demetriou 2009; Infante et al. 2010), the game mission (e.g., "save the man to be hung on the gallows") did not have a semantic, intrinsic connection with either the learning action or knowledge to be activated (e.g., "answering knowledge questions on nutrition and food"). In those cases, the practice of contextualization is content-irrelevant—any content topics can be inserted into the same gameplay and reward mechanisms without changing the play experience.

Theme 3: Learning spaces contrived by game mechanics and game world

According to the literature (e.g., Garris et al. 2002; Lindley and Sennersten 2008), game play skills are acquired by iterative, cognitive processes of apprehending a local in-game situation, evaluating the current play state in terms of local goals and anticipation of rewards, planning next tactics and actions, and performing actions. The cognitive structures underlying game play skills, called "game play schemas" by Lindley and Sennersten (2008), include schemas for action planning and performing based on the apprehension of game mechanics and those for understanding narrative structures of the game. Consistently, it was found that an in-game learning space was contrived by the design of learning-mapped game mechanics and/or a content-presenting game world in prior research.

Learning space created by mapping learning actions onto game mechanics

A conception in prior research on learning integration in games is that it is the structure of gameplay activities (as opposed to the content embedded) that gives learners a 'mental workout' to develop cognitive skills (Robertson and Howells 2008). Yet others (e.g., Andersen et al. 2011; Ke and Abras 2013; Plass et al. 2012) are concerned that separating game mechanics from domain-specific content will make players involved in the gamer mode (i.e., gaming the system to avoid content-relevant strategies) rather than the learning mode—playing to learn or learning to play.

According to Habgood and Ainsworth (2011), core game mechanics, compared with game narratives, are intrinsic to the educational value of a game. They argued that learning elements should be delivered "through the parts of the game that are the most fun to play," and via the core mechanics of gameplay learners then explore the game world as "an external representation of the learning content" (p. 174). Habgood and Ainsworth (2011) designed and examined a math game Zombie Division, in which players had to defeat Zombies (wearing numbered uniforms) by selecting varied swords (incarnated as divisors/numbers) that would divide numbers/dividends on the uniforms into whole parts. The study indicated that primary school children learned more from the aforesaid intrinsic-fantasy version of the game under fixed time limits and spent seven times more time playing it in free time situations, than with the extrinsic-fantasy version (in which math was presented as multiple-choice quizzes in between game episodes).

Plass et al. (2012) also argued for the essential role and design of game mechanics that integrate learning mechanics intrinsically. They defined learning mechanics as learning actions serving the target learning objectives of a game, and game mechanics as game actions that contextualize or incarnate learning actions in the game world. In other terms, game mechanics is subject to and constrained by learning mechanics (Echeverria et al. 2011). The use of specific game actions, such as collection, pattern recognition, object maneuvering, selection, construction, can be matched with the targeted learning/cognitive processes of memorization, understanding, application, analyzing, evaluating, and creation respectively (Anderson et al. 2001). The assumption is that directly mapping learning mechanics onto game mechanics ensures that learning is an inevitable part of game play. After studying a math puzzle game designed to teach the concepts of angles (called "Noobs vs. Leets"), Plass et al. (2012) reported that the game mechanic of "rule identification" (i.e., identifying a geometry rule to be used without specifying the numeric solution), in comparison with that of "problem solving" (i.e., solving the problem through numerical calculation and number specification), better promoted the targeted conceptual knowledge outcome. The finding evidenced the importance of choosing a game mechanic that reflects the intended learning actions.

Learning space situated in the game world/narrative

In the literature on learning games, the game world is frequently used to frame and necessitate a series of learning tasks, and also acts as "information dumps" that supply the player with task-oriented learning content and scaffold (Dickey 2006, 2007). The game world, encompassing narratives, environment design, and/or characters, is the core game design element that frames fantasy to foster engagement and allows players to "fashion identities" (Klopfer et al. 2009) during play. This section reviews the design propositions and cases that aim to frame learning spaces in the game world and narrative.

As a proponent of narrative-driven learning-play integration, Dickey (2005, 2007) argued that game fantasy depends on a fictional or realism-based narrative, though narrative only defines certain game genres (e.g., role-playing and adventure games). Scholars like Dickey (2007) and Barab et al. (2010) claimed that narrative provides both motivation and a cognitive framework for problem solving in those game genres. Prior research argued that narrative is a cognitive schema that is essentially causal thinking, and the mental representations are based on experiences that are narrative in nature (Dickey 2006; Blakesley 2013; Sarbin 1986). Narrative enables players to assign meaning to their experiences, and to identify and construct causal patterns that integrate their prior experiences and knowledge (e.g., of backstory, rules, strategies) with principles about future problem solving. In accordance, a game world with game-based narratives would assist players to construct causal relationships among various forms of information/resource obtained during game play, thus providing a cognitive framework for problem solving. A narrative-defined game world can also provide intrinsic motivation via "plot hooks" (i.e., uncertainty that plants questions to make players feel compelled to answer) and "emotional proximity" (i.e., empathy and identification players feel toward game characters), and then promote learning engagement via narrative-based "agency" and "consequentiality" in problem solving (Dickey 2006, p. 251; Barab et al. 2010).

Both overarching (e.g., a backdrop story/mission) and local narratives (e.g., the plot) have been employed to motivate and frame problem-based learning tasks in games. Among the articles reviewed, around 57 % described games that employed either a backdrop mission or an environmental narrative structure (i.e., using the game environment and character to tell the story). Others (around 37 %) also provided plot-based local narratives across game levels. Only three articles portrayed learning games that did not deliver a narrative element.

Emerged from the literature is a design configuration on constructing a learning space via the game world and narratives, which encompasses one or multiple of the following processes: (a) framing the central learning problem as the backdrop mission, (b) depicting learning community members (e.g., learner, mentor, or evaluator) as game characters, (c) representing learning materials as multimodal objects in the game world, (d) framing learner-content interactions (identification, communication, synthesizing, and procedural or strategized implementation) as player–object interactions, and (e) designing the game reward/feedback in accordance with the development of local narratives. A learning game project exemplifying such a design configuration is *CSI: The Experience* (Miller et al. 2011)—a role-playing game educating forensic science to youth and adults aged 12+. Selecting a hit TV show (CSI: crime scene investigation) as the backdrop story, the game comprised five state-of-the-art forensic cases. A learner would play the role of a crime scene investigator and complete a series of lab sessions in order to identify criminals out of suspects. The backdrop mission and local narratives were presented via cut-screen scripts and videos featuring both fictional and real-life forensic scientists (as mentors). Content knowledge, presented via graphics, animations, and an interactive simulation of the lab equipment/operation, were embedded in the fictive game world. The core game action was to interact with (i.e., clicking, selecting, dragging, and collecting) those dynamic knowledge objects as directed by the game narrative. The evaluative study (Miller et al. 2011) reported that the game CSI promoted science content knowledge development and career motivation of secondary school students.

Blended learning space between game mechanics and narratives

The literature is inconclusive as to whether game design should prioritize the design of game mechanic or that of narrative (i.e., game world). Correspondingly, scholars disagreed as to whether the design of in-game learning spaces should be mechanics-driven or narrative-dependent. On one hand, prior research (e.g., Adamo-Villani and Wright 2007; Koenig 2008) argued that an intriguing narrative or fantasy context establishes, frames, and motivates content-specific activities; on the other, certain studies (e.g., Adams et al. 2012) reported that there was no evidence supporting the benefit of a narrative game (in comparison with a non-narrative version) on retention and learning transfer.

When examining the design of an adventure narrative game, Blakesley (2013) reported that narratives should be created based on the game mechanics and then guide the gameplay by encompassing play strategies and motivating continuous play. Specifically, he suggested that the designers should align game tasks to the overarching narrative, then adjust local narratives based on the task flow, while using event- and/or character-based narratives to engage players and scaffold content and gameplay. Such a design proposition supports the perspective of Bruner (1990) on the two ways of thinking- the paradigmatic and the narrative. The paradigmatic way of thinking seeks to explain the underlying relationships between observable variables to predict observable phenomena, whereas the narrative mode of thought produces well-formed stories in making meaning of those relationships to capture lived experience. Consistently, game mechanics involve a player in predicting, testing, and explaining rules governing the simulated phenomena, whereas the game world helps the player to capture these gaming interactions and actions as personalized, meaningful memories and expectations. Therefore, learning spaces contrived by both game mechanics and narrative design should best promote the development of mental models grounded in both paradigmatic and narrative modes.

Theme 4: Meta-reflective and iterative learning moments during game play

According to d Baker et al. (2013) and Klopfer et al. (2009), meta-reflective or discovery learning may take place when players who submit to arbitrary game rules start to push against rules and "game" the system to test and take advantage of the properties and limits of the system. Learning moments in the game occur when players, with a stance of "playfulness" (Webster et al. 1993), develop new cognitive understanding and knowledge of play strategies and the rules of play. A core facet of such a "playful" learning perspective is reviewed and synthesized in the following section—the occurrence of learning moments (improvisational or meta-reflective) in game play.

Awareness and meta-reflection in game-based learning moments

Although stealth learning was claimed as a unique feature of game-based learning (MacCallum-Stewart, 2011; Prensky 2005), creating a fully improvisational, subconscious learning experience is difficult since acquiring novel knowledge usually involves conscious reflection in addition to the subconscious process of insight development (Boud et al. 2013). The tacit use of knowledge, as another part of stealth learning, requires a high degree of automaticity in knowledge recall from players and put a demand on their prior knowledge. The literature on meta-reflection and awareness in learning may shed a light on the nature and development of learning moments during game play. Von Wright (1992) distinguishes two levels of meta-reflection. A low-level reflection refers to the process in which the thinker reflects "*on her means of coping in familiar contexts" but not "about herself as the intentional subject of her own actions"* (von Wright 1992, pp. 60–61). A higher-level reflection is what is generally called metacognition, in which "*reflecting about one's own knowledge or intentions" with "access to a model of one's own reasoning performance*" (von Wright 1992, p. 61). Further, Schwartz and Perkins (1989) defined four levels of meta-cognitive awareness—tacit use (decision making without thinking about them), aware use (being consciously aware of a strategy or decision-making process), strategic use (organizing thinking by selecting strategies for decision-making), and reflective use (reflecting on thinking before, during, and after the process to improve decision-making).

Synthesizing the aforementioned theoretical perspectives, a speculation on the presence of metacognition and awareness in game-based learning moments is that the manifestation of those learning moments may range from a tacit experience to an aware, strategic, and reflective use of the target knowledge. Yet prior research examining the occurrence, including the supportive game structures, contexts, and the attributes, of meta-reflective learning moments is lacking. The most relevant discussion of meta-reflective learning moments are associated with the design of in-game learning support in the literature, and will be reviewed later in the paper.

Design for iterative occurrence of learning moments during play

The spirit of game play involves the freedom of effort—a player can shift between effortful and casual play. The optimum play experience leads to the state of "flow" in which the player *iteratively* interacts with the game and loses the track of time (Csikszentmihalyi 1991). Among the studies coded and explicitly reporting the time of game usage ($n = 46$), 50 % used/examined the learning game only as a one-shot lab or in-class practice (lasting no more than 2 h), around 15 % examined web-based, voluntary play longitudinally, and others examined gaming as organized in-class or after-class activities over multi sessions (from 1 week to a semester).

Prior research suggested that the state of flow can be created by an intrinsically-motivating game that satisfies players' psychological needs for *autonomy*, *competence*, and *relatedness* (Deci and Ryan 2010; Ryan et al. 2006), or immersion, achievement, and socialization as termed in Yee's (2006) online gaming motivation model. The literature on game design proposed that autonomy should be activated via different trajectories (or progression toward a goal) during game-based puzzle solving (Gee 2004), interactive story experiencing (Dickey 2006; Barab et al. 2010), and the expansion of game play to game co-authoring/modding (Sotamaa 2010; Weppel et al. 2012). The creation of game-based competency relates to the design of intuitiveness in the game control and an optimum level of game challenge (Ke and Abras 2013). Relatedness in gaming was found to rely on an opportunity to play with others, either collaboratively or competitively (Buchanan 2007; Infante et al. 2010), and the possibility for players to fashion identities in play (Shaffer 2006; Barab et al. 2009, 2010).

Some scholars attempted to find a game-based learning design framework that would harness the sustained engagement of gameplay to enable an iterative learning process. Garris et al. (2002) proposed an 'experiential' game model that highlights an iterative, self-motivated play cycle—comprising the sectors of user judgment (e.g., interest and confidence), user behavior (i.e., persistent engagement with the task), and system feedback (on the performance). This game cycle, embodying the perspective of experiential learning (Kolb et al. 2001), is supplemented by external learning processes (e.g., debriefing). The experiential game model described a desirable state of game-based learning, without explaining how "the instructional content is paired with game characteristics" to create such a self-motivated game-learning cycle (Garris et al. 2002, p. 445).

Killi (2005) also proposed a design model that intends to reinforce iterative learning moments during game play. Different from that of Garris et al. (2002), it highlights the central role of creating a bank of challenges rooted in educational objectives, with each challenge "pumped" in a proximal level to continuously engage players. It is speculated that players will be motivated by proximal challenges, then proceed from the ideation phase in which solutions are generated, to the experience loop in which solutions are actively tested, refined, and synthesized. Killi (2005) emphasized the critical role of designing adaptive game challenges—challenges that are aligned with the player's initial skill level, presented in a tempo balanced with the player's skill development, and will optimize the cognitive load to create a flow-like learning experience. Killi's model (2005) did not discuss how game challenges will be developed based on educational objectives.

Focusing more on the technical design process, Amory (2007) described a Game Object model of which the key constructs for learning game design are "objects." These objects include authentic tasks contextualized by model-building simulations, explicit knowledge-representing artifacts, narrative objects that won't compete with gameplay to overload players, and interface objects that are gender-inclusive and support social collaboration. In comparison with the previous two design models, Amory's game object model presents a better explanation of the design structures aiming to stimulate iterative manifestation of in-game learning moments.

Theme 5: In-game learning support

In a recent meta-analysis that synthesized 29 studies on game-based instructional or learning support, Wouters and van Oostendorp (2013) classified support features into two major categories—features that support the selection of relevant information, and the ones that facilitate information organization and integration via reflection and explication. They then listed 10 types of learning support—reflection, modeling, advice, collaboration, control, narrative elements, modality, feedback, personalization, and others. Their meta-analysis reported that in-game learning support improved learning ($d = 0.34$, $p < 0.001$). In particular, the effect of learning support was found to be largest when the outcome involved the learning of skills and when the support aimed at the selection of relevant new information. Notably, the effect of narrative elements as a support feature did not reach statistical significance. Wouters and van Oostendorp (2013) did not operationally define the 10 types of learning support or how they were classified into the two major categories. Besides, many support features they reviewed were game-extended, external learning arrangements instead of in-game learning supports.

Of the articles reviewed in this study, more than half discussed or studied the in-game learning supports. This paper categorized those in-game learning supports by their associations with the core game-design elements (i.e., the game world/narrative, game actions, and rules), including: Cues and feedback, explicit instruction, prompts for self-explanation and reflection, content processing tools, incentive structures, and the gameplay/level progression.

Learning scaffold presented within the game world

Cues, feedback, and *explicit instruction* are the most frequently-used support features and often associated with the game world design. For example, in an educational puzzle game on transformation geometry concepts (Sedig 2008), instant visual feedback—a "ghost image" of a transformed geometry shape—was presented once the player typed an input value for the targeted transformation (e.g., the angle/degree for a planned rotation). Moreover, a visual presentation of the intermediary state (e.g., the display of a line of reflection for the transformation) worked as a visual scaffold. These visual feedback or cue features scaffolded persistence and content learning. In games reviewed, learning scaffolds could be embedded as multimedia learning objects situated in the game world, such as a "scroll fragment" (Barab et al. 2009, 2010) or an "exploration map" that plots a rough idea of the solution landscape (Cooper 2014). In other cases, written cues were presented via the Head-Up Display (e.g., Martinez-Hernandez 2012), local narratives (e.g., Blakesley 2013), or an end-of-level summary screen (e.g., Leemkuil and de Jong 2012).

Explicit in-game content instruction was sometimes presented via an ever-present, background game object, such as a training video, a virtual book, or an in-game glossary (e.g., Koenig 2008; Liu et al. 2013; Weppel et al. 2012; Zapata-Rivera et al. 2009); it was also deliver by an interactive pedagogical agent that provides hints and prompts (e.g., Habgood and Ainsworth 2011; Wu 2009). A good example is Crystal Island: Uncharted Discovery—a narrative-centered learning game (Lester et al. 2014). The game encompassed not only agent-based information presentation and learning prompts, but also a multi-functional instructional package (including multimedia content presentation, problem-solving guidance, journal, text messages/cues, and a camera—information collection tool). The game produced significant learning gains for diverse learner groups (Lester et al.

2014). Consistently, the study of Schrader and Bastiaens (2012a, b) found that a 3D physics learning game with intrinsic support (i.e., pedagogical agent) enhanced both learning and a stronger sense of presence when compared with the game with extrinsic support (i.e., an ever-present hyperlinked book).

Learning support associated with game actions

In-game prompts aim to make players take the initiative to articulate and reflect on the content to be learned, as part of the game actions. For example, in a recent study (Pareto et al. 2012) designed and examined a 2D math game that illustrated addition and subtraction as card packing. A major in-game learning support was a teachable agent—an apprentice to be mentored—who prompted the player to model and explain play strategies, and hence externalize his/her mathematical thinking. The study found that math comprehension scores increased significantly for the game-playing group but not the control group. In another study, O'Neil et al. (2014) examined a math puzzle game that employed self-explanation prompts. At the end of each game level, the player had to answer one of three questions that prompt for content-related essential processing (i.e., information selection) or generative processing (i.e., strategies reflection). The study found that only prompts that were less intrusive and emphasizing the combination of information selection and strategy reflection would promote performance. This finding is consistent with the report by Hsu and Tsai (2013) that in-game self-explanation prompts would not necessarily improve players' performance of reflection or self-explanation for content processing.

To motivate and necessitate the player's engagement with *content processing*, Adams and Clark (2014) made prediction and argumentation as the game actions of SURGE (an educational physics game) and required the player to conduct self-explanation with the pedagogical agent. Yet the study did not find any significant effect of the self-explanation features on learning outcomes. It reported that the cognitive load of gameplay may be in conflict with that for self-explanation. Other learning games employed *encoding*- and *concept-mapping tools* in gameplay. For example, in the study by Williams et al. (2007), players of a science adventure game were provided with an analytical, encoding tool that scaffolded case comparison for knowledge retrieval and transfer. Similar encoding tools were also used by the game Alien Rescue III (Toprac 2009; Liu et al. 2013), in which the player was provided a data collection tool and a notebook tool to select and record relevant information for each scientific inquiry. Both Hwang et al. (2013) and Charsky and Ressler (2011) examined concept mapping during game play. The former reported that the in-game concept-mapping feature promoted knowledge test performance, self-reported mental effort, and perceived usefulness, but not motivation. The latter found that concept mapping made game play less autonomous and hence decreased players' motivation toward game-based learning.

Learning support framed by game rules

Game is structured play with predetermined rules. The game's incentive structure and level progression, as core aspects of the game rule design, also framed learning support in the games reviewed. For example, O'Rourke et al. (2014) designed four metrics (named "brain points") to capture and reward players' (novel and incremental) content-related play performance. They found that the "brain points" version of the game, in comparison with the control version of the game, increased overall time played, strategy used, and perseverance after challenge. Hwang et al. (2012) examined the role of game level progression in a role-playing science game. They reported that students who learned with the personalized game-level progression (by matching their learning styles with the game level navigation style—linear or non-linear) showed significant better learning achievement, learning motivation, and acceptance toward game-based learning than those who learned with the game without personalized level progression. In some other studies (e.g., Echeverria et al. 2011; Perry et al. 2014), the support of collaborative learning and meaning negotiation in a game was provided via a purposeful design of interdependence in gameplay (e.g., a solution to the game challenge requires the expertise of multiple players).

Although providing support on demand (or ever-present help at learners' control) is dominant in the literature, adaptive learning support—support at game's control and contingent upon the learner's dynamic needs during play—did emerge as a focus game feature in a few articles reviewed (Leemkuil and de Jong 2012; Kickmeier-Rust and Albert 2010; O'Rourke et al. 2014). Specifically, adaptive feedback and adaptive level progression were proposed and examined. They were implemented based on a non-intrusive assessment of the in-game performance (e.g., the game play log) via the creation and tracking of evaluation indices and threshold values (Shute et al. 2013; Leemkuil and de Jong 2012; Ronimus et al. 2014; Zapata-Rivera et al. 2009). For example, Leemkuil and de Jong (2012) examined the function of adaptive advice (e.g., alerts and hints) in an online business simulation game, of which the display and content were pending on the game performance—whether it is below a threshold value of the performance evaluation index. They reported that adaptive advice fosters exploratory behaviors, though not learning outcomes. In a recent study by Ronimus et al. (2014), the designers set the level of difficulty of every subsequent trial of a reading game adaptively for each child player by using a Bayesian-probability-model-based adaptation technique. The target difficulty level of every game trial was placed at approximately the upper or lower middle of the range of uncertainty of the child's level, given the results of the previous trials (correct or incorrect). Ronimus et al.'s study (2014) did not indicate a significant effect of the adaptive challenge on game engagement.

Discussion and conclusions

In this literature review, five salient themes have emerged and compose a potential conceptual design framework regarding the design of learning-play integration in digital learning games. The five themes inform on the nature of intrinsic integration by operationally defining what game-based learning actions have been designed or targeted, how those domain-specific learning processes/actions are integrated in game development, where game-based learning spaces are contrived, and when or in what supportive context (iterative) game-based learning moments occur.

The literature indicated that domain-specific learning actions in digital games are designed as prior-knowledge activation in excess of novel knowledge acquisition. Research examining the design heuristics for game-based proactive presentation and instruction of content is obviously less. Such a pattern relates to the predominant description of "immersion", "interactivity", and discovery-oriented "experiencing" as the major theoretical and design constructs for game-based learning (Barab et al. 2010; Buchanan 2007). Consistently, practice, exploration, and information collection become more prevalent in-game learning activities than knowledge comprehension or organization.

In prior research, domain-specific learning integration in games comprises mainly three approaches: (a) dynamic conceptual representation via game objects and environmental design; (b) interactive simulation of the central problem or phenomenon, extended with a backdrop mission and game rewards, and (c) contextualization of the focus content and problem via interactive narratives and immersive role-playing. Among these three approaches, the first two embrace the design protocol of a scientific (or system) simulation to promote system understanding, problem solving, and discovery learning, whereas the third emphasizes relevance and autonomy in active experiencing and practice.

The in-game learning spaces have been contrived and driven by both game mechanics and the narrative structure (i.e., the game world that comprises characters and game objects). The former is core in activating and confining the interaction and actions that are learning constructive, whereas the latter helps to frame and motivate these interactions and actions with meaningful experiences.

It is commonly agreed that iterative learning moments may occur in consequence of a blended balance between gameplay and learning. Yet it remains murky as to how game-based learning may continue from a tacit experience to the attentive, reflective use of the target knowledge. Research examining the occurrence (including the supportive gaming structure and attributes) of meta-reflective learning moments is warranted.

To support the occurrence of learning in gaming, varied learning supports have been designed as part of the game world, actions, and rules. Cues, feedback, and content instruction, either written or visual, are provided as part of the game world via cut-screen scripts, background content objects, or pedagogical agents. In-game prompts for self-explanation and reflection, as well as tools that scaffold information collection and organization, are usually incorporated as secondary gameplay actions. Recently, the structures of game reward and level sequencing are designed to be learner adaptive based on a non-intrusive game performance assessment, in order to motivate and support learning engagement and meaning making.

The design and learning effectiveness of the aforementioned learning scaffolds is still in need of further research. The in-game learning scaffolds differ in the demand on players, with some requiring players to be attentive information receivers and others expecting them to take the initiative to actively seeking, collecting, and organizing information. Importantly, prior research suggested the necessity of managing cognitive load and play flow when designing in-game learning supports. Self-explanation prompting, concept mapping, and other in-game scaffolds, if cognitively demanding and not directly integrated in gameplay, will become intrusive and negatively influence in-game performance and learning engagement (Adams and Clark 2014; Andersen et al. 2011; Charsky and Ressler 2011; D'Angelo Cynthia 2010; O'Neil et al. 2014; Schrader and Bastiaens 2012a, b).

Implications for learning game design

Find gameplay in the domain knowledge

The review findings implied that the nature of the domain knowledge and the targeted type of learning should drive the design of learning games. The prospect of using an educational game to motivate learning lies in the assumption that this game will involve learners in what is fundamentally engaging about the subject, via a dynamic representation of the "epistemic frames" or the simulation of the most "fun" (dynamic) part of the academic domain (Shaffer 2006; Habgood and Ainsworth 2011). The game-based content interactions can range from collecting facts or practicing procedures, interpreting or classifying conceptual representations, solving problems, to experiencing and constructing a simulated system. The process should be aligned with the target learning objectives and hence the major learning functions of the game—as a practice tool, as an electronic manipulative for a dynamic representation of complicated concepts, or as an interactive simulation that escalates qualitative, informal understanding to formal knowledge.

Game-mechanic-based, game-narrative-confined learning actions

Prior research on learning game design, in general, supports the central role of game mechanics for the learning-play integration. Mapping learning actions onto the play actions is a core mechanism of intrinsic fantasy (Habgood et al. 2005; Plass et al. 2012). Design of game rules, such as learning-supportive incentives and the learner-adaptive level progression, help to necessitate and scaffold learning efforts. As a supplementary mechanism for the learning-play integration, the narrative structure can embed content objects and frame experiential learning interactions. Yet it may demand extraneous cognitive processing and become destructive.

Non-intrusive, meta-reflective learning scaffolds

Research examining the occurrence of meta-reflective learning in games is still lacking. However, the practice of using meta-reflective learning scaffolds (e.g., prompts and concept mapping tools) may act as a catalyst for insight and increased research on the design of an iterative, meta-reflective use/experience of the target knowledge in gaming. On the other hand, prior research suggested that those potentially-beneficial scaffolds may be segmented from the gameplay and compose extra cognitive load, thus being play- and learning-disruptive (Adams and Clark 2014). Thus it is important to integrate the active usage of scaffolds as part of core game actions and strategies. The emergence of adaptive and dynamic learner support (Leemkuil and de Jong 2012; Kickmeier-Rust and Albert 2010; O'Rourke et al. 2014; Shute et al. 2013; Zapata-Rivera et al. 2009) presents promising examples of meta-reflective and non-intrusive learning support.

Future research

The game-based learning field, as Klopfer et al. (2009) argued, is still "ripe for innovations and creative destruction" (p. 17). This systematic review of the literature has highlighted the following opportunities for future research:

- Research on learning games have predominantly focused on reporting the learning effectiveness of games without a detailed record of game design features and processes. It is recommended that scholars should provide a phenomenological description of their learning-game development experiences, by elaborating on the theoretical underpinnings, overarching design strategies, design rationales for game mechanics and the game world design, and key lessons/tips.
- The field of learning games is short of empirical and theoretical investigations on non-intrusive and learner-adaptive in-game scaffolds that support the processes of

knowledge extraction, structuring, and organization while not interrupting the game flow.

- Although scholars (e.g., Howard-Jones and Demetriou 2009; Wilson et al. 2009) have started to explore the association between salient game attributes and learning outcomes, these explorations have generally focused on individualistic attributes or remained as theoretical propositions. Research that systematically investigates the set of game attributes and experimentally controls the nuances during the feature comparison is warranted.
- There is evidence suggesting that learner characteristics, such as gender and navigation preference (Buchanan 2007; Kinzie and Joseph 2008), mediate the effectiveness of game-based learning actions. Yet research investigating the interactions between learner characteristics and learning game design features, or that on the learner-adaptive game design features, is still limited.

This paper does not intend to be thorough in the discussion of domain-specific learning design and integration in games. The investigation has focused on a congregation of common patterns for game-based learning-play integration that emerged from the literature and the exemplary games reported. Other potential game design and usage phases relating to content learning, such as needs and task analyses for choosing the game genre, game-based pedagogy or external instructional support, and game-based learning assessment, are beyond the scope of this paper but important for future investigations.

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