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The Role of Feedback in Game-Based Learning:

A Review of the Literature

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The Role of Feedback in Game-Based Learning:

A Review of the Literature

by

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Dedication

To my family, my parents, and my lovely friends

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Abstract

The Role of Feedback in Game-Based Learning:

A Review of the Literature

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Since the second half of the 20th century, various educational games have been developed and gradually used in the classroom. Although research over many years has shown games to be effective in enhancing learner performance, studies that focus on the feedback in game environments are lacking. Through a systematic review of the literature on game-based learning, this report presents a discussion on the role of feedback in game environments. A total of 21 peer-reviewed articles and conference proceedings ultimately met the inclusion criteria and were included for the literature synthesis. Exemplary educational games reviewed in the articles were also analyzed for domain-specific learning. The cumulative findings and propositions of the game-based learning have been extracted and synthesized. Future directions for design and research on feedback system in digital games are then proposed.

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Chapter 1: Introduction

In the second half of the 20th century, the explosion of personal computers and the rapid development of the Internet revolutionized learning and teaching. Along with this effect, computer games have gained a momentum as an increasingly important medium of reference in the education field in the past several decades. This popularity can be mainly explained by the huge amount of time that children and adults spent playing computer games (Papastergiou, 2009). Computer games play a central role in young people's lives, holding a unique fascination and provoking a strong sense of engagement in them. Besides students, educators have also been incorporating various computer games into their teaching curriculum to create a fun and engaging learning environment for students. Moreover, different educational games have been developed to focus on a particular domain: language (*POOT*), humanities (*Men and Animals, BiLAT*), math (*Sonic Divider, Noobs vs. Leets: the Battle of Angles and Lines*), and science (*ASTRA, Taiga, Carrot Land*). It is obvious that game-based learning is a promising trajectory for future interactive digital learning.

Many educational researchers support the use of educational games and claim that games are beneficial to learning: games have a moderate to strong effect on cognitive learning outcomes (Clark, Tanner-Smith, & Killingsworth, 2014); games have a significant moderator effect of visual and narratives on the affordances of games for learning (Ke, 2008; Young et al., 2012); games can offer instant and visual feedback that motivate learners (Charles, Bustard, & Black, 2011); and students can take control over their own learning processes (De Grove, Bourgonjon, & Van Looy, 2012). But others argue that students may be distracted by the play part and not

achieve the learning goals (Miller, Lehman, & Koedinger, 1999) or games do not support in-depth learning like articulation and reflection on the target content knowledge (van de Meji, Albers, & Leemkuil, 2011). However, the growing amount of research focused on game-based learning in recent years (e.g., Clark et al., 2014; Cooper, 2014; Shute, Ventura, & Kim, 2013; Andersen, Liu, Snider, Szeto, & Popovic, 2011) indicates that game-based learning is receiving increasing attention and it is becoming popular to use games in the educational environments.

Research over many years suggests that feedback is a critical aspect of the learning environment. Feedback is depicted as a significant factor in motivating learning (e.g., Narciss & Huth, 2004). Despite its powerful influences on learning, its impact can be either positive or negative. There are many conflicting findings and there is no consistent pattern of results on the impact of feedback on learning. But Shute (2008) found that feedback generally improved learning after several meta-analyses using a large corpus of research on feedback.

Although there are numerous studies that have proved the effectiveness of games as well as the important role of feedback in learning, there are only a few literature review studies regarding the different game attributes employed in game-based learning (Wilson et al., 2009). Studies that specifically focus on feedback in game-based learning are still lacking. In particular, studies dealing with the central role of the built-in feedback for the positive effects are sparse, not to mention discussing important issues like different types of feedback and the way feedback is delivered in the game environments. Drawing on the feedback attributes, the goal of this report is to conduct a literature review on articles from 2007 to present that provide findings and insights for researchers who are interested in applying feedback to enhance game-based learning experiences.

Outline and Purpose of the Report

Despite the lack of current research on how feedback is employed in game-based learning, research results testing the effects of feedback in games on motivation have been inconclusive according to many studies. This report is a literature review of relevant articles on feedback in game-based learning, including empirical studies and theoretical articles in the past ten years from 2007 to present.

The goals of this report are to: (a) provide an overall literature review of relevant articles on feedback in game-based learning, including empirical studies and theoretical articles in the past decade; (b) explore current techniques that learning game interfaces employed to provide feedback; (c) offer implications for the interface and user experience design for educational games; and (d) highlight future research directions for scholars who are interested in studying feedback in game-based learning environments.

The overarching research question guiding this review is: What is the aggregate of findings and propositions on the role of feedback in game-based learning? The specific questions guiding this review are:

1. What types of feedback were emphasized in the literature reviewed?

2. What techniques have been employed in the learning game environments to provide feedback?

The report describes previous articles focusing on feedback in game-based learning. How feedback is provided and employed in the game environments in these studies are reviewed, with a focus on recent studies and trends related to game-based learning. This review also presents an examination of how these studies conducted their research in order to investigate their methodologies. The findings of this literature review can provide insights into the potential appropriate use of feedback in

game-based learning environments. The report concludes with implications for educational game designers and researchers and recommendations for future research are also proposed at the end.

This review is constrained by several factors. First, some of the studies reviewed in this report examined several game attributes besides feedback. Therefore, this report did not solely focus on feedback and might not be comprehensive. Moreover, some of the games lack accessibility and detailed descriptions; for example, they do not have a public online website or require permission for access. The number of games reviewed in this report is also limited by the author's language capabilities and timeframe. The author is only fluent in English and Chinese, so the generalization in this report is based on English and Chinese educational games. Finally, only the author coded the articles during the process. The consistency and rigor of analyses and results could be improved by using several coders for peer examination and inter-rater checking.

Defining Games

Terms like *games*, *simulation games*, *learning games,* and *digital-learning games* are used interchangeably in the education and training field. However, these terms have slightly different definitions across different articles (O'Neil et al., 2005). Therefore, it is important to define the term *games* used in the report to avoid confusion and ambiguity.

According to Hays (2005), a *game* is "an artificially constructed, competitive activity with a specific goal, a set of rules and constraints that is located in a specific context" (p. 15). Furthermore, Young et al. (2012) discussed the six features of a game as defined by Juul (2003): "(a) a rule-based formal system, (b) variable and

quantifiable outcomes, (c) different assigned values for different outcomes, (d) an outcome influenced by the efforts that the player exerts, (e) players feeling emotionally attached to the outcome, and (f) consequences of the activity that are negotiable" (p. 63).

As for *simulation games*, it is defined in Fan and Geelan's article as "computer-based 'exploratory' applications and considered as representations simulating dynamic systems of scientific phenomena in virtual 'laboratories'" (p. 126).

Learning games were categorized into three types based on the type of learning integrated in Ito's article (2008): educational games (i.e., games that privilege the drill-and-practice of a subject matter), entertainment games (i.e., games that privilege narrative and play, with domain-generic, incidental learning as a side effect), and construction games (i.e., games that privilege providing tools for construction and tinkering rather than conveying academic or cultural content; e.g., *SimCity*).

According to Klopfer, Osterweil, and Salen (2009), a *digital-learning game* is the one that "targets the acquisition of knowledge as its own end and foster cognition that is either generally useful or useful within an academic context" (p. 21).

This report used the term *games* under the assumptions that *games* is a broad category containing *games*, *simulation games*, *learning games*, and *digital-learning games* with educational objectives. Additionally, this report used *game-based learning* under the assumption that any initiative that mixes games and education can be considered as *game-based learning*.

Defining Feedback

Several attempts have been made to define feedback, as it is a broad term. This

report used the term *feedback* by the definition that it refers to any message generated in response to a learner's action, usually after something is done. The definition indicates that there is an interactive flow between the learner and the game environment, coming from some information collected or generated by the learner and coming back to the learner as an output. This report characterizes feedback mainly by the types of feedback involved in game-based learning, and the way in which feedback is integrated into the game-play in the learning environments.

Chapter 2: Method

A systematic review was conducted with the multidisciplinary literature on the role of feedback in game-based learning. Although there are many articles about this topic, the priority for the inclusion of the resources in this report concentrates on the data-based empirical and meta-analyses theoretical journals. The review employed a two-phase search. The selection criteria were specified as: (1) Content relevance - studies that examined or described the *game-based learning*, *games*, *feedback*, and *assessment* (2) year of publication within 2007-2017, and (3) English, peer reviewed research publications or research reports. The aim of the literature search was to include as many studies as possible within the data pool consisting of computerized bibliographic databases (i.e., ERIC, Academic Search Complete, PsycInfo, JSTOR, LearnTechLib - former EdITLib, and Wiley Online Library), 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), and the reference lists of several reviews.

The initial online searches of the aforementioned data pool identified 52 articles (using *and* and *or* operators in advanced search). The author read the abstracts and references, applied the following inclusion and exclusion criteria to determine the final set of articles for review. These criteria focused on whether the study could provide enough information to answer the research questions stated above, as follows:

(1) described the effectiveness of feedback in game-based learning
(2) described how feedback is delivered in the educational games environments

Studies that did not satisfy at least one of the inclusion criteria were excluded.

After removing the duplicates and reading the abstract, 45 articles were retained for screening at the full text level. In the end, 21 articles were found most relevant, coded and included in the final literature synthesis.

When conducting the literature search and initial content coding, the author paid special attention to the articles that would establish preliminary components of an analytical framework to guide the later comparative and categorical aggregation analyses. An initial coding framework was then developed in the culling process based on the research focus, methods, number of participants, grade level, game, and key findings, as outlined in Table 1. The research designs employed in the reviewed studies are discussed and researchers' findings and conclusions are evaluated in order to compare the impact of feedback in game-based learning among the research designs as well as provide design insights for future related studies.

In order to further investigate how feedback was employed in the games, relevant information was extracted from the articles. In Table 3, detailed information about the games reviewed in this report is examined. If studies did not mention the development process or provide detailed information about a game, other resources such as a website or other related articles were used to investigate a game. Studies that examined feedback in learning but did not emphasize on the game environment itself are not included in Table 3.

The coding framework was refined as the analysis process proceeded. Salient themes on the role of feedback in game-based learning were extracted and corroborated with the literature review findings, which will be discussed in the following chapter.

Table 1.
Empirical studies on feedback and game-based learning reviewed in this report

Reference	Research focus	Methodology	No. of participants	Game	Conclusion
Svingby (2010)	To explore the role of feedback in educational games	Mixed	120 high school students	*Men and Animals*	Results indicate the need either to embed the feedback, reflection and guidance as an integral part of the play or/and to integrate teachers into the game play.
Burgers et al. (2015)	To study the impact of verbal feedback in stimulating player motivation and future play in a brain-training game	Mixed	157 (most were highly educated)	*Concentration*	Results demonstrate that evaluative feedback increases, while comparative feedback decreases future game play. Negative feedback thus motivates players to repair poor short-term performances, while positive feedback is more powerful in fostering long-term motivation and play.
Law & Chen (2016)	To examine the effects of the types of question prompts (Knowledge vs. Application Prompts) and feedback types (KCR) vs. ER on science learning outcomes in a game-based learning environment	Quantitative	105 students (7th grade)	*Carrot Land*	Students with ER (Elaborated Response) feedback performed better than those with KCR (Knowledge of Correct Response) feedback when knowledge prompts were given; however, students with KCR feedback performed better than those with ER feedback when application prompts were given.

Table 1 (continued)

Reference	Research focus	Methodology	No. of participants	Game	Conclusion
Serge et al. (2013)	To examine the effects of differing feedback content, focusing on adaptive feedback in game-based training environment minutes or longer	Quantitative	104 university students and surrounding community	Game Distributed Interactive Simulation (GDIS) of *Half-Life2*	Results suggest that detailed feedback early in the training cycle is the most beneficial for the fastest learning of new task skills.
Erhel & Jamet (2013)	To set out to determine whether the presence of KCR feedback in DGBL quizzes can influence the types of learning strategies induced by the instructions	Quantitative	44 university students	*ASTRA*	Results show that KCR feedback, coupled with an entertainment instruction, can promote deep cognitive processing during learning, thus enhancing learners' motivational investment.
Lane, Hays, Core, & Auerbach (2013)	To investigate the role of fidelity in a game-based, virtual learning environment as well as the role of feedback delivered by an intelligent tutoring system	Quantitative	47 college students	*BiLAT*	No differential effect with the tutor engaged, but it was found to have a positive impact on learner success in a transfer task. This difference was most pronounced when the feedback was delivered in a more general form versus a concrete style.
Kickmeier-Rust, Hillemann, & Albert (2014)	To investigate the motivational aspect and the feedback system employed in the Math app in primary school classroom	Mixed	40 primary school students	*Sonic Divider*	Formative feedback provided by an autonomous system can improve learning (even if not dramatically or as in our case statistically significant).

Table 1 (continued)

Reference	Research focus	Methodology	No. of participants	Game	Conclusion
Burgos, Nimwegen, Oostendorp, & Koper (2007)	To study the differences between having and not having instant destination feedback in game-based learning	Quantitative	43 university students	*Conference Planner*	Results show only positive effects of having no feedback. Be careful with providing interface cues that give away too much and must be designed in such a way that learners think and act is optimally supported.
Conati & Manske (2009)	To evaluate the impact of adaptive feedback on the effectiveness of a pedagogical agent for an educational computer game	Mixed	44 students (6th-7th grade)	*Prime Climb*	Found no difference in student learning across the three conditions.
Hickey, Ingram-Goble, & Jameson, (2009).	To investigate broad learning outcomes for a 15-hour game-based learning curriculum in Quest Atlantis with two virtual formative feedback introduced	Mixed	105 students (6th grade)	*Taiga* in *Quest Atlantis*	The revised curriculum with virtual formative feedback resulted in larger gains in understanding and achievement.
Charles et al. (2011)	To examine the use of a game-based feedback system that offers reward-based feedback in the form of points and achievements for voluntary and non-voluntary participation within classes	Quantitative	1st phase: 18 4th-year college students 2nd phase: 70 1st-year college students	*Software Development1 (COM158C1)*	Student participation and performance can be improved by providing Game-Based Feedback (GBF) to students.

Table 1 (continued)

Reference	Research focus	Methodology	No. of participants	Game	Conclusion
Killham, Saligman, & Jette (2016)	To identify what supported and impeded student participation in EFL within this game-based learning environment	Mixed	35 students (9th grade)	*Place Out of Time (POOT)*	Exercise precaution when labeling learning environments as "games" Apportion frequent, contextualized, and consequential feedback are crucial factors to instituting creative fluency instruction.
Kickmeier-Rust, Marte, Linek, Lalonde, & Albert (2008).	To investigate the effects of different types of interventions and feedback with French students playing the demonstrator game	Mixed	40 school students (12-14 year olds)	*ELEKTRA demonstrator game*	The results indicate that (micro) adaptive interventions (i.e., appropriate and meaningful interventions/feedback for an individual learner, his/her knowledge and learning progress) are superior to neutral (i.e., non-individualized but semantically correct interventions) and inappropriate interventions (i.e., non-individualized, unsuited interventions) in terms of learning and gaming measures.
Kinzer et al. (2012)	To examine the impact of a varying learning mechanic and an assessment mechanic modified in an existing educational video game on students' learning, motivation, and in-game performance	Quantitative	138 students (6th grade)	*Noobs vs. Leets: the Battle of Angles and Lines*	Results suggest that providing players with a choice of NPC from whom to receive feedback results in significantly higher learning outcomes and desire to continue playing compared to a non-choice condition. Comparisons between informative and elaborative feedback did not influence student.

Table 1 (continued)

Reference	Research focus	Methodology	No. of participants	Game	Conclusion
Tsai, Tsai, & Lin (2015)	To explore how different gaming modes and feedback types in this game-based formative assessment affect knowledge acquisition effectiveness and participation perceptions	Quantitative	109 students (9th grade)	*TRIS-Q Tic-tac-toe quiz game*	Results indicate that providing immediate elaborated feedback (IEF) for facilitated the enhancement of both energy knowledge acquisition and student tic-tac-toe ability than not providing it.
Segedy et al. (2013)	To explore the effects of contextualized conversational (CC) feedback implemented in an open-ended learning environment	Quantitative	44 students (8th grade)	*Betty's Brain*	Results illustrate some advantages of the CC feedback in comparison with a baseline dialogue mechanism that presents similar strategies in a non-conversational, non-contextualized form.
Fiorella et al. (2012).	To explore the presentation of feedback during simulation-based training (SBT) of a complex decision making task	Mixed	60 undergraduate students	*Fire Support Team (FiST)* using *DVTE simulator*	Results indicated that students who received spoken feedback demonstrated greater decision-making performance during training compared to the students who received printed feedback.
Mayer, R. E., & Johnson, C. I. (2010)	To determine whether instructional design principles that improve learning with non-interactive multimedia presentations also apply to learning with interactive computer games	Quantitative	117 college students	*Circuit Game*	Results indicate the role of prompts for reflection and direct guidance as effective supplements to learning by doing in an educational game.

Table 1 (continued)

Reference	Research focus	Methodology	No. of participants	Game	Conclusion
Yang (2017)	To compare the differences in the learning behavior of students using the two feedback models (Regular Feedback Group and Corrective Feedback Group) in a mastery theory-based digital game	Quantitative	75 elementary school students (5th grade)	*The Little Five-Star Chef*	With proper design, students in both feedback methods can achieve the same learning performance as that in the conventional learning method with a teacher involved. Moreover, students in RFG reviewed the learning materials more times than those in CFG.

Chapter 3: Findings and Discussion

This chapter focuses on describing different issues and findings of the data-based empirical studies and meta-analyses theoretical studies primarily interested in feedback in response to the research questions that proposed in Chapter 1.

FEEDBACK ISSUES IN GAME-BASED LEARNING ENVIRONMENTS

This section focuses on three themes that emerged from the reviewed articles concerning feedback issues in game-based learning environments: the descriptions and effectiveness of different types of feedback, as well as game-based feedback in different subject areas, are discussed.

Descriptions of Different Types of Feedback

In the context of learning, the literature review by Hattie and Timperley (2007) defined feedback as "information provided by an agent (e.g., teacher, peer, book, parent, experience) regarding aspects of one's performance or understanding" (p. 102), which occurs typically "after instruction that seeks to provide knowledge and skills or to develop particular attitudes" (p. 102). Feedback is one of the most frequently-used support features and often associated with the game world design (Ke, 2015). Feedback is critical for learning as it provides support on the educational process and motivation. It is also an important component of games. As one of the eight dimensions used to assess the educational game's enjoyment scale, feedback "allows the player to determine the gap between the current stage of knowledge and the knowledge required for ultimate completion of the game's task" (Fu, Su, & Yu, 2009, p. 105). In classroom teaching practices, seven criteria of good feedback practices

were proposed by Nicol et al. (2005).

However, in the context of Human Computer Interaction (HCI), feedback usually refers to "communicating the results of an action" (Norman, 2013, p. 23), which is an important concept from the science of control and information. Norman (2013) argued that feedback must be immediate, informative, and planned. Providing poor feedback is worse than no feedback at all, which can be distracting, irritating and anxiety-provoking. In Graphical User Interfaces (GUI), Burgos, Nimwegen, Oostendorp, and Koper (2007) claimed that one of the guidelines was to "keep users informed about what is happening by the provision of an appropriate communication flow between user and application through a bi-directional feedback" (p. 190).

There are many existing studies discussed about different types of feedback based on the content, control, delivery, length, specificity, and complexity of the feedback. Table 2 presents the different types of feedback along with their related descriptions and findings in the articles reviewed. In this report, terms about types of feedback were from the literature reviewed.

Table 2.

Types of feedback and descriptions reviewed in this report

Types of feedback	Descriptions and Findings	Reference
Adaptive feedback	Adaptive feedback means the amount of information provided will be based on the learners' real-time performance.	Serge, Priest, Durlach, & Johnson (2013)
Comparative feedback	Comparative feedback provides social comparison information by comparing the performance to those of others. It can positively affect pro-social behavior.	Burgers, Eden, Engelenburg, & Buningh (2015)
Consequence/consequence-based feedback	Consequence/consequence-based feedback is where the system reacts to the user's responses or actions by changing the system path (paths of actions taken by the system).	McNamara, Jackson, & Graesser (2010) Svingby (2010)
Contextual conversational feedback	Contextual conversational feedback means that feedback is contextualized by the learners' task goal and delivered in a mixed-initiative conversational format.	Segedy, Kinnebrew, & Biswas (2013)
Corrective feedback	Corrective feedback guides a learner with instructions. If the learner did the wrong thing, he or she will be prompted, guided, or pointed toward a more appropriate action. Corrective feedback informs the learner that their response was incorrect and provides knowledge of the correct or desired response.	Yang (2017)
Delayed feedback	Delayed feedback provides feedback messages after a few minutes or longer.	Shute (2008)
Descriptive feedback	Descriptive feedback reports back to individuals summing up their attitudes or behavior, either based on participants' own input or observational data.	Burgers et al. (2015)

Table 2 (continued)

Types of feedback	Descriptions and Findings	Reference
Destination feedback	Destination feedback informs the user about the possible actions that can be taken, for example, externalizing information by greying-out items. Only recognition not recall is needed, so it can relieve working memory. Bu it might cause users to behave less proactive and lazy.	Burgos et al. (2007)
Formative feedback	Formative feedback refers to information communicated to the learner that is intended to modify the learner's thinking or behavior for the purpose of improving learning.	Shute (2008)
Elaborated feedback	Elaborative feedback refers to providing an explanation about why a specific response was correct, and it might allow the learner to review part of the instruction. It also might present the correct answer.	Shute (2008)
Evaluative feedback	Evaluative feedback adds a level of judgement to an individual's performance.	Burgers et al. (2015)
Immediate feedback	Immediate feedback occurs right after a student has responded to an item or problem or, in the case of summative feedback, right after the student has completed a quiz or rest.	Shute (2008)
Information/informative/information-based feedback	This type of feedback provides information on results, does not explain why the results are right or wrong. It is concentrated on providing the accuracy and quality of answers and actions including immediate corrections, delayed corrections, level of mastery achieved on specific content.	Kinzer C. et al (2012) McNamara et al. (2010)
Knowledge of Correct Response (KCR) feedback	KCR feedback informs the learner of the correct answer to a specific problem with no additional information. Coupled with an entertainment instruction. KCR feedback can	Shute (2008) Erhel & Jamet (2013)

Table 2 (continued)

Types of feedback	Descriptions and Findings	Reference
	promote deep cognitive processing during learning, all the while enhancing learners' motivational investment.	
Negative feedback	Negative feedback emphasizes the gap between the desired goal and the actual behavior, and it may be more persuasive than positive feedback. It may, counter-intuitively, be good in stimulating short-term and immediate gaming behavior.	Burgers et al. (2015)
No feedback	No feedback refers to conditions where the learner is presented a question and is required to respond, but there is no indication as to the correctness of the learner's response.	Shute (2008)
Peer feedback	Peer feedback refers to feedback delivered in the presence of a peer/follow group.	Hattie & Timperley (2007)
Point-based feedback	Point-based feedback can be conveyed in the form of cumulative points, progress bars, and levels.	McNamara et al. (2010)
Positive feedback	Positive feedback will positively affect need satisfaction and intrinsic motivation, compared to negative feedback. It can make the receivers feel more competent and autonomous and desirous in the future, thus sustaining long-term gameplay. Participants who received positive feedback during a learning task also completes that task faster than participants who received negative feedback.	Burgers et al. (2015) Barrow, Mitrovic, Ohlsson, & Grimley (2008)
Audio/Visual feedback	Audio/Visual feedback refers to feedback that is delivered via audio/visual form.	Hattie & Timperley (2007)

Table 2 (continued)

Types of feedback	Descriptions and Findings	Reference
Summative feedback	Also known as summative assessment, which refers to the assessment of participants where the focus is on the outcome of the learning.	Hattie & Timperley (2007)
Text/Written feedback	Text/Written feedback refers to feedback that is delivered via text, compared to oral/verbal feedback.	Fiorella, Vogel-Walcutt, & Schatz (2012)
Try-again feedback	Also known as *repeat-until-correct* feedback, it informs the learner about an incorrect response and allows the learner one or more attempts to answer the question.	Shute (2008)

Effectiveness of Different Types of Feedback

A total of 19 empirical studies out of 21 selected articles were analyzed by examining the effectiveness of different types of in-game feedback (see Table 2). Most of these studies examined how different feedback models in games stimulated thinking and improved students' learning achievement. Tsai et al. (2015) examined the effect of feedback timing on junior high students' energy learning and found that providing immediate elaborated feedback was more effective for knowledge acquisition than not providing it. Some researchers confirmed that in-game formative feedback resulted in larger gains in students' understanding and achievement (Hickey et al., 2009; Kickmeier-Rust, et al., 2014). Erhel and Jamet (2013) found that KCR feedback in *ASTRA* promoted students' deep cognitive processing and motivational investment during learning. Compared to text feedback, audio feedback was found to demonstrate greater decision-making performance during training in Fiorella et al.'s study (2012). Contextual conversational feedback also showed more advantages in improving students' performance (James et al., 2012; Killham et al., 2016). Moreover, different types of feedback seem to foster students' learning in different ways. For example, in Burgers et al.'s (2015) research, they found that negative feedback motivated players to repair poor short-term performances since it emphasized the gap between the desired goal and the behavior, while positive feedback was more powerful in enhancing long-term motivation and play. Their findings about in-game negative feedback might be different from previous studies (e.g., failure to meet obligations; Van-Dijk & Kluger, 2004) that claimed negative feedback could frustrate learners' confidence and motivation.

However, not all empirical studies found promising effects of feedback in

game-based learning environments. Burgos et al.'s research (2007) showed only positive effects of having no feedback in the game *Conference Planner*. They observed that providing no feedback resulted in students' longer thinking times before they started to solve the problem. Having feedback led them to make more extra/error moves. And they concluded that educational game designers should control how much feedback is provided and avoid making learners too lazy to think.

Game-Based Feedback in Different Subject Areas

This section addressed the two research questions about the types of feedback were emphasized in the literature reviewed as well as the techniques have been employed in the learning game environments to provide feedback by describing what kinds of feedback have been adopted and how they are employed in current game-based learning environments. This report first presents the game-based environments used in the empirical studies and the feedback that researchers primarily discussed in their studies. It then presents the types of feedback that were studied in the game-based learning environments in order to analyze any distinguishable different usage of feedback depending on the subject areas. The games reported by the empirical studies covered various subject areas: communication, humanities, language, social studies, health education, math, and science. In order to investigate games and different feedback types, this report used the feedback types discussed in Table 2. An overview of the games and feedback that have been studied from 2007 to present is provided in Table 3.

Table 3.

List of games and feedback types in subject areas reviewed in this report

Subject	Game	Description	Grade level	Feedback Types
Communication (intercultural communicative skills)	*BiLAT*	a game-based simulation for learning intercultural communicative skills	Adults	• Elaborated feedback • Adaptive feedback • Contextual conversational feedback • Text feedback
Disease education	*ASTRA*	a simulated game with a pedagogical agent provides learners with information about four aging-associated diseases	Adults	• Point-based feedback • Text feedback • KCR feedback
Humanities (moral sensitivity)	*Men and Animals*	an educational computer game to enhance students' development of moral sensitivity	High school	• Immediate feedback • Delayed feedback • Consequence feedback • Information feedback • Contextual conversational feedback • Peer feedback
Language	*POOT (Place Out of Time)*	a text-based, multi-user virtual simulation	Middle-High school	• Peer feedback • Text feedback • Contextual conversational feedback
Math (division)	*Sonic Divider*	a game designed to rehearse the formal sequence of written division	6-8 year olds	• Point-based feedback • Delayed feedback • Text feedback • Visual feedback

Table 3 (continued)

Subject	Game	Description	Grade level	Feedback Types
Math (angle rules)	*Noobs vs. Leets: the Battle of Angles and Lines*	a game that teaches 6th grade students angle rules	6th grade	• Text feedback • Audio feedback
Science (general)	*Betty's Brain*	an open-ended learning environment in which students learn about science topics by teaching a virtual agent named Betty	Elementary - Middle School	• Contextual conversational feedback • Text feedback
Science (ecology)	*Taiga, Quest Atlantis*	a multi-user virtual environment to study water quality concepts	Elementary - Middle School	• Contextual conversational feedback • Point-based feedback • Formative feedback • Summative feedback
Science (physics)	*Carrot Land*	a game to teach the elementary-middle school students force	Elementary - Middle School	• KCR feedback • Elaborated feedback • Point-based feedback
Science (physics)	*ELEKTRA* demonstrator game	a 3D adventure game in first-person view	12-14 year olds	• Informative feedback • Adaptive feedback • Text feedback • Contextual conversational feedback
Science (physics)	*Circuit Game*	an arcade-type computer game that helps students learn how electrical circuits work	University students	• Audio feedback

Table 3 (continued)

Subject	Game	Description	Grade level	Feedback Types
				• Point-based feedback • Evaluative feedback • Elaborated feedback Text feedback
Science (energy education)	*TRIS-Q*	A tic-tac-toe quiz game for energy education	8th grade	• Point-based feedback • KR feedback
Social studies (culture and food)	*The Little Five-Star Chef*	a game that helps students learn the domestic and foreign food culture unit in social studies	Elementary school	• Corrective feedback • Formative feedback

Communication

BiLAT is a game-based simulation to provide learners an immersive and compelling training environment to practice their bilateral communicative skills in a specific cultural context. It is available for download from the U.S. Army's MilGaming website (https://milgaming.army.mil/). In the game, learners assume the role of a U.S. Army officer who needs to conduct a series of bi-lateral meetings with local leaders (virtual humans) to achieve the mission objectives in fictional cities. For example, in Lane et al.'s study (2013), learners are put in Iraqi city and they are supposed to study Arab business cultural expectations and norms by practicing communication skills like win-win negotiation techniques. The intelligent tutoring system in BiLAT provides feedback to learners as they interact with characters. The

feedback types in this game are as follows: elaborated feedback (e.g., explain a reaction from the character by describing an underlying cultural difference or a hint about what action is appropriate at a specific given time), adaptive feedback, contextual conversational feedback, and text feedback.

Disease Education

ASTRA (Appréhender par la Simulation les TRoubles liés à l'Age) is a simulation game in which a female pedagogical agent stands in a living room next to a TV screen. She provides learners with oral information about four aging-associated diseases: Alzheimer's disease, Parkinson's disease, myocardial infarction and stroke. After the agent presents the information, leaners will be given a quiz with four questions assessing their recall. A window opened with the message "Right answer" will appear when learners have answered correctly. The correct answer will be presented when the learners choose the wrong answer along with the window opened with the message "Wrong answer." The feedback types in this game are as follows: point-based feedback (e.g., learns can earn points by answering question correctly), text feedback, and KCR feedback.

Humanities

Men and Animals is a 2D educational computer game that aims to enhance high school students' development of moral sensitivity, which takes about 45 minutes to play. The game narrative presents a small fictional city, where the inhabitants are plagued with a variety of illnesses. The learners act as virtual mayor of the city and are supposed to take decisions on whether and how to use various animals for research, as food, and for enjoyment. The feedback types in this game are as follows:

immediate and delayed feedback (e.g., learners get feedback on their choices by direct comments from the game characters and by the change of "level of happiness"), consequence feedback (e.g., incidents occur as a result of the games' choices), information feedback (e.g. facts about diseases as well as lab animals and other animal use are presented to learners on demand), contextual conversational feedback (e.g., players can seek advice from five members of the City of Ethical Committee), peer feedback.

Language

Place Out of Time (http://poot.icsmich.org/) is an interactive text-based, multi-user virtual world developed several years ago by the University of Michigan - Interactive Communications and Simulations (ICS) group. Its target audience involves middle-high school students. Players assume the identities of various historical and contemporary figures to debate controversial socio-cultural issues in the fictional courtroom. In Killham et al.'s study (2016), they brought *POOT* into English Foreign Language classroom. The feedback mechanism in this game is quite simple, mainly text feedback, contextual conversational feedback (e.g. characters can have small talks to stimulate trial specific dialogue) and peer feedback from other characters during and after the debate.

Math

Among the studies this report reviewed, two articles dealt with math. *Sonic Divider* is designed to rehearse the formal sequence of written division in math. The target age group of the game is six to eight years. There is a scoring mechanism in the game in which players can earn certain scores depending on the difficulty of the task

they achieve. Players can alter the processing time to perform the task to alter the basic pints for a task. Feedback is displayed in the form of a smiley face and a text block with speech output. Another important feature of the game is discussed by Kickmeier-Rust et al. (2014), the "probabilistic character of the feedback mechanism" (p. 40). Feedback on problems or errors is triggered when a certain pre-defined probability threshold is reached rather than triggered immediately after the occurrence of an incorrect action. The assignment of feedback rules can be freely edited by a teacher. The feedback types in this game are as follows: point-based feedback, delayed feedback, text-based feedback, and visual feedback.

Noobs vs. Leets: the Battle of Angles and Lines is devised by researchers at the Games For Learning Institute (G4LI) at New York University (http://www.murphystein.com/games/noobsvsleets/index.htm). It is available online and compatible with Flash Player 6. The game aims to teach 6th grade students angle rules in math with a simple narrative in which players help save their friends by unlocking paths via calculating unknown angles. Each of the game's six chapters introduces a new concept about identifying and calculating angles. The feedback mechanism in the original game is quite simple, mainly text feedback and audio feedback. But Kinzer et al. (2012) modified the original game for experiment by implementing contextual conversational feedback.

Science

Among the articles this report reviewed, 6 studies dealt with science. They were further categorized into general science, ecology, and physics for analysis.

General

Betty's Brain (http://www.teachableagents.org/research/bettysbrain.php) is an

open-ended computer-based learning environment that utilizes the learning-by-teaching paradigm to engage elementary-middle school students in learning about science topics by teaching a virtual agent named Betty. It is developed by researchers from The Teachable Agents Group at Vanderbilt University. Players need to construct a causal map that represents relevant science phenomena as a set of entities connected by directed links which indicate causal relations. Betty will use the causal map to answer questions and explain later in the quiz. The feedback mechanism in the original game is quite simple, mainly text feedback and audio feedback. The feedback types in this game are as follows: contextual conversational feedback and text feedback. Feedback in the game is contextualized by the student's task goal, the current causal map, and the student's recent activities in the system. Moreover, the feedback is delivered via conversations like back-and forth dialogues between the student and the agent as conversation trees.

Ecology

Taiga is a game-based, multi-user virtual environment, which is one unit (a park) in *Quest Atlantis* (http://atlantisremixed.org) that supports school-based participation in socio-scientific inquiry in ecology. Learners are invited to serve as field investigators to help Ranger Bartle figure out why the fish population in the *Taig* river is decreasing. Players gather information by interviewing NPCs (non-player characters) who inhabit or use the park, collect and analyze water samples, evaluate their hypotheses and speculate on alternative causes of the problem. The feedback types in this game are as follows: contextual conversational feedback (e.g., interaction with NPCs), point-based feedback (e.g., two types of in-game currency "cols" and "lumins" which connect various adventures to the broader *Quest Atlantis* narrative), formative feedback, and summative feedback.

Physics

Carrot Land is an instructional game, aimed to teach elementary-middle school students the effects and types of force, to describe the force equilibrium condition, and to understand the impact force generated by objects. Different rabbits are given to the students and students are supposed to locate the appropriate sizes of carrots concerning the weights of rabbits. Then, they need to decide on the best way to pull the carrot out of the group using their knowledge about the concept of force. The feedback types in this game are as follows: KCR feedback (e.g., the feedback to the question prompts with would appear after students choose and submit one answer), point-based feedback and elaborated feedback.

ELEKTRA demonstrator is based on a classical 3D adventure game in a first-person perspective. The narrative in the game is that the players aim to save the girl Lisa and her uncle Leo who have been kidnapped by the evil Black Galileans. During the journey, the learners need to acquire curriculum-related knowledge and skills related to 8th grade optics. The feedback types in this game are as follows: informative feedback (e.g., the ghost of Galileo Galilei who is the hidden teacher can give the learners certain hints or feedback), adaptive feedback (e.g., each of the learners receive different feedback, tailored to their individual knowledge level as well as learning and gaming progress), text feedback, contextual conversational feedback.

Circuit Game is an arcade-type computer game that helps students learn how to solve problems by understanding how electrical circuits work. Audio feedback is provided via a tone after each learners' each response: a "ding" for a correct response and a "buzzer" for an incorrect response. Learners will be awarded with 50 points for each correct response and punished by losing 10 points for each wrong response. The

total points earned are presented at the top of the screen along with the amount of time passed. Evaluative feedback will be presented with the amount of points earned and the total points possible in that level at the end of each level. Mayer et al. (2010) added elaborated feedback to the original in their research by providing an arrow over the correct answer and a textbox contains the explanation of the correct answer. The feedback types in this game are as follows: audio feedback, point-based feedback, evaluative feedback, elaborated feedback, and text feedback.

Energy Education

TRIS-Q is a tic-tac-toe quiz game for energy education appropriate for junior high school students, in which students will learn the sources of energy, application of energy, energy conservation, and new energy. The player competes either in single-player or multi-player mode against the computer or other players, taking turns to place pieces on a nine-square grid. Students are required to answer questions within a set time frame. With a correct answer, they can only place their own pieces while they have to make a move for the other party if answered wrong. The feedback types in this game are quite simple, mainly point-based feedback and KR feedback.

Social Studies

The Little Five-Star Chef is a game that helps elementary students learn the domestic and foreign food culture unit in social studies. In the game, players take on the role of a little boy who wants to receive certification as a chef by mastering the cooking skills and knowledge of the food from 5 different countries. After receiving instruction, students can challenge themselves by taking the formative assessment in the game. Corrective feedback will be provided with students who do not pass the assessment so as to help them take another formative assessment. The feedback types

in this game are as follows: corrective feedback and formative feedback.

Summary

In summary, thirteen games were extracted from the aforementioned empirical studies (see Table 2) for a closer examination. The target users ranged from elementary children to graduate adults. Based on this literature review, it seems that more educational games were devised to teach science related subject areas than liberal arts (9 games were related to science while 4 games were dealt with liberal art subjects). Most of games adopted a complex feedback mechanism (e.g., *Men and Animals* and *Circuit Game*) with different types of feedback involved instead of just using one or two types of feedback. Also, some researchers modified or improved the original games (Kinzer et al., 2012; Mayer et al., 2010) in their studies and showed positive results on the modified features.

By analyzing the frequency of each type of feedback featured in the games, text feedback, point-based feedback, and contextual conversational feedback emerged as the three most frequently used types of feedback. Text-based feedback is the most commonly used type of feedback. Almost every game reviewed in this report uses text-based feedback. Point-based feedback brings a lot of advantages with simple efforts. For example, the scoring system can provide students with evaluative feedback (*Circuit Game*) with a score panel showing the amount of points earned and the total points possible in that level at the end of each level. Contextual conversational feedback also comes with virtue characters (*BiLAT* and *Men and Animals*), agents (*ASTRA*, *Betty's Brain*, and *ELEKTRA*), and NPCs (*Taiga*). In general, although some types of feedback are adopted in only a few games, that does not necessarily mean they are less effective than the others. Different types of

feedback provide different levels and ways of scaffolding according to the findings in these empirical studies as concluded in Table 2.

EXPERIMENTAL DESIGNS IN GAME-BASED LEARNING ENVIRONMENTS

This section focuses on describing different experimental designs in the empirical studies so as to provide some research design insights for future researchers who are interested in studying feedback in game-based learning.

Feedback Embedded vs. Non/Basic Feedback Embedded

Burgos et al.'s research (2007) developed two versions of the game *Conference Planner*, a feedback version and a no feedback version. The feedback version provided visual destination feedback related to the learner's actions and moves so far. The feedback was fostering orientation on what to do next and is guiding the player in a way that showed what choices were available by highlighting all possible time slots in green where a conference-goer could be put as well as greying out the unavailable slots. As a result, the experiment showed only positive effects of having no feedback.

Mayer et al. (2010) used a mixed-method research to investigate learners in the game *Circuit Game*. The study randomly assigned subjects to four groups: (1) no-feedback/no-self-explanation (base version); (2) feedback/no-self-explanation (feedback version); (3) no-feedback/self-explanation (self-explanation); and (4) feedback/self-explanation (both version) groups. The latter three versions were built up from the base versions with some additions. In feedback version, an arrow appeared over the correct answer and a textbox displayed the explanation for the correct answer after each learner's response. In the self-explanation version, the game displayed a textbox with 8 possible answers for the answer. As a result, the

experiment showed that adding elaborated feedback is an effective supplement to learning in the game.

Yang (2017) also assigned three elementary school classes to three groups for comparison in her research based on the game *The Little Five Star Chef*: Group A learned from the game with regular feedback (only showed the answer was correct or incorrect), Group B learned from the same game with corrective feedback (with description or text from course materials), and Group C learned from a conventional classroom that used PowerPoint slides. As a result, the experiment showed that students in group A needed to go back and review the learning materials more times than those in Group B in order to do the activity. It indicated that corrective feedback brought more support to the Group B students' learning compared to Group A students.

Pre- and Post-Experiment

Svingby (2010) conducted a mixed method research on the educational game *Men and Animals*, using a test on knowledge and attitudes to men's use of animals as well as a questionnaire on students' experiences of gameplay before and post after the intervention. The answers to the questionnaire and the test showed that the game offered a variety of built-in feedback mechanisms and was of value for reflection on a complex moral issue.

Lane et al. (2013) administered a pretest-posttest design when they tried to examine the role of feedback delivered by an intelligent tutoring system in *BiLAT*. They used the pre- and post-test approach so that learning could be defined as the increase in the correlation from pretest to posttest to collect quantitative data. The pre-test was a situational judgment test focused on the participants' ability to

recognize and understand concepts about intercultural interaction, which measured learning at the lower levels of Bloom's taxonomy of cognitive skills. The post-test measured the participants' ability to apply the learned intercultural interaction with a new issue in the game, which measured learning at the middle levels. The results suggested that conceptual feedback transfers more readily than concrete feedback does.

Law and Chen (2016) also used a pre- and post-test approach by using the performance test devised by two experienced science teachers and included 20 multiple-choice questions before and after the intervention in the game *Carrot Land*. It assessed students' conceptual understanding of force and motion in the game and also their ability to apply the concepts in real life contexts. They found that students with Elaborated Response feedback performed better than those with Knowledge of Correct Response feedback when knowledge prompts were given.

Summary

In summary, there are different experimental designs employed in the empirical studies reviewed. Most of them adopted a mixed or quantitative method with only one empirical study using a qualitative method. Feedback versus no/basic feedback as well as pre- and post-test emerged as the two most commonly used research designs among these empirical studies. Several studies even combined these two research designs. For example, besides feedback versus no/basic feedback research design, Yang (2017) also used a social studies pretest and posttest as the research tools, which included a learning attitude questionnaire and a cognitive load questionnaire, to assess the students' pre-existing knowledge as well as their understanding and knowledge acquisition of foreign food cultures. In summary, these findings can provide insights

that educators and researchers can use to figure out what is an appropriate research design method in a specific setting.

Chapter 4: Conclusion and Implications

This report reviewed the empirical studies along with several theoretical articles primarily interested in feedback involved in game-based learning environments from 2007 to present.

Regarding the first research question, about what types of feedback were emphasized in prior research, the report first examined the descriptions and findings about different types of feedback in both empirical and theoretical articles selected for this report. A total of 23 types of feedback were outlined based on the content, control, delivery, length, specificity, and complexity of the feedback. Then, a closer look at the built-in feedback mechanism was provided in the report by analyzing different game-based learning environments discussed in the empirical studies via different subject areas: communication, humanities, language, social studies, health education, math, and science. Finally, text feedback, point-based feedback, and contextual conversational feedback emerged as the three most frequently used types of feedback in those games. Most of the games have a complex feedback mechanism with several types of feedback. Moreover, most of studies have confirmed how different feedback models in games stimulated thinking and improved students' learning achievement, but there was also one study that found that having no feedback in games yielded more positive results.

The second research question, concerning how feedback employed in the games, was discussed when analyzing different game-based learning environments in Chapter 3. Designers used a variety of techniques such as immediately providing feedback on the correctness or incorrectness of the answer, allowing the player make an error (trial and error) and move on, adding pop-ups and showing a new score panel for evaluative

feedback.

Based on this report's analysis on in-built feedback in game-based learning, below are recommendations for educational game designers and developers to consider:

(1) Provide as-needed information in feedback. Feedback that gives too many cues will potentially reduce learners' thinking time before they play.

(2) Negative feedback can also be persuasive. It can motivate players to improve poor short-term performances.

(3) Immediate and delayed feedback can be provided by whether reaching or not reaching a certain pre-defined probability threshold, thus making it possible to give learners time to reflect on their action before they get the feedback.

(4) Audio feedback is more effective than text-feedback.

(5) Novices may need a lot of detailed feedback, but the level of detail decreases as the learners' skill increases.

(6) A complex feedback mechanism with different types of feedback involved is preferred than a simple one.

This systematic review of the literature has highlighted the following opportunities for future research:

(1) The field of game-based learning is limited in empirical and theoretical investigations on non-intrusive and adaptive in-game feedback such as scaffolding that supports the processes of knowledge extraction, structuring, and organization while not interrupting the game flow.

(2) Research on the feedback involved in educational games has predominantly focused on reporting the research design and learning effectiveness without a comprehensive description of game design features and processes. Some of

the reviewed articles only mentioned different modified game versions for comparison but did not specify on what exact modifications concerning the feedback mechanism they made to the game. It is recommended that scholars should provide a detailed record on their educational game development experiences, by elaborating on the theoretical underpinnings, overarching design strategies, and key lessons they have learnt during the process.

(3) Although researchers have started to explore the role of feedback in game-based learning environments, their explorations have generally focused on the effectiveness of the specific feedback types embedded in the games. They seldom explained the reason why feedback could or could not improve players' learning in the game. More research that investigates the relationship between feedback and other game attributes like motivation is needed.

This report does not intend to be comprehensive in the discussion of feedback integration in games. The investigation has focused on an analysis of common research patterns and built-in feedback mechanism involved in the studies that emerged from the related literature and the games examined. Other potential game designs relating to game-based pedagogy or external instructional support are beyond the scope of this report but worthy of future investigation.

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