

Features of entertainment digital games for learning and developing complex problem-solving skills: A protocol for a systemic review

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Features of Entertainment Digital Games for Learning and Developing Complex Problem-Solving Skills: A Protocol for a Systemic Review

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Abstract

Entertainment digital games (EDGs) can be used to promote real-world-relevant learning, even if they have not been specifically designed for educational purposes. This is especially true for EDGs that engage players in contexts that mimic real-world problem scenarios and support the development of knowledge and skills that can be transferred to out-of-game contexts. In these cases, *gameplay learning* can be a very effective means of promoting those cognitive capabilities that are central to addressing real-world challenges requiring complex problem-solving (CPS), but at the same time are particularly difficult to foster through formal educational environments and approaches. However, what features of EDGs can simultaneously promote player enjoyment and CPS processes, which specific CPS skills can be fostered, and by which mechanisms, are questions that remain largely unanswered in the current literature. This paper presents a protocol for a systematic review that aims to address this gap by examining relevant analysis and design frameworks for entertainment games. Selected frameworks will be reviewed by combining a game-centric and a player-centric perspective to identify structural elements of gameplay environments and tasks that may affect psychological processes relevant to the promotion of CPS capabilities. To this end, each framework will be subjected to a formal content analysis in which data will be extracted, coded, and analyzed based on the Work System Theory (WST) and the Cognitive Work Analysis (CWS) frameworks. The main outcome of the proposed systematic review will be a knowledge base that can help researchers, developers and practitioners to select the most appropriate methodological frameworks for the analysis and design of entertainment games capable of promoting CPS skills through *gameplay learning*. In addition, this protocol can also inform and guide further reviews of methods for analyzing and designing educational games.

Keywords

entertainment game analysis, entertainment game design, methodological frameworks, gameplay features, gameplay learning, cognitive complex problem-solving capabilities

Introduction

Digital games can be powerful learning environments, capable of promoting learning processes and outcomes that are difficult to achieve in ordinary educational contexts (Boyle et al., 2016; Fabricatore & Lopez, 2019; Gee, 2003; Prensky, 2003; Whitton, 2014; Wouters et al., 2013). For this reason, research on game-based learning has investigated for over three decades how to develop and use games specifically designed to promote desirable learning (Abt, 1987; Avila-Pesantez et al., 2017; De Freitas, 2018; Fabricatore et al., 2020; Rieber, 1996;

Squire, 2005). In parallel with this attention to educational games, there is also growing interest in entertainment games (i.e., commercial digital entertainment products designed for

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recreational purposes) and how they can be used to promote meaningful learning (Clark et al., 2016; Jayakanthan, 2002; Martinez et al., 2022; McClarty et al., 2012; Paraskeva et al., 2010).

Game research has amply recognized that good entertainment games have the ability to engage players in highly motivating experiences that elicit significant *gameplay learning*, i.e., the integrative development of knowledge, attitudes, and cognitive, social, and practical skills required to pursue game goals (Boyle et al., 2016; Connolly et al., 2012; Fabricatore, 2018; Gee, 2003; Vlachopoulos & Makri, 2017). Furthermore, depending on game requirements and contextualization (e.g., objectives, settings, and narratives that drive and underpin gameplay activities), what players learn through gameplay may be relevant outside of the game and transferable to real-world scenarios and activities (Boyle et al., 2016; Clark et al., 2016; Fabricatore & Lopez, 2019; Granic et al., 2014; Hobbs et al., 2006; McClarty et al., 2012). Finally, players learn through entertainment games because they choose to do so. *Gameplay learning* is fully intrinsically motivated, i.e., it is motivated solely by the goals, contextualizations, and mechanics that games provide (Egenfeldt-Nielsen, 2006; Fabricatore, 2000; Gee, 2003; Mitchell & Savill-Smith, 2004; Prensky, 2002) and, thus, it represents an optimal learning experience (Habgood et al., 2005; Guay et al., 2008; Malone & Lepper, 1987; Shernoff & Csikszentmihalyi, 2009). The combination of these factors (i.e., transferability to out-of-game contexts, intrinsic motivation, and integrative development of knowledge, attitudes, and skills) make *gameplay learning* a particularly relevant form of learning to investigate, emphasizing the importance of understanding which features can make entertainment games enjoyable and at the same time suitable for promoting learning processes and outcomes relevant to contexts outside the game (Boyle et al., 2016; Clark et al., 2016; Connolly et al., 2012; Granic et al., 2014; Martinez et al., 2022; Prensky, 2002).

The heterogeneity of meaningful learning processes involved in entertainment games can lead to different learning outcomes of varying relevance (Biggs & Collis, 2014; Fabricatore & Lopez, 2019; Ivanitskaya et al., 2002; Tynjälä, 1997). One such outcome that is critical for addressing real-world challenges is the development of cognitive capabilities appropriate to engage in complex problem-solving (CPS) (e.g., situational assessment and decision-making under uncertain conditions) (Dörner & Funke, 2017; Fabricatore et al., 2020; Fischer et al., 2011; Funke et al., 2018). Complex problem-solving is a self-regulated process aimed at defining and executing courses of actions suitable to achieve and maintain desirable environmental states in dynamically changing environments (Dörner & Funke, 2017). Complex problem-solving therefore requires the ability to continuously monitor problem scenarios, and iteratively define and adapt action plans in order to timely respond, based on incomplete and uncertain information, to relevant environmental changes

(Dörner & Funke, 2017; Dörner & Wearing, 1995; Fischer et al., 2011; Funke et al., 2018).

Despite the increasing need to acquire and apply CPS skills, formal learning environments find difficulty in promoting them effectively (Dörner & Funke, 2017; Fabricatore & Lopez, 2019; Fabricatore et al., 2020; Jonassen & Rohrer-Murphy, 1999). Entertainment games, however, can address these issues because they have the potential to engage players in enjoyable tasks set in complex scenarios that elicit CPS skills and foster their development (Eseryel et al., 2014; Fabricatore et al., 2020; Gyaurov et al., 2021; Whitton, 2014). It is therefore important to understand these opportunities and analyze how gameplay features designed to promote player engagement and enjoyment can also support CPS capabilities. Game research provides a variety of methodological frameworks for developing engaging entertainment games and facilitates the analysis of gameplay features that can promote or hinder player enjoyment (e.g., Avedon, 1981; De Byl, 2015; Hunicke et al., 2004; Kiili et al., 2014; Raybourn, 1997; Sweetser & Wyeth, 2005). To our knowledge, however, only a few of these frameworks have considered the impact of such gameplay features on learning (e.g., Deterding, 2015; Fabricatore, 2018; Fabricatore et al., 2019), and none of them have specifically addressed CPS.

In light of these observations, this paper presents a protocol for a systematic review of existing methodological frameworks for the analysis and design of entertainment games. This review will contribute to the state of the art by investigating: (a) which gameplay features can simultaneously promote player enjoyment and CPS capabilities, and (b) which CPS capabilities can be promoted by these gameplay features and by which mechanisms.

The systematic review will adopt an integrative approach to analyze the gameplay features proposed by the selected methodological frameworks, since these tend to be either game-centric or player-centric (Fabricatore, 2018; Fabricatore et al., 2019). Game-centric frameworks emphasize structural elements of a gameplay environment that affect player engagement by defining gameplay objectives, tasks, challenges, and means provided to the player, and the mechanics by which these elements interact with each other (Fabricatore, 2018; Fabricatore et al., 2019; Larsen & Schoenau-Fog, 2016; Sicart, 2008). Player-centric frameworks focus on the psychological processes that drive player engagement, and the aspects of player activities that make them comprehensible, meaningful, motivating, and therefore engaging (Bernhaupt, 2010; Fabricatore, 2018; Fabricatore et al., 2019; Ryan et al., 2006). In any problem scenario, the structural elements that define a problem environment and the psychological processes involved in a problem-solving activity interact, and are equally important to define demands, dynamics, and outcomes of a problem-solving process (D'zurilla & Goldfried, 1971; Newell & Simon, 1972). Because of this, both game-centric and player-centric features should be considered when

investigating what may elicit or foster CPS in a gameplay activity.

Therefore, the integrative approach of the proposed review will analyze: (a) structural elements of gameplay processes and environments involved in gameplay tasks (e.g., goals, workflows, artifacts, and actors), (b) their interplay (e.g., interaction mechanics), and (c) the effects these may have on players' cognitive processes and capabilities that are relevant to CPS (e.g., motivation to learn, elicitation and support of decision-making processes, stimulation of abductive reasoning, etc.). Specifically, the review will conceptualize gameplay as a goal-directed activity (Fabricatore, 2018), and consequently identify, describe, and analyze gameplay features by relying on two frameworks, namely the Work System Theory (WST) (Alter, 2013) and the Cognitive Work Analysis (CWS) (Roth and Bisantz, 2013). The rationale for this choice is the following.

Work System Theory models goal-directed activities as sociotechnical task processes that: (a) are performed by actors (human and non-human) who use tools, knowledge, and collaboration to achieve their intended goals, and (b) are defined by key environmental conditions under which the tasks are performed (Alter, 2013). Work System Theory provides formal approaches to analyzing the key elements of the domain in which the work is performed and their potential function in facilitating or hampering practical task performance (Alter, 2013). Work System Theory will be therefore used to analyze each methodological framework selected for full review and to identify and classify the structural elements of a gameplay environment that the framework considers and that may affect gameplay tasks.

The CWS framework provides formal methods for identifying cognitive processes and capabilities involved in work activities and analyzing how they might be stimulated, facilitated, or hampered by a variety of interacting elements in a work environment (Roth and Bisantz, 2013). The identification of relevant cognitive processes and capabilities involved in gameplay, and how the gameplay elements affect them, will be carried out by analyzing each of the selected methodological frameworks using CWS methods. The analysis will be based on selected taxonomies relevant to classifying and describing the cognitive processes and capabilities involved in CPS, such as the Cattell-Horn-Carroll theory of cognitive abilities (Schneider and McGrew, 2018), the constructivist framework for problem-based learning (Savery and Duffy, 1995), and the computer-simulated theory of CPS (Dörner and Wearing, 1995).

The proposed review will be guided by the following research questions:

- Which gameplay features can simultaneously promote player enjoyment and CPS capabilities?
- Which specific CPS capabilities can be promoted by gameplay features?

- By which mechanisms can these CPS capabilities be promoted by gameplay features?

In addition, the following research question will help examine the methodological soundness of the analyzed frameworks:

- What are the theoretical or conceptual underpinnings of different frameworks?

The relevance of this systematic review protocol is emphasized by (a) the recognized contribution of protocols to reducing bias in research (Kitchenham and Charters, 2007; Moher et al., 2015), (b) the specific need for protocols to guide games research (Caldero'n & Ruiz, 2015; Saucedo- Araujo et al., 2020), and (c) the potential of this protocol to inform future reviews of methods for analyzing and designing educational games. In addition, we highlight the novelty of the proposed systematic review. To our knowledge, this is the first work of its kind to approach the field of game studies with the intention of examining how available methodological frameworks cover gameplay features that may promote both player enjoyment and cognitive CPS capabilities through *gameplay learning* (Neil, 2012; Neves & Zagalo, 2021). The proposed systematic review will therefore complement and expand the existing knowledge body provided by previous reviews of game analysis and design frameworks, which have been focused on either general gameplay features (Almeida & Silva, 2013; Caroux et al., 2015), isolated factors of the player experience (Avila-Pesantez et al., 2017; Boyle et al., 2016), or game-based learning in specific domains such as history courses (Ghulamani et al., 2020) and science education (Tsai & Tsai, 2020). It is therefore expected that the proposed systematic review will be useful to facilitate the comparison and selection of appropriate methodological frameworks for analyzing and designing entertainment games that may foster the development of cognitive CPS capabilities through *gameplay learning*, which is of great importance in research and practice (Caroux et al., 2015; Fabricatore et al., 2019; Natucci & Borges, 2021; Neil, 2012; Neves & Zagalo, 2021; Tahir & Wang, 2018).

Methods

The protocol for this systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocol (PRISMA-P) statement (Moher et al., 2015). The PRISMA-P checklist for the protocol is available in the Supplemental material section (S1 File).

Eligibility Criteria

Eligibility criteria are based on the research questions proposed for this systematic review in the Introduction section. Studies will be included in the review if they:

1. Present a methodological framework for the analysis and design of entertainment games;
2. Have been written in English;
3. Have been published in peer-reviewed journals, book chapters, or conference papers (thus, excluding editorials, abstracts, posters and panel discussions);
4. Have been published between January 1, 2000 and December 31, 2021;
5. Have demonstrable impact, e.g., are papers that either (a) advance empirical studies (e.g., a methodology or instrument applied – in its original form or with modifications – to conduct a case study), or (b) inform the formulation of other methodological papers (e.g., an extension of a theory or an adaptation of an instrument).

Information Sources

Eligible studies will be identified through a comprehensive search of the following four databases: ACM Digital Library, IEEE Xplore, Scopus, and Web of Science. In addition, the reference lists of the identified articles will be hand-searched for other relevant studies (Horsley et al., 2011; Moher et al., 2015).

Search Strategy

The strategy for identifying studies eligible for inclusion in the review will follow the iterative approach proposed in (Lockwood et al., 2017). This process will start from an already completed initial search, which consisted of (a) formulating a pool of key search terms, (b) generating generic query strings based on the identified key search terms, and (c) translating the generic query strings into the syntax required for each database. The initial set of key search terms in step (a) was obtained by analyzing titles, abstracts and keywords of articles in Scopus that describe methodological frameworks for analyzing and designing entertainment games (e.g., ; Carvalho et al., 2015; De Byl, 2015; Hunnicke et al., 2004; Sweetser & Wyeth, 2005). These terms were then conceptually organized based on key terms from the research questions (e.g., gameplay, features, framework, analysis, design, etc.) and expanded to include synonyms, variants, and related terms (e.g., videogames and playability, models and approaches, elements and mechanics, development and evaluation, etc.). Subsequently, generic query strings were formulated based on the expanded search terms (step (b)), considering the inclusion criteria as additional filters. The initial list of identified search terms (S2 File) and the preliminary search strategy for all four databases (S3 File) are included in the Supplemental material section. As mentioned earlier, these initial search terms and query strings will be revised iteratively as new data emerge during the development of the systematic review and analysis of selected articles.

Study Selection

The selection of items for review will be done by two reviewers, following the steps suggested in the PRISMA checklist (Page et al., 2021). First, duplicates will be removed and the results will be consolidated in a Mendeley database. Then, the remaining studies will be independently screened by two reviewers based on their title, abstract, and keywords, and marked for inclusion or exclusion based on the eligibility criteria 1–4. A coefficient of inter-reviewer agreement (e.g., Cohen's Kappa (Cohen, 1960)) will be calculated to confirm that a sufficient level of inter-reviewer agreement has been achieved (Park & Kim, 2015). Remaining disagreements will be resolved through discussion. If consensus is not reached, the disputed articles will be examined by a third reviewer to complete the evaluation (Barbour, 2001; Berends & Johnston, 2005). Subsequently, the list of references of the selected studies will be analyzed to identify additional relevant articles according to the aforementioned screening process (Horsley et al., 2011; Moher et al., 2015).

Finally, each candidate paper will be read completely by both reviewers, who will also collaboratively assess its impact, applying eligibility criterion 5 (demonstrable impact), by determining whether it has been cited by further research, and what type of research referenced it. The details of the study selection process will be documented using a PRISMA flowchart (Page et al., 2021).

Data Extraction and Synthesis

The studies selected for full review will be examined through an inductive qualitative content analysis approach (Hsieh & Shannon, 2005), using a template analysis technique (King, 1998, 2012). Template analysis is a form of thematic analysis of textual data that focuses on the iterative and flexible development of a coding template that can contain both descriptive and interpretive thematic categories (King, 1998, 2012).

Following the template analysis method and based on the WST, CWS, and CPS-relevant taxonomies of cognitive processes and capabilities, the reviewers will formulate an initial analysis schema to code text in order to identify, in each of the reviewed studies: (a) specific gameplay features that are highlighted as relevant to promoting game enjoyment; (b) how these gameplay features should be configured to promote player engagement; (c) what types of CPS-relevant cognitive capabilities may be elicited or supported by the gameplay features; and (d) the mechanisms by which these capabilities may be elicited or supported. Consistent with the template analysis approach (King, 1998), the analysis schema will be iteratively updated by adding and revising categories based on data emerging from the review. On the one hand, gameplay features that promote player enjoyment and their recommended configurations will be coded as descriptive categories in the analysis schema.

On the other hand, the types of CPS capabilities that may be promoted by the identified gameplay features and their associated elicitation or support mechanisms will be derived through a theory-based inductive analysis (Thomas, 2006) based on the relevant literature on Human Factors Engineering, CPS, and human-computer interaction and coded as interpretive categories.

To improve data coding reliability (Cornish et al., 2013; Patton, 2014; Perreault Jr. & Leigh, 1989; Richards & Hemphill, 2018; Shenton, 2004), two reviewers will collaborate using the analysis schema to extract, code, and derive data from each eligible study. Initial codes and analysis schema have already been developed and are available in the Supplemental material section (S4 File).

Discussion

Entertainment games have the potential to engage players in intrinsically motivating *gameplay learning* processes (Boyle et al., 2016; Connolly et al., 2012; Fabricatore, 2018; Gee, 2003; Vlachopoulos & Makri, 2017), which can promote the development of cognitive CPS capabilities that are particularly relevant for addressing real-world challenges (Eseryel et al., 2014; Fabricatore et al., 2020; Gyaurov et al., 2021; Whitton, 2014). A necessary step to fully exploit this potential is to review existing methodological frameworks for the analysis and design of entertainment games, as even features intended to promote player enjoyment can be very helpful in fostering *gameplay learning* and, in particular, CPS capabilities. Therefore, the systematic review based on this protocol aims to examine methodological frameworks for the analysis and design of entertainment games to explore which gameplay features can simultaneously promote player enjoyment and *gameplay learning*, and what mechanisms allow such features to specifically promote CPS.

As previous research has shown, review protocols can inform and guide the development of sound research methods both generally (Kitchenham & Charters, 2007; Moher et al., 2015) and specifically in the field of game studies (Caldero'n & Ruiz, 2015; Saucedo-Araujo et al., 2020). In addition, systematic reviews (e.g., Bisantz & Roth, 2007; Sun et al., 2019; Unertl et al., 2010; Wei & Salvendy, 2004) represent an appropriate approach to analyze methodologies for analyzing and designing human activities and human-system interactions and, consequently, identifying which aspects of a system can promote desirable effects on the actors involved and how. To our knowledge, in the domain of games and game-based learning studies, this use of systematic reviews has never been leveraged to investigate potential impacts of entertainment game features on *gameplay learning*, and in particular, on CPS skills. Hence, a strength of the proposed systematic review is that it will be the first of its kind to contribute knowledge relevant to analyze and design gameplay features that promote both *gameplay learning* and player enjoyment (Neil, 2012; Neves & Zagalo, 2021). In addition, the study selection

criteria and the methodological approaches planned to analyze existing game analysis and design methodological frameworks will promote the relevance and reliability of the results of the proposed review. By including only studies that have some demonstrable impact, the review will guarantee that the identified gameplay features are effectively applicable in practical game analysis and design contexts, or to inform novel theoretical work. By combining WST and CWA for the analysis of the selected frameworks, the review will ensure that gameplay features are analyzed based on formal methods, accounting for both structural elements of a game system, and their effects on key psychological processes that may contribute to the development of CPS skills.

The scope of the proposed review will be deliberately limited to game analysis and design frameworks specifically focused on entertainment products. This is because of the educational potentialities that these entertainment games offer, and the lack of knowledge relevant to harness such potentialities. Despite this limitation, the proposed review will serve as an important basis for further research, by applying the same review methodology to examine analysis and design frameworks focused on educational games, and comparing and contrasting them with frameworks conceived for entertainment games. Another important limitation of the proposed review concerns the interpretive nature of qualitative content analyses, which inevitably introduces an element of subjectivity in the review processes. However, in order to mitigate reliability risks, a rigorous data extraction and synthesis process has been planned, as described in the Methods section of this protocol. Further limitations will be addressed in the full systematic review.

In conclusion, the authors expect that the results of the proposed review will facilitate the identification and understanding of characteristics of entertainment games suitable to both engage players and promote CPS. Thus, the review will support game analysts and designers interested in creating new entertainment games or leveraging existing ones to foster CPS *gameplay learning*. Furthermore, the review will provide a knowledge base helpful to compare and contrast different methodological frameworks for entertainment game analysis and design, and consequently select and combine the most appropriate ones for specific research and practice needs.

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Supplemental Material

Supplemental material for this article is available online.

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