# Academic Games - Mapping the Use of Video Games in Research Contexts


Marcello A. Gómez-Maureira
m.a.gomez.maureira@liacs.leidenuniv.nl
Leiden University
Leiden Institute of Advanced Computer Science
Leiden, The Netherlands

Max van Duijn
m.j.van.duijn@liacs.leidenuniv.nl
Leiden University
Leiden Institute of Advanced Computer Science
Leiden, The Netherlands

Carolien Rieffe*†
c.j.rieffe@utwente.nl
University of Twente
EEMCS Faculty
Enschede, The Netherlands

Aske Plaat
a.plaat@liacs.leidenuniv.nl
Leiden University
Leiden Institute of Advanced Computer Science
Leiden, The Netherlands



## ABSTRACT

Video games have been used as tools for non-entertainment purposes, including research contexts. This paper defines 'academic games' as games that are used and developed within academic institutions for the generation, evaluation, or dissemination of knowledge. Broad intentions related to this unique use of games are rarely explicitly discussed. When they are mentioned, they tend to be specific to an individual game's implementation, or the field of study in which it is situated. This article maps the different fundamental purposes that motivate the use of games in research contexts: involvement as stimulus, intervention, incentive, or as modeling platform. A compact review of existing literature is provided, complemented by a discussion of different facets shaping the use of games in research contexts: the flow of information, the dependency between academic effort and game artifact, and the specificity that is required. This discussion is informed by the analysis of various example games from previous work. A research agenda for the future professionalization of academic game development and its discourse concludes the article.



## CCS CONCEPTS

• **General and reference** → **Reference works**; • **Applied computing** → **Computer games**; • **Software and its engineering** → *Interactive games.*

## KEYWORDS

academic games, serious games, applied games, research games, games for non-entertainment purposes, game development


*Also with Developmental Psychology, Leiden University.
†Also with Department of Psychology and Human Development, University College London.




*FDG '22, September 5–8, 2022, Athens, Greece*



ACM ISBN 978-1-4503-9795-7/22/09.
https://doi.org/10.1145/3555858.3555926

**ACM Reference Format:**
Marcello A. Gómez-Maureira, Max van Duijn, Carolien Rieffe, and Aske Plaat. 2022. Academic Games - Mapping the Use of Video Games in Research Contexts. In *FDG '22: Proceedings of the 17th International Conference on the Foundations of Digital Games (FDG '22), September 5–8, 2022, Athens, Greece.* ACM, New York, NY, USA, 10 pages. https://doi.org/10.1145/3555858.3555926


## 1 INTRODUCTION

The popularization of digital games has gone hand-in-hand with that of consumer electronics, personal computing and mobile devices. With the vast majority of digital games being made with visual displays in mind, digital games and video games are colloquially used in a synonymous manner, with digital games acting as an umbrella term that also includes games such as physical automated chess boards [55], hybrid board games [44] or audio-based exercise games such as *Zombies, Run!* [53]. Over time, the tools to make such diverse products have become more and more accessible. This has allowed small development teams and studios to exist, creating games that do not require a large budget [21]. Similarly, it has enabled the creation of games as tools for purposes other than entertainment.

The term 'applied games' describes games in which the qualities that can make a game entertaining are used in a context that is not primarily intended to be entertaining. While many types of such games exist, in this paper we focus on **video games in research settings**. It has been observed that many participant-based experiments already resemble the formal structure of a game, involving tasks, goals, and measures for success; making games naturally suited as experiment tools [63]. In some cases, this has led to the direct involvement of games in research projects. An early example of this is the game *Space Fortress*, which was used to attract participants and collect data that would be difficult to obtain without the use of a game [28].

In this article, we define **'academic games'** as a sub-field of applied games and, more specifically, as **games that are used and developed within academic institutions for the generation, evaluation, or dissemination of knowledge**. Note that, with this definition, our focus is not on *educational games*, i.e., games that aim to teach or train the player in particular knowledge or skills. While it is possible for academic games to have educational aspects

or intentions, it is not a requirement. We also exclude research that is *about the game itself*, e.g., efforts that analyze existing games in regard to their cultural impact or matters of improving their *own* experience for players.

Although the literature on applied game [48] development is extensive, studies of games used for research purposes are sparse. This may be due to the fact that these games were instrumental in researching something else, which made taking them as an object of study less obvious. Therefore, in this article we focus on such games and the academic context in which they are developed.

**Firstly, our aim is to determine the fundamental purposes for using academic games.** We argue that insight into these purposes is key towards better informed guidelines and best practices for the development of academic games, and in enabling a more targeted discourse for evaluating their efficacy.

**Secondly, we describe facets of game involvement.** While the purpose describes *why* a game is involved, facets describe *how* that game interfaces with the academic context. The formulation of purposes and facets are based both on the study of existing work, and on prior development and research experience of the authors across different academic fields. We discuss case studies both as illustrations and as an argumentative foundation for defining commonalities and differences in why and how these games have been used.

In the next section, we define what constitutes an academic context on the basis of prior work (section 2). Section 3 outlines purposes for involving video games in this context: **stimulus**, **intervention**, **incentive**, and **modeling**. These purposes are further defined through facets of involvement presented in section 4: **information flow**, **artefact dependency**, and **specificity requirements**. In presenting an initial inventory of both purposes for academic games and facets of their involvement, the article culminates in **the foundation for a research agenda, aimed at improving the use and development of games for academic purposes**, as outlined in the concluding section.

## 2 DEFINING ACADEMIC GAMES

Defining what is or is not a game is notoriously difficult [1], and this difficulty extends to the area of academic games. Our view is that the separation between what is or is not a game depends to a large extent on whether a task or activity is *framed* as being a game. This framing exists separate from academically formal definitions of what constitutes a game, and rather concerns what the involved stakeholders perceive to be a game, or expect from that framing. An activity might, for all intents and purposes, include many of the elements that suggest that a game is being played. For example, in experimental psychology, participants are often asked to carry out tasks within an intentionally bounded system (the lab setting) that is designed to cognitively and/or affectively engage them through interaction. Following various formal definitions (e.g., [3, 46, 47]), such tasks could well be seen as games; however, they are rarely framed as such in experimental psychology. In other fields such framing can be more common.

In this section, we set out to establish a working definition of 'academic games', in part based on existing definitions of 'games' and 'applied games'.

### 2.1 Framing of Games

The act of playing a game has been described as entering a 'magic circle', a conceptual space and time that is shaped by a consensus of its participants to establish rules and rituals that apply within it. Within game studies, the metaphor of the magic circle, coined by Johan Huizinga [19], is frequently used to discuss how a game context differs from the surrounding context; in essence, the 'real world' in which a game is played. It is in part the framing of the context that shapes its perception. This explains why similar activities can be experienced as enjoyable or not, simply by changing the framing of the activity [27].

Games are commonly considered as 'fun' activities; providing entertainment through the engagement of involved participants: the players. As a medium, games may provide that entertainment through different means, such as providing pleasure through appealing aesthetics, surmountable challenges, or agency in how narrative events unfold, to name a few. Formal definitions of games tend to focus on describing the conceptual artifact in its physical or virtual manifestation rather than the emotional impact that it creates in a player. Avedon and Sutton-Smith's book *The Study of Games* [3] defines games as an "... exercise of voluntary control systems, in which there is a contest between powers, confined by rules in order to produce a disequilibrial outcome." In Jesse Schell's book for aspiring game designers *The Art of Game Design* [47], this definition is unpacked and compared to definitions from other scholars, ending with a definition by Schell that hints at the emotional aspect (i.e. 'fun') that is often associated with games: "A game is a problem-solving activity, approached with a playful attitude". Both definitions describe **games as ontological entities; as conceptual systems that are framed as constituting a 'game' in the mind of potential participants.**

What is less explicitly mentioned, but implicit in the notion of rules and activities, is the involvement of one or more game designers. As a profession, game designers define the actions that players can take, the actions that are carried out by elements in the game, and the aesthetic through which these actions are communicated to players. Designers may further frame these actions through narrative structures to contextualize actions in the game and to engage the player emotionally.

**While commercial game development involves the work of dedicated game designers, the task of game design takes place whenever activities are carried out to develop a game.** Academics who involve games in their research may find themselves in the role of game designer, possibly without realizing it.

Although playful activities can and do emerge without intentional planning, games are authored with a purpose and involve strategies that support the realization of that purpose. For the vast majority of games, that purpose is to entertain players for the duration of their involvement with the game. The entertainment value is what drives the perception of games being 'fun', despite involving a wide range of affective states that can, at least in the moment, be considered to be negative. Games frequently present players with challenging tasks requiring physical dexterity, or involve narrative elements that convey sadness or fear. Providing entertainment in this context is thus not necessarily a moment-to-moment goal, but

rather the subsequent appraisal that a player makes about their time with a game.

For the purpose of this work, we understand games to be **intentionally bounded systems, designed to facilitate cognitively or affectively engaging scenarios through interaction.** This understanding builds on the aforementioned definitions, with a more explicit focus on authorial intent; a crucial element for classifying the use of games for academic purposes, as we will discuss.

**Inherent in this way of understanding games is the existence of purposeful authorship during the creation of scenarios, and the realization of purpose through interaction in a manner that invokes attention of a player, or players.**

## 2.2 Games for Non-Entertainment Purposes

Outside the entertainment industry, 'serious' games are frequently created with a non-entertainment purpose, e.g., to impart information or collect data through the use of game elements. Such games may well still be experienced as entertaining; in fact, the potential entertainment value remains an important quality for the efficacy of serious games as it directly relates to how motivating or engaging the game is expected to be. However, entertainment plays a supporting role for the primary purpose; often in the form of providing training or experiential simulations of hypothetical scenarios. With the notion of 'seriousness' not necessarily matching the aesthetics or apparent design of a game that has been created for non-entertainment purposes, other labels such as 'applied games' or 'gameful design' have been proposed and are frequently used in the related literature [10].

In this work, we use applied games (a term that we consider more apt in describing how games are involved) as synonymous with serious games. Whether the intention for involving games is 'serious', for the most part it refers to **applying games in settings that are otherwise not considered involving games.**

Applied games can be considered an umbrella term for several sub-fields that involve the use of games. Game-based learning and 'educational games' [58], for example, deal with the use of games to support formal education and lifelong learning efforts. 'Games for health' [64] are intended to promote activities and provide information to positively influence health care. 'Exergames' [52] are meant to improve the physical performance and related lifestyle behaviors of players. 'Advergames' [57] are created to promote awareness or evaluation of products and companies. We explicitly exclude 'gamification' as a field under the applied games umbrella, following Deterding et al.'s [10] definition as "the use of game design **elements** in **non-game contexts**" (emphasis added). Applied games are defined by their purpose while maintaining a game context. By this definition, a context can involve gamification or be an applied game, but not both at the same time. On a practical level, what separates gamification from applied gaming is the amount and necessity of game design elements, as well as the framing of these elements in the context in which they are used.

## 2.3 Demarcating the Academic Context

With the popularization of digital games as a medium for entertainment and beyond, academic endeavors have also increased the use of them for their purposes. In disciplines such as psychology or computer science, digital games are increasingly involved as research artifacts [7, 26, 42]; used to enable or support research goals that are not intrinsically connected to digital games as a medium. In these contexts, games fulfill the role of a research tool that, while potentially being very effective, could be substituted with different approaches (e.g., a physical experiment). This stands in contrast to digital games as the object of study, as is often the case in 'game studies', a specialization within humanities and cultural studies [29], where games could not be substituted with other types of objects. The same holds for research in which games are both a research artifact and object of study, which can be the case in 'game user research', which seeks to generate knowledge from games as research artifacts for the benefit of games as a medium [50].

**In this article we focus on the utilitarian aspects of involving digital games in research efforts that are not about the game itself.** This includes research that can contribute to understanding player behavior, game experience, or technical advancements in general. However, it excludes efforts that analyze existing games in regard to their cultural impact or matters of improving their *own* experience for players. The intention behind this omission is to understand the contribution that games can make to *other* academic efforts.

Earlier work by Ivory [22] has proposed a typology of video game research approaches for studying the role of video games in social science contexts. They differentiate between 'video games as stimulus' (effects on psychological states and behaviors), 'video games as avocation' (motivations, and personal consequences of playing games), 'video games as skill' (game impact on perception, cognition, and motor skills), and 'video games as social environment' (player interactions and relationships within games). While some of Ivory's proposed types can fit a focus on the utilitarian aspect of games for academic purposes, they are formulated with an emphasis for understanding video games as a medium. In this article we argue that 'academic games' are not confined to academic fields that study the medium, but rather, make use of it as a beneficial tool.

Video games that are created within an academic context are thus necessarily considered as fulfilling non-entertainment purposes. Even when employing games that have been originally developed to entertain, their use in an academic context renders them essentially 'applied', regardless of the entertainment value that might be experienced when they are played. As such, the use of digital games in academic contexts should be understood as a more closely defined use-case within the area of games for non-entertainment purposes, or 'applied games'.

We define 'academic context' here as being established if involved **stakeholders conduct their work as part of education and research institutions aimed at the development of knowledge.** This context does not require that game involvement itself needs to be part of developing knowledge. Games might be created or used with the intention to disseminate knowledge that has been developed within those institutions. This is because the academic context does not only consist of activities that are epistemic in nature. It also consists of the discourse surrounding such activities, as well as logistical, political, and financial efforts to improve the conditions of academic institutions. Games are widely seen as a medium that provides enjoyment and entertaining experiences. This can

make the involvement of games enticing as a form of shaping public perception about a field of research or connected institutions (for example, the use of *Minecraft* [32] in showing archeological sites [36]). Simply put, if games are fun, perhaps they can make any connected activity seem fun as well. Such cases share considerable similarities with advergames, only with the use-case being part of academic institutions instead of for-profit corporations.

Game involvement as part of supporting institutional efforts, such as shaping public discourse, necessarily depends on the existence of an institution to support. Equivalent cases could be considered as the corporate use of games (such as business-to-business games [30]), but fall outside of the academic context. However, efforts that are conducted by corporations can and do enter the academic context when intellectual output is created for academic purposes (such as through peer-reviewed publications).

## 3 PURPOSES FOR INVOLVING GAMES

Research involving games often takes place within interdisciplinary teams, and thus tends to involve varying intentions and perspectives of individual stakeholders. Such differences, if left unaddressed, can impact the project in unexpected ways. The value in clearly determining the purpose of game involvement is to align perspectives, and better shape the subsequent game development efforts and goals as a result.

In this section, we propose four 'fundamental' purposes for involving video games in academic contexts: **stimulus**, **intervention**, **incentive**, and **modeling**. These purposes are informed by case studies in contemporary literature. The qualification of a purpose being 'fundamental' is meant to hint at the fact that purposes are not entirely mutually exclusive. Multiple purposes can and do co-exist. However, while research efforts might include multiple fundamental purposes, this can present challenges in ensuring that the game lives up to all of them.

Each purpose is first described in terms of what defines it, and how it differs from other fundamental purposes. This is followed by prior work that exemplifies the purpose. Examples might explicitly mention the purpose or are ascribed to one of the purposes based on the properties of the work.

### 3.1 Stimulus

The act of playing a game typically requires attention and navigational skills, or invokes emotions such as happiness, anger, or curiosity. It causes a reaction in the player based on the scenario that is established by the game. **Whenever a game is used to cause a measurable reaction or change in the player, and the research context is interested in monitoring and measuring that change, the purpose of that game is to use it as a stimulus**. In such a case, the game is ideally selected or specifically created to maximize the likelihood of eliciting the intended reaction.

When a game acts as a stimulus, players generate data through their actions in the game or by having played the game before measures are taken. A defining aspect of games as stimuli is that **data is dependent on the specific game context, and is created due to a change that takes place within the player.** A change in the game can therefore result in a change in the measure; not only based on the quality of the game implementation, but in the way in which it is designed.

One example for a stimulus game is *Squirrel Away* [38], a single-player tablet game for studying human foraging behavior. In the game, players take control of a squirrel gathering food in a virtual park from a first-person perspective. Players are tasked with collecting 'target' objects among 'distractor' objects, both of which are scattered across the virtual environment. The game allows researchers to replace the images used for target and distractor objects, as well as modify the ratio and overall amount in the game.

Another example that illustrates the use of a game as experiment stimulus is *Affective Pacman* [40], a modified version of the classic arcade game that is designed to study the impact of frustration on brain activity (EEG measures). For the study, the researchers have created a version of *Pacman* in which part of their input is randomly ignored by the game and visual output is randomly withheld for a few frames. The modification is designed to appear as technical issue of the game instead of an intentional stimulus. Although these issues are triggered randomly, they are controlled, can be tracked, and thus allow for analyzing the impact on brain activity. The game could also be used in studies investigating affective responses, and illustrates the use of video games as emotion elicitors [65].

Using games as stimuli is common in psychology and related fields [15, 37] given that the focus is on changes in the player caused by a game artifact. Compared to non-game stimuli, games are lauded for their potential to increase motivation and performance for completing research tasks [11]. Games are also considered as having the potential to act as ecologically valid experimental environments [23], in part because the framing of a task as a game makes it more likely for participants to ignore aspects that are not part of the game space.

Studies about cognitive or emotional states, for example, typically require participants to enter such states in a lab environment that may not be conductive to elicit them naturally. Invoking familiar properties of games that mark the transition into a 'magic circle', i.e. into a make-believe space, helps participants to enter the states that are of interest for the study. In doing so, games act as a stimulus for a change in psycho-physiological state.

### 3.2 Intervention

While stimulus games are concerned with inducing a short-term response in the player, specifically to be measured for research purposes, **interventions are concerned with causing a long-term change in the player *for their benefit***. This type of game has also been described as 'transformational'; as games that are designed to change players [9]. The 'Transformational Framework' describes types of transformation, such as 'knowledge', 'disposition', 'physical', or 'behavior', to name a few. To note for the purpose of this article is that a game designed to change behavior falls under a different type of academic game than one that is designed to study it, as is the case for stimulus games. Examples of academic games designed to act as intervention include those made for therapy purposes (e.g., in health care [24]) or supporting habit changes.

An example for an intervention game is *HitnRun* [49], a single player mobile game based on 'endless runner' games (such as *Temple Run* [20]). The game incorporates 'target' and 'distractor'

objects showing smoking-related or neutral images. The goal of the game is to decrease the desire for smoking through creating a negative association with smoking-related imagery. Another example is *Speech Adventure* [45], a speech training game for children with cleft palate or cleft lip. The game features speech recognition that is capable of discerning mispronunciations due to cleft speech problems. The game takes the format of an interactive storybook in which words must be pronounced correctly in order to progress.

A game might act as a catalyst for change, but the game does not exist in order to measure the change for research purposes; instead, it exists to elicit it for the player's benefit. And yet, in order to develop games that can act in such a capacity, measures are required to assess whether the intended change is taking place and whether the extent of the change justifies the effort compared to non-game interventions. Projects with the eventual aim to develop a treatment or intervention are thus likely to start with laboratory experiments in which the game or parts thereof act as a stimulus. Generally speaking, it is not the academic partners in such projects that will eventually release the game 'into the wild'. Rather, this happens with the collaboration of industry partners once the game has been proven to be effective.

## 3.3 Incentive

Another fundamental purpose for involving games is to tap into the widely held perception that games are entertaining. For those who enjoy playing games, **the execution of an otherwise undesirable task might appear appealing if it is framed in the context of a game. In such cases, games are involved for their potential to act as an incentive; as a reward for executing a task.**

This might involve collecting measures that are created as part of the game. In contrast to pure stimulus games, however, **the data that is collected results from a task being executed, rather than a change in the player specifically elicited through the game's design**. Changes in the game may impact how effective the game is in its ability to incentivize players to perform a task; but it does not meaningfully impact the data that is being generated.

Games can be used as an incentive to collect or process data. Citizen science games are good examples where gameplay provides an incentive for executing scientifically useful tasks. The game *Foldit* [60] tasks players with optimization puzzles that are based on the real world process of protein folding. Rules in the game are designed to work analogous to the biochemical reactions that impact the three-dimensional structure of proteins. By playing the game, players are 'working' on organizing protein structures in a manner that is meant to predict how a protein structure would fold given its amino acid sequence. In doing so, they create data that can be used to train computational strategies, as well as highlight structures that warrant more detailed research. A similar example can be found in the game *Phylo* [25] for multiple sequence alignment optimization in DNA sequences, or in *Sea Hero Quest* [54] for collecting data on navigation behavior for researching Alzheimer's disease. In these examples, participants are tasked with processing or creation of data on a large scale. By framing tasks as a game, participants - now players - are presented with an incentive for completing a task. Their participation provides a service for scientific studies, but in the short term they are incentivized by progressing a game narrative, compete against other players, or by game-based feedback, such as an in-game scoring system, for improving their performance. The tasks could, however, be executed through other incentives, such as monetary rewards, as is the case in crowdsourcing platforms such as Amazon Mechanical Turk [51]. Although the game context holds the promise of establishing an 'intrinsic motivation' [41] for task completion, it depends on the participant's interest for the context, and their ability to enter and leave the context freely. If participants are not interested in the game context or perceive it as a chore that must be completed, the game context risks becoming little more than a work task with extraneous elements attached to it. It is worth noting that even if a task is experienced as being enjoyable, the quality of its completion might not necessarily improve [18].

Another use-case for involving games as incentives are educational games that are developed within academic contexts. The topics of such games are likely to target specific topics that are not covered by commercially available education games. Games in which the education material exists to a large extent separately from the game mechanics use the medium of games as an incentive to play. In such cases the material does not uniquely benefit from being conveyed through a game, but makes it more likely for players to engage with it.

One such example is the mobile game *Herbopolis* [12] which aims to educate players about herbal medicine. In the game, players are tasked with operating the business of growing, processing, and selling herbal medicine. The purpose of the game is to educate players about the appearance of herbs and concepts of potency and dosage. Additional aspects, such as managing a business, exist to facilitate (prolonged) engagement with the game. The purpose of educating about the appearance, potency, and dosage of herbs could be communicated without the use of a game. Most actions in the game are arguably more synonymous with the tasks and challenges of running a farming business. However, the game frequently exposes players to the educational content, even if the mechanics of the game are more likely to educate about business principles. The game mechanics thus provide an incentive to engage with the educational content.

Education games that seek to incentivize players by their game context are often aimed at children to make educational content appear more palatable. However, educational games can be designed in such a way that the content is understood through the act of playing them. In such a case, games are not only (and perhaps not even primarily) used for their ability to incentivize but to make a subject experientially understandable. This purpose is closer to 'modeling', which is described in more detail in the following subsection.

## 3.4 Modeling

The involvement of a game can be motivated by the **desire to understand a phenomenon by constructing or experiencing it through a game.** Modeling can take place on a conceptual level, or be an attempt to simulate a topic of interest as accurately as possible. **When involving a game to model phenomena, processes in the game act as the object of study.** It concerns the evaluation of the sum of actions that happen as part of the game

that is being played. This purpose differs from the previous three in that the research focus tends to lie with the system more so than the player, or that there is no player required at all.

Within technologically-minded sciences, modeling usually refers to the practice of simulating processes with computer algorithms. For the intention of categorizing the fundamental purpose of involving games, however, modeling should be understood more broadly. It refers to the process of building knowledge by observing or interacting with a simplified artifact that acts as a representation of a more complex phenomenon. That artifact can be actual, such as a physical miniature or the virtual representation of a physical environment. It can also be conceptual, such as a hypothetical thought experiment, as is the case in the game *Something Something Soup Something* [16, 17] which asks players to reflect on the mutable nature of definitions. In the case of academic video games, modeling largely means to create or modify a game, and thus make it an actual artifact, even when used as a thought experiment.

Games, especially well known ones, can provide an experiential understanding for interpreting results or for the implementation of modeling parameters. It allows researchers to use game-specific terminology to explain and understand modeling outcomes. Optimizing of parameters can, for example, be framed as 'winning' or 'losing'. Interactions in the game, especially those of individual entities, can be discussed through the metaphor of incentives, goals, and desires. By using games, such features can be communicated in a way that is easily understood by other researchers and the general audience. 'Enemies' are in competition with a player character; collectibles such as coins or food are objects of desire; deep pits pose a danger for the player, but can be surmounted; and so on.

Examples of using games for modeling are often found within computer science and related fields, such as artificial intelligence research. Efforts to 'solve' games, i.e., identifying the most optimal decision a rational actor can take, provide testing grounds for computational strategies in uncertain or complex environments.

The development of *AlphaStar* [61] involves the real-time strategy game *Starcraft II* [6] in which multiple entities are controlled as virtual armies to fight against other players with their own armies in a complex virtual terrain. Due to the real-time nature of the game, the state of the game changes from moment to moment, thereby restricting the amount of time that can be taken to evaluate optimal actions. The purpose of involving *Star Craft II* in this example is to study and improve the development of intelligent programs through a complex environment. Using a game that can be played against a human player allows for the evaluation of the program, not on individual parameters, but given its performance through the sum of actions that happen in the game.

The use of games for modeling purposes might not even require the participation of a player in the traditional sense. Instead, a game serves as a simplified testing ground, such as using Atari games like *Pong* [2], to train and compare computational models [8, 56]. Instead of attempting to 'solve' such relatively simple games, they serve as a benchmark. A game artifact is involved because it provides a clear, comparable experimental condition. The only player in such a case is the computational system, playing with (or against) itself, resulting in a form of a 'zero-player game' [5].

As already hinted at in the previous subsection, educational games may be motivated by a desire to make content more memorable by allowing players to engage with it playfully. Sandbox games such as *Minecraft* provide players with large environments and rule-based interaction mechanics that can be used for a wide range of educational topics. Based on this, the game is available as 'Education Edition' [33], giving educators a tool for shaping educational experiences in which players learn through their engagement with the game. That is not to say that all educational content mediated through *Minecraft* is automatically so connected to it that the game is an integral part of understanding a phenomenon. One can conceive a *Minecraft* environment littered with signs that 'educate' players on a topic by having them read through all of them to convey knowledge. Doing so uses *Minecraft* as an incentive to read the content, but does not require meaningful engagement to better understand it.

A counterexample to that use of *Minecraft* can be found in the game project *RoMeincraft* which uses *Minecraft* as a platform for collaborative play between archaeologists and members of the public [36]. Using the virtual space of *Minecraft*, the project reconstructs Roman architecture; providing players with a space to explore and expand it. Rather than educate specific points of knowledge, the project seeks to encourage interest in Roman heritage, using *Minecraft* as a tool to induce curiosity about the topic. Although the context of the game surely acts as an incentive to engage, the purpose of involving *Minecraft* is to gain an experiential understanding by playing it.

# 4 FACETS OF GAMES IN ACADEMIC CONTEXTS

Whereas the previous section outlined why a game might be used, this section focuses on how it interfaces with the academic context. Three facets are described: information flow, artifact dependency, and specificity requirements. These facets are clearly not meant to cover all ontological features in any academic endeavor involving games, but they are thought to be key topics for discussion when planning for the use of games for academic purposes.

## 4.1 Information Flow

Every game used in an academic context involves an exchange of information. Players receive information, such as how the game is played, what actions can be executed, or are introduced to out-of-game information using the game as a medium (for example, in text boxes overlaying the game interface). Facilitators of the game (e.g. researchers, educators, game developers) may receive information through the act of it being played; either during the activity itself (through the logging of play data), or through a subsequent activity that is impacted by the game artifact (e.g., a survey or interview).

The information flow facet concerns **what information is exchanged through a game artifact**, and **which direction is dominant** for each piece of information. Additionally, a sum could be made of the overall direction for the entire game.

Not all information exchanged through a game relates to the fundamental purpose of the game. For example, while information on game controls is necessary for the player to receive, it is generally not specific to the academic context. However, it is possible for this

information to affect the research outcomes. The presentation of in-game goals, for example, may impact how players behave [14]. As such, we propose that there is a scale of relevance to the academic context for all information passed through the game. The framing of the game's purpose and related information are considered critical, while functional information (e.g., controls) is generally less important. Nevertheless, both potentially influence how the game is perceived and eventually played.

Information flow towards a game facilitator is **information acquisition.** A game used to acquire information can collect data that is generated by playing it or eliciting a reaction in players that provides information. Games such as the aforementioned *Foldit*, *Phylo*, or *Sea Hero Quest* (see section 3.3) are examples that are developed with the goal of acquiring data from players. While they might impart some knowledge to players, this is motivated by the desire to capture as much data from players as possible, and ensure that the quality of that data meets the requirements of the project.

Information flow coming from a game facilitator should be considered as a form of **information dissemination.** In such cases, a game is used primarily to educate players or to communicate an argument. Additionally, it can be to instruct players as to how a game is meant to be played.

It may involve measures regarding the efficacy of the dissemination effort; still emphasizing that the leading intention is to disseminate information rather than to collect it. Game-based learning initiatives such as *Ludwig* [35, 62] or *Curio* [13] are examples of games that disseminate information. The games inform about a topic (STEM subjects in the case of *Ludwig*), or educators in the form of a teaching toolkit (as is the case in *Curio*). Games that are meant to fulfill therapeutic purposes should also be considered as disseminating information in terms of their development purpose (requiring data acquisition primarily to validate their own efficacy). As mentioned in section 3.4, games can also serve as artifacts for thought experiments. Here too, information is primarily directed towards a player rather than towards the game facilitator.

The facet of information flow may not always land squarely on either acquisition or dissemination. Games may be used for both purposes. *Sea Hero Quest*, for example, can also be considered as disseminating information by raising awareness about dementia research. Likewise, games that are created with the goal to impart information may require significant data acquisition to evaluate whether that goal is met. The value in thinking about information flow is to shape development of a game (or its purposeful modification) accordingly.

In practice, even if a game is meant to acquire data, it might not require much additional development effort to also provide additional information about the research context beyond the need of acquisition efforts. This can not only be in the interest of research transparency, but also to argue for the importance of the research field that it is part of. On the other hand, game development (including modification) is resource intensive and thus warrants intentional emphasis on whether an artifact is meant to acquire information or provide it.

## 4.2 Artifact Dependency

While some academic efforts may completely depend on a specific game, in other cases, it may be that the use of games simply makes it easier to attract a larger number of participants. Games can be a useful addition to research projects, even when they do not fully depend on them. However, being aware of their importance and reaching an agreement about that among all stakeholders helps to ensure that development resources are well distributed.

The involvement of a game can range from being merely **supportive** to being **catalytic** for an academic effort. As a catalyst, a game is essentially just as much what guides the design of the academic context as it is the other way around. For instance, studying exploratory behavior in video game environments (e.g., [14]), is dependent on the involvement of a game in which participants can be observed while exploring such an environment. Research into virtual foraging behavior using a video game, to name another example [38], could be considered somewhere between the two ends of the spectrum, given that a virtual environment does not fully necessitate a game context. Studies may require the use of virtual environments to create experiment circumstances that can be easily replicated. Other times they are needed to elicit and observe behavior in scenarios that would be unethical, dangerous, or impossible to expose participants to in reality. Such virtual environments or simulations can be designed or framed as games. Oftentimes, however, the simulation of the situation is focus of the study, rather than the elements that make it a game.

Games can be considered to be in a supportive role if the task or measure they are part of could be carried out without their involvement. This may be because a game artifact acts as a form of incentive for participation that could be fulfilled through financial compensation or other extrinsic rewards, without significantly impacting the quality of the research. This is not to say that supportive games are involved arbitrarily. Using a game might, for example, attract more participants compared to a non-game implementation, and thus add real value.

## 4.3 Specificity Requirements

Aside of the question of how dependent a project is on the involvement of a game artifact, it is also important to consider how specific it should be. If an existing game can be used with little or no modifications, its specificity requirements for the academic context are low. The specificity in this case does not depend on a wide range of possible options. Instead, it regards how much design and development effort will be required to involve a game artifact in the academic project.

A high degree of specificity is warranted if few existing games can be modified to fit a research task or if it is in the interest of the project goals to create a specialized game artifact. This could be to avoid pre-conceived ideas if a known game is modified, to gain full control over all parameters, or to promote an academic endeavor through an original game.

While it can be tempting to create a game specifically for an academic effort, doing so comes with additional challenges. Although game development has become increasingly more accessible, it remains a time-consuming activity in which not all tasks directly benefit the larger academic context. The effort required just to

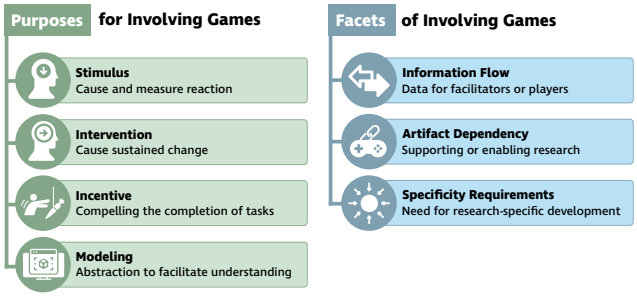


**Figure 1: Diagram of fundamental purposes and facets for involving games in academic contexts.**

implement basic functionality such as virtual camera control or player-character controls is easily overlooked. Small imperfections in the execution of academic games can also be harder to ignore for participants if they compare them to more sophisticated commercial implementations. This is especially noteworthy if a game is meant to act as an incentive, as the perception of what games are and ought to be necessarily exists in context with what games are commonly available.

## 5 DISCUSSION AND CONCLUSION

This article defined the use of games for academic contexts - 'academic games' - as a sub-field of applied games, shaped by a purpose and the involvement of stakeholders from research and education institutions. Based on examples of prior work in that context, **four fundamental purposes for using games are identified:**

- as psycho-physiological stimulus.
- as intervention mechanism.
- as incentive for completing tasks.
- as modeling platform to facilitate understanding.

Making the purpose for game involvement explicit is especially important in the planning stages of an academic endeavor. Game development requires the collaboration of several stakeholders, some of whom might be more attuned to the academic content, while others focus more on technical or logistical considerations. In such cases, it is important to explicate assumptions for why a game is created or modified and discuss these assumptions openly among all stakeholders. Indeed, the complexity of both game development and research design can easily focus the attention too quickly on more detailed topics; bypassing an explicit, shared agreement.

In addition to purposes, facets of game involvement are defined based on how games interface with the academic context that they are a part of: information flow, dependency on a game artifact, and specificity of the artefact to the academic effort. These facets are defined to provide a basis for making decisions on how to develop, select, or modify a game artifact to fulfill the purpose for its involvement.

The purposes and facets defined in this article, visually summarized in Figure 1, are meant to support early discussions and decisions in academic efforts, especially when several stakeholders are working together. Not only that, we pose that intermittent evaluation of whether the facets are still used as originally intended can be helpful as well. As a project develops, new ideas and considerations can enter the development process, possibly moving it in another direction. Although this does not necessarily pose a problem, it is important that practitioners are aware of such changes occurring, how they may impact the game artifact and, in turn, the research effort.

At this stage, the proposed purposes and facets do not comprise the full extent of all considerations that come into play when games are used in academic contexts. However, they are defined on the basis that all academic efforts should be able to address them before moving on to more concrete development steps. Additional support regarding development, especially as the work becomes more specific to the needs of a particular academic purpose, can be found in development frameworks that are meant to aid with the creation of applied games [4, 59], although future work should aim to examine which approaches are more or less valid for academic contexts. Previous work has made strides in outlining challenges and guidelines for developing stimulus games [23] or to identify fitting games [31, 39], so a basis exists from which to further expand the field of academic games.

Based on the analysis and identification of fundamental purposes and facets of game involvement in this article, we now propose the foundation for a research agenda aimed at improving the use and development of games for academic purposes.

Future work on this agenda should investigate:

- To what extent applied games, as well as game design, requires specialization to better fit the academic context.
- How different academic fields approach the involvement of games for research purposes, e.g., through the mapping, discussing, and combining of (individual) case studies.
- What stakeholders are most often involved in the use and creation of academic games, what they expect from the use of games, and how they influence decision-making.
- The formulation of development guidelines, frameworks, and tool-kits that are aimed at academic games.

As games increasingly involve user-generated content (e.g., in *Roblox* [43] or *Super Mario Maker* [34]) and development tools become still more accessible and user-friendly, the use of games for non-entertainment purposes will likely only continue to grow. The academic context, whether it is research or education, has already benefited from this trend. As this trend continues, academics will find themselves filling roles that are new to them. This article documents some of the efforts that have been conducted on this path already, and argues for the need to create knowledge specific to the use of games in the academic context. Rather than turning academics into professional game developers, the aim is to establish a better understanding for using the medium of games, and shape it to their specific needs.

Ultimately, academic games are similar to entertainment games, and much of the lessons that apply to one will also apply to the other. The academic context does not turn them into an entirely different medium. Nevertheless, the context that games are a part of has an impact on their creation and on those who play them. After all, the metaphor of the 'magic circle' does not describe a hard border defined by metaphysical rules, but rather one that is shaped by the surrounding context. Ignoring this risks losing the 'magic' that

shapes the experience of playing games. Addressing and embracing that context, on the other hand, can help to improve discourse, bridge efforts across fields, and lead to the professionalization of academic game development.

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