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Game modding: A design cognitive perspective in entrepreneurship education

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Abstract

This design-based research investigates how game modding—intentional alterations to a game's original content—can foster a cognitive approach to design thinking among business students, grounded in constructionist theory. A two-stage game-based activity was created and implemented in a Business Game class at a specialized entrepreneurship college in São Paulo, Brazil. Data collection included video recordings, interviews, and student reports. The analysis focused on a representative group of four students, examining the design cognitive processes employed during their redesign journey. Our analysis reveals that due to the absence of a repertoire of previous design solutions, the students grounded their analogies in their own sociocultural context, reflecting their social norms, and through interdisciplinary thought processes. To address the research question, 'How can game modding support the development of business students' cognitive perspective in design?' we propose that game modding serves as a useful pedagogical tool to foster essential cognitive processes in design thinking, particularly within a business education context. Game modding helps develop business students' cognitive perspective by creating an experiential learning environment emulating the entrepreneurial journey.

Introduction

In entrepreneurship education, more notably at the undergraduate level, design thinking pedagogy often relies on stepped or prescriptive methods embodied in templates and toolkits (e.g., Business Model Canvas) to support non-designer students in understanding design thinking (Wrigley & Mosely, 2023). Thus, design thinking instruction emphasizes the process over design cognition (Chan, 2015). However, understanding the cognitive elements of design can enhance students' comprehension of problem and solution spaces (Dorst & Cross, 2001). While business students are often trained to focus on solving predefined problems efficiently, designers are trained to first explore and define the true nature of the problem they are addressing (Norman, 2013). Thus, entrepreneurship education could benefit from incorporating a design cognition viewpoint into its pedagogical frameworks (Garbuio et al., 2018). This perspective would equip prospective entrepreneurs and managers with innovative strategies, providing them with the competitive edge to thrive in the complex and ever-evolving business world. Additionally, insights into the designers' thought processes can enrich students' design skills and utilization of prescriptive tools and improve their overall project outputs. Armed with this understanding, they would be adept at making informed decisions even in ambiguous and unstructured scenarios (Garbuio et al., 2018).

In order to cultivate design cognition within the framework of design thinking pedagogy, we have put forth a game-based intervention rooted in the principles of constructionism (Kafai, 2006a; Papert, 1980, 1991). Constructionism is a learning theory that emphasizes the profound learning potential that arises from students actively constructing artifacts, including games (Harel, 1991; Kafai, 2006a; Kafai & Burke, 2015a).

Our primary objective is to answer the following question: How can game modding support the development of business students' cognitive perspective in design? Game modding, short for game modification, involves altering the original content of a game to add new challenges, change mechanics and aesthetics, or create novel levels. By examining the design journey of a group of students with no prior design experience, this study delves into the cognitive design processes they employed to address a game design challenge, navigating the task without the aid of prescriptive tools.

We adopted games for our pedagogical approach because they are more than mere cognitive exercises; they tell stories and offer dynamic representations of the real world. For our examination, we used a board game designed to teach fundamental business concepts. Board games foster conceptual understanding by engaging students with complex systems while minimizing irrelevant variables (Castronova & Knowles, 2015; Squire, 2003). Additionally, this research utilized board games to decelerate the learning process and encourage student reflection. The urgency, immediacy, and instantaneousness fueled by technology, globalization, and real-time economic operations (Rosa, 2013) often suppress necessary reflection time. This prevailing sense of urgency contrasts with the time required for deep learning. Our pedagogical intervention aims to counteract this immediacy, serving as a mediational artifact to support reflection and analysis. This approach anticipates positive outcomes for both deep learning and student engagement. As Kaufman and Flanagan (2016) noted, board games "slowed down play and allowed more turn taking in conversation, creating less rush and more room for each player to engage in thoughtful discourse." (p. 12)

This pedagogical approach signifies a departure from the conventional teacher-centric transmission of knowledge, emphasizing the understanding of knowledge as a dynamic construct shaped by the students themselves (Games & Squire, 2008). Consequently, the educator's focus extends beyond merely evaluating students' end products. Instead, it becomes crucial to recognize and appreciate the design journey in which students actively engage.

Design thinking

After many years of research nested in traditional disciplines such as architecture and design, the concept of design thinking was embraced by the management literature in the 2000s. In business and management, design thinking is related to practice (Hassi & Laakso, 2011; Johansson-Skoldberg et al., 2013) as a process or even a mindset (Sarooghi et al., 2019) to solve problems. This new interpretation turned design thinking into a tool that defines a way of working with design and innovation grounded in the IDEO experience (Kelley, 2001).

The well-known American design company IDEO and the Stanford d.school popularized the concept of design thinking, codifying it in a stepped method to help managers innovate and solve problems. These phases are identified as (1) discover or empathize (to find a way to approach the problem), (2) interpretation or define (to interpret the problem), (3) ideation (the creative process to find a solution), (4) experimentation or prototype (to make tangible the possible solution), and (5) evolution or test (to assess the possible solution). From this perspective, design thinking can be understood as "a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity" (Brown, 2008, p. 86).

Quickly, the popular business press championed the five-step design thinking method, which boosted its dissemination over many segments, such as business consulting (Norman, 2010) and education (Riverdale Country School & IDEO, 2011). These phased models of design thinking, however, have been criticized, among other reasons, for portraying a naïve vision of design. Through these models, non-designers search for the correct answers by applying a straightforward process or an algorithm to solve problems (McCullagh, 2010; Sosa, 2015) rather than preserving ambiguity in the design process in an iterative idea exploration context (Meinel & Leifer, 2012).

Moreover, using design thinking as a phased tool for problem-solving can limit creativity in the design process (Mayer, 1989). Norman (2010) described how design thinking in business is just another name for creative thinking, highlighting the confusion about the role of design. Design thinking became a useful myth for designers and business consultants. Johansson-Skoldberg et al. (2013) observed that design thinking is very often interpreted as a ready-to-use toolbox. In their opinion, designer methods are taken out of context to be used by a person without any previous training, knowledge, or skill.

A possible approach to foster the design thinking creative process might be to complement the phased method with concepts neglected by the management literature and practice so far: understanding the cognitive processes involved in design thinking.

Design cognition

When solving design challenges, human designers use cognitive processes and techniques known as "designer thinking" (Dinar et al., 2015). Attempting to urge the management community to adopt a cognitive perspective in entrepreneurship education, Garbuio et al. (2018) presented four different cognitive acts as the basis of design and entrepreneurial cognition: framing, abductive reasoning, analogical reasoning, and mental simulation. Similar design cognitive acts were identified by Micheli and colleagues (2019) as attributes of design thinking.

Framing

Framing relates to the creative aspect of the design process and may be thought of as a designer's attempt to portray the issue and find a solution (Stumpf & McDonnell, 2002). The framing process embraces the development of a viewpoint to address a problematic situation or as a schema to interpret a problem (Garbuio et al., 2015; Kim & Ryu, 2014). This schema comes from a process of association and dissociation between the situation, assumptions, and precedence (Garbuio et al., 2018).

In contrast to design research, framing in the behavioural decision literature has a distinct focus. Framing is generative in design. Since there are no known alternatives, the first set of options can be created with no restrictions. In decision research, however, framing is analytical since it is linked to analysis, assessment, and selection of an alternative from a specific set of options (Dong et al., 2016; Garbuio et al., 2015). Framing is examined in entrepreneurship research in a similar way to design research: for instance, through the lens of reframing as an enabler to find problems worth solving as a critical attribute of entrepreneurs in the modern business environment (Bianchi & Verganti, 2022) and to show how experienced entrepreneurs face decision-making problems in creating new ventures (Dew et al., 2009).

Abductive reasoning

Abductive reasoning is a form of logical inference that leads us to the best explanation (not precisely the correct one) for a problem. It is a meaningful and reasonable theory to explain the circumstances at hand (Shank, 1998). Although this explanation may not be correct in terms of logic or science, it connects the worlds of "what is" and "what may be" (Guenther et al., 2021).

Different typologies have been proposed in the literature to classify abductive reasoning. Dorst (2011) presented the concepts of Abduction-1 and Abduction-2. To explain them, Dorst employed the equation "what + how = value." In Abduction-1, both "how" (the working principle) and "value" (the final product) are known. In Abduction-2, neither the "what" (a thing) nor the "how" is known. As Garbuio (2015) highlighted, in Abduction-2, "designers must abductively propose both the design artifact and the means of achieving it" (p. 456).

In a different typology, Roozenburg (1993) also proposed two types, explanatory and innovative abductions. The explanatory abduction attempts to find a likely cause, forming a possible explanation of an effect, synthesizing complex, contradictory or incomplete information. The innovative abduction predefines unknown variables (e.g., value to be created, how to solve a problem) to explain how it will affect a given parameter (e.g., a new business model) (Garbuio & Lin, 2021; Guenther et al., 2021).

The literature on entrepreneurship explored explanatory and innovative abductions, outlining, for instance, that when an entrepreneur is trying to interpret the reaction of an incumbent in the industry, they are using explanatory abduction. Yet, when entrepreneurs invent a new product or business model, they employ innovative abduction (Garbuio et al., 2018).

Analogical reasoning

Analogical reasoning is the cognitive act associated with the transfer process when a mental representation goes from a source domain to a target domain (Garbuio et al., 2018). Ball and Christensen (2009) said that analogical reasoning "involves accessing and transferring previously acquired knowledge of objects, attributes and relations to support current problem-solving and decision-making activities" (p. 169). Analogical reasoning is described as a fundamental cognitive process in areas such as cognitive problem-solving (Chan et al., 2012; Gick & Holyoak, 1980), creative design (Ball & Christensen, 2009), architecture (Ozkan & Dogan, 2013), scientific discovery (Gentner et al., 1997), learning (Gentner et al., 2003), and business innovations (Hargadon, 2002).

The design literature has described analogical reasoning as a way to overcome design fixation (Crilly, 2015; Moreno et al., 2014; Ozkan & Dogan, 2013; Smith et al., 1995), which is defined as "a blind adherence to a set of ideas or concepts limiting the output of conceptual design" (Jansson & Smith, 1991, p. 3). In innovation and entrepreneurship research,

analogical thinking is perceived as a source of inspiration for product breakthroughs (Herstatt & Kalogerakis, 2005) and support for discovering and developing new business opportunities (Dew et al., 2009; Van Burg & Romme, 2014).

Mental simulation

Mental simulation represents the capacity to reassess past events and project future ones before any actions, or even decisions, are taken (Garbuio et al., 2018), aiming to predict cause–effect relations (Casakin et al., 2015). Ball and Christensen (2009) highlighted that mental simulations are not limited to technical design properties but are related to various circumstances, including the end-user impression based on interaction with the design artifact.

Gaglio (2004) presented two functions of mental simulation to emphasize its significance. The first function is affective. Through mental simulations, we may revisit and process feelings that help us learn how to deal with a situation, control our emotional reactions, or rebuild our self-esteem. The preparative function is the second function. Through mental simulations, we may picture various outcomes, prepare potential reactions, project events, foresee circumstances, and devise plans and tactics to accomplish our objectives. In the same vein, Casakin et al. (2015) pointed out that mental simulations are helpful for designers to imagine new design solutions, predict potential outputs, and assess their viability.

Referred to also as imaginativeness, mental simulation is examined in entrepreneurship research as a creative force to help entrepreneurs disrupt the status quo through a recombination of resources to envision and build what could be (Kier & McMullen, 2018). Mental simulation is also discussed as one of the mechanisms to identify and develop innovative opportunities (Gaglio, 2004; Haynie et al., 2010).

Design thinking pedagogy

The design thinking education literature in business and entrepreneurship is quite broad, mainly grounded around the stepped IDEO method or with no or negligible emphasis on design cognition (Glen et al., 2015; Huq & Gilbert, 2017; Matthews & Wrigley, 2017; Nielsen & Stovang, 2015; Sarooghi et al., 2019; Von Kortzfleisch et al., 2013; Zupan & Nabergoj, 2016). Garbuio et al. (2018), most likely the earliest reference to cognitive design in entrepreneurship education, pointed out that a problem- and team-based pedagogy could stimulate the introduction of design cognition, mainly when lecturers act as coaches rather than just instructing their students. Yet, design thinking pedagogy's would focus on project-based learning with student teams (ideally interdisciplinary) rather than formal lectures or other didactic methods (Glen et al., 2014).

We support the idea that game design fits perfectly as one of the problem-based paedagogies to foment design thinking in entrepreneurship education (Neck & Greene, 2011). This view embraces games not only as artifacts to play and learn with but also as artifacts to make it, representing and embodying students' knowledge as promoted by the constructionism perspective (Kafai, 2006b; Kafai & Burke, 2015b; Papert, 1991). Pedagogic activities around game design support students' capacity to think about any discipline and develop a range of technical and soft skills, connecting students (Kafai, 2006b; Kafai & Burke, 2015b; Kim & Bastani, 2017; Marasco et al., 2017). Game design is also an innovative instructional practice and an alternative to design thinking activities centered on the traditional five-step method. Grounded in these premises, we designed a board game activity to engage learners and mediate their design-thinking learning process.

Research design

In this design-based research (DBR), we developed a two-stage game-based activity aimed at exploring the design process undertaken by undergraduate students lacking formal design training. In the initial stage, students participate in a customized board game designed to introduce key business concepts alongside foundational game mechanics. This stage encourages students to strategize, adapt to simulated economic fluctuations, and engage in competitive play. The second stage, which forms the core of this study, involves collaborative group work focused on modifying the existing game. This process culminates in the presentation of a functional prototype.

The study received ethical approval from the Research Ethics Board at the hosting Canadian university. In Brazil, where the college lacks a dedicated ethics board, the research was approved by the government-affiliated Comitê de Ética em Pesquisa (CEP) (Research Ethics Committee), complying with Brazilian ethical research regulations.

DBR was initially conceptualized in the 1990s (Brown, 1992; Collins, 1992) as a response to diverse challenges in educational research. DBR addresses theoretical questions concerning the nature of learning in authentic contexts, moves beyond narrow measures of learning, and emphasizes deriving findings through formative evaluation and interventions in real-world settings rather than controlled laboratory environments (Collins et al., 2004). Barab and Squire (2004) define DBR as "a series of approaches, with the intent of producing new theories, artifacts, and practices that account for and potentially impact learning and teaching in naturalistic settings" (p. 2). By engaging with real educational contexts, DBR enhances the ecological validity of the research, ensuring that its findings are meaningful and applicable to the specific intervention context, while also having the potential to inform broader settings (Anderson & Shattuck, 2012).

Unlike traditional experimental research, DBR does not seek generalizability in the statistical sense but instead focuses on developing a deep understanding of the learning processes in specific, complex educational environments. Generalization in DBR is often achieved through transferability, wherein the insights gained are contextually situated but can offer valuable implications for similar settings through thick descriptions and detailed contextual accounts. Similarly, rather than emphasizing reliability in terms of replicability under identical conditions, DBR prioritizes design reliability,

which entails consistent processes of iterative refinement (McKenney & Reeves, 2012). This iterative, cyclical approach helps ensure that the interventions are responsive to the learning environment, producing outcomes that are both credible and adaptable.

The game

Our game-based activity revolves around a competitive board game called Entrepreneurial Thinking. Our game balances playability and education, integrating game structure, learning objectives, and enjoyable gameplay. Components, rules, and mechanics were designed for realism while reducing complexity. The omission of certain business notions (e.g., inventory costs, taxes) encourages student awareness and engagement in the (re)design phase.

In Entrepreneurial Thinking, up to four players compete as owners of industrial companies on a market board representing two Canadian provinces with eight interconnected cities. Each city has varying costs for establishing offices, factories, and warehouses and markers indicating customer expectations for product quality and price. The game concludes after 24 rounds, with the company earning the highest profit declared the winner.

More details about the game components and rules can be found in the Appendix.

Data collection

The sample for this study consisted of 12 male Brazilian students, aged 20 to 24, enrolled in a Business Game class at a specialized entrepreneurship college in São Paulo, Brazil. All participants were Portuguese speakers from similar socio-economic backgrounds. The selection of this group was driven by the unique opportunity it provided to observe the use of cognitive design acts within a controlled and consistent educational environment. Our intent was to build a nuanced understanding of the cognitive processes at play during game modification.

The existing educational setting, where the instructor Marcos (pseudonym) had already collaborated with us to incorporate the board game into his curriculum, presented an ideal context for this exploration. The board game Entrepreneurial Thinking was selected to offer students a distinct experience that differed from typical digital simulations and to expose them to a diverse range of gaming approaches.

Data collection occurred during a game modification session (Figure 1) and included video and audio recordings, classroom photographs, in-depth interviews with each student (lasting approximately one hour), and the final written reports submitted as part of their end-of-term assignments. These reports provided comprehensive reflections on their experiences and contributions throughout the activity. Individual interviews further explored relevant themes, such as students' prior exposure to board games and video games, their professional backgrounds, and their motivations for studying entrepreneurship. This combination of data sources allowed us to capture the complexity of students' design thinking processes in a holistic manner.

Figure 1. Game design session.

In our analysis, we focused on a specific group composed of Paulo, Lucas, Adriano, and Ricardo (pseudonyms), as illustrated in Figure 2. By conducting an in-depth investigation of this single group, we were able to closely examine the nuanced ways in which the students engaged with design challenges, navigated creative problem-solving, and employed cognitive strategies during the game modification process. The selection of this particular group was driven by the specific educational opportunity it presented, rather than by an effort to control for demographic variables. Their engagement, however, proved representative of broader trends, as supported by Sengupta et al. (2015) and Taber (2008).

Our decision to concentrate on this group aligns with a rich qualitative tradition that emphasizes the value of in-depth case studies in revealing the nuanced realities of complex phenomena (Yin, 2014). DBR provides an ideal framework for such an exploration, as it encourages an iterative, context-sensitive approach to understanding learning processes. Within DBR, the focus on a specific group serves not only to understand the intervention in its natural setting but also to iteratively refine both the intervention and our understanding of how participants interact with it in practice. The deep insights derived from the four students are significant, not because of the sample size but due to the depth and richness of their contributions—an approach well recognized for its methodological rigour (Flyvbjerg, 2006).

Comparative analysis and consistent observations from various game modding activities indicate that Paulo, Lucas, Adriano, and Ricardo's behavioural patterns and thematic parallels are representative rather than exceptional. This analysis's robustness is enhanced by methodological triangulation, aligning qualitative insights from individual cases with perspectives from interviews and written reports, thereby strengthening the credibility of our findings (Denzin, 2017).

The pedagogical implications of our findings are significant, offering a granular view of the design processes that often remain obscured in larger samples. The distinctive roles and diverse ideas discussed by these students have contributed to entrepreneurship education, especially in game-based learning. This focused analysis is consistent with educational

research precedents where small group analyses have provided significant insights, showing that even a small sample can reflect broader trends and behaviours (Creswell & Poth, 2017; Stake, 1995).

The case of these four students is not an isolated instance but a reflective microcosm of the entrepreneurial program at this institution. It exemplifies the typical undergraduate experience while providing unique insights that are pedagogically relevant and methodologically sound (Sengupta et al., 2015; Taber, 2008).

Figure 2. In the foreground, the four students during the activity (from left to right): Paulo, Ricardo, Adriano (pointing to the main board) and Lucas.

The class dedicated 15 hours to the game-based activities, spread across seven distinct sessions, as indicated in Table 1. In our analysis, we focused on Session 4, in which the students revamped the game they had played during Sessions 2 and 3.

Table 1. Activities in class.

Session	Duration	Activity
1	1h30m	Understanding the rules
2	1h30m	Gameplay – basics
3	3h	Full gameplay
4	1h30m	Game (re)design
5	1h30m	Crafting the new game
6	3h	Gameplay – playtesting
7	1h30m	Debriefing

Data analysis

All video content and interviews were transcribed, and the entire dataset, including audio recordings, was translated from Portuguese to English by the first author, a native Portuguese speaker. The translation process required meticulous attention to ensure accurate interpretation of expressions within their cultural context.

Our first step in interpreting the data collected was the creation of open codes (Table 2) in line with the research goal. Furthermore, eight codes were created, reflecting themes described in the literature. Four codes were used to examine the design thinking process and derived from the four cognitive acts (abductive reasoning, framing, analogical reasoning, and mental simulations) presented by Garbuio et al. (2018). The other four codes (objects, attributes, internal relationships, and environment) were adopted to reflect the elements of the game (Salen & Zimmerman, 2004).

Table 2. Examples of open codes.

Open Code	Dialogue example
Business understanding Seasonality	"So, every three rounds everything changes, every quarter. Like... usually between quarters is the time when the economy changes, and companies bring in new products."
Identity	"Map of several cities, city of Guarulhos, city of São Paulo, city of Juquitiba, because for example, we have already played three times."
Logistics	"The warehouse gives me greater freedom than I can... I can be here [Referring to the factory] and the warehouse here."
Business understanding Tax system Legal/Accounting	"Income tax, we can put it at the beginning as an example. But... the government collects the tax from you monthly according to your accounting framework, which is ... teacher help me here..."
Mental simulation	"Relax man…listen to me. Then in the future, the guy starts to make more than one sale per round. If he has one of these cards each round and each sale, he must pay a percentage over the sale, and if the guy makes three sales, it will start getting expensive for him."

The next step was clustering the codes according to themes (Table 3) that emerged from the analysis, such as sociocultural context, real life (business environment), and disciplines (program's courses). Game and design thinking themes have already been clustered into the eight described codes. Finally, we confirmed the pieces of evidence verified in the video segments by analyzing the interviews and students' reports, looking for inconsistencies in our first coding.

Building conceptual representations and design reasoning

The students in this activity, Paulo, Lucas, Adriano, and Ricardo, along with the other groups, were free to navigate their own paths to complete the game design assignment rather than following a prescriptive approach to overcome the activity's constraints and create conceptual business representations within a playable game prototype.

Unlike traditional design thinking methods that rely heavily on visual drawings and sketches for crafting conceptual representations (Visser, 2006), these students adopted a collaborative meeting dynamic. They centered their discussions on business concepts, utilizing argumentation to explore and evaluate design possibilities without relying extensively on visual representations. In the following sections, we describe how these four students engaged in cognitive design acts to modify the game, despite their limited experience and lack of design instruction. Their work is presented chronologically to illustrate the progression and use of cognitive design acts.

Table 3. Themes and correlated codes.

Themes	Codes created
Sociocultural context	Business understanding
	Identity
	Student role (within the group)
	Presentation (design idea)
	Critic (design idea)
	Defence (design idea)
Real life (business environment)	Tax system
	Seasonality
	Special days (holidays)
Disciplines	Sales & Marketing
	Human Resources
	Logistics
	Production
	Operation Management
	Purchase
	Legal/Accounting
	Economics
Game	Objects
	Attributes
	Internal relationships
	Environment
Design Thinking	Framing
	Analogical reasoning
	Abductive reasoning
	Mental simulation

Framing the design task

Discussions and reflections among the classmates that happened post-gameplay sessions made clear to the students the type of problem they have to address. A specific problem, the monopoly, a term the students coined to describe an instance where a player managed to gain control over a specific raw material, has emerged as the main problem. In many gameplays, house rules (player-created modifications to the official game rules) were tried by other students to overcome the problem.

In consequence of these observations, they framed their design task in response to the monopoly concern, hypothesizing that introducing greater randomness into the game and imposing elevated costs on the companies would enhance the overall gameplay experience by mitigating the occurrence of monopolistic situations.

Applying abductive reasoning to imagine solutions

To address the monopoly problem, Paulo, Lucas, Adriano, and Ricardo proposed ideas to increase the game's randomness and impose additional costs on companies to deplete their cash reserves. A more randomized game would necessitate new strategies, rendering the monopoly approach less effective. Additionally, with fewer resources, players would be unable to purchase all available raw materials. These solutions emerged through abductive reasoning, enabling the students to begin tackling the monopoly issue.

A conversation between Paulo and Lucas, who devised a new game mechanism to increase costs related to managers' salaries, started the quest for solutions. Adriano interjected and suggested a structured approach to the design process. He proposed discussing each idea separately, noting the decisions made before moving on to the next idea. The group readily embraced this approach.

Thus, they decided to discuss the idea of new maps for the mainboard, depicting the players' residing areas, which would introduce more unpredictability into the game by presenting a new market where the monopoly would not work. The players decided to start the discussion with the maps, considering them to be simpler compared to the other ideas.

Introducing new maps would encourage players to develop innovative strategies for business locations, marketing, and distribution. Multiple maps were viewed as a way to increase unpredictability and prevent monopolies. However, incorporating new cities raised the question of whether additional macroeconomic cards were needed for each new city. In the original deck, eight cards triggered changes in the demand for any of the eight original cities. Removing these cards would undermine the goal of increasing unpredictability. To address this challenge, Lucas proposed an alternative approach to enhance unpredictability.

> Lucas: Instead of having macro cards that change the demand in specific cities, we can change all cities' expectations every X rounds. Let's say, we change the customer expectations every three rounds because the market is volatile. This way, players cannot create a monopoly.

While framing facilitated the identification of the design problem (the monopoly), the application of abductive reasoning allowed for the emergence of ideas to tackle the design challenge. In the following section, we will demonstrate how analogical reasoning helped the students incorporate their own experiences and perspectives, which in turn led to improving their design concepts.

Grounded on analogical reasoning: Constructing actual representations

Analogical reasoning was also crucial to the (re)design process. Lacking an established repertoire of patterns from previous solutions (Chan, 2015), Paulo, Lucas, Adriano, and Ricardo relied on analogical reasoning to draw representations from their personal experiences and worldviews to the game elements and rules they proposed. For instance, Paulo, inspired by his experience working at his parents' convenience store, introduced the concept of seasonality in their design discussion to justify Lucas's idea of demand change every three rounds.

Thus, the randomness brought by the seasonality (changing the demand every three rounds) was established, and they realized they did not need new maps, and neither did the original eight macroeconomic cards that changed the demand of the original cities. As they knew that a new macroeconomic card marks the beginning of each round, a deck with 24 cards promotes a game with 24 rounds. Thus, at this point in their design, the number of rounds was in suspension.

Ricardo pointed out that they had to speed up the gameplay, which meant that the game must have 16 rounds (24 cards minus the eight cards); therefore, no extra cards were needed. However, the others argued that the gameplay with 16 rounds was too short. The gameplay length was highlighted by Lucas, who argued that the game must have 20 rounds. They just needed to create four extra cards. Lucas said they could copy some cards to make the process easy in the following craft session. They all agreed. However, Paulo came up with a different idea for the extra four cards.

> Paulo: Hmm... We could include other cards.
>
> All: Which ones?
>
> Paulo: Obligation to pay a tax to the government.
>
> Lucas: Man, I like it! I like it!

The students used analogies based on real-world phenomena like seasonality and annual income tax to promote their design concepts (e.g., shorter playtime, less predictability). Afterwards, they used mental simulations to assess the feasibility of their ideas, envisaging potential game scenarios to gauge their practicality and effectiveness.

Evaluating design ideas with mental simulations

Mental simulation, as a cognitive process, entails the ability to mentally revisit past events and envision future scenarios to anticipate cause-effect relationships. Paulo, Lucas, Adriano, and Ricardo employed mental simulations as an integral part of their design process, serving two pivotal functions. Firstly, mental simulations played a crucial role in their ability to translate real-world information into concrete game design concepts. Through mental simulations, they envisioned various events and devised strategies based on analogical reasoning.

Secondly, mental simulations served as a valuable tool for evaluating their design ideas and exerted influence over peer opinions. For instance, Ricardo utilized mental simulations to visualize the end-users' interaction with the game, thereby dissuading Lucas from implementing the concept of representing seasonality through a Children's Day event card. Additionally, the group collectively rejected the idea of introducing new maps, taking into account considerations related to logistics and strategy.

By employing mental simulations in their design process, Paulo, Lucas, Adriano, and Ricardo could conceptualize game elements, assess their viability, and make informed decisions based on the projected user experience and strategic considerations. For instance, the suggestion to introduce cards representing corporate income tax needed assessment via mental simulation. However, they admitted a lack of sufficient knowledge on the topic and sought Marcos (the instructor) for a brief explanation of Brazil's complex tax system.

> Ricardo: To make it easier, we should set a value, a percentage.
>
> Marcos: A percentage over the amount of money a player has.
>
> Ricardo: Yeah, the total money the player has!
>
> Marcos: 20% more or less?
>
> Lucas: No, no. I think it's a lot. Shall we put 10%?
>
> Ricardo: The game must teach something to the players. Let's assume 20%.
>
> Lucas: I think 20% is too much!
>
> Ricardo: Bro, you will lose 1/5 of your cash. It will be great!
>
> Adriano: I suggest that the player must pay according to the product's level. For example, if you have access to Product 1, you pay 10%. If you have access to Product 2, you pay 15%. If you have access to Product 3, you pay 25%.
>
> Lucas: Come on, 25?! No. Not 25, 20! 20, I agree.

The team decided to create new cards with the taxes reflecting the pre-agreed product level rates (10%, 15%, and 20%). Lucas proposed incorporating a specific Brazilian tax (related to the circulation of goods, interstate and intercity transportation, and communication services) to heighten the game's realism. After weighing the complexity this could introduce, Ricardo and Adriano convinced Lucas to abandon his idea. The focus then shifted to managers' roles. In sync with Paulo's previous conversation about cost increases through higher managerial salaries, the group agreed that respective manager salary boosts should compensate for advancements in marketing mix levels. While aiming to inhibit monopolies by imposing costs on companies, this decision simultaneously underlined the importance of human capital.

The discussion then turned to the production system. Paulo proposed allowing players to exceed the 10 units per turn production limit upon product level enhancement. Ricardo, as before, used mental simulation to envision how such a change could affect the overall game dynamics and worsen the issue (monopoly) they were trying to address.

> Ricardo: What prevents a player from making many sales? The inventory. Players have to wait for several rounds to accumulate enough inventory for multiple sales. Changing this rule would allow players to easily

> form a monopoly by passing all raw materials to the outbound area and then making several sales. It would harm everyone. I wouldn't make that change. It disrupts the entire game system.

In a final attempt to avoid monopolies, the team decided to incorporate a house rule observed in some gameplay sessions. After choosing to sell, players are limited to selling in their subsequent decisions. Such a restriction prevents successful players from using their sales proceeds to purchase a large number of raw materials pieces in the same turn, effectively preventing the formation of a monopoly.

Discussion

Traditional design thinking pedagogy is often characterized by linear steps such as empathize, define, ideate, prototype, and test. While effective in conveying the basics, such methods have been criticized for oversimplifying the inherently complex design process (McCullagh, 2013; Sosa, 2015) and failing to fully embrace the ambiguity needed for creative exploration (Meinel & Leifer, 2012).

In contrast, our approach diverges from these prescriptive methodologies by incorporating the principles of constructionism through game modding. Game modding, as a teaching strategy, fosters an experiential learning environment that emphasizes cognitive acts such as framing, abductive reasoning, analogical reasoning, and mental simulations (Garbuio et al., 2018). This empowers students to construct their own understanding of design and entrepreneurship, deploying their sociocultural backgrounds and interdisciplinary knowledge to make learning both engaging and personally relevant.

By using game modding, we create a pedagogical environment that emulates the entrepreneurial journey. As we examine the design process, exemplified in Figure 3 by the initial stages, we noticed that students actively frame problems, explore ideas, construct meaning, and verify propositions, thereby navigating complex challenges in a non-linear manner—an essential skill for real-world business scenarios. Through framing, they learn to identify and define key challenges, cultivating the ability to distill complex scenarios into manageable strategies. Abductive reasoning encourages creative and plausible hypotheses, essential for navigating uncertainty in entrepreneurship. Analogical reasoning enables students to draw connections between personal experiences and business problems, fostering the development of novel, interdisciplinary solutions. Mental simulations further support iterative refinement, allowing students to visualize outcomes and enhance decision-making.

This approach has significant implications for entrepreneurship education. First, it emphasizes problem-identification skills, guiding students to understand core challenges before jumping to solutions (Norman, 2013). Second, it encourages creativity and innovation by challenging traditional perspectives and exploring novel possibilities. Third, the iterative refinement of ideas promotes reflective thinking, critical for adapting to the dynamic nature of business. Finally, it emphasizes systems thinking, highlighting the interconnected nature of decisions and teaching students to approach entrepreneurial challenges holistically. Together, these elements prepare students to navigate the complexities and uncertainties inherent in entrepreneurship.

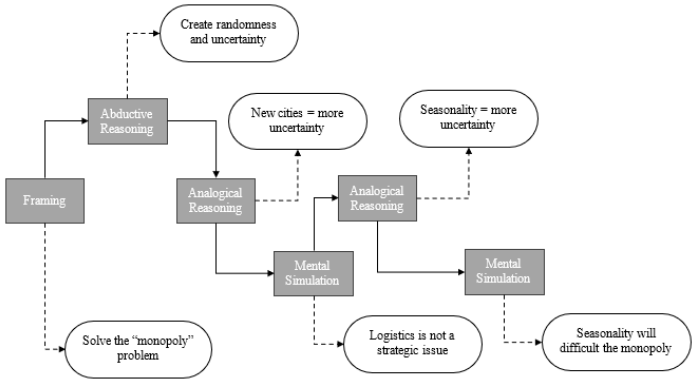

Figure 3. Initial stage of the design process.

Overall, game modding allows students to become more aware of the design process, helping them foster a mindset that values iterative exploration and adaptability—qualities that are indispensable for aspiring entrepreneurs.

Building on these cognitive design acts, constructionism, as a pedagogical foundation, further supports our approach by recognizing the significance of students' sociocultural context and interdisciplinary integration in shaping their learning experiences and outcomes. Interdisciplinarity is critical in constructionism, as it promotes the integration of multiple disciplines and perspectives into the learning process. This approach encourages learners to explore connections between various subjects, fostering a comprehensive understanding of complex issues (Kafai, 1995). Real-world problems often require an interdisciplinary perspective, and the game modding task allowed students to adopt a holistic view, drawing from multiple fields to enhance their sociocultural analogies. This perspective, integral to design thinking and entrepreneurship education, contrasts with traditional, compartmentalized educational approaches that are common in business schools (Welsh & Dehler, 2013).

By integrating multiple disciplines, learners develop the ability to analyze and address complex problems that transcend single disciplinary boundaries (Pfeffer & Fong, 2004). Interdisciplinary thinking fosters creativity and innovation in problem-solving by encouraging consideration of diverse perspectives and solutions. For instance, during discussions about seasonality, students combined insights from operations management, marketing, and economics, as well as their personal consumer experiences. This integrated approach provided them with a broader understanding of the impact of seasonality, making it more meaningful and effectively integrating it into the game design.

Our findings indicate that the sociocultural context was instrumental in generating analogies and design ideas (see Table 4). Personal elements, such as places of residence, market assumptions, and favourite holidays, prominently featured in students' discussions, underscoring the role of

sociocultural experiences in shaping the design process. By linking an artifact to the students' cultural context, their knowledge becomes more meaningful, relatable, and applicable. This approach enables students to integrate their prior knowledge and experiences with new concepts, leading to a more profound understanding of entrepreneurial activity (Kafai, 2006b).

Table 4. Discussed design ideas.

Idea	Author	Argument	Presented Criticism	Discipline	Result
New maps with new cities (new main board)	Paulo	Create randomness in demand and a new localization strategy	Require time to produce and new macroeconomic cards Do not represent a meaningful change to avoid the monopoly Localization is not an important asset in the strategy of the game	Logistics Marketing Strategy	Discarded
Change customer expectations every three rounds	Lucas	Create randomness in demand	Difficult to implement	Economics Marketing Operations Management	Implemented
Create four new macroeconomic cards	Lucas	Keep the game in 20 rounds	Gameplay takes time; 16 rounds could speed up gameplay	Economics	Implemented
New cards representing income tax	Paulo	Reduce companies' profitability	Companies can bankrupt with these cards in the game	Law Accounting	Implemented
New cards representing ICMS	Lucas	Reduce companies' profitability	Increase complexity	Law Accounting	Discarded
Seasonal card *Children's Day*	Lucas	Represent Seasonality	It is not an international holiday	Marketing	Discarded
Idea	Author	Argument	Presented Criticism	Discipline	Result
Seasonal card *Christmas*	Lucas	Represent Seasonality	It might not correspond to the time in the game	Marketing	Discarded
Play with more than one map (two countries with different economies)	Lucas	Create randomness in demand and a new localization strategy	Increase complexity	Economics Marketing	Discarded
New models to transport goods	Paulo	New localization strategy	Increase complexity	Logistics	Discarded
Increase managers' salaries according to market mix level	Paulo	Reduce companies' profitability	Difficult to implement	Human Resources	Implemented
Remove constraint in the production system	Paulo	Improve the production volume	It will change the system completely since the production constraint limited companies' revenue	Operations Management	Discarded
After deciding to sell, the player cannot do anything else (just sell)	House rule	Reduce companies' revenue	Constrain decision-making	None	Implemented

Conclusion

To address the research question, 'How can game modding support the development of business students' cognitive perspective in design?' we propose that game modding serves as a useful pedagogical tool to foster essential cognitive processes in design thinking, particularly within a business education context. Game modding helps develop business students' cognitive perspective by creating an experiential learning environment emulating the entrepreneurial journey.

Our findings demonstrate that design thinking, mediated by cognitive acts such as framing, abductive reasoning, analogical reasoning, and mental simulations, enabled students to reproduce their conceptual representations within the game. These representations were deeply informed by students' sociocultural contexts and multidisciplinary reasoning, highlighting the value of incorporating diverse perspectives into the design process.

We argue that reconceptualizing design thinking as a cognitive process mediated by game design creates opportunities for students to engage in reflective practice. Unlike the traditional stepped or "ready-to-use toolbox" approach to design thinking (Johansson-Skoldberg et al., 2013), this pedagogical intervention encourages students to think critically and deeply about their own problem-solving methods. Such reflection allows students to develop a nuanced understanding of the complexities underlying entrepreneurial challenges.

The implications of our findings align with a growing body of literature linking games and game design with competency development (Clark et al., 2016; Connolly et al., 2012; Jabbar & Felicia, 2015; Kim & Bastani, 2017; Vandercruysse et al., 2012). From a constructionist perspective, this approach positions students as creators of knowledge (Kafai, 1995; Rahimi & Kim, 2021), rather than passive consumers. As games are "problem-solving spaces designed to engage players" (Gee & Hayes, 2012, p. 129), this intervention helps students develop a language to think about business concepts (Squire, 2012) while cultivating the cognitive and adaptive skills necessary for entrepreneurial success.

However, challenges in implementing this approach must be acknowledged. First, students' lack of design expertise may lead to surface-level engagement with the system represented by the game. For example, while students framed their design problem as the monopoly, their solutions focused on adding constraints rather than addressing the internal relationships (e.g., between game objects and attributes) that underpin the monopoly. This limitation reflects the need for higher critical thinking skills and a deeper understanding of the underlying content to effect more systemic change (Rahimi & Kim, 2019).

Second, the adoption of game-based learning introduces challenges for educators. Students accustomed to traditional instruction may resist new pedagogies that embrace ambiguity, iterative problem-solving, and the absence of right-versus-wrong answers (Garbuio et al., 2018). This resistance is often rooted in the narrow, exam-oriented mindset that dominates traditional academic structures (Günzel-Jensen & Robinson, 2017). For novice educators, navigating students' frustrations and managing their expectations are critical skills for successfully implementing design-based interventions.

Despite these challenges, the findings of this study illustrate the potential for game design to transform entrepreneurship education. Further studies might also explore the integration of methodologies like Lego Serious Play® into board game usage. This method leverages three-dimensional media to facilitate strategic reflection and creative problem-solving (Bürgi et al., 2005; O'Brien, 2019; Roos et al., 2004). Game design shares these characteristics and could potentially extend the benefits of such methodologies. However, the craft aspect of game design, linked to the hand-mind relationship (Roos et al., 2004), was not examined in the current study.

Research could also investigate games as embodied metaphors, produced by students in the role of game designers. This concept encompasses both the iterative creation process of a tangible metaphorical object and the resultant physical metaphor, which can serve as a powerful

tool for sense-making (Heracleous & Jacobs, 2008). Such studies could shed light on how students formulate and interpret new concepts, fostering critical reflection on their learning processes.

Ultimately, integrating game design into entrepreneurship education offers a promising pathway to cultivate adaptive, innovative, and resilient future entrepreneurs.

Appendix

Entrepreneurial Thinking is a game for four players who compete as owners of industrial companies in a market represented on the main board (Figure 4). The main board depicts two provinces in Canada with eight cities connected by roads. The cities have information on the cost of building offices, factories, and warehouses and will receive markers that inform the customers' expectations (product quality and price). Offices, factories, and warehouses are essential to the company's operations. At the end of 24 rounds, the company that exhibits the highest capital wins the game.

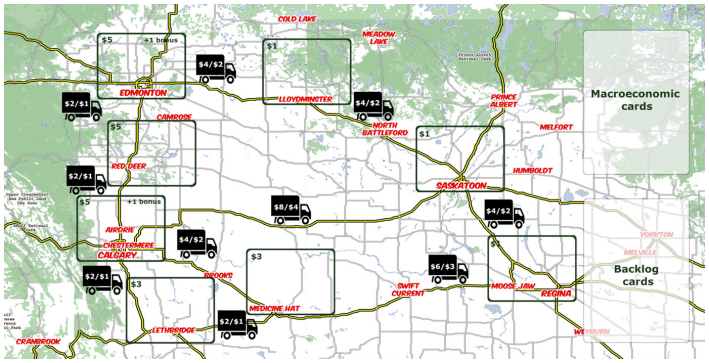

Figure 4. The main board.

The cities receive a demand marker representing customer expectations regarding product quality and willingness to pay for it. Customer expectations are also expressed by levels (from 1 to 3) for both Product and Price (Figure 5). All customers' expectations are unknown (placed face down) and must be revealed by paying for marketing research.

Figure 5. Examples of demand customer expectation) markers.

The players' boards

A personal board portrays the player's company (Figure 6). The company evolves based on players' strategy, managers hired, and investment capacity. The strategy is represented by the four P's of marketing (product, price, promotion and place). There are three levels to each component of the marketing mix. The lowest quality the business may provide, for instance, is represented by the first level of Product (level 1). To increase a product's quality, the company must improve the product's level to levels two or three. Players' chances of selling and/or becoming more lucrative rise as their marketing mix develops.

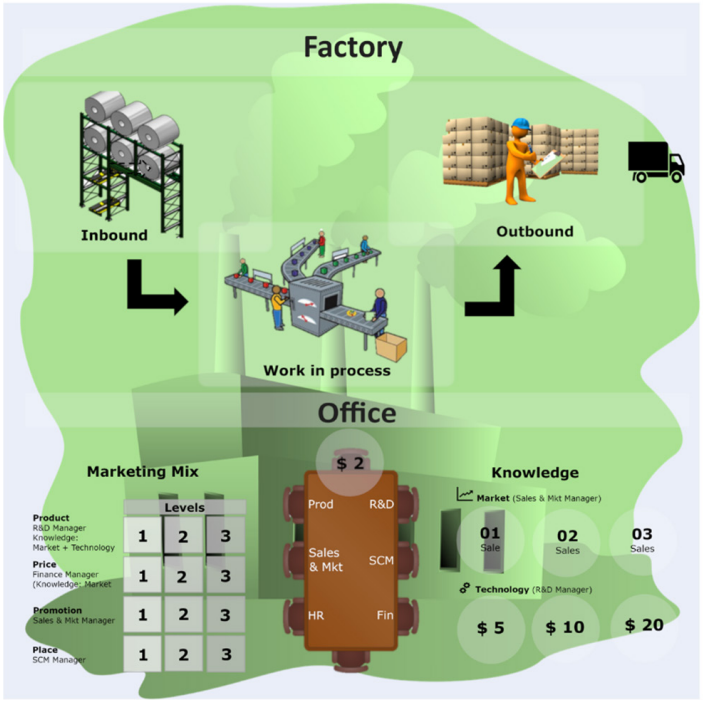

Figure 6. One of the player's boards.

However, to evolve their marketing mix, players must hire executives and/or increase organizational knowledge about the market and technology. Hiring managers is also an important decision in improving operational performance. This game's mechanism also encourages students' reflection on the importance of teamwork and cooperation. Executives such as supply chain managers allow companies to perform better in distribution, finance managers help in the pricing process, and research and development (R&D) managers work in product development. Table 5 summarizes the executive competencies.

Table 5. Manager skills.

Manager	Competencies
Human Resources (HR)	Allows a player to hire more than two managers.
Research & Development (R&D)	Allows a player to upgrade the Technology Knowledge and Product level.
Finance	Allows a player to upgrade Price level.
Sales & Marketing	Makes it possible to sell in different cities, upgrade the Market Knowledge, and the Promotion.
Production	Speeds up the production system (two movements with one decision).
Supply Chain Management (SCM)	Reduces the cost of shipping, allows a player to build a distribution center or contract Third-Party Logistics, and upgrades the Place level.

Decision-making

To start the game, every player receives 10 dollars. However, players have access to additional funding options, including bank loans and the chance to pitch their business to potential investors. Players have up to four decisions to meet market demand, assure profitability, and surpass rivals during their turn. Topics such as investment, marketing, strategy, knowledge management, human resources, production

management, selling, distribution, and negotiations are examples of player decisions (Table 6).

Table 6. Examples of decisions in the Entrepreneurial Thinking game.

Areas	Examples of decisions
Finance	Increase the product price
	Borrow money from the bank
Human Resources	Hire executives to improve business processes, such as a Production
	Manager or Marketing and Sales Manager
	Lay off executives to save money
Operations	Buy raw materials
	Produce finished goods units
Marketing	Improve product quality
	Improve product promotion
Strategy	Focus the business in one city
	Try to expand the business to other cities
Sales	Sell in the current city
	Sell in another city

Demand and the market environment can alter, much like in real life, in response to economic developments revealed by macroeconomic cards (Figure 7) drawn from the deck before the start of a new round. Players, as entrepreneurs, must adapt their strategies to respond to these events.

On their personal board, players also run the factory by purchasing raw materials, producing, and sending the finished goods to the dispatch area (respecting the processing times). The raw materials must be received by players in their "Inbound" area. They can decide to transfer them to the "Working in process" area on the following round, and only then will they have finished items in the "Outbound" area. However, the Production Manager can allow a player to speed up the production process.

A limited number of little cubes in different colours for each stage represent the raw materials. Level 1 has 80 pieces ($1 each), Level 2 has 40 pieces ($2 each), and Level 3 has 20 pieces ($3 each) of the raw material to make finished goods. Levels 2 or 3 of raw materials can only be purchased if the marketing mix area reflects those levels. The player must possess the corresponding raw material level to make a finished good (Level 1 raw materials only yield Level 1 goods, etc.). The finished good is produced from one unit of raw material.

Product selling via a stochastic game mechanism

Product selling requires adherence to the supply-demand matching card (Figure 8). A player's supply is determined by their Product and Price levels in the marketing mix, while demand relies on customer expectation markers in cities. The matching cards provide information on the required dice roll to determine units sold and the resulting price per unit. Four dice options are available: D4 (a four-side die), D6 (a six-side die), D8 (an eight-side die), or two D6.

For example (Figure 8), if a player wants to sell a Product level 1 at Price level 1 in a city where the customer expectation marker shows Product Level 2 and Price Level 2, the player

Figure 7. Example of macroeconomic card.

consults the supply-demand matching card for their Product Level 1 offer. They locate the relevant customer expectation column (Level 2 for Product and Price) and the corresponding Price level column (Level 1). The intersection of these columns indicates that the player needs to roll a D4 to determine units sold and will receive $3 per unit.

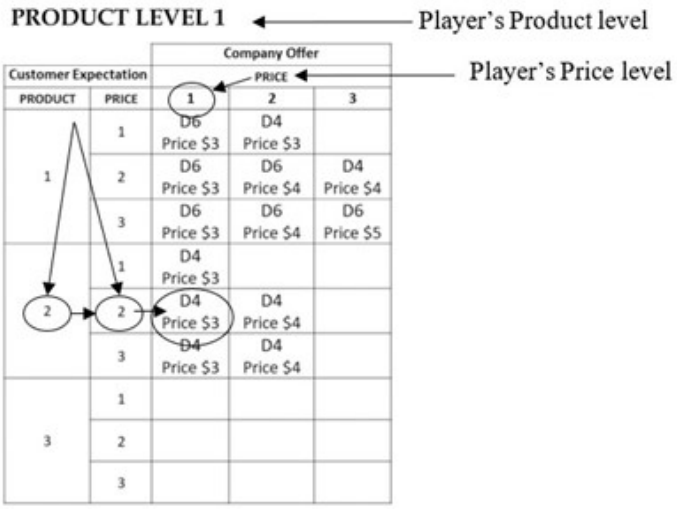

Figure 8. Supply–demand matching card example.

Exceeding inventory quantity when selling units results in a proportional backlog marker. The player must then draw a backlog card and follow the instructions. Back-ordered units must be addressed and fulfilled once the player has

sufficient completed goods in their inventory.

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