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A GAME TO TEACH AND APPLY DESIGN THINKING FOR INNOVATION

UM JOGO PARA ENSINAR E APLICAR O DESEIGN THINKING PARA INOVAÇÃO

UN JUEGO PARA ENSEÑAR Y APLICAR EL DESIGN THINKING EN LA INNOVACIÓN

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Abstract

Objective: Develop and apply a game to facilitate the use of design thinking for innovation.

Method: The construction of the game was based upon the Constructivism Theory. The game was developed following the steps of: (i) understanding the target audience and the context; (ii) defining learning objectives; (iii) structuring the experience; (iv) identifying resources and applying gamification elements; (v) evaluation.

Originality/Relevance: Design Thinking emerges as an alternative to improve the innovation process in companies. To facilitate this innovation process, this paper presents a game, through its development and application, based on the principles and stages of Design Thinking, focusing on difficulties of its implementation.

Results: The game provides an iterative passage through all stages of the design thinking, giving a holistic view of the process, starting with a deep understanding of the problem, and coming to a design solution.

Social / management contributions: The results of the game application have shown its potential to: (i) ease teamwork, avoiding negative discussions and providing active participation from all students; (ii) lead to insight generation in a comprehensible way, making clear the difference between insights and ideas; (iii) simplify the use of inspiring methods and techniques (such as Persona, Empathy Map and Napkin Pitch); (iv) develop creative confidence; (v) provide a pleasant and motivating learning environment for collaborative multidisciplinary work.

Theoretical/Methodological contributions: The game provides a method for building serious games and the game as a method of applying Design Thinking for Innovation.

Keywords: Innovation. Design. Design thinking. Game.

Resumo

Objetivo: Desenvolver e aplicar um jogo para facilitar o uso do design thinking para inovação.

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Método: A construção do jogo foi baseada na Teoria do Construtivismo. O jogo foi desenvolvido seguindo as etapas de: (i) compreensão do público-alvo e do contexto; (ii) definir objetivos de aprendizagem; (iii) estruturação da experiência; (iv) identificar recursos e aplicar elementos de gamificação; (v) avaliação.
Originalidade / Relevância: O Design Thinking surge como alternativa para melhorar o processo de inovação nas empresas. Para facilitar esse processo de inovação, este artigo apresenta um jogo, por meio de seu desenvolvimento e aplicação, baseado nos princípios e etapas do Design Thinking, com foco nas dificuldades de sua implementação.
Resultados: O jogo fornece uma passagem iterativa por todas as fases do design thinking, dando uma visão holística do processo, começando com uma compreensão profunda do problema e chegando a uma solução de design.
Contribuições sociais / gerenciais: Os resultados da aplicação do jogo mostraram seu potencial para: (i) facilitar o trabalho em equipe, evitando discussões negativas e proporcionando a participação ativa de todos os alunos; (ii) levar à geração de insights de forma compreensível, deixando clara a diferença entre insights e ideias; (iii) simplificar o uso de métodos e técnicas inspiradoras (como Persona, Empathy Map e Guardanapo); (iv) desenvolver confiança criativa; (v) proporcionar um ambiente de aprendizagem agradável e motivador para o trabalho multidisciplinar colaborativo.
Contribuições teórico-metodológicas: O jogo fornece um método para a construção de serious games e o jogo como método de aplicação do Design Thinking para a inovação.

Palavras-chave: Inovação. Design. Design thinking. Game.

Resumen
Objetivo: Desarrollar y aplicar un juego para facilitar el uso del Design Thinking para la innovación.
Método: La construcción del juego se basó en la Teoría del Constructivismo. El juego se desarrolló siguiendo los pasos de: (i) comprender al público objetivo y el contexto; (ii) definición de objetivos de aprendizaje; (iii) estructurar la experiencia; (iv) identificación de recursos y aplicación de elementos de gamificación; (v) evaluación.
Originalidad / Relevancia: El Design Thinking surge como una alternativa para mejorar el proceso de innovación en las empresas. Para facilitar este proceso de innovación, este trabajo presenta un juego, a través de su desarrollo y aplicación, basado en los principios y etapas del Design Thinking, enfocándose en las dificultades de su implementación.
Resultados: el juego proporciona un pasaje iterativo a través de todas las etapas del Design Thinking, brindando una visión holística del proceso, comenzando con una comprensión profunda del problema y llegando a una solución de Design.
Contribuciones sociales / de gestión: Los resultados de la aplicación del juego han demostrado su potencial para: (i) facilitar el trabajo en equipo, evitar discusiones negativas y proporcionar una participación activa de todos los estudiantes; (ii) conducir a la generación de conocimientos de una manera comprensible, dejando clara la diferencia entre conocimientos e ideas; (iii) simplificar el uso de métodos y técnicas inspiradoras (como Persona, Empathy Map y Napkin Pitch); (iv) desarrollar la confianza creativa; (v) proporcionar un entorno de aprendizaje agradable y motivador para el trabajo multidisciplinario colaborativo.
Contribuciones teóricas / metodológicas: El juego proporciona un método para construir juegos serios y el juego como método de aplicación del Design Thinking para la innovación.

Palabras clave: Innovación. Design. Design thinking. Juego.

1 Introduction

Even before the presentation of design thinking as an approach for innovation (Brown 2008), some authors (Buchanan 1992; Ho 2001; Liu 1996) already used the term as a way of thinking that was part of the Design discipline. Lloyd (2017) highlights design thinking as more

than a method since it has emerged and spread beyond the traditional disciplines of Design and can be used to stimulate creativity and to solve problems – which are important cognitive skills for the 21st century (Akcaoglu 2014; Hwang, Wu & Chen 2012).

Design thinking is a human-centered process, with emphasis on the deep understanding of consumers, targeted at the innovation of products, services, processes, and businesses in a holistic, integrative, creative, and inspiring way. Design thinking translates observations into insights and insights into innovation through an exploratory, iterative, and non-linear process, which leads to unexpected discoveries since the process is fundamentally exploratory. Design thinking is supported by themes that form its mentality: empathy, curiosity, collaboration, experimentation, visualization, flexibility, and continuous learning (Akili 2015; Andreassen et al. 2016; Buchanan 1992; Brown 2008; Brown & Katz 2009; Brown & Martin 2015; Carlgren et al. 2016; Gleason & Cherrez 2020; Davis 2010; Dorst 2011; Ferreira et al. 2015;Goodspreed et al. 2016; Holloway 2009; Hussaini & Vinnakota 2015; IDEO 2015; Jiao & Zhang 2015; Johansson & Woodilla 2009; Koliji 2016; Leverenz 2014; Liedtka 2014; Liedtka e Ogilvie 2011; Lockwood 2009; Luchs et al. 2016; Olsen 2015; Rylander 2009; Uehira e Kay 2009; Sato et al. 2010; Stickdorn & Schneider 2011; Sköldberg et al. 2013; Seidel e Fixson 2013; To & Liu 2021; Vianna et al. 2012; Ward et al. 2009).

Based on the importance of design thinking, it should be integrated with models of learning and knowledge production (Burdick and Willis 2011). However, even though Brown and Katz (2009) state that design thinking is a simple and accessible approach, there are some obstacles for its teaching in practice. In addition to these obstacles, there is a gap between academic contents and the needs, interests, and motivations of students in the learning process, as discussed by Barab, Thomas, Dodge, Carteaux & Tuzun (2005). Cross (1982) already stressed that education should be deliberately designed to increase and develop students' cognitive process and abilities. Schon (1987), in the same context, emphasizes that learning by doing helps developing abilities related to continuous learning and problem solving. Oxman (2004) states that encouraging experimentation through methods of experimental teaching can make knowledge become more accessible and possible.

In a historical context involving design, games, and learning, Talbot (1973) proposed the GRIPS (Gaming Random Interfacing and Problem Structuring) approach for the solution of teaching problems. From the point of view of education and learning, Habraken and Gross (1988) developed a series of games and identified that games provide an adequate environment to work in groups, allowing the isolation of concepts and helping to transform complex questions in simple results. The same authors state that games are a useful way to learn both

theory and methods of design. Recently, Shih Hu & Chen (2006) developed an approach to analyze cooperative learning based on games and have concluded that group activities, using games, provide support for cooperation among the participants, which contributes to better results. Some games have already been developed exclusively for education in Design. Shih et al. (2006) developed the Prisoner's Dilemma game aiming to analyze complex cooperation and competition behaviors in design studios. McCain (2014), who presented the game theory, affirms that experimental methods focused on personal interactions are a powerful source of insight generation. Eppler (2016), recently, proposed the Dynagrams, which are visual tools that offer more than just summarized information since they help to bring attention to the discussion. Patrício et al. (2020) used gamification to implement Design Thinking in companies and found that gamification helps to improve practices, collaboration and engagement in these processes.

Based on the mentioned issues, the present study proposes a game to teach design thinking based on the education games development process, that seeks to reach theoretical and practical learning objectives. This game is consistent with the design thinking principles and contributes to overcoming the difficulties for its application. Thus, this paper is organized as follows: section 2 presents a study on the design thinking stages and principles; section 3 discusses the difficulties for teaching design thinking; section 4 presents the methodological procedures used to develop the game; section 5 describes the game for teaching design thinking; section 6 shows the results and discussion of the application of the proposed learning game; and section 7 summarizes conclusions.

2 Design thinking stages and principles

Based on the approaches identified in the design thinking literature review, it was possible to observe that, although authors present some stages differently, they describe the same activities or purposes. Thus, the design thinking stages were translated into three macro stages (inspiration, ideation, and prototyping and testing), and five stages: (i) exploration, (ii) insight definition, (iii) idea generation, (iv) idea refinement and (v) prototyping and testing (Table 1).

To support these stages, design thinking can be translated into eight principles: (i) iterate, (ii) immerse yourself, (iii) empathize, (iv) be intuitive; (v) be visual, (vi) inspire, (vii) be generative, (viii) prototype and (ix) be creative confident.

Table 1

Design thinking stages and description

Stages	Description	Authors
1. Exploration	This stage deeply explores the factors associated to people and contexts.	Brown & Katz 2009; Davis 2010; IDEO 2015; Liedtka & Ogilvie 2011; Seidel & Fixson 2013; Sitckdorn & Schneider 2011
2. Insight Definition	This stage defines and identifies the problem, pointing to opportunities that will lead the search for a design solution.	Brown & Katz 2009; Carlgren et al. 2016; Ferreira et al. 2015; IDEO 2015; Luchs 2016
3. Idea Generation	This stage involves the generation, development, and testing of ideas in the search for design possibilities and solutions.	Brown & Katz 2009; Johansson & Woodilla 2009; ; IDEO 2015; Kelley & Kelley 2015; Liedtka & Ogilvie 2011; Olsen 2009; Sköldberg et al. 2013; Stickdorn & Schneider 2011
4. Idea Refinement	It involves the selection and reduction of ideas to a lower, manageable number.	Brown 2009; Liedtka & Ogilvie 2012; Luchs 2016; Olsen 2015
5. Prototyping and Testing	This stage moves from ideas (abstract) to concrete design solutions	Brown 2009; Jiao & Zhang 2015; Liedtka & Ogilvie 2012; Seidel & Fixson 2013

Source: Created by the authors.

Iterate comprises working in cycles in a non-linear, emergent, divergent, collaborative, and flexible process that facilitates and reduces the innovation development time. (Akili 2015; Brown & Katz 2009; Brown & Martin 2015; Carlgreen et al. 2016; Ferreira, Song, Gomes, Garcia & Ferreira 2015; Goodspeed et al. 2016; Holloway 2009; Hussaini & Vinnakota 2016; Leverenz 2014; Liedtka 2014; Liedtka & Ogilvie 2012; Luchs 2016; Olsen 2015; Rylander 2009; Sato 2009; Sato, Lucente, Meyer & Mzarek 2010).

Immerse yourself comprises promoting a deep immersion, understanding the context of the problem, knowing the current reality regarding the environment, social factors, market trends, and the ways that people deal with the problem, coping with the real world natural complexity, questioning as many things as possible concerning the researched theme, looking beyond the immediate boundaries of the problem, searching for the roots of the problem, being curious and expecting to find the unexpected (Akili 2015; Brown & Katz 2009; Davis 2010; Ferreira et al. 2015; Holloway 2009; Liedtka & Ogilvie 2011; Luchs 2016; Olsen 2015; Rylander 2009; Sköldberg et al. 2013; Vianna, Vianna, Adler, Lucena & Russo 2012).

Empathize involves the comprehension of the user's perspective (empathy), putting oneself in the user's position to deeply understand their needs, wishes, thoughts, feelings, experiences, interactions, and behaviors, including extreme users (Andreassen et al. 2016;

Brown & Katz 2009; Brown & Martin 2015; Carlgren et al. 2016; Goodspeed et al. 2016; Holloway 2009; IDEO 2015; Liedtka & Ogilvie 2012; Luchs et al 2016; Olsen 2015; Rylander 2009; Uehira & Kay 2009; Ward, Runcie & Morris 2009).

Be Intuitive is the creative integration of the information gathered, synthesizing data, and making new connections between the elements involved. Intuition is a condensation of pieces of information through a process of rapid thinking that relates past experiences to important information of the present moment, not necessarily going through cognition processes (Cervo & Brevian 2002; Davis 2010; Sato et al. 2010). Intuition is connected to the creative capacity and, when stimulated, facilitates insight generation (Brown & Martin 2015; Cervo & Brevian 2002; Olsen 2015;).

Be Visual comprises making ideas visual, developing a common view of the proposed solutions, helping knowledge and concept externalization. The use of visual representations is important since it makes the expression of complex thoughts easier, demonstrating relations and creating a common view between the team members (Buchanan 1992; Carlgren et al. 2016; Ferreira et al. 2015; Holloway 2009; Liedtka & Ogilvie 2011; Luchs 2016; Olsen 2015; Rylander 2009; Sato et al. 2010; Ward et al. 2009).

Inspire involves team motivation and must be done through insight generation, which will point to new perspectives that converge to the problem solution (Brown & Katz 2009; Buchanan 1992; Goodspeed et al. 2016; Liedtka 2014; IDEO 2015; Luchs 2016; Sköldberg et al. 2013; Stickdorn & Schneider 2011; Ward et al. 2009).

Be Generative contemplates the structured and systematic way of thinking, based on the creative confidence (Kelley & Kelley 2015), balancing intuition and the analysis of the data obtained in the exploratory process, associating words, exploring new concepts, and integrating new ideas to the existing ones. The higher the number of ideas, the better (Akili 2015; Andreassen et al. 2016; Brown & Katz 2009; Carlgren et al. 2016; Davis 2010; Dorst 2011; Holloway 2009; Hussaini & Vinnakota 2015; Koliji 2016; Liedtka & Ogilvie 2011, 2012; Luchs 2016; Rylander 2009; Sato et al. 2010; Olsen 2015; Ward et al. 2009).

Prototyping involves testing ideas, using the experiment results and constant user feedback to improve the solution. This should be supported by simple prototypes with low detail level, but sufficient to test the concepts. (Brown & Katz 2009; Brown & Martin 2015; Carlgren et al. 2016; Davis 2010; Goodspeed et al. 2016; IDEO 2015; Jiao & Zhang 2015; Liedtka 2014; Liedtka & Ogilvie 2011; Luchs 2016; Olsen 2015; Stickdorn & Schneider 2011).

Be Creative Confident regards the creative integration of information through the ability of creating new connections, leading to new paths and possibilities. Kelley and Kelley (2015)

use the term creative confidence as a way to express the importance of creativity to accomplish successful innovation. Those who have creative confidence have characteristics, such as believing in the creative potential, in the capability of finding solutions to apparently impossible problems, exploring new possibilities, and easily changing directions (Seidel & Fixson 2013; Vianna et al. 2012).

3 Difficulties in teaching design thinking

As presented in the introduction, even though design thinking seems to be a simple and accessible approach, in practice there are some major obstacles for its teaching. Among these obstacles (or difficulties) some can be highlighted: (i) reaching a holistic view of the design thinking process (Noweski et al., 2012; Earle & Hiz, 2020); (ii) understanding the difference between insights and ideas (Brown; Katz, 2009; IDEO, 2015; Sato et al., 2010; Liedtka, 2014; Vianna et al., 2012); (iii) using methods and techniques at the right moment (Sköldberg et al., 2013; Liedtka, 2015; Carlgren et al. 2016); (iv) the gain of creative confidence associated with real gains in creativity (Rao et al., 2021). Besides that, there are two other elements that must be considered for the effective learning process: (i) motivation (Collins, 1992; Hwang et al., 2012;) and (ii) experimentation (Barab et al., 2005).

Regarding the lack of holistic view, Noweski et al. (2012) states that when a system is presented as a whole, it is necessary to understand each one of the parts that compose it. The traditional teaching way is still targeted at explaining the parts without fully approaching the system, which makes it difficult for students to connect themes and topics.

Concerning the problem of understanding the difference between insights and ideas, the insights, differently from the ideas, are the findings that come from problem immersion and from the identification of an opportunity and must be revealing and inspirational, motivating people for a subsequent moment, which is the idea generation process. Insights are obtained through connections made from the information obtained in the exploratory process of design thinking and, later, will be the foundation for idea building. Ideas (which can emerge from one or more insights), however, are alternatives for the solution, feasible or not, that will later culminate in results through a convergence process (Brown & Katz 2009; IDEO 2015; Liedtka 2014; Sato et al. 2010). In the idea generation process, Jobst, Köppen, Lindberg, Moritz, Rhinow & Meinel (2012) highlight the importance of developing the students' creative confidence by using design thinking, but they question which methods and techniques would establish this creative confidence. This leads to the last difficulty aforementioned, regarding the

use of methods and techniques at the right moment. Carlgren et al. (2016) and Liedtka (2015) point that design thinking is a difficult and controversial concept to be studied due to its multifaceted nature and the lack of coherence between what DT is in academic terms and in practical terms. Furthermore, design thinking is frequently seen only as a method or a group of tools and methods by practitioners and researchers (Liedtka 2015; Sköldberg et al. 2013).

Thus, motivation is an essential element, because it includes understanding the needs and interests of the students, challenging them to answer questions and solve problems, engaging them in real world activities (Barab et al. 2005; Burdick & Willis 2011). Barab et al. (2005) argues that the education community developed a lot of studies focused on contents to support the learning process, however these studies do not necessarily capture students' interests and motivations. The interest, motivation and engagement in real world activities is more easily achieved by experimentation. Experimentation enables learning by doing, through the practice, action, and reflection about what has been done, understanding the impact on the results generated (Barab et al. 2005; Hwang et al. 2012; Schon 1987).

4 Method

Hwang et al. (2012) highlight the need to incorporate learning theory in the development of games for learning. The construction of the game was based upon the Constructivism Theory. The adequacy of the use of Constructivism for the development of games aimed at learning is verified in the literature (Barzilai & Blau 2014; Kordaki & Gousiou 2017; Li & Tsai 2013; Qian & Clark 2016). According to Constructivism, education must be experimental and experiential (Huang 2011). The *learners* will actively construct knowledge through their experiences (Huang, Huang & Tschopp 2010). Thus, the emphasis of the game must be in the learning environment and not in a sequence of instructions (Johansen 1994).

According to the Constructivist Theory, the use of groups during the learning job will enable learners to share knowledge, contributing to learning (Assaraf 2011). Within this perspective, the role of the teacher is not only to transmit information, but to act as a facilitator of the learning process (Bell, Maeng & Binns 2013; Palmer 2005).

4.1 Game development process

The game was developed based on the games for education development process proposed by Huang & Soman (2013). The five steps proposed by Huang & Soman (2013) were grouped into four, and a new evaluation step was introduced. The two final steps of the model

proposed by Huang & Soman (2013) were grouped in the step of identifying resources and applying gamification elements. The evaluation of the games developed is one of the limitations found in the literature of game development (Dichev & Dicheva 2017; Faiella & Ricciardi 2015; Hanus & Fox 2015; Hernández, Baroni, Bieger, Chmait, Dowe, Hofmann & Thórisson 2017; Petri & Wangenheim 2017). In view of that, an evaluation step was inserted with the aim to assess the results of the game development project. Therefore, the game was developed following the steps of: (i) understanding the target audience and the context; (ii) defining learning objectives; (iii) structuring the experience; (iv) identifying resources and applying gamification elements; (v) evaluation.

In the first step of the process, the profile of the students (learners) that would participate in the game was defined, as well as the formation of the groups and their sizes. Besides that, the environment and the time duration of the game were defined.

The learning objectives were defined following Bloom's Revised Taxonomy (Krathwohl 2002). This taxonomy defines the learning objectives in terms of the dimensions of cognitive processes and knowledge. The cognitive dimension process is subdivided into six categories (Anderson & Krathwohl 2001): (i) remember, (ii) understand, (iii) apply, (iv) analyze, (v) evaluate and (vi) create. While the knowledge dimension encompasses the dimensions of factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge (Anderson & Krathwohl 2001).

Table 2

Profile of the workshop participants for the experience structuration

Participants	Background	Field of work	Profession	Experience	Institution
1	Industrial Engineering	Education and Research	Professor of Service Engineering	>10 years	UFRGS
2	Business Administration	Education and Research	Professor of Marketing	>10 years	UFRGS
3	Civil Engineering	Education and Research	Director of the Technological Development Office	>20 years	UFRGS
4	Business Administration	Education and Research	Professor of Strategic Management	>5 years	UFCSPA
5	Civil Engineering	Education and Research	Director of Technological Incubator	>10 years	UFRGS
6	**Statistics**	**Education and Research**	**Professor of Innovation and Product Development**	**>10 years**	**UFRGS**

Source: Created by the authors based on research data.

The structuration of the experience was executed in two steps: (i) theoretical and practical foundation, and (ii) game assessment. Initially, a theoretical basis of design thinking, its stages and principles, as well as, the difficulties in teaching design thinking found in the literature were used to format an initial structure. Furthermore, authors experiences teaching design thinking were used to build the game. Then, game structure was assessed by means of a workshop with specialists in teaching and in design thinking (Table 2), and the improvements were incorporated in the game. Experience structuration was assessed qualitatively by specialists using the criteria motivation and user experience proposed by Petri & Wangenheim (2016).

During the step of identifying resources and applying gamification elements, design thinking resources and tools were used in the game, and gamification elements were also applied. Gamification elements were based on the game attributes identified by Bedwell, Pavlas, Heyne, Lazzara & Salas et al. (2012): (i) action language, (ii) assessment, (iii) conflict/challenge, (iv) control, (v) environment, (vi) game fiction, (vii) human interaction, (viii) immersion and (ix) rules and goals. The methods and techniques of design thinking were initially selected by the authors based on their experience in teaching design thinking. Afterwards, a workshop with specialists was used to validate the set of methods and techniques selected and the gamification experience proposed (Table 3).

The evaluation of the game was performed through 3 pilot applications. Learning objectives were evaluated through a structured questionnaire. The questionnaire was built following the guidelines of Zikmund, Babin, Carr & Griffin (2012), Blumberg, Cooper & Schindler (2014) and Cowles and Nelson (2015). The questionnaire was composed using simple language, short and direct questions that encompassed one single aspect per question, not requiring the respondent to have thought about the issue previously and avoiding questions that require memories of past events (Cowles & Nelson 2015; Zikmund et al. 2012). To minimize the anchoring effect, the items were randomly presented throughout the questionnaire (Zikmund et al. 2012). Leading and loaded questions were avoided (Cowles & Nelson 2015; Zikmund et al. 2012). The questions addressed one aspect at a time and the final points of the scale were periodically inverted between positive and negative categories to avoid the halo effect (Blumberg 2014). Questions were randomly presented to minimize the anchoring effect (Zikmund et al. 2012).

Table 3

Profile of the specialists participating in the game validation

Participants	Background	Field of work	Profession	Experience	Institution
1	Business Administration	Education and Research	Professor of Entrepreneurship and Innovation	>20 years	University de Pittsburg, USA
2	Industrial Engineering	Education and Research	Professor and Researcher in Artificial Intelligence and Technology Management	>20 years	Central University of Florida, USA
3	Industrial Engineering	Education and Research	Professor and Researcher of Engineering and Technology	> 20 years	Universidad de Carabobo, Venezuela
4	Civil Engineering	Education and Research	Professor and Researcher of Entrepreneurship and Innovation	>10 years	UFRGS, Brazil
5	Business Administration	Education and Research	Professor of Strategic Management	>5 years	UFCSPA, Brazil
6	Civil Engineering	Education and Research	Director of the Technological Development Office	>20 years	UFRGS, Brazil
7	Industrial Engineering	Education and Research	Dean of the Universidad Nacional Mayor de San Marcos	>20 years	Universidad Nacional Mayor de San Marcos, Perú

Source: Created by the authors based on research data

The questionnaire used for game evaluation uses a five-point Likert scale. This scale was chosen by its adequate properties for the objective of the proposed assessment (Blumberg 2014; Zikmund et al. 2012). According to Cowles and Nelson (2015), this type of scale is adequate and commonly used to evaluate opinions and attitudes. The number of points in the scale was defined as five by its adequacy in terms of reliability and validity (Maydeu-Olivares et al. 2009) for questions addressing an object/construct (Cox III 1980). Furthermore, Preston and Colman (2000) highlight that five-point scales are easily understood by the respondents.

5 Results and discussion

The game has been applied to more than 312 people, with 58 different groups (teams of 5 to 8 people). These groups were composed of undergraduate students, graduate students,

professors, researchers, and professionals. Nevertheless, in this study, the results obtained with 67 participants, from three different groups will be presented: (i) 18 undergraduate students, (ii) 22 professors and (iii) 26 professionals. Questionnaires were applied to this group based on the learning objectives that will be presented. Thus, quantitative data obtained from the questionnaire application, as well as qualitative results observed will be presented.

5.1 Understanding the target audience and context

In the first step, *understanding the target audience and context*, three main potential user profiles were identified for the game: (i) undergraduate students, for design thinking teaching and the development of competencies; (ii) professors, for the development of competencies to improve teaching; and (iii) market professionals, for design thinking teaching and the development of competencies for innovation and problem solution in companies and in the market. Furthermore, group size was also identified as an important element, therefore, groups were limited to 30 people so adequate support could be given to each group during the activity. Regarding the environment, the need to create a suitable material was identified. The material should enable a proper environment, keeping the students focus on the activity and allowing the conduction to the desired results.

5.2 Defining learning objectives

In the second stage, defining learning objectives, the objectives to be reached by means of the game application were identified. Thus, based on the Bloom taxonomy, the objectives were developed, dividing them in the two proposed dimensions: (i) cognitive process and, (ii) knowledge.

Within the cognitive process dimension in its six categories, nine objectives were defined: (i) identifying the challenge elements (remember), (ii) categorizing the elements (understand), (iii) translating the elements (understand), (iv) summarizing the information, translating into a new challenge (understand), (v) generating ideas for the solution of the challenge (create), (vi) selecting ideas for the final solution (analyze), (vii) planning how to execute ideas (create), (viii) executing ideas (apply) and (ix) testing the ideas (analyze).

In the knowledge dimensions, from the four categories, three were developed: (i) identifying the challenge elements (factual), (ii) understanding the difference between insights and ideas (conceptual) and (iii) using methods and techniques at the right moment (procedural).

Each one of the objectives presented was linked to the principles and to the methods and techniques. For each one of the objectives, the results observed were presented, as shown in Table 4 and Table 5.

Table 4

Learning objectives and results observed – knowledge dimension

Objectives	Categories	Methods and Techniques	Observed Outcomes
Identifying challenge elements	Factual	Inspiration Map	Topics of the inspiration map developed a broad and deep view of the problem.
Understanding the difference between Insights and Ideas	Conceptual	Inspiration Map x Ideas Board	The groups generated a big quantity of insights through the Inspiration Map and then transformed insights in ideas using the Ideas Board.
Using methods and techniques at the right moment	Procedural	Inspiration Map x Ideas Board	The students understood the importance of the sequence of methods and techniques used to support the results.

Source: Created by the authors

Table 5

Learning objectives and Results observed – cognitive process dimension

Objectives	Categories	Principles related	Methods and Techniques	Observed Outcomes
Identifying the challenge elements	Remember	Immerse yourself Empathize	Inspiration Map - exploration area	Focusing on quantity, on average 52 elements of problem understanding were generated.
Categorizing the elements	Understand	Be intuitive	Inspiration Map - exploration area	The elements were allocated according to the items proposed by the topics that compose the map.
Translating the elements	Understand	Be intuitive Inspire	Inspiration Map -Insights Definition / Persona	Each group generated the personas that personified the problem based on the elements identified.
Summarizing the information, translating in a new challenge	Understand	Inspire	Inspiration Map - Opportunity Definition	The groups reduced the initial broad challenge to a relevant opportunity for the user based on the elements identified and on the persona.
Generating ideas for the solution of the challenge	Create	Be Generative Be Creative Confident	Ideas Board	The groups focused on generating a big quantity of ideas, generating on average 48 ideas per group.
Selecting ideas	Analyze	Be intuitive	Ideas Board / Venn Diagram	After idea refinement, the groups selected an idea according to design thinking criteria: desirability, practicability, and feasibility.
Planning ideas	Create	Be creative confident Be visual	Ideas Board / Napkin Pitch	Based on the idea selected, the participants were supposed to fill in a Napkin Pitch to develop the idea, by completing: the idea description, the execution, user benefits and business benefits.
Executing	Apply	Be visual Prototype	Ideas Board - Prototype	The solution selected and developed should be prototyped by the group, aiming to make the idea tangible and to enable initial testing. The objective is the early identification of errors as a low-cost improvement opportunity.
Testing ideas	Analyze	Iterate Prototype	Elevator Pitch	Brief presentation of the idea (60 seconds) to get the feedback from the colleagues and the professor.

Source: Created by the authors

5.3 Structuring the experience

Based on the stages and principles of design thinking (section 2) and difficulties in teaching design thinking (section 3), we began to structure the game. Previous experiences in design thinking teaching were used for its construction. As originally presented by Collins (1992), design science of education has to understand how different environments contribute to the learning process and how different designs contribute for better results.

The registered observations of these activities were relevant to improve and adjust the game, converging to its final version. Initially, the teaching process was focused on dynamics, aiming at generating a relevant and innovative solution at the end of the process. The logic of presenting a problem and building an innovative solution was kept, due to the importance of challenges and experimentation to enhance the learning process, as presented by Schon (1987), Barab et al. (2005) and Hwang et al. (2012). However, several adjustments were made to better differentiate insights and ideas and to avoid participants' rapid conversion to a solution without sufficiently exploring the problem. Furthermore, frequently the ideation process did not lead people to solutions that were creative enough. Thus, the game was adjusted to reinforce creative confidence and overcome the identified difficulties.

Besides, a minimum and a maximum time for the execution of the activity was identified, ranging between 2 hours and 30 minutes, as the minimum time to reach the results, and 4 hours, which is the maximum time a group can remain focused on the activity. These experiences were also very important to confront the desired results with the results actually achieved through the identification of participants' difficulties in the learning process.

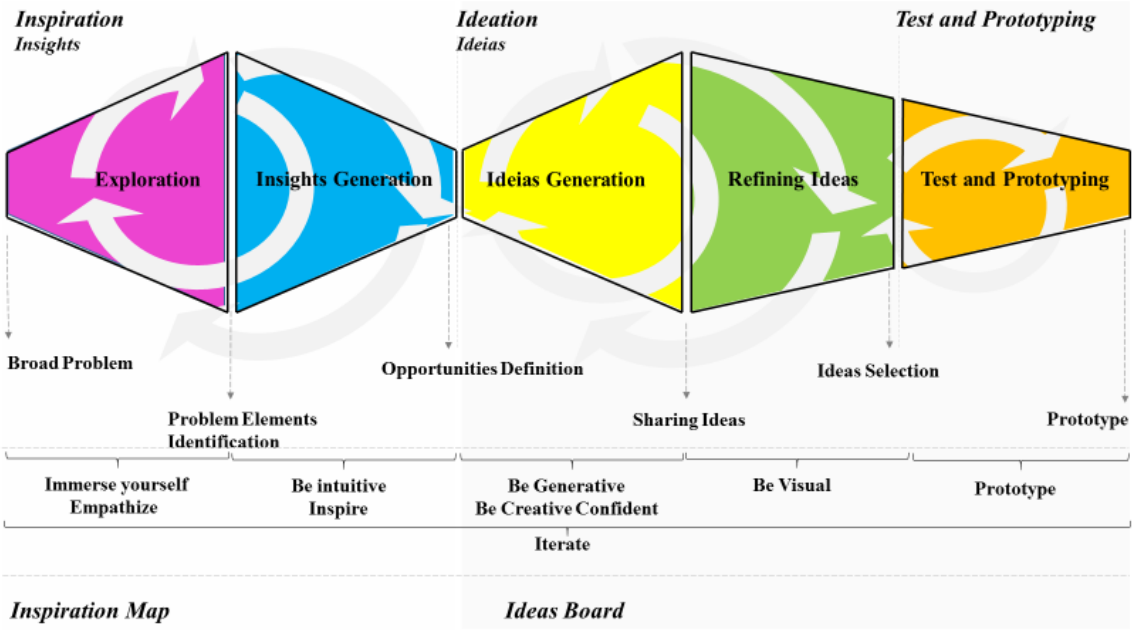
The game is composed by two tables, one table focused on insight generation and the other focused on idea generation: (i) the inspiration map and (ii) the idea board. The inspiration map is composed of three main areas: (i) exploration map; (ii) insight definition; and (iii) problem definition.

In addition, some methods and techniques are used to support these stages, such as: Persona, Empathy Map, idea generation techniques, Venn Diagram, and Napkin Pitch. For each of these areas, a time interval is established to complete the area, according to the complexity of the step. The minimum time to complete the game is 2 hours and 30 minutes. The ideal time is 4 hours.

Figure 1 presents the relation between the principles, stages, and game. It is important to state that the principles are allocated at the moments where they are emphasized, but they are present to a greater or lesser intensity throughout all the stages of the game.

Figure 1

The stages of design thinking integrated to principles and the game



Source: Created by the authors

Besides the learning objectives, there are two other factors that constitute the quality of a game: motivation and user experience. These two aspects are presented in Table 6 and Table 7, which portraits the factors, the categories that compose each one and the results observed and measured through the game application.

Table 6

Motivation objectives and specialist assessment

Objectives	Categories	Experts evaluation
Keeping participants focused on the activity during the whole time of the game execution	Attention	Game structure kept participants focused on the game. Game activities are well positioned and are attractive to players.
Using the persona and the empathy map to generate relevant results	Relevance	Tools proposed enabled to identify relevant opportunities.
Generating solutions during the game to deliver value to the user	Confidence	Based in the opportunities identified was possible to generate solutions which deliver value to the user.
Achieving a high degree of players' satisfaction	Satisfaction	Results achieved playing the game generated a feeling of satisfaction. Game dynamic made it pleasurable.

Source: Created by the authors

Table 7

Motivation and user experience objectives and specialist assessment

Objectives	Categories	Experts evaluation
Forgetting what was happening in the surroundings	Immersion	Even in a four hours game, participants did not see time passing
Cooperatively interacting with teammates	Social interaction	Game enables and stimulates team spirit between participants, who focus on the result and not on personal differences.
Be challenging to the participants	Challenge	Game structure challenges participants to give their best to generate better solutions.
Not being monotonous	Challenge	The game structure, with boards, clear tasks and limited time for activities motivates the participants during the whole activity.
Learning in a fun way and be willing to play again	Challenge	Participants were satisfied with game dynamics. Some specialists asked to play the game in their reality.
Achieving results using previous knowledge from the participants	Competence	The game does not require previous knowledge from the participants, since every participant uses their own knowledge and experiences to contribute to the team and generate the best results.
Developing competences through the game	Competence	The game helps in developing the competences needed to innovate and solve problems through the game.

Source: Created by the authors.

5.4 Identifying resources and applying gamification elements

The fourth stage, identifying resources, corresponds to the resources needed to gamify education. In this context, we developed two game boards and cards to support the idea generation for the idea board. These resources were selected based, mainly, on a design thinking principle, Be Visual, which seeks to make ideas visual through drawings. These drawings are placed on the board with post-it notes. Also, this creates an environment where everyone can access information at the same time in an interactive way.

The applying gamification elements stage is how the game will work. Characteristics of these elements applied to the game are presented in Table 8, detailing how each of them are applied to the Design Thinking Game.

For a better understanding of the game application Figure 2 presents a game application case with a group of university professors in southern Brazil. The application objective on this workshop, in particular, was the development of a product to contribute to the education of freshmen in the Architecture Course of the University.

Table 8

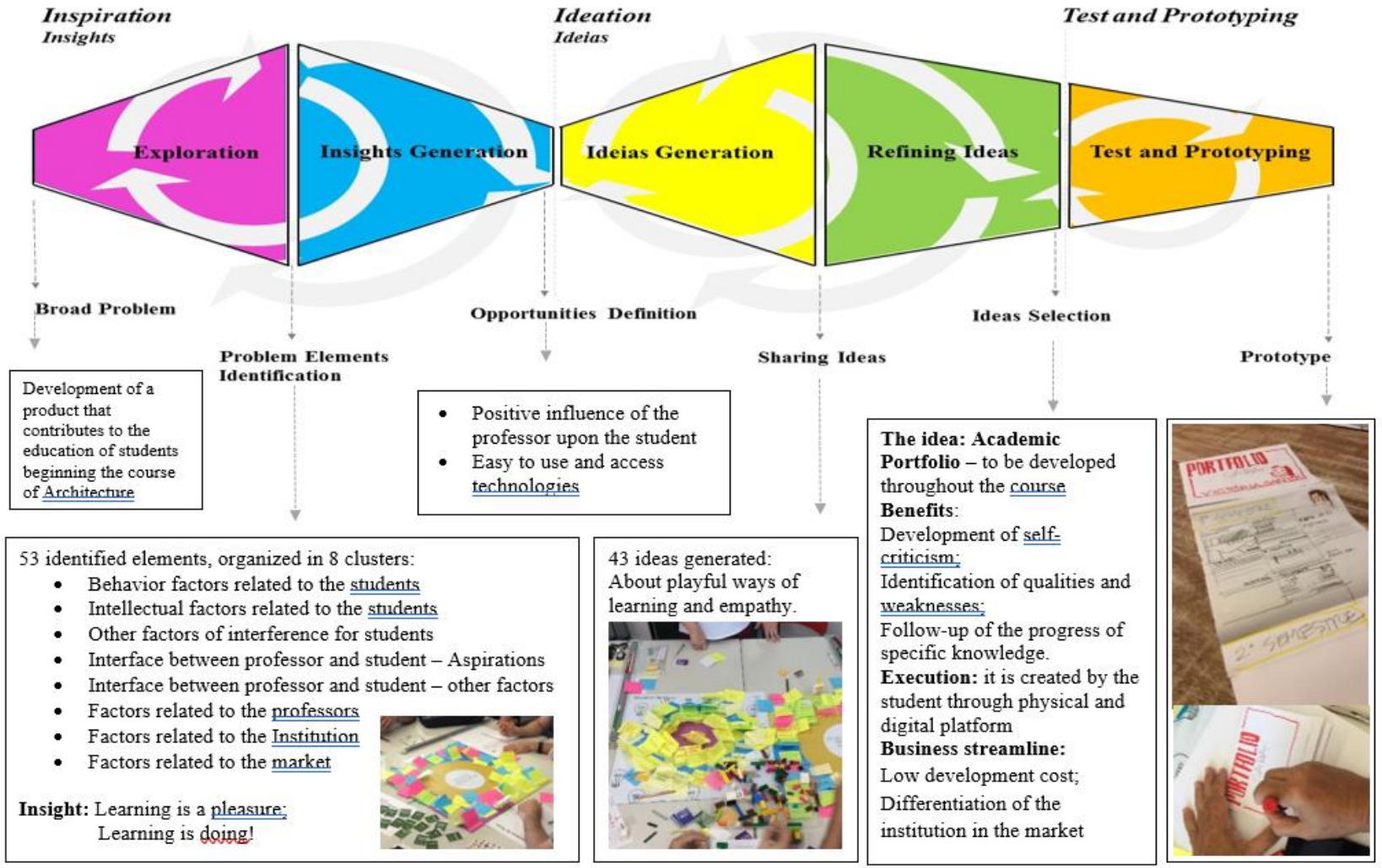
Characteristics of the gamification elements applied to the game

Elements	Concepts	Design Thinking Game application
Action Language	Refers to the method of interaction.	The game is played by groups, where each group must solve a challenge in a collaborative and interactive way.
Assessment and Progress	Assessment: scoring Progress: how players advance toward the game goals.	Assessment: number of insights and number of ideas generated scores are used to stimulate teams to be generative. Progress: a time is set for each activity be performed. During this time players should achieve the goals proposed.
Conflict / Challenge	Presentation of game challenge; difficulty of the game.	The game is conducted based on a challenge that have a high degree of abstraction, creating uncertainties to the possible results. The results depend on each team's characteristic.
Control / interaction	Amount of active learner control over content or gameplay and the extent to which the game changes in response to player actions.	The game relies on the interaction of player's ideas and vision to build better solutions.
Environment	Where the player is and how the player sees this world.	The game is based on real challenges, demanding that players use and share their experiences and world perspectives with the team to build solutions.
Game fiction	The nature of the game world and story.	The game world is based on real challenges, demanding that players use their own experiences to reach objectives.
Human interaction	Deals with human-to-human	Human interaction happens all the time because all game activities are collaborative and the game result is a product of this interaction.
Immersion	The player's perceptual and affective relationship with the game fiction.	Two points are to be highlighted in this element: the building of the persona and the solution generated. The persona comes to life by the team's participants, with name, personality, face, and needs. The solution is the accomplishment of a surprising result, since the participants could not even imagine such result in such short time.
Rules / Goals	The degree to which the game has clear rules and goals. It determines the method through which a player can solve problems in the game.	The game has clear rules that seek to guide the actions of players in order to accomplish the best team results: (i) all opinions are welcome; (ii) do not judge or criticize; (iii) encourage others; (iv) keep the focus on the problem; (v) hold one conversation at a time; (vi) be visual – write down EVERYTHING!!!; (vii) focus on quantity.

Source: Created by the authors

Figure 2

Results of the game application



Source: Created by the authors.

5.5 Evaluation

An evaluation was carried out with 67 people with three different profiles: (i) undergraduate students, (ii) professors and (iii) market professional. The groups observed in the game application had some elements examined through a survey based on the learning objectives of the Design Thinking Game.

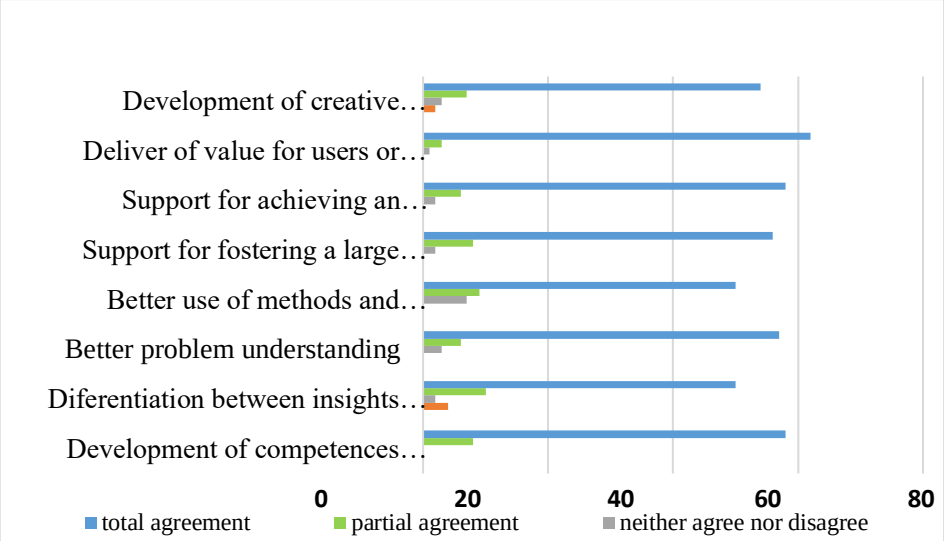
There was no respondent identification to allow more independence in the answers. Most of the participants (68,18%) had not had previous experiences with design thinking. Concerning their satisfaction towards the game, a seven-point scale was used (0 – totally unsatisfied; 1 – very unsatisfied; 2 – unsatisfied; 3 – neither satisfied nor unsatisfied; 4 – satisfied; 5 – very satisfied; 6 – totally satisfied), in which 100% of the respondents claimed to be satisfied with the game (answers 4, 5 and 6), being 36.36% totally satisfied and 54.54% very satisfied. The results show that professors, students, and professionals enjoyed the game and found it useful as a learning instrument both to generate ideas and to find solutions for problems.

Based on this, it is possible to elicit that the game stimulates satisfaction, because, according to Kinzie and Joseph (2008), a game is immersive, voluntary, and enjoyable. Hwang et al. (2012) adds that, more than a pleasant experience, games engage students in the learning process and contribute to knowledge and skills development.

The participants also evaluated seven statements regarding the game's efficiency. This evaluation was done by using a five points scale (I totally disagree, I partially disagree, I neither agree nor disagree, I partially agree, I totally agree). Figure 3 presents the results. The vast majority of the respondents totally agree that the game contributes to: (i) better problem understanding, (ii) development of competences for design thinking (DT), (iii) understanding the difference between insights and ideas, (iv) better use of methods and techniques, (v) generation of a higher number of ideas, (vi) higher value delivery to users or clients and (vii) development of creative confidence. Still, regarding the problem understanding through design thinking, Hwang et al. (2012) argue that this is a critical skill for the problem-solving ability, including the problem-solving strategies – that are ideas generated through the game – and the process of choosing appropriate information and allocating proper resources –through the ideas selection with the Venn Diagram.

Figure 3

Perception of 67 participants concerning the game's efficiency



Source: Created by the authors

Hwang et al. (2012) point out students' difficulty to effectively and efficiently use collected information to solve problem. The game provides a holistic view of the proposed challenge to solve students' difficulty in use information. As Chen and Hwang (2014) point out, the game has a clear proposition focused on an effective learning strategy, based on tools and a theoretical background in a well-integrated way.

Table 9

Results of Fisher's least significant difference (LSD) procedure for comparing averages

	Professors	Students	Professionals
Satisfaction	4,86	4,72	4,92
Development of competences for design thinking	4,77	4,89	4,96
Differentiation between insights and ideas	4,50	4,61	4,69
Better problem understanding	4,77	4,78	4,88
Better use of methods and techniques	4,50	4,50	4,88
Generation of a large amount of ideas	4,64	4,94	4,88
Support for fostering a large amount of ideas	4,82	4,89	4,96
Support for achieving an appropriate solution	4,68	4,83	5,00
Deliver of value for users or clients	4,86	5,00	4,92
Development of creative confidence	4,64	4,56	4,88

Source: Created by the authors based on research data.

Using Fisher's least significant difference (LSD) procedure for comparing averages, the results show that professors, students, and professionals enjoy the game and find it useful both as a learning tool and also to generate ideas and find solutions to the problem under study. Considering the set of questions, on a scale from 1 to 5, the general average resulted in 4.70 (for professors), 4.77 (for students) and 4.90 (for professionals). Although the evaluations of the three segments referring to the set of questions were notably positive (varying between 4.5 and 5.0) some differences between the segments were detected. In general, compared to professors and students, professionals assigned higher scores for the different aspects evaluated, with differences (small but statistically significant) in the aspects: better use of methods and techniques, support for achieving an appropriate solution, and development of creative confidence. It is possible that these results are due to the fact that, in the professional environment, because of the pressures of the daily routine, there is less time for using methods to reach optimal solutions. Thus, professionals were particularly satisfied with the characteristics of the game that support these aspects, assigning an average of 4.9 to better use of methods and techniques and development of creative confidence, and an average of 5.0 for the ability of the game to provide support for achieving an appropriate solution. Table 1 presents the results for all questions and segments. Interrupted bars assign statistical difference on a 90% confidence level.

7 Discussion and final remarks

This paper presented the design thinking principles and stages and a game to facilitate the learning process of design thinking. The principles identified and incorporated into the proposed game were: (i) iterate, (ii) immerse yourself, (iii) empathize, (iv) be intuitive; (v) be visual, (vi) inspire, (vii) be generative, (viii) prototype, and (ix) be creative confident. The identified stages, also incorporated into the game, were: (i) exploration; (ii) insights generation; (iii) ideas generation; (iv) ideas refinement; (v) testing and prototyping. To conduct these stages, methods and techniques were identified and incorporated.

Also, learning, motivation and user experience objectives were identified. The learning objectives tend towards two dimensions: (i) cognitive process dimension, and (ii) knowledge dimension. The objectives of the cognitive process dimension were: (i) identifying challenging elements, (ii) categorizing elements, (iii) translating the elements, (iv) summarizing the information, translating in a new challenge, (v) generating ideas for the solution of the challenge, (vi) selecting ideas, (vii) planning ideas, (viii) executing and (ix) testing ideas.

Motivation objectives were: (i) keeping focused on the activity during the whole time of the game execution, (ii) using the persona and the empathy map to generate relevant results, (iii) generating solutions during the game to deliver value to the user, (iv) achieving a high degree of players' satisfaction. User experience achieved objectives were: (i) forgetting what was happening in the surroundings, (ii) cooperatively interacting with teammates, (iii) being challenging for the participants, (iv) not being monotonous, (v) learning in a fun way and be willing to play again, (vi) achieving results using previous knowledge from the participants and (vii) developing competences through the game.

The game was developed based on the identified gamification elements. Based on this, two boards were created (inspiration map and ideas board) to meet the proposed principles and stages of Design Thinking. The game provides an iterative passage through all stages of the design thinking, giving a holistic view of the process, starting with a deep understanding of the problem, and coming to a design solution. The results of the game application have shown its potential to: (i) ease teamwork, avoiding negative discussions and providing active participation from all students; (ii) lead to insight generation in a comprehensible way, making clear the difference between insights and ideas; (iii) simplify the use of inspiring methods and techniques (such as Persona, Empathy Map and Napkin Pitch); (iv) develop creative confidence; (v) provide a pleasant and motivating learning environment for collaborative multidisciplinary work. The experience of using the game revealed that: (i) the greater the number of thinking elements, the better the insights generated, (ii) the better the insights, the greater the number of ideas, and (iii) the greater the number of ideas, the better the result of the design solution generated. This conclusion was observed throughout many editions of courses taught, which shaped the final version of the game. Also, the game helped to solve difficulties regarding the understanding and implementation of design thinking.

The game requires the use of fewer methods and techniques than the complete set reported in the literature. However, since it conducts the student through all stages of design thinking, supported by a hands-on approach, the positive results of the learning process are evident. Concerning the learning process, we recommend using the game in the first contact with design thinking, due to the holistic view it offers through experimentation. Along with the game, a theoretical seminar may be presented to students, allowing a detailed discussion of principles, stages and techniques that may be employed in the design thinking approach.

The holistic and integrated view promoted by the game helps understanding and leading the innovative design solution. Considering the Design Thinking stages, there are two moments

that should be emphasized. The initial moment, comprehending divergence and convergence, supported by the Inspiration Map, is associated to insight generation and involves understanding and exploring the problem. The second moment, also comprising divergence and convergence, supported by the Ideas Board, is related to the design solution. This approach is typical of the design thinking and avoids a precipitated convergence to a solution. The initial exploratory process, involving empathy and problem immersion, allows identifying and defining relevant issues related to people's real needs. The idea generation process allows exploring people's creative confidence, increasing the quality and comprehensiveness of the generated solution. The game structure leads to a better understanding concerning these topics.

This study has some limitations and results should be interpreted with caution. There're two aspects to be observed: sample (sample size, participants profile and the professor) and game's format. The results of this study are limited by the total sample size (n = 67), selected by convenience. The number of participants evaluated is relatively low compared with the number of people that used the game. Besides that, there's no control group learning without the support provided by the game, Such control group answering the same questions used to evaluate and compare the objectives assessed would strength conclusions. Another concern is the heterogeneous profile of the participants, which might have impacted perceptions and understanding about the game. An instrument for measuring students' competences for innovation could be used to provide a better characterization of the participants. This study is also limited by the geographical location, since all participants reside in Porto Alegre, a major city in southern Brazil. The last concern about the experiment is that the game sessions were always conducted by the same professor. This is positive concerning variability among sessions and groups' performance, but it doesn't ensures that the replication of the game by other professors would have the same results and impacts on its participants. Concerning the game's format, the present version uses a physical board. The evolution towards a digital panel could lead to new inferences and opportunities, enabling the enlargement of the game's scope and experiences.

Although the major part of the studies concerning games is based on computer games, the theoretical basis of the potential of transformation through this learning strategy is similar for digital or physical platforms. However, for future studies, the possibility of developing the proposed game for computers has been studied, as well as its applications.

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