EDUCATIONAL GAMES FOR DESIGN AND INNOVATION: PROPOSITION OF A NEW TAXONOMY TO IDENTIFY PERSPECTIVES OF DEVELOPMENT

Cortes Sobrino, Ana (1); Bertrand, Miliane (2); Di Domenico, Enzo (2); Jean, Camille (2); Maranzana, Nicolas (2)
1: Universidad del Norte, Colombia; 2: Arts et Metiers ParisTech, France

Abstract

The main purpose of this paper is to present a new taxonomy to identify perspectives of development of educational games for design and innovation. To develop this proposal, we first presented a state of the art about educational games definitions and taxonomies. After describing their limitations, we then proposed a new taxonomy in the second part with three specific criteria: public, purpose and skill. In the third part, we classified within this new taxonomy all the articles concerned by educational games of the Design Society Database containing more than 7000 papers. Finally, the results are discussed to identify perspectives of development of new educational games.

Keywords: Design education, Education, Innovation, Educational game

Contact:
Dr. Nicolas Maranzana
Arts et Metiers ParisTech
LCPI
France
nicolas.maranzana@ensam.eu

1 INTRODUCTION

Design and innovation are necessary for companies to succeed in a globalized and competitive world. For that reason, one of the key issues for companies lies in employing engineers and designers that understand the full technique of design and innovation as well as continuously train those already hired. In addition to formal education, educational games are another way to meet this objective. They can be defined as games specifically designed with an educational aim, a training purpose, and/or a behaviour change incentive (Mettler and Pinto, 2015).

The main objective of this article is to enrich the teaching and design community in highlighting potential value creations in educational game in design and innovation. To do it, the first part of this article presents definitions and existing taxonomies of educational games. The second one proposes a new classification specially designed for our purpose. The third part identifies and classifies all the articles related to educational games indexed by the Design Society community, one of the main international organisations on design. In the last part, the results are discussed to identify some directions to fill the identified gaps.

2 EDUCATIONAL GAMES

Educational games are games explicitly designed or used with educational purposes. They can take a variety of forms, from card games to board games and video games. They contribute to the acquisition of knowledge or skills in every stage of life (childhood, student life, professional life). Their usage is frequent as they can provide enjoyment, passionate involvement, structure, motivation, ego gratification, adrenaline, creativity, social interaction and emotion in the game itself while the learning takes place (Prensky, 2001). They are already widely used in the specific field of design and innovation (Braghirolli et al., 2016).

Several taxonomies exist to classify those games. For example, Sawyer and Smith (2008) propose to classify them per:
- *Market segment* (ex: healthcare, public policy, strategic communication, defence, training and education).
- *Type of activities / purpose* (ex: logistics, operations, marketing, human resource management and technology).
- *Targeted users* (ex: pre-k, elementary, middle school, high school, university, adult, general).
- *Way for the skills to be transmitted* (ex: informal, formal).

Another example is the G/P/S taxonomy of Djaouti et al. (2011). They propose to classify serious game with three categories:
- *Gameplay* determines whether the game is a "serious games" or a "serious play". A game is classified as a "serious game" if the educational objectives are clearly and explicitly stated. It is a "Serious Play" if the goals to be achieved by the user are blurred or non-existent.
- *Purpose* defines the utility function of the game. It can be to broadcast a message, to improve cognitive performance or to encourage people to exchange data.
- *Scope* concerns the *market targeted* by the game (healthcare, ecology, culture and art, politics) and the *public targeted* (students, professionals, general public).

Those taxonomies offer quick overviews for parents, teachers and companies to easily identify educational games for their children, students and employees depending on the desired purpose. However, the competencies associated with innovation and design are not highlighted in those taxonomies. We therefore judge necessary to propose a new one more adapted to the specific field of design and innovation. The next part presents this new classification.

3 PROPOSITION OF A NEW CLASSIFICATION

We propose a new classification canvas presented in Figure 1 with three specifics criteria: public, purpose and skills. We were inspired by the G/P/S model of Djaouti et al. (2011) to which we made changes and create new categories.
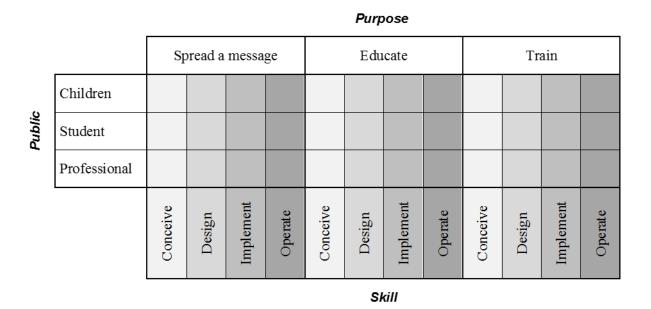
Purpose

	Spread a message				Educate				Train			
	Conceive	Design	Implement	Operate	Conceive	Design	Implement	Operate	Conceive	Design	Implement	Operate
Children												
Student												
Professional												

Skill

Figure 1. Proposed classification

Concerning the *public* category, we modified the G/P/S *scope* category. About the *public targeted*, we created three groups: "children", "students" and "professionals". A children educational game will be more game-playing while a professional educational game will be more conventional with more formal orientations. About the *market targeted*, we removed it as design and innovation fields are cross-cutting market segment.

Concerning the *purpose* category, we get inspired by the G/P/S purpose category. The idea is to describe the utility function of the game. We choose three groups: "spread a message" (inform people about a subject), "educate" (learning by doing) and "train" (coach people about a subject with a virtual training before a real doing).

Concerning the *skill* category, we based our concepts on the work of Crawley (2002). He proposes an universal template to determine the competencies associated with innovation and design: the C.D.I.O. as Conceive (ability to plan mentally the image of a product or service), Design (ability to model the imagined product), Implement (the ability to materialize a product turning a virtual product into a real one) and Operate (ability to add value to a product or service, to industrialize it and to benefit from it).

We believe that this classification is both simple and easy to use as well as useful to highlight potential value creations in educational game in design and innovation. In the next part, all the articles concerned by educational game of the Design Society Database are classified in this taxonomy.

4 CLASSIFICATION OF THE DESIGN SOCIETY ARTICLES

4.1 Protocol

The Design Society Database (www.designsociety.org) includes, from 1980 to 2016, 7477 articles coming from 168 conferences or events supported by the Design Society like: ICED, DESIGN, ICoRD, ICDC, E&PDE, etc.

In this database, the word "game" was searched. 35 articles were found. 24 were about educational games among which only 17 concerned specific educational games on design and innovation. The remaining ones focusing on different research fields like "game theory", were non-related to a specific educational game or were not in the field of design and innovation.

All articles were read, analysed and classified in our taxonomy by 2 design engineers.

4.2 Results

Table 1 presents all the articles related to our scope found in the Design Society database. For each game, the article reference is presented in column 2. The last column give a reference number for Figure 2.

Table 1. Games retained from the Design Society Database

Name of the Game	Article(s) Reference	Reference Number for Figure 2
Delta Design Game	*(Maaike, 2007, Legardeur et al., 2008, Geis and Birkhofer, 2009, Masclet and Boujut, 2010)*	[1]
Kantjil Design Game	*(Maaike, 2007)*	[2]
Bath Boat Game	*(Outram et al., 2007)*	[3]
Suli Sustainable Living Game	*(Judmaier et al., 2008)*	[4]
Electronic Delta Design Game	*(Masclet and Boujut, 2009)*	[5]
Eco-Board Game	*(Boks and McAloone, 2009)*	[6]
Video Game	*(Hébert et al., 2010)*	[7]
Buyer-Supplier Relationship Simulation Game	*(Hölttä and Eisto, 2011)*	[8]
Innopoly Game	*(Berglund et al., 2011)*	[9]
18-Wheeler Game	*(Juuti and Lehtonen, 2012)*	[10]
Apollo 13 Game	*(Juuti and Lehtonen, 2012)*	[11]
Gamestorming	*(Meuris et al., 2013)*	[12]
Edips	*(Uei et al., 2014)*	[13]
The Wild, The Pub, The Attic and The Workplace Game	*(Setola and Leurs, 2014)*	[14]
Product Development Process (Pdp) Game	*(Becker and Wits, 2014)*	[15]
Simulation Game	*(Juuti et al., 2014)*	[16]
Smart City Game	*(Wang and Huang, 2015)*	[17]

After listing all the articles, each of them were read and classified in the taxonomy presented in part 3. For example, in Delta Design Game (Maaike, 2007; Legardeur et al., 2008; Geis and Birkhofer, 2009; Masclet and Boujut, 2010) a team of students has to design a virtual building ("cluster") on a fictional

two-dimensional planet ("Delta"). Each player is briefed on some special professional skills (architecture, thermal engineering, structure engineering and project management) and become an expert. At the end of the game, various criteria have to be fulfilled to assess the teams' performance. Therefore, this game was related to the "student" group of the *public* category, to the "educate" and "train" groups of the *purpose* category and to the "conceive" and "design" groups of the *skills* category.

In the Eco-Board Game (Boks and McAloone, 2009) participants have to design a board game to learn sustainable products design. We classified it in the "Children", "Student" and "Professional" groups of the *public* category, to the "educate" groups of the *purpose* category and to the "conceive" and "design" groups of the *skills* category.

Figure 2 presents the final classification of the 17 games retained from the Design Society Database. The colors of figure 2 represent a rating scale according to the number of games per category. The score table is presented in Table 2.

Purpose

		Spread a message				Educate				Train			
		Conceive	Design	Implement	Operate	Conceive	Design	Implement	Operate	Conceive	Design	Implement	Operate
Public	Children		[17]			[6]	[6]						
	Student		[17]			[1] [3] [5] [6] [9] [10] [11] 12 [13][15]	[1] [5] [6] [9] [10] 11 [12]		[15]	[1] [2] [5] [7] [16]	[1] [2] [5] [7] [14]		
	Professional				[8]	[6] [10] [11]	[4] [6] [10] [11]		[4]	[7]	[7]		

Skill

Figure 2. Classification of the games retained from the Design Society Database

Table 2. Score table

	0	None - Lack of game proposals.
	1-4	Intermediate - It's possible to find some models
	>4	Good. Significant amount.

5   DISCUSSION

In relation to the *public* category, Figure 2 shows that there are very few educational games destined to the children. Furthermore, there are more educational games for "student" than "professional". This can be explained easily as most of the article's writers are academics close to students. However, developing educational games destined for the three kind of public can be valuable. Even creating educational games for the children should seriously be considered. In fact, instilling a design and innovation culture from an early age is important to create future vocation and awareness of tomorrows challenges. Creating more educational games for professionals could also be a good instrument to get better results in their companies' performances.

In relation to the *purpose* category, Figure 2 shows that there is a lack of educational games in the "spread a message" group. However, it should be advantageous to extend it. In fact, a sensitized public is a public that understand the importance and ramifications of tomorrows challenges. This is not about issuing but about explaining the issues and disseminating information that will enable people to design and innovate in a better way.

In relation to the *skill* category, Figure 2 shows that there are much more educational games in the "conceive" and "design" groups than in the "implement" and "operate" groups. One of the possible reasons is that the Design Society community mainly focuses its work on the upstream phases of design. Another explanation might be that educational games are only learning supports that do not encourage the development of practical skills, such as the industrialization of a product. The potential high cost of the machines and materials is a constraint to create cost-effective educational games. However, we think that it can be interesting to develop innovative games to extend these groups.

Concerning our taxonomy defined in part 3, we find it effective to identify developmental perspectives of educational games for design and innovation. If other criteria may have been used, our article demonstrates the feasibility of use and the utility of this taxonomy to detect potential value creation for educational games development.

6   CONCLUSION AND PERSPECTIVES

The objective of this paper is to present a new taxonomy to identify perspectives of development of educational games for design and innovation. We first presented a state of the art about educational games definitions and we described some existing taxonomies. After showing that the competencies associated with innovation and design were not well highlighted in them, we judged necessary to propose a new one. Our new taxonomy contains three specific criteria: public, purpose and skill. The last one answers to the underlined limitation by incorporating the C.D.I.O. competences template. Then we selected, analysed and classified in a rigorous way all the articles concerned by educational games of the Design Society Database in this taxonomy. The result of this classification enabled us to identify perspectives of development. The two principal ones were: to create more educational game for children and professionals, and to reinforce them to "spread messages" to sensitized all public types to design and innovation fields. Future work concerned the improvement of the taxonomy and classification of articles coming from other databases. We believe that this work will help game developer to design new educational game creating high values in design and innovation.

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