Learning Game Co-Design by Second-Year Nursing Students and Its Effects on Knowledge

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Abstract: Previous research works show the role of game-based learning to improve student's learning. Furthermore, there are more and more game design tools. They are easy-to-use even by people without any technical skills. This paper presents the experimentation of learning game co-design by the 110 second-year nursing students of the Catholic Institute of Lille conducted from April to June 2022, and its effects on learning. To measure the effects of the learning game co-design on learning, the students answered a knowledge questionnaire before (pre-test) and after (post-test) the learning game co-design. The results highlight that the knowledge score increased after the learning game co-design. However, no significant difference was found between the students who co-developed successfully a playable game and those who didn't.

1 INTRODUCTION

Previous research works show the role of game-based learning to increase the students' learning and motivation (Tan *et al.*, 2017). Game-based learning includes gameplay-based learning and game design-based learning (Kafai, 2006). In the gameplay-based learning, students play a game to learn while in the game design-based learning, they learn by designing their own games. So, this paper is about game-based learning and more specifically about game design-based learning because (1) game design engines are increasingly easier to use even by people without any technical skills and (2) students learn better when they are actively engaged in the construction of concrete artefacts, as video games, they can share with others (Papert & Harel, 1991).
This paper is a part of a thesis work where we experimented a method of learning game co-deign with second-year nursing students and assessed the effects of this learning game co-design on students' learning and motivation. However, in this paper, we especially focus on its effects on learning.

This paper is structured as follows. Section 2 oversees the theoretical works which conduct us to propose our method of learning game co-design and to choose the game design tools the more suitable for our needs. Section 3 details how we have experimented the method of learning game co-design. Section 4 presents the results which are discussed in section 5. Section 6 concludes this paper and presents further perspectives.

2 RELATED WORK

In this section, we first present the method of learning game co-design we have developed (Gajewski *et al.*, 2020). Then, we present a guide to help teachers, game designers, pedagogical engineers, and researchers to identify the game design tool the more suitable for their needs (Gajewski *et al.*, 2022, 2023).

2.1 Our Method of Learning Game Co-Design

Since nursing students are learning, they are novices in the topic, and since they have not any programming experience, we needed a method of learning game co-design with pedagogical objectives, clear steps and not requiring pedagogical and technical skills.

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Table 1: Comparison of game design methods.

	Pedagogical objectives	Clear steps	Pedagogical skills not required	Technical skills not required
The six facets of serious game design	X	X		
LEGADEE	X	X		
ARGILE				X
DODDEL	X	X		
EMERGO	X	X		
KTM Advance	X	X		
The content-centric development process model				X
La méthode du jeu cadre		X		X
Adventure Author		X	X	X

We have conducted a literature review on methods of game design. Nine methods of game design have been identified: the six facets of serious game design (Marne *et al.*, 2011), LEGADEE (Marfisi-Schottman, 2012), ARGILE (El Mawas, 2013), DODDEL (McMahon, 2009), EMERGO (Nadolski *et al.*, 2008), KTM Advance (Ibanez *et al.*, 2009 ; Yusoff, 2010), the content-centric development process model (Moreno-Ger *et al.*, 2008), *la méthode du jeu-cadre* (Sauvé, 2010), and Adventure Author (Robertson & Nicholson, 2007). As shown in Table 1, none were suitable for our needs: Almost all require pedagogical or technical skills. One of them has no pedagogical objectives.

So, we needed to develop our method of learning game co-design.

From a literature review based on 20 papers on game design-based learning, we developed a method of learning game co-design (Gajewski *et al.*, 2020).

This method involves four different actors (the game designer, the teacher, the researcher, and the students), and is composed of 11 steps. In step 1, the teacher specifies the pedagogical objectives. In step 2, the game designer identifies the game design software the more suitable for his needs. In step 3 the game designer identifies games with similar field. In step 4, the students play games with similar field for inspiration for their own games. In step 5, the teacher delivers learning content to students. In step 6, the students read, watch and listen the learning content. In step 7, the game designer teaches students about how to design a game. In step 8, the game designer teaches students about how to use the game design software. In step 9, the students co-design the game. In step 10, the students co-develop the game. In step 11, the four actors (the game designer, the researcher, the students, and the teacher) evaluate the game (Gajewski *et al.*, 2020). Table 2 illustrates our method of learning game co-design.

2.2 Choice of the Game Design Tool

Since in step 2, the game designer identifies the game design software the more suitable for his needs, we have conducted a systematic literature review following the *PRISMA* methodology between 2010 (2010-01-01) and 2020 (2020-12-18) from five databases (*IEEE Xplore*, *ScienceDirect*, *Scopus*, *Springer*, and *Web of Science*), with the search words “game design tools” and its synonyms (Gajewski *et al.*, 2022, 2023).

From 302 identified research works, 18 have been used for the discussion. And from eight game design tools advised by a pedagogical engineer, three have been used for the discussion. Figure 1 illustrates the flow diagram of that systematic literature review.

Table 2: Our method of learning game co-design (Gajewski *et al.*, 2020).

Steps	Actions	Actors
1	Specify the pedagogical objectives	Teacher
2	Identify the game design software	Game designer
3	Identify games with similar field	Game designer
4	Play games with similar field for inspiration	Students
5	Deliver learning content to students	Teacher
6	Read, watch, listen the learning content	Students
7	Teach students about how to design a game	Game designer
8	Teach students about how to use the game design software	Game designer
9	Co-design the game	Students
10	Co-develop the game	Students
11	Evaluate the game	GD / R / S / T

GD (Game Designer) / R (Researcher) / S (Students) / T (Teacher)

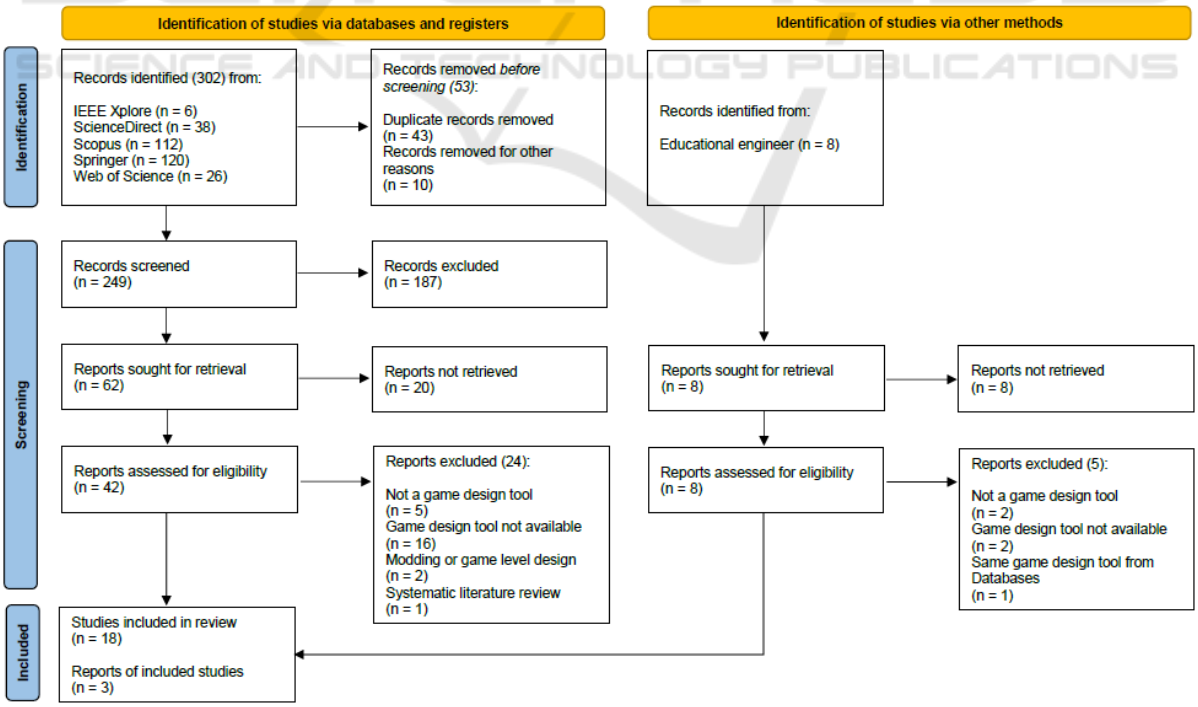

Figure 1: *PRISMA* flow diagram for a systematic literature review about game design tools from 2010-01-01 to 2020-12-18 (Gajewski *et al.*, 2022, 2023).

Overall, 12 game design tools have been identified: *Agentsheets*, *Alice*, *Celestory*, *GameMaker*, *Gamestar Mechanic*, *Microsoft Kodu*, *RPG Maker VX Ace*, *Scratch*, *Stagecast Creator*, *Unity*, *Unreal Engine*, and *VTS Editor*.
Those game design tools have been described and compared according to nine criteria: programming language, tool language, tutorials, scenes and characters, game type, target audience-designer, 2D or 3D modelling, prize, and export.

Regarding the programming language, "*programming a video game traditionally required extensive typing in which the smallest syntax error could offset game play*" (Burke & Kafai, 2014, p. 8) whereas other game design tools use a visual and simple programming languages as "*drag-and-drop*". Regarding the tool language, some game design tools are only in English. Others are in different languages as in French. Regarding the tutorials, some game design tools provide tutorials (manuals, videos, *etc.*); others don't. Regarding the scenes and characters, some game design tools provide resources as backgrounds for the scene and sprites for the characters. If the game design tool doesn't provide resources, users have to draw them by themselves (requiring skills and time) or ask a game design character to do it for them. Regarding the game type, some game design tools offer the possibility to develop different game type (*e.g.*, adventure, arcade, racing); others are limited to just one. Regarding the target audience-designer, some game design tools are intended for adults or experts; others are suitable for children or novices. Regarding the 2D or 3D modelling, some game design tools allow users to develop 3D games. "*Compared to 2D environments, the ability to create 3D games* […] *makes it visually more appealing for young students*" (Akcaoglu, 2016, p. 115). Regarding the prize, some game design tools are freeware; for others, users have to pay a fee to use it. Regarding the export, the games developed by some game design tools can be played offline; others require an internet connexion. Table 3, which is a guide to help teachers, game designers, pedagogical engineers, and researchers to identify the game design tool the more suitable for their needs, describes and compares the 12 game design tools according the nine criteria.

3 EXPERIMENTATION

Our method of learning game co-design has been experimented with the 110 second year nursing students of the Catholic Institute of Lille from April to June 2022 which were divided into 21 groups.

3.1 Method

In step 1, the teacher specified the pedagogical objectives. In our experimentation, the pedagogical objective was to allow students to co-design a learning game about liver cirrhosis for them to learn about this topic.

In step 2, the game designer identified the game design software the more suitable for his needs. To identify the game design software, we used the summary table (Table 2) of the different game design tools. We decided to use *VTS Editor* because it doesn't require any technical skills. Indeed, *VTS Editor* uses a drag-and-drop interface. *VTS Editor* interface is in French making the game design tool easier to use. *VTS Editor* provides tutorials. *VTS Editor* provides backgrounds for scenes and characters. *VTS Editor* allow users to develop simulation games which are suitable because "nursing students are generally well acquainted with visually realistic game environments" (Koivisto *et al.*, 2016)

In step 3, the game designer identified games with similar field. In our experimentation, the learning field is about nursing and clinical reasoning. Different games were identified, as *The blood typing game* or *eMergenSIM*.

In step 4, the students played those games for inspiration for their own learning games.

In step 5, the teacher delivered learning content to students. The learning content was uploaded on our Learning Management System (LMS) Moodle. The learning content was an eBook with the anatomy and the physiology of the liver, the definition, the pathophysiology, the clinical signs and the treatments of the liver cirrhosis, etc. (Figure 2), videos, and exercises (case studies).

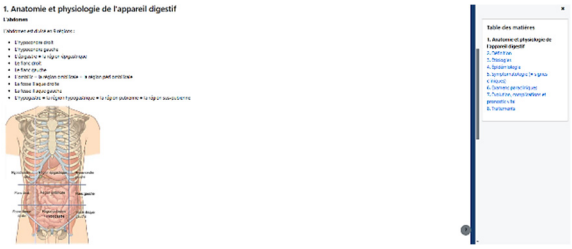

Figure 2: Screenshot of the eBook created in Moodle.

Table 3: Comparison of game design tools according to 9 criteria (Gajewski *et al.*, 2022, 2023).

	Programming language	Language	Tutorials	Scenes and characters	Game Type	target audience-designer	2D or 3D modelling	Prize	Export
Agentsheets	Drag and drop	English French	English	✓	-	For kids	3D	Free	Online
Alice	Drag and drop	English	English	✓	-	For anyone	3D	Free	Locally
Celestory	Drag and drop	English French	English French	✓	≠ types of games	-	2D	Free or Fees	Various
GameMaker	Code or Drag and drop	English French	English French	×	≠ types of games	beginners and professionals	2D	Free or fees	Various
Gamestar Mechanic	Drag and drop	English	English	✓	≠ types of games	7 to 14-year old children	2D	Free	Online
Microsoft Kodu	Visual by tiles	English French	English	✓	≠ types of games	9 to 10-year old children	3D	Free	Online
RPG Maker VX Ace	Point and click	English French	English	✓	RPG	For anyone	2D	Free (30 days) 64,99 €	Windows
Scratch	Drag and snap	English French	English French	✓	≠ types of games	8 to 16 years old	2D	Free	Locally or online
Stagecast Creator	Point and click	English French	English	✓	≠ types of games	8-year old children	2D	Demo (120 days)	Locally or Online
Unity	Code	English	English	asset store Not for free	≠ types of games	For professionals	2D or 3D	Free conditionally	Various
Unreal Engine	Code or visual	English	English	Templates	≠ game templates	For professionals	3D	Free conditionally	Various
VTS Editor	Drag and drop	English French	English French	✓	Simulation games	-	2D and 3D	Trial or fees	Various

In step 6, the students read, watched, and listen to the learning content for them to understand them. In this step, the students could help each other. They could compare their understanding of the learning content.

In step 7, the game designer taught students about how to design a game (What is a learning game? What are the benefits of using games at school? What are game mechanics? *Etc.*).

In step 8, the game designer taught students about how to use the game design software. Firstly, in half group, while the teacher created a project on *VTS Editor*, students reproduced it by mimicry. Secondly, students had to watch the tutorials uploaded on our LMS. Thirdly, students had to realize exercises on the use of *VTS Editor*. Finally, students explored in depth *VTS Editor* for them to discover all its functionalities. Figure 3 is an overview of the *VTS Editor*'s interface.

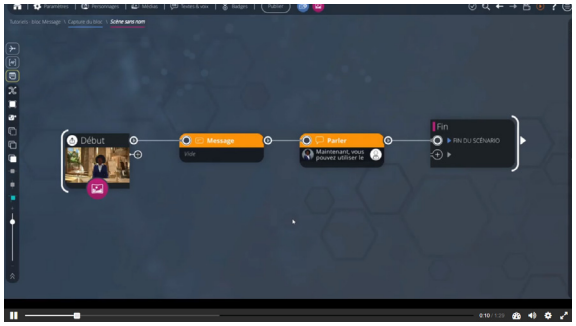

Figure 3: Screenshot of the *VTS Editor*'s interface.

In step 9, the students co-designed the game. The students were asked to create a paper prototype of their game. To do that, they had to describe the game storyline, the characters, the rules of the game, the sound effects and the music, the gameplay, the game mechanics, the aim of the game, the pedagogical objectives, etc.

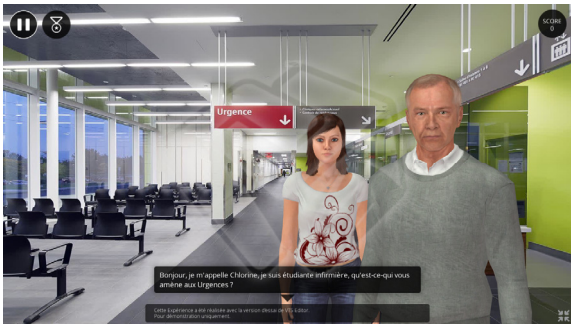

Figure 4: Screenshot of the learning game of one of the groups.

In step 10, once the paper prototype was over, students could co-develop their games by using *VTS Editor*. Figure 4 is an example of one learning game developed by one of the groups.

In step 11, the game was evaluated. The students were encouraged to look at and to test the games of the others groups, so that they could get inspiration for their own games, and give feedbacks to the other groups to help them to improve their games. The game designer evaluated the playful aspects introduced into the games. Is the game playable? What are the game mechanics introduced into the games? Etc. The teacher evaluated the serious aspects introduced into the games. Did the game meet the pedagogical objectives? Did the students discuss all the aspects of the liver cirrhosis? Is the knowledge introduced into the games true? The researcher evaluated the method of learning game co-design. Is it suitable? What are the effects of the learning game co-design on learning?

3.2 Instrument

One of the aims of this study was to measure the effects of the learning game co-design on the students' knowledge.

A 20-item questionnaire was developed by the researcher to assess the students' knowledge on liver cirrhosis. Each question was marked on one point. The questionnaire was therefore marked on 20 points.

4 RESULTS

As shown in Figure 5, there was a significant difference between the pre-test (M = 6.77) and the post-test (M = 9.78) mean score on knowledge ($p < .001$) with an increase of 3.01 points (out of 20) in the post-test in comparison with the pre-test.

However, as shown in Table 4, no significant difference was found in the post-test between the students who co-developed successfully a playable game and those who didn't. Indeed, there was a significant difference between the pre-test (M = 6.72) and the post-test (M = 9.62) mean score on knowledge within the students who co-developed successfully a playable game ($p < .001$) with an increase of 2.90 points (out of 20) in the post-test in comparison with the pre-test. In the same way, there was a significant difference between the pre-test (M = 7.13) and the post-test (M = 10.85) mean score on knowledge within the students who didn't succeed in co-developing a learning game ($p < .05$) with an increase of 3.72 points (out of 20) in the post-test in comparison with the pre-test.

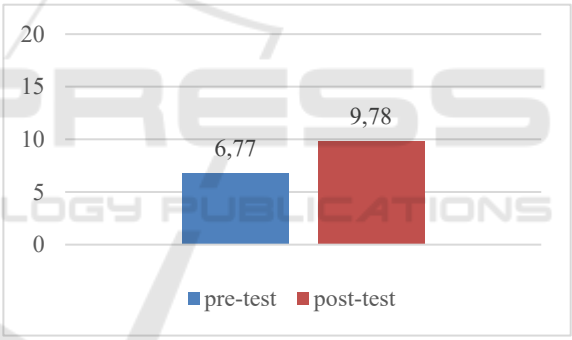

Figure 5: Pre-test and post-test mean scores on knowledge.

5 DISCUSSION

As shown in Table 4, no significant difference was found in the post-test between the students who co-developed successfully a playable game and those who didn't. Indeed, the students who co-developed successfully a playable game and those who didn't have increased their mean score on knowledge in the post-test in comparison with the pre-test. We can conclude that co-development a learning game didn't improve students' knowledge. The mere participation in the learning game co-design activity even if students didn't succeed in co-developing a learning game increased mean score on knowledge.

Table 4: Mean scores on knowledge within the students who co-developed successfully a playable game and those who didn't.

	Total	Yes	No	Difference
n	48	42	6	
Pre-test	M = 6.77 SD = 2.14	M = 6.72 SD = 2.06	M = 7.13 SD = 2.82	*ns*
Post-test	M = 9.78 SD = 3.13	M = 9.62 SD = 3.07	M = 10.85 SD = 3.70	*ns*
Difference	3.01 (+ 44 %) $p < .001$	2.90 (+ 43 %) $p < .001$	3.72 (+ 52%) $p < .05$	

Furthermore, even if no significant difference was found in the post-test between the students who co-developed successfully a playable game and those who didn't, the post-test mean score on knowledge within the students who didn't succeed in co-developing a learning game is higher than those who co-developed successfully a playable game. In the same way, the post-test mean score on knowledge further increased within the students who didn't succeed in co-developing a learning game than within the students who co-developed successfully a playable game. We can suppose that students who didn't succeed in co-developing a learning game focused more on serious aspects to introduce into the game than playful aspects.

6 CONCLUSION AND PERSPECTIVES

This paper is about game-based learning and more specifically about game design-based learning.

We first have presented the method of learning game co-design we have developed (Gajewski *et al.*, 2020). Then, we have presented a guide to help teachers, game designers, pedagogical engineers, and researchers to identify the game design tool the more suitable for their needs (Gajewski *et al.*, 2022, 2023). We finally have presented the experimentation of a learning game co-design activity by using our method.

The results highlight that the knowledge score increased after the learning game co-design. However, no significant difference was found between the students who co-developed successfully a playable game and those who didn't. We could conclude that the mere participation in the learning game co-design activity even if students didn't succeed in co-developing a learning game increased mean score on knowledge.

In terms of perspectives, it could be interesting to let the students explain their games during a showcase to evaluate if they are able to articulate the knowledge introduced into their games, as other authors have already done (Khalili *et al.*, 2011).

Furthermore, it could be interesting to conduct a second experimentation with control groups (playing a game or taking a lecture) to evaluate the relevance of game design-based learning in comparison with other pedagogical methods.

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