CONSTRUCTIONIST DESIGNS IN GAME MODDING: THE CASE OF LEARNING ABOUT SUSTAINABILITY

Nikoleta Yiannoutsou[1], Chronis Kynigos[1], Maria Daskolia[2]

nyiannoutsou, kynigos, mdaskol}@ppp.uoa.gr
[1]Educational Technology lab, [2]Environmental Education Lab

Abstract
In this paper, we explore the role of game modding tools in supporting creative domain learning. Modding as learning activity so far has mainly focused on students' abilities and knowledge with regards to computational thinking, programming and game design. Very few studies extended their focus on domain pedagogy using to this end modding tools coming with popular games. Yet, domain knowledge, demonstrated by the modded games, was fact-oriented and superficial. Drawing from this observation we argue that modding tools in order to provide rich learning opportunities need to be carefully designed so as to provide students with tools that offer access to the model of the game which integrates a set of assumptions related to different scientific domains. We implemented this design approach in what we call "half-baked games", that is games designed to invite modification of those game features that are important not only from a game design perspective but also from the perspective of domain learning. We present the example of "«Perfect-Ville» a SimCity-like game and a modding tool designed by learning experts using a GameKit we called SusX, to support learning about sustainability. We focus on its design features and we provide some data from its use in the classroom.

Keywords half-baked games, modding, learning, game-design, sustainability

1. Introduction

The importance of play in learning has long been researched and discussed in educational research (only to mention the pioneering work of [1]). With the proliferation of digital technologies in education, gameplay has been revisited and a new dimension related to games emerged: that of game design. Game design as a context for learning was first studied from the perspective of Constructionist learning [2] exploring games as learner constructions with personal meaning [3]. After that several studies focused on the learning dimensions of engaging students in game design (see for example [4], [5]). In this line of research game design is identified as an activity for contextualized domain learning (i.e. mathematics, programming, language and history) but also as a context where new skills and ways of thinking emerge (i.e. design thinking etc).

Literature on learning through Game Design has explored two strands of design activity. One delves into the learning involved in game design in general (for an overview of different game design platforms used to support domain learning and design thinking see [4]). The other strand focuses on modding i.e the modification of popular digital games. Game modding is the space where designers and players meet, in the sense that modding can be a designer's practice to support generation of ideas for new games [6] but first and foremost modding is a gamer's practice: *mods –* i.e. game moddifications- *are digital artefacts that avid gamers design by tinkering with their*

favorite games [7, p. 240]. In this paper we discuss modding tools designed to support learning about the complex concept of sustainability by engaging students in a creative constructionist activity of modding a half-baked game centred on the idea of the sustainable city. We use this example to argue for the need of empowering end- users (like teachers and researchers) with tools that will allow them to integrate their personal pedagogies in game modding tools.

2. Related work

2.1. Game Modding as learning activity

The strong social dimension of modding, its widespread use , it's role in raising engagement with the game [8] its impact on the success of the game among communities of gamers, its power as a game refining tool [7] have lead the gaming industry to embrace and support this practice. As a result, several gaming companies release along with their Games, Game Design Kits that support game modding; for example El-Nasr & Smith [9] mention WarCraft III, Unreal Tournament 2003 and 2004, Half Life, Half Life 2, and Morewind, Moshirnia [10] presents the modding tool for "Civilization IV", Robertson & Howells [11] refers to the use of the free tool kit accompanying the "NeverWinterNights" game. Furthermore, game design platforms such as the "Game Maker" support modding by offering tools to modify a set of well-known sample games, implemented with the game engine of the platform [12]. Most of these tools are designed to support modding by non technical users (i.e. knowing a programming language is not a requirement to change the game).

The examples we mentioned earlier deal with modding as an end user practice demonstrating an alternative way for engagement with the game. Building on this dimension of modding –i.e. as a alternative creative way of becoming involved with the game – we embark to explore the following question: What are the advantages of modding as learning activity over game design from scratch? One response, relevant to our discussion here, relates to the very nature of modding which allows focusing on what is important for the design of the game because *the game engine eliminates the overhead of building a convincing product* [9]. Studies investigating modding as a context for learning, have used modding tools like the ones we described above to support learning of programming languages, and skills related to design thinking [9], [11], [13].

Only recently studies introduced the idea of employing modding to pursue domain learning [10] [12] [14]. From these studies Moshirnia [10] focuses on teachers modifying "Civilization IV" whereas the other two focus on student learning and more specifically on nutrition [10] and language learning [14]. Based on the reported students' game modifications as both studies do not provide more data documenting the learning experience, we discern that in both cases learning is not essentially integrated in game mechanics. This means that while students get involved in changing some variables of the game (i.e. replacing ghosts with unhealthy food in [10]), they don't get into manipulating the model of the game (i.e what it means to create a balanced diet). In trying to understand the limitations restricting the learning activity in a superficial level, we argue that the quality of learning in these studies is highly related to the modding tools which are bound by the way the game engine implements the game and the learning elements are ad-hoc imposed on the game idea.

Content integration in games is a critical factor determining the quality of learning experience: learning in serious games depend –apart of pedagogy and game mechanics- on the integration of content so that learning is intrinsic to play [15]. The two different approaches in integrating learning in games is depicted in the terms endogenous (i.e. "*games in which context and gameplay*

are inextricably linked") and exogenous games ("*games in which context is extrinsic to game play*") used by Squire [16]. In elaborating on the difference between these two approaches Squire [16] explains that knowledge in exogenous games involves discrete facts – true by authority-whereas in endogenous games knowledge is a toolset to solve problems. Similarly, instruction in exogenous games involves transmission of information and content whereas in endogenous games instruction involves confronting existing beliefs, performing skills in context and reflecting on understandings.

Integration of learning in the game is essential not only to game play but also to game design and game modding we discuss here. We argue that in order to offer rich learning opportunities while students engage in game modding we need tools that will allow them to access and tweak with the model of the game and its underlying assumptions. To better explain this we need to refer to the criticism pinpointing that the simplified assumptions of games like the Sims or SimCity become unquestionably accepted [17] and create or reproduce false perceptions of reality. An example of such an assumption is drawn from The Sims: "*Class mobility is somewhat idealized and segregated, once a Sim enters the game his wealth level can increase but never drop*" [18]. This is not to say that games should be realistic representations of the world. On the contrary, these simplistic assumptions are important because they ensure playability and easy entry point for the game. Furthermore we maintain that learning in these games is better facilitated if we focus on challenging these models a practice followed also by the "ed- community" of SimCity (see for example the suggested activity "*Discussing how SimCity is not an accurate reflection of real city design and behaviour*" in http://www.instituteofplay.org/wp-content/uploads/2013/07/ISTE2013_SimCity_Board_Final.pdf) We suggest that "game modding" can build effectively on this idea taking it step further by involving students in modifying the initial assumptions and expressing their own in the context of changing the initial game.

2.2. Game modding to support creative learning around sustainability

In this paper we discuss game modding around the concept of sustainability which is by nature complex, ambiguous, context-specific and value-laden, and therefore difficult to address. These characteristics render sustainability quite elusive and ambiguous and therefore 'difficult' to address through traditional approaches. Yet, teaching and learning about sustainability is included among the top priorities of most school curricula worldwide since students are empowered to be more critical about current realities and their action competence is fostered as a prerequisite for bringing change into their everyday life and the world [19], [20]. The innate complexity and fuzziness of the concept led us to explore new learning environments where students could allow their creative potential to articulate, display, and elaborate new ideas and to develop and negotiate alternative perspectives by getting involved in playful and innovative practices such as the design and modding of a digital game.

Another dimension of the learning design behind the modding tool we discuss in this paper is creativity. Creativity is acknowledged as the backbone of the skills required for equipping young people not only for new jobs but for innovative work too [21], [22]. It is also viewed as a transversal lifelong learning competency necessary for attaining personal fulfilment, social inclusion, active citizenship and sustainable growth [23]. However, even though it is identified as an essential learning ability to develop in youth populations, the whole endeavour is inevitably associated with bringing forth changes in educational systems, among which putting forth new pedagogies combining playfulness with challenge and practice and taking advantage of the potential of digital technologies [24]. Along this line of thought Shaffer and Gee [21] suggest the

development of some 'post-progressive pedagogies of practice' centred around the design of current popular digital media for entertainment (such as digital games) as pedagogical tools allowing students not only to gain pleasure out of playing them but to actively generate new knowledge by 'modifying' (*modding*) them into new games, through intervening in the game mechanics or adding new content and exchanging them within communities of other students. Game modding is therefore proposed as a new source of creative learning and learning for creativity, apart from being an already recognised source of innovation in the creative digital games industry per se [25].

3. Using Game Kits to design Half-Baked Games and Modding Tools

The concept of half-baked games is an extension of the idea of half-baked microworlds coined by Kynigos [26] to describe exploratory digital environments which by design call for modification and change by teachers and students. The aspects of the microworld that call for change and the tools available for interaction and modification of the microworld are related to the concepts under investigation. Furthermore, the tools available in half-baked microworlds allow for deep structural access to the mechanism of the microworld [26]. Based on this idea, we developed the concept of half-baked games which are designed so that they are fully functioning games but they have characteristics that "provoke" students to change them because they don't like them. These characteristics, as we will show next, aim to engage students with modifications which focus on questioning the main assumptions of the initial half-baked game. Accessing these assumptions is important for the type of learning we pursue here for two reasons: a) they draw from specific scientific domains (consider here the assumption underlying class mobility in SimCity we mentioned earlier) and b) they constitute the game model and thus they define the game experience.

From the point of view of learning through modding the design of half–baked games needs to take into account the following considerations: One is to do with which game idea fits best the specific concepts under investigation -as one game is not usually suitable for learning any subject although interdisciplinary knowledge is required for the design of the game. The second consideration involves "twisting" the game so as to become "half-baked". The third consideration is related to the second and involves deciding which aspects of the half-baked game will be black boxes and which aspects of the game will be open for change and modification by the students. The last consideration has to do with the kind of tools that will be provided to the students so as to interact and change the game in a way that is focusing on the concepts under investigation. For example, if game draws on sociology and class mobility, the modding tools should not require advanced knowledge in mathematics or programming, instead they should allow students to manipulate directly concepts related to class mobility.

To design half-baked games we used the GameKit idea but we gave it the following meaning: GameKits are thematically coherent generators of games and of the respective modding tools which support the embedding of specific pedagogies in games, and empower non technical users (like teachers, educational researchers) to design games that allow modding. Next, we present the example of «Perfect-Ville» a half-baked game designed to engage students in exploring the concept of sustainability, created by a GameKit called SusX.

3.1. «Perfect-Ville»: a half baked game designed to challenge concepts around sustainability

«Perfect-Ville» is a SimCity like game but it is implemented in a very simplistic way in terms of graphics and concept (for an analysis of "Perfect-Ville" from the point of view of domain learning see [27]) . The game consists of a game play and a game design mode. «Perfect-Ville» includes a

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set of city-sites like "restaurant", "library", "work" etc. Each site has a specific value with respect to a set of properties – sustainability indicators (such as energy, hygiene, money, health etc). To win the game, students need to: a) decide which places to visit after reviewing the attributes of each place by clicking on it and b) take into account the changes in their resources (i.e. energy, money etc) if they decide to visit one of the city-sites.
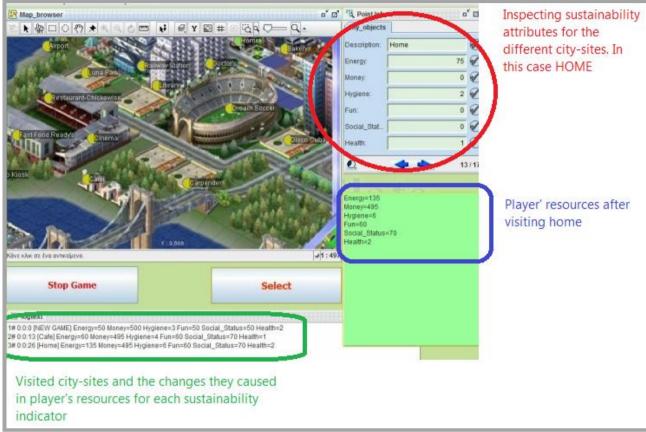

Figure 1: PerfectVille- Game Play environment

During game play, if the players choose to go to the "restaurant", to the "cinema", to the "Concert-Hall", without going at al to work, they will run out of money soon and the game will end. The main assumption underlying «Perfect-Ville» is that players in order to win, should lead a hectic way of living that is, going to as many places as possible within the day and managing to collect as much money, energy, fun, social status as possible. However, this is hardly a 'healthy' and 'sustainable' way of living, as it is heavily based on a pressing, greedy and consumerist model of life, very much aligned with the dominant western neo-liberal lifestyle emphasizing individualistic values and a commercialisation of the quality of life, both standing at the roots of most unsustainable practices run by modern societies (Lange and Meyer, 2009). Designing a half-baked game is not an easy process and requires a deep understanding of the domain. Next, we explain how game modding focuses on changing the underlying model of the game with tools that are specific both to game design and to the concept of sustainability

3.2 Form «Perfect-Ville» to MySusCity: providing tools to change the main assumption of the game.

The main assumption underlying «Perfect-Ville» is expressed through a) the selection of the sites of the city b) the sustainability indicators of the city (see *Figure 1 and Figure 2). In *Figure 2* we provide a

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view to the way the game indicators are implemented – i.e. they are fields in a database which students can rename, delete and define new ones) c)the values of each site with respect to the sustainability indicators (these are mainly arithmetic values see *Figure 2*) c) the attributes that determine the end of the game (i.e. if it is only money, if it is money and energy, if it is money or energy, or fun or social status etc see *figure 3*) d) the attributes that determine who is the winner i.e. which sustainability attribute or attributes is the most important for winning the game (i.e. the one who has collected more money) e)control mechanisms that provide feedback to the player in order to reorient his/her actions (i.e. if the money runs bellow 200 show the following message "*Careful, you will not have enough money to continue. Consider going to work*").

# __E-Slate_Ico.	Description	Energy	Money	Hygiene	Fun	Social_Status	Health
	Disco Cuba	-30	-100	-1	50	55	0
	Airport	20	-100	1	100	50	1
	Luna Park	-30	-50	-1	60	40	1
1292199422...	Cafe	10	-5	1	10	20	-1
1292199420...	Library	-50	0	1	5	20	-1
1292199426...	Dream Soccer	-50	-50	-2	30	15	2

Figure 2.Changing the Sustainability indicators of the Game.

From the perspective of tools available for the modification of "Perfect-Ville" students can change the sites of the city through drag and drop (delete existing ones, rename them, relocate them, add new ones). As we showed earlier, students can define the sustainability indicators by adding, renaming or changing the fields of a database. Similarly, students can define the end and control conditions through adding values in a data base (See *Figure 3*)

End_Condition1	End_Condition2	End_Condition3	End_Condition4	End_Message	End_Enabled
Energy<0	Money<300			Game over!	true
Fun<0				Game over!	false
Health<-3				Game Ove...	true
Hygene<-3				Game ove...	true
Money<0				Game Over!	true

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Figure 3: Changing the end conditions of the game

In *Figure 3* above, we present an example where the game ends when "Energy falls under zero and Money is less than 300 or when Health is less than -3 or when Hygene is less than -3.

4. Method and Context of the Study

Modding with «Perfect-Ville» was part of a larger study focusing on collaborative game construction for learning concepts related to sustainability. We employed Design Based Research [28] to investigate learning through modding in the context of a pedagogical intervention [29]. Eighteen (18) students from 7th, 8th and 9th grade of a Secondary School in Athens, participated in the study which took place in the context of an afternoon Environmental Education Club. The school was an Experimental School associated to the University of Athens and the Educational Technology Lab (http://etl.ppp.uoa.gr). We made this choice not only because this school offered easy access for our research but also because it allowed for the design of new interventions outside the National Curriculum due to its classification as Experimental School.

The study evolved in eleven (11) two hour sessions (22 hours) which included group work and assembly discussions. Three researchers took the role of participant observers intervening to re-orient students to the task, to resolve technical problems and to conduct the assembly discussions. Data collection included a) student discussions of all six groups (i.e. the 18 students for 22 hours) b) screen capturing of their interaction with «Perfect-Ville» and c) the student's games. The sequence of the learning activities was the following: game- play with «Perfect-Ville» (group work), comparison of the game results discussing and challenging the assumptions of the game (assembly discussion), modifying «Perfect-Ville» into a Sustainable city (group-work), game exchange and evaluation between the groups (group work), discussion on the evaluation of the games (assembly discussion) and final refinement of the games based on evaluation (group work).

5. Data Analysis

The data we present in this section aim to show how students played with «Perfect-Ville» and then used the modding functionalities we described earlier to challenge and change the basic assumptions of the game. We focus on student dialogues taken from group work and assembly discussions. The excerpts we cite, are highlights of student activity i.e. the best instances with respect to modding. We use them here not to indicate that all students followed the same learning trajectories but to show the potential of «Perfect-Ville» as a "half-baked" game and as modding tool.

5.1 Challenging the assumptions of the game

The students participating in our study did not challenge the assumptions of «Perfect-Ville» during gameplay. Instead, they followed the flow of the game in order to win. Taking this into account in our pedagogical design and based on the half-baked characteristics of "Perfect-Ville" – the fuzziness of ending conditions- we organized after game-play an assembly discussion on the winner of the game. In the excerpt below, students from three different groups share their views.

> *1. R1:So who is the winner?*
> *2. S8: We all are! We all finished the game.*
> *3. S1- We won, because we have the largest amount of money: 1200*
> *4. S8: Who said that money was most important for the game? All you did was to go from*

work to home and vice versa
5. S5: I think we won, cause we have the highest energy levels and the highest social status
6. S11: Wait, wait. The winner is the one who has the highest values in all these: money, energy, fun, social status, health, hygiene.
7. R1: What kind of life do you have to live in order to achieve that?
8. S16: You have to do a lot of everything: have a lot of fun, have a lot of money, do not neglect your social life… This is all too much
9. S3:You have to be a freak to live like this, you won't have a moment of peace.
Excerpt 1: Identifying and challenging the way of living in "Perfect-Ville"

Fuzziness around wining conditions was one of the provocative features of the half baked game. In the excerpt above we can see how this feature triggered students to reflect on the importance of the game indicators (money, health, fun, etc in lines 4-6) at the level of game design. S1 claimed victory for his group based on that they had managed to collect the largest amount of money. In challenging this claim, S8 grounded his argument on two different types of evidence: a) one is related to the rules of the game which do not explicitly state whether money is the winning attribute and b) the other is related to the concept of life style –"*you go from work to home*" (line 4)- which of course is related to game play actions (how many sites a player visits during the game) but the wording allows for an extension to the life style implied by the specific game play strategy. Other students' assertions on their scores, introduced the idea of having high values in more than one attributes (line 5) or reaching the highest values in all game attributes (line 6). This allowed the teacher to push the discussion further into relating the winning conditions of the game to the assumptions about the pursued life style of the game (Lines 8 and 9). Based on these observations we can gain some evidence on how the design of the half baked game in the context of a specific pedagogical activity – i.e. a reflection discussion-, can support students to link game elements with domain-specific assumptions built in the game and initiate a critical reflection leading to the generation of new domain knowledge.

5.2 Changing the model instead of following its rules

*M*odding with «Perfect-Ville» is designed to encourage students to state their own assumptions about the game and express them in terms of game rules: i.e. rules that support a sustainable way of living in the game city. In the excerpt below we present a dialogue between two members of the same group who are engaged in modifying "Perfect-Ville" to a sustainable city. This dialogue has evolved into a strong disagreement about not having cars in the city of the game:

10. S2:I am not sure about not having cars in the city
11. S3: I am telling you it has been done in Freiburg. Cars are related to pollution.
12. S2:Yes, but imagine how much more time you need if you go at work by bicycle. You need to wake up at least one hour earlier
13. S3: Ok then, we will add time in the indicators. Taking the bicycle should have reduce pollution but raise time.
Excerpt 2: Expressing sustainability in terms of game rules

From this group discussion we would like to highlight the point that students engage in creating the rules that will underline the player choices during game play. This is interesting from a learning perspective because students instead of taking for granted that taking the bicycle will affect the pollution and time levels while playing the game (like in the extract of the video) they engage in the following learning trajectories: first they relate pollution to a sustainable way of living, next they

identify the role of cars in the pollution, a following step was to explore the impact of the transportation means in the life of a citizen and they identify two influential factors: pollution and time. The dimension of the time consumed in order for a citizen to reach his/her work is an important aspect of a sustainable way of living. In line 13 it is demonstrated how the functionalities of the tool allowed students to easily integrate in their game the two sustainability indicators related to the transportation means (pollution and time). Consequently it seems that modding with "Perfect-Ville" can offer a rich learning environment in which students can engage with analyzing a complex concept like sustainability and expressing this analysis in terms of game assumptions integrated in the model of the game (i.e. describing how the player's resources will be affected if they use the bicycle as transportation medium). Thus, it seems that there is a learning potential in changing the rules instead of unconsciously using them.

6. Concluding Remarks

In this paper we discussed game modding as a constructionist activity aiming to support domain learning and specifically creative learning about sustainability. Our analysis aimed at demonstrating the learning potential of half-baked games as two fold tools a) as games that are designed for change and thus supporting focused modification b) as modding tools that can allow access to the assumptions underlying the game model. The data from student engagement with "Perfect-Ville" a half-baked game and modding tool, showed that specific features of the "half-baked" game (fuzziness of ending condition) can be linked to a domain specific assumption (i.e. life style promoted by the game) the challenging of which can offer to the students chances to critically reflect on the ideas integrated in the game. Furthermore, challenging the assumptions of the game is an activity that can happen more effectively after game-play in a structured pedagogical activity (reflective discussion) anchored on a game feature. Another finding of our study was that providing students with tools that allow them to access and modify the model of the game and thus its underlying assumptions can be a) a focused learning activity bringing into the foreground domain specific concepts (in our case sustainability b) a context where students investigate domain specific concepts in order to integrate them in the game and thus influence the game play experience. The latter observation is important for the constructionist perspective because in the examples we presented learning about sustainability was not an objective per se (something that students learn to know) but an instrument to formulate the game play experience. Our future research will include redesigning the "Prefect-Ville" game so as the sustainability indicators will come more strongly at the focus of student modifications as our data showed that students tended to work more with the sites of the city and with the values of existing indicators. Furthermore we plan to explore how end users (i.e. teachers, master's students etc) use SusX to develop game ideas and modding tools.

Acknowledgements

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