A game implementation approach for design education

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A Game Implementation Approach for Design Education

Within the Content of Architectural Design Studios

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This paper proposes a new implementation of video games to be used as an architectural design education tool within design studios. There are studies which include video games in design education, however, they include video games either as mere representational media, or simplified design environments, or as just visualization tools. Video games' structures provide a ground for designing with constraints to find solutions to ill-defined design problems with a trial-and-error process. As an addition to traditional master and apprentice model of learning in the studio, video games can reduce the workload of the tutors and allow them to focus on design itself rather than focusing on hard constraints. Video games provide a highly immersive, fast, and accurate feedback to students to improve their designing skills, allow them to generate a design library and provide a platform to gain know-how in terms of solving design problems. Our contemporary architectural design education can benefit from the proposed implementation method with the video games in the market.

Keywords: video games, design education, design with constraints, design studio, problem-solving

Introduction

We are faced with wide range of problems in our lives and different types of problems require different solutions. While well-defined problems can easily be solved with the help of systematic approaches, ill-defined problems can be solved by non-routine strategies (Simon, 1973), and often require a different type of knowing , i.e., designerly way of knowing (Cross, 1982). Solving an ill-defined problem requires a person to undertake extensive cognitive processes to be able to come up with a solution in the first place, and enough experience to see the errors in the solution. This design solution must fulfil some requirements within certain constraints. Design education, even if there is no agreed system as of now, is primarily based on learning by doing (Casakin & Goldschmidt, 1999; Lawson & Dorst, 2009a; Schön, 1992). Students often are exposed to new materials, conditions, elements, functions, organizational schemes, contextual relations, and various analyses throughout their design education. Tutors evaluate students' projects based on the outcomes of the design studios. These outcomes include architectural value, contextual relations, as well as the fit of the students' projects to the constraints and rules tutors gave during the problem introduction (Webster, 2021). While this method is highly subjective (Rapoport, 1984), it is still not clear which and what kind of instructions and tools are more effective in learning how to design. A search for a tool to teach how to design is still a valid question in the field.
Design process is eventually an exploration among alternatives which are best satisfying each set of constraints (Gross, 1978). In architectural design education, studios are in the core of the training. Within the content of the studios, students are introduced to a series of problems to be solved within a design project. During the process, master and apprentice relation takes place, students develop their projects with critiques and panel reviews with their tutors to satisfy different constraints predefined by their instructors (Lawson, 2019).
As much as design courses are vague in terms of objectives and methodologies, there are platforms where design action occurs, and the objectives are clearer. Playing a game requ significant amount of cognitive process. Players are expected to come up with solutions to different problems. Each game has specified rules, mechanics, and goals. All these elements are also the features of an ill- or well-defined problem. Unlike in real

life, these strict elements of video games allow players to get to know the limitations of the game and provide them with a ground to understand the solution space after they gain experience with the game elements. Constraints and to-the-point and instant feedback of the games allow players to explore the potential solutions to specific problems (Sanina et al., 2020).
When investigated, contemporary video games include a tutorial at the beginning of the games. Even if the tutorial contents change, their goal is to teach the necessary elements of the games to the player. These elements are most of the time the game mechanics, however, often they also introduce significant features of the game such as constraints, parameters, game environment, and intractable elements. This information about game elements allows players to fully understand the game environment and mechanics. Through these tutorial, players gain full control over their creative process in the virtual game environments with their self-learning actions (Toh & Kirschner, 2020). Due to strictly coded background of the games, every move and action has a counter action. Therefore, players are fully immersed with the environment, and ready to learn by doing. This feature of the games allows contemporary games to be used in different disciplines to train novices.

Problem Definition

In the literature, many studies (such as Almeida & Simoes, 2019; Haahtela et al., 2015; Jayakanthan, 2002) indicate video games are used as tools to teach specific topics in every level of education. While their application in elementary and high school education is more common than their use in higher education, some studies also include video games in the higher education as well. Studies based on video games (Parsons et al., 2019; Sun & Gao, 2016; Vidergor, 2021) are often used as tools to make education entertaining for small kids in their teaching environments. In higher education, the reason to use games is to create a safe simulating environment for non-experienced professionals. There is no categorization and utilization technique for the video games to be classified within such use. In a significant number of studies (e.g. Marlow, 2009; Örnek, 2013), games are being used as environments to design, interact, fulfil a quest, increase hand-eye coordination, presentation environment. However, there is no use of game environment to be used as a tool to teach designing with a set of specific constraint.

Scope, Aim, and Methodology

Within the scope of this research, studies which investigate the use of games in education will be critically reviewed to introduce a pedagogical framework for design learning. As a methodology, we are following an argumentative method to construct the framework and to introduce a new implementation.
There are different ways to use games in the curriculum for educational purposes. While some of the studies are using games as a tool to introduce new concepts, some are using them just for presentation purposes, others to investigate the effects of video games in the process of learning. In other disciplines games are already being used as learning tools and this paper will revisit these to understand how different professional practices and their education systems incorporate them within their curricula. Later, methodological differences in games will be studied further to demonstrate the current state of the art.
After the review, the way instructors utilize these games in their teaching environment will be categorized. The main aim here is to understand what games could be used in what manner for ill-defined design problems and propose a brief framework for design learning.

Design and Design Education

As it has been put before, here the problem is more about the requirements, and provisions to see the fit between them (Alexander, 1964; Archer, 1979). Disciplines which have “design” in their cores deal with ill-defined problems. Even though it is not an easy task to define exactly what is ill-defined problem, Simon (1973) explains what makes a problem ill- or well- defined in reference to whether the problem space, or the solution space, or the operators to be used to go from the problem space to the solution space is underspecified. For well-defined and ill-defined problems, initial state, goal state, and operations differ drastically. Games proposes a highly well-defined environment, where the rules and movements are strictly organized with a well-thought pattern like in the game of chess (Simon, 1973).
Even though design problems are ill-defined, a design problem comes with rules and certain constraints which can be discarded, modified, added during the process, or evaluated at the end. When one undertakes design tasks, constraints emerge at different phases of the design problem. Some are stated at the very beginning of the design brief, some constraints emerge in relation to a particular design solution during the design action. Rather than seeing these constraints as limitations or blockages for free-will, they form the vague boundaries

for the solution space, in a multi-dimensional manner. They can also extend the solution space as well (Gross, 1985). Apparently, designers generate solutions by activating different constraints and associate them with their previous experiences. Design ability includes implementation of the new design solution to new constraints (Chan, 1990). Recent studies based on this assumption also indicates that designers who are led by visual constraints approach to design action in a different manner than those who were not exposed to any constraint (Ashrafganjouei & Gero, 2020). Another unique aspect of design action is the way designers generate new task goals and redefine the constraints along with it (Akin, 1978). Designers, even if the specific constraint was not put at the early stage of design process, can propose a new constraint, or edit it with their expertise in the field. However, this process requires a wide range of domain knowledge for the designer, as well as a know-how to handle it.

It is not an easy task to educate designers. While design students are required to improve their technical skills such as representing ideas, new methods, CAD use, they are also expected to learn profession related knowledge (Lawson & Dorst, 2009b). Learning how to design is also a skill which students are expected to learn, improve, and demonstrate. Acquiring expertise in design education is only achievable through practice (Lawson, 2019). Due to architectural design education's "learn by doing" approach, students are set in a simulated real-life like projects, where they undertake an architectural design project. This system has various shortcomings in terms of mimicking the practice. Even a well-defined problem in architectural terms can be a brand-new problem for students. While professionals easily solve such a problem, students need to generate enough design skill and experience to cope with the slightest problem in their design education (Goldschmidt, 2001).

In architectural design courses, students often use their tutors' experiences to create the control mechanism for the design decisions. Here, tutors have various roles, they become the client, the consultant, project team member, instructor. One of the major roles of instructors is to understand the student's evolution in expertise level and force them to undertake even more challenging tasks. While this is not an easy task to properly satisfy, tutors are often involved with the projects more than students are able to. Studies indicate tutors have more to say for a student's project than student has during the design crit and panel review (Khaidzir, 2007). Through a long and extensive trial-and-error phase, students rely on their instructors' previous experiences, skills on transferring knowledge, and representational language (Oxman, 2001).

Games in Education

Nowadays, game industry is one of the most profitable entertainment industry in the world (Statista, 2018). Serious gaming redefines the purpose for which the games are used for. This implementation of games creates an alternative as an educational or psychotherapeutic tool (Lievense et al., 2020). Gamification is another way of using the games for specific learning outcomes. It entails the use of game environments and outcomes for specific pre-defined aims in non-game contexts (Abou-Shouk & Soliman, 2021; Whittaker et al., 2021). Gamification, serious gaming, and use of games for different purposes are more and more used in education (Dicheva & Dichev, 2015). In learning, video games are used extensively in the higher levels for the last few years for purposes ranging from representation to designing due to their user-friendly interfaces, three-dimensional capabilities, and transferring knowledge for a profession-specific topic (Almeida & Simoes, 2019; Kharvari & Hohl, 2019). However, there is still ongoing research to explore the possible uses of games in different training and education fields (Gunter et al., 2006, 2008). In a broad sense, games allow players to monitor and have control on their progress through instant and efficient feedback process of the games. Players also develop motor, cognitive and space-related skills while playing games for educational purposes, rather than solely for entertainment. Another important aspect is to illustrate the conditions and rules, where it is hard to imitate in real life environments (Simkova, 2014).

Throughout the years, serious games were categorized in different manners. Main categories can be named as public policy, strategic communication, defense, education, healthcare according to a study by Zyda (2005). Another categorization includes more genre such as military games, government games, educational games, corporate games, healthcare games, political games, religious games, art games, advertising games, cultural games (Alvarez & Michaud, 2008; Chen & Ringel, 2005). Categorizations can be extended for marketing, genre, audience focuses (Bergeron, 2006; Despont, 2008; Miguel Encarnação, 2009). However, within the content of this paper, only educational games are reviewed.

Training for different purposes is one of the major aims of gamification for serious gaming. Examples can be found easily in the medical field, military use, and skill-based practices. Educational paradigms for gamification in higher education can be put as interface design for disabled people, transferring academic knowledge, and gaining professional expertise (Jayakanthan, 2002). In war games, military strategies can be learned and

practiced through gaming (Smith, 2010). Here the games are mostly used for their simulating features for battlefield, where military actions can be understood in action and strategies can be implemented. The game mechanics and goals immerse the players, so that they can learn the very core outcome of military use. Another satisfactory field is the medical use of gamification. Researchers state that serious games have a wide range of potentials for educating surgeons. Technology based education in surgical games create the cognitive and perceptual models for the trainees. Not only knowledge-based games, but application based, hands-on games to undertake the action of games with the help of virtual reality systems are the safest ways to train surgeons to demonstrate in real-life examples (Baby et al., 2016). History teaching is also possible through satisfactory serious game design for historical objective, which develops enthusiasm, motivates and engages students, reduces monotonous learning methods, helps students to focus, gain self-esteem, and improve the memorization of the historical content (Zirawaga et al., 2017). In engineering, serious gaming supports learning course materials and effect student's perception of course content positively (Bodnar et al., 2016). Not only students learning capabilities, but transfer of academic knowledge to the industry seems to be maximized with the help of games in the academic curriculum in higher education (Deshpande & Huang, 2011). Mayo (2007) states that educational benefits of video games in science and engineering fields are scalability of the audience, being available any time for students, compelling nature, improving learning abilities, and being better than a lecture. Research indicates improvements of learning outcomes are typically 30% and more when gamification applies to engineering education.
Games are also used in design education. A study conducted by Radford (2000) created a game-like environment where students interact with historical structures to learn about shape grammar and come up with ideas in the game environment itself. Further research used this learning outcome in an interactive manner, where creational objectives were also introduced to novice designers. Students' understanding of spatial relationships and formal decisions were taken into consideration within the game environment through automated scripts. However, it was used only as a design grading element rather than providing a feedback during the design action (Sandstrom & Park, 2019). Another study used a gaming platform to design in a collaborative manner within its environment, however researchers and participants struggled with the technicality of the game, even though at the end the collaborative design environment was set, it was harder to design than with the traditional methods (Warmerdam et al., 2007). In landscape design education, games are used as a representational tool (Örnek, 2013) as well as a platform to teach technical, material, historical, sustainable approaches (Marlow, 2009). In a study, a massive-multiplayer role-playing game was used as a representational shared online medium for students to showcase their works to their tutors in the final reviews (Abdellatif & Calderon, 2007). Another prototype was for everyone to learn the basic architectural workflow for housing projects. The tool was generated to maintain a design environment and provided the player with the tools to design (Otten, 2014) with no further implementation of trial-error based reasoning and learning. Application of serious gaming in design education also includes the shift of game purpose into a virtual studio, where students and tutors come together to work on individual or group projects (Moloney, 2001; Moloney & Amor, 2003) . However, within such case, game environment is nothing more than a collaborative communication platform. Another game prototype was generated to create spaces out of blocks to enhance students' creativity towards spatial creations (Sanchez, 2015). No constraint definition, feedback process or design satisfactory criteria were applied in the content of the game, therefore the prototype was used only as a platform to create a virtual replication of the design, like a computer-aided design software.

Critical Review Outcomes

Games, when they are considered in a serious gaming context during education, proves to have multi-dimensional advantages. Apart from being only entertaining and immersive, in most of the professional fields, games introduce real-life like scenarios to juniors and provide them with technical and cognitive skills they will need further in their professional lives. One of the major things in all these fields is that the game environments are not only to maintain a platform to simulate professional practices, but they also have the feedback mechanisms, where actual expertise is acquired through strictly defined problems and satisfactory objective oriented solutions. These mechanics in the games serve as not only constraints but also as tools to play around and better realize the solution space in the well-defined problem systems in specific professional fields. Especially the strict and various constraints in games can create a manageable design environment for players.

However, design fields when compared to others, include gamification and serious gaming into their curriculums in a different manner. While other fields use the immersive environment to maintain the feedback process and fitness of the design decisions with regard to design constraints, games in design education are used primarily for representational reasons, collaborative environments, and as tools to support the design action's technical side. No design cognition challenge or no feedback process is considered with the games and the educational objectives with which a learner could set design constraints, modify them, and when necessary, drop them with instant feedback from the game environment.

A New Implementation of Games for Design Education

In non-design fields, games' advanced feedback mechanisms are being used to create an immersive and real-life like environments for players and students. However, in design field this feedback process of game algorithms is usually not introduced. The potential in games to support instant feedback in reaction to a certain move is not explored in the literature. Games consists of many algorithms and background calculations to provide working game mechanics. Every game and scenario have a goal, where they are highly well defined. For design education, games with ill-defined problem-solving game mechanics can be used to make students to explore the potentials of the game's first. Within the infrastructure of the game the hidden algorithms can easily track students' actions, and decisions which can be easily calculated and reflected back to them to allow them to generate a new solution or adjust their current design solution. Not only to provide feedback and evaluate, but the video game also can act as an artificial tutor to teach students about constraints, support their prioritization skills in professional manners, as well as manipulate the current constraints and set up new constraints.

In design education, tutors constantly evaluate students' projects and provide regular feedback. They try to find out the problems, errors in design, and provide suggestions for their design or rational for their design decisions. Due to students' lack of experience in design, some of the basic design decisions are hard to grasp. Right at this point, full potential of games can be used. Games can support the design learning experience by using finite elements in infinite combinations, where students can try to solve problems, fail, and try it again until they acquire the experience to cope with the technical difficulties. Tutor's role here changes. Rather than trying to find the errors in design, and failed design decisions, hard built constraints can be left to strict algorithms to check in students' designs. At that point, tutors can start dealing with the intricacies of design itself, student's approach to design problem, unique ideas, design concepts, which are the soft constraints, therefore reduce the tutor's workload.

The proposed new implementation is a hybrid system to design courses, where traditional method is coupled with contemporary serious gaming in a designerly way. However, it is important to select the game best suitable for this manner. Most of the games in the market are based on simulation and management games. These games provide an environment where players oversee a specific facility (such as a hospital, prison, colony, spaceship, airport, collage, hotel, etc.) and their actions are affecting the occupants of the game environment. Players are expected to design a working program with certain specifications. In this manner, what players (students in educational settings) must do is to maintain a working scheme throughout the game with dynamic and changing demands based on the simulation algorithms. To give an example, a game called *Prison Architect* is a simulation game where players create prisons for specific needs (see Figure 1). Architectural elements such as foundations, walls, furnishings, plumbing and electrical systems, zones such as kitchen, cell, armory, staff room, garden, interrogation rooms, showers and many others are present. Players start with certain specifications for a design project, such as fifty prisoner inhabitants, with a cafeteria for eighty people, a staff room, two offices, and a garden, with service spaces enough to facilitate them. A certain amount of funds is given to players to come up with a design. What is important here is, players must be aware of their actions before prisoners arrive to the prison. Players must understand the program and place each zone with certain requirements in a meaningful order. Possible consequences can be generated by the game algorithm to provide feedback during the design process. For example, if the player puts a cell close to one of the major exits, during the free hour (where prisoners can move as they want), prisoners will most likely start escaping the prison. Therefore, player can adjust the design in accordance with this specific situation. Another consequence for the design can be, if the square meter for the cafeteria is not adequate, and if the prisoners sit too close to each other, they get psychologically stressed and start a rebellion, where staff members are in danger and a lock down must be announced.

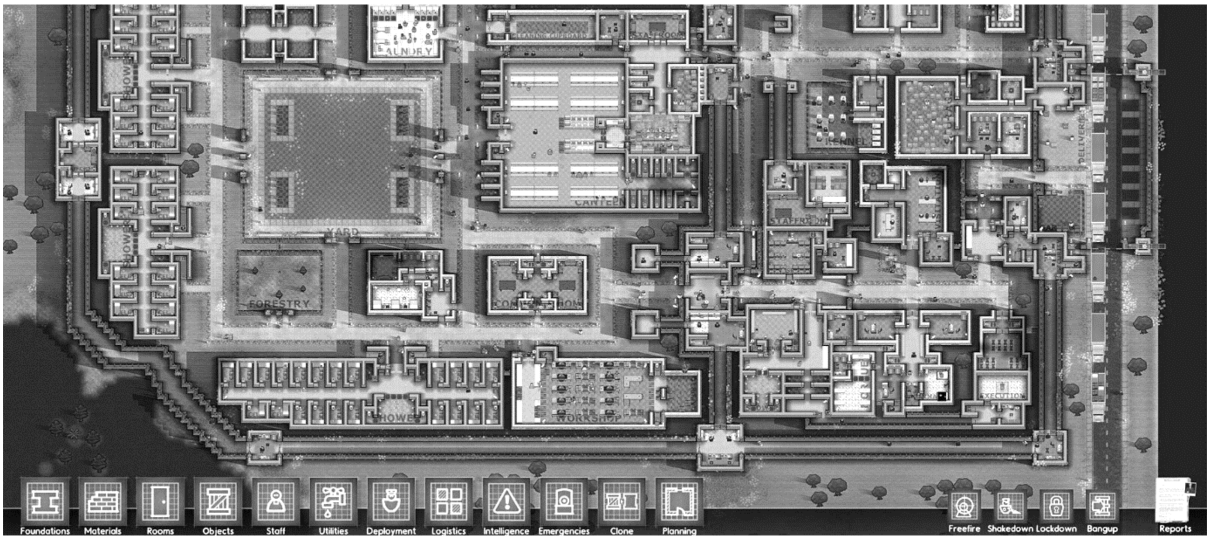

Figure 1. Prison Architect, In Game Heads-up Display (Fernan, 2019)

Another example for a simulation game can be *Project: Highrise* which has a side-view section like game environment to create a resemblance with architectural notations (see Figure 2). In the game, players oversee balancing the supply and demand chain in a high-rise project. The game elements include a wide range of functions which are represented with different styles, and attributes that both adds up to the workload and the infrastructural needs for the whole building. Main constraint in the game is to follow the uses of the spaces and re-arrange the spaces' uses as well as add new offices, accommodation units, shafts etc. accordingly. Even if the game proposes a simple challenge, to understand the vertical relations and some of the main constraints in terms of structural, plumbing, electrical, and mechanical systems can be learned through the game challenges, as well as manipulating the existing spaces for the demands of the occupants.

Figure 2. Project Highrise Game Environment (Gault, 2016)

These kinds of situations in game environments can make the player (student) generate an experience for the designed spaces and foresee the consequences of their actions, which can lead them to make more appropriate decisions along an automated, fast, and rigid trial-and-error based design process.

Conclusion

Today, design education is based on models created in Bauhaus and partially a continuation of Ecole des Beaux Art with some minor contemporary additions. This study proposes that adding video games in the design studio might foster checking the objectives with constraints and providing instant feedback. In the last decade, gamification and serious gaming are introduced in education to teach certain skills and knowledge to novices. In this study, the use of games in different learning disciplines are reviewed. After stating the main difference between different disciplines' approaches to gamification, it is seen that the use of games in design education is rudimentary. A new approach to use video games in design courses within a hybrid system of traditional design crit system is proposed. The new hybrid system allows the course instructors to deal with the design idea related items, rather than the organizational problems of the projects, while game itself can create a self-learning environment for such outcomes. One of the major focuses of the proposed methodology is to allow students to overcome the lack of design skill in early phases of their design education. Providing a meaningful platform for an automated trial-and-error based system for students can enhance their abilities to understand

the consequences of their design decisions, which corresponds to the design experience.
For further studies, this new approach must be tested with a group of novice designers. An experimental study based on the outcome assumptions will provide a deeper understanding and foresight for the idea of implementation of serious gaming and gamification concepts in design education's core.

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