Classifying and Evaluating Computer Games to Explore their Potential Use in Landscape Architecture Education

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ABSTRACT

Computer games have been used for educational and training purposes for over a decade. Examining these games to distinguish their beneficial didactic and pedagogic potential is important for determining the possibilities for their application in design education. Studies on classifying computer games have assisted educators in identifying their potential utilization areas and have guided educators through adaptation processes. Until 2008, computer games were classified based on their purposes or their application areas, however in 2008, Sawyer and Smith introduced a new comprehensive system that classifies computer games by considering both criteria. The following year, Foster and Mishra (2009) suggested evaluating computer games according to their contribution to skills and motivation. Most recently, Djaouti et al. (2011) developed another classification system that considers interactions between games and players. Although these classification models help considerably to identify the general educational potential of computer games, they do not necessarily provide specific information for application to landscape architecture educational models. This paper introduces an evaluation system that is developed to help identifying educational potential and opportunities of computer games for use in landscape architecture education. The evaluation system used reviews computer games according to their visual and technical qualities, and also according to their contribution to skill development. As part of our research, we also applied the developed evaluation system to 60 landscape-related computer games to identify game genres with pedagogic potential specific to landscape architecture education. Our findings indicate that Simcity4, Leafsnap, Build-a-Prairie, Thisissand, ASPIS Sustainable, and UWB Wetlands Restoration games can be used in landscape architecture education without any modification, while Minecraft needs to be modified according to the curriculum. We suggest modifying the Minecraft game for use in facilitating and leveraging the learning of landscape grading and construction materials topics and developing tailored educational games for landscape architecture by utilizing game engines.

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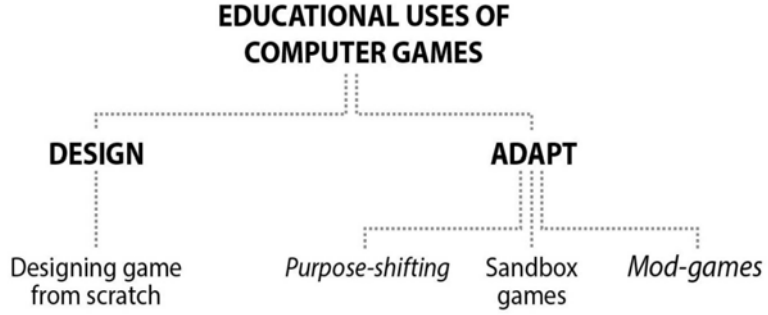
INTRODUCTION: COMPUTER GAMES AND THEIR USE IN EDUCATION

Although computer games are often seen as a time-wasting addiction of the younger generations, recent research reveals possibilities to utilize these games to develop valuable knowledge and professional skills. Green and Bavelier (2003; 2007) conducted a series of experimental studies that aimed to measure visual and cognitive skill development through playing action video games. In his book, *Digital Game-Based Learning*, Marc Prensky (2007) defines a new generation that has grown up spending more time with computers and smart gadgets and are more familiar with human-computer interaction as *Digital Natives*. Prensky claims that human-computer interactions have changed the mechanisms of understanding for digital natives. Thus, they tend to learn through reading visualized information rather than text, hyperlinking information in a network, and receiving rewards during the process. Thereby, he suggests a revision of the existing education system in correspondence to the learning requirements of this new generation. The term *Serious Games* has appeared in the associated literature and refers to the use of computer games for other primary purposes besides entertainment. According to Michael and Chen (2005), the earliest serious game applications were developed for military training purposes.

In order to utilize computer games in educational practices, existing literature suggests either directly designing new educational games or adapting existing commercial video games. Although designing a new game seems the most effective way to satisfy educational demands, this process requires a significant budget, and extensive effort and time. Commercial video game developers can overcome these limitations by hiring experts, but educational institutions are often limited by funding. These reasons compel educators to find alternative utilization methods. Shaffer (2006) suggests utilizing existing computer games by changing their purposes to include educational goals (*purpose-shifting)*. Another method is the use of customizable *sandbox* games that allow educators to design games by customizing game environments, scenarios and goals. The third method is *re-coding* or *re-programming* existing computer games by modifying their platforms through the use of computer game development software, such as *game engines* and *multi-user virtual environments* (MUVEs).

FIGURE 1: Methods for utilizing computer games in education



Each of these methods has different requirements and customization capabilities. Since creating a game from scratch is very costly, it is not often utilized. While the purpose shifting method provides significant cost savings, it may not fully meet the curricular demands. In order to utilize games within a specific discipline, the games should be carefully analysed through a consideration of the educational demands of that discipline. Classification research helps to evaluate existing games for specific educational purposes. Djaouti et al. (2011) suggest classifying computer games according to their game structure, purpose, and target audience, while Foster and Mishra (2009) evaluate games for their contribution to skill development. Although they provide an outlook on the relationship between the games and education, they may be inadequate for discipline specific educational demands. For instance, there has been too little research related to the use of computer games in the landscape architecture discipline to draw any conclusions on their educational benefits. This paper introduces an evaluative framework that identifies the educational potential of computer games specifically for landscape architecture education.

CURRENT CLASSIFICATION METHODS FOR COMPUTER GAMES

Until 2008, computer games were classified either based on their purposes or their application areas (market). Although these classification methods appeared to be different and were helpful in evaluating games based on their different aspects, there were many overlaps as shown in Table 1 (Djaouti et al. 2011).

In 2008, Sawyer and Smith introduced a classification system, *Serious Games Taxonomy***,** which classifies games by combining and improving upon the market and purpose-based classification systems. This research creates a taxonomy matrix by redefining the subcategories of both systems (Table 2). The Serious Games Taxonomy provides a more accurate and detailed categorization of games and indexes sub-categories for each intersection of purposes and application areas

Purpose-based Alvarez & Michaud (2007)		**Market-based** Alvarez et al. (2008)
Advergames	<< >>	Advertising
Activism games	<< >>	Activism
Edu games		Culture
Edumarket games		Defense
News games	<< >>	Information & Communication
Training & Simulation games	<< >>	Training & Education games
		Health games

TABLE 1: Overlaps in market and purpose-based classifications (Djaouti et al. 2011)

TABLE 2: Serious Games Taxonomy classification system (Sawyer & Smith 2008)

	Games for Health	Advergames	Games for Training	Games for Education	Games for Science and Research	Production	Games as Work
Government & NGO	Public Health Education & Mass Casualty Response	Political Games	Employee Training	Inform Public	Data Collection/ Planning	Strategic & Policy Planning	Public Diplomacy, Opinion Research
Defense	Rehabilitation & Wellness	Recruitment & Propaganda	Soldier/ Support Training	School House Education	Wargames/ planning	War planning & weapons research	Command & Control
Healthcare	Cybertheraphy / Exergaming	Public Health Policy & Social Awareness Campaigns	Training Games for Health Professionals	Games for Patient Education and Disease Management	Visualization & Epidemiology	Biotech manufacturing & design	Public Health Response Planning & Logistics
Marketing & Communications	Advertising Treatment	Advertising marketing with games, product placement	Product Use	Product Information	Opinion Research	Machinima	Opinion Research
Education	Inform about diseases/ risks	Social Issue Games	Train teachers/ Train workforce skills	Learning	Computer Science & Recruitment	P2P Learning Constructivism Documentary	Teaching Distance Learning
Corporate	Employee Health Information & Wellness	Customer Education & Awareness	Employee Training	Continuing Education & Certification	Advertising/ visualization	Strategic Planning	Command & Control
Industry	Occupational Safety	Sales & Recruitment	Employee Training	Workforce Education	Process Optimization Simulation	Nano/ Bio-tech Design	Command & Control

(Djaouti et al., 2011). Based on this model, Djaouti et al. (2011) developed another classification system, the *G/P/S model*, which classifies games based on three criteria: Gameplay, Purpose, and Scope (Figure 2).

Gameplay represents the structure of the game. This criterion was defined based on two forms of gameplay: *game-based,* where the players must follow the rules or achieve the goals in order to successfully complete the game, and *play-based,* where there are no stated goals or rules for completion of the game.

The second criterion of the G/P/S model is Purpose. The games were classified under three purpose categories: *message-broadcasting*, *training,* and *data exchange*. Message broadcasting refers to games that aim to inform players on a specific topic. Training refers to games that aim to develop an expertise or ability through practice. Data exchange refers to games that aim to collect information from players and only a small portion of computer games is designed with this purpose.

Scope is the last criterion of the G/P/S model. It is divided into two subcategories: *market* and *public*. While market defines thirteen application areas of the educational computer games, public defines the target audience.

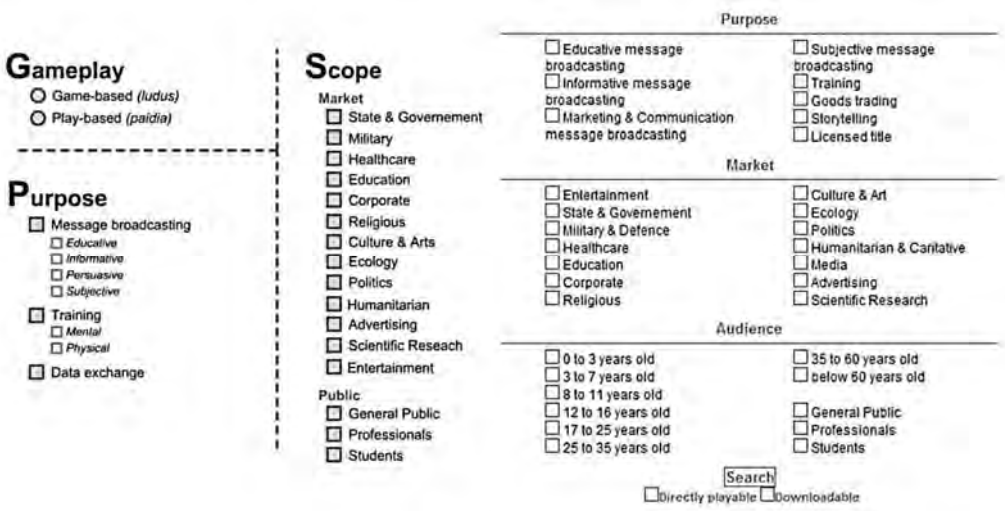


FIGURE 2: G/P/S classification system (Djaouti et al. 2011)

Unlike the Serious Games Taxonomy or G/P/S models, Foster and Mishra's (2009) classification framework, *TPCK* (*Technological Pedagogical Content Knowledge*), focuses on the positive and negative effects of computer games on players and their contribution to skill development. This method analyses games in two categories: *physiological* and *psychological* effects. The physiological category is focused on the behavioural effects of computer games, such as *aggressiveness, antisocial behaviour, coordination, introversion, motor skills, obesity* and *violence*. The psychological category is focused on the effects that are related to *practical, cognitive, social skills,* and *motivation* (Figure 3).

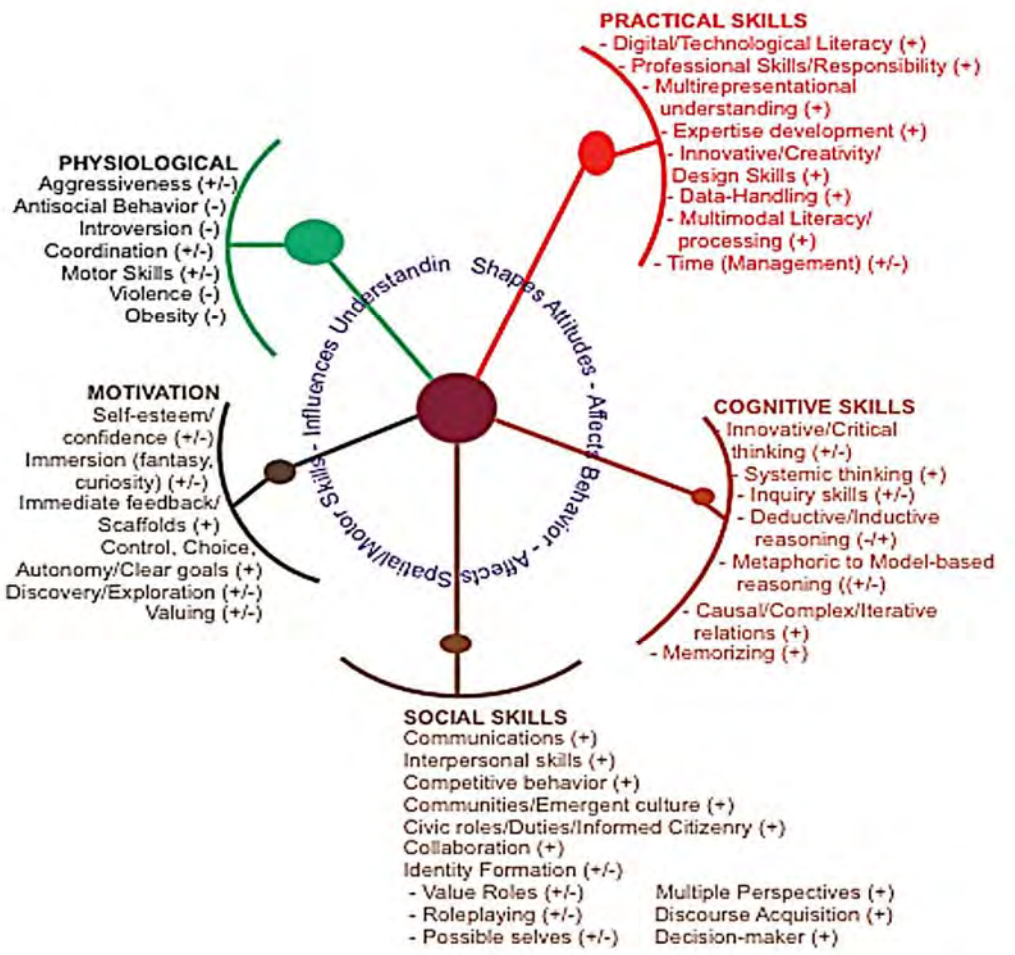
"Practical skills refer to learning in game that contribute directly to the development of skills that are applicable to the real world or authentic settings," states Foster & Mishra (2009, p.36). *Technological literacy, professional skills, expertise development, time management, creativity* and *multimodal processing* are listed as some of the subcategories of the practical skills in the TPCK model.

Cognitive skills refer to learning by doing. Game players learn by engaging in some activity and develop first-hand experience of that activity or system. Making decisions, observing effects or managing parameters in computer games can help to develop cognitive skills. *Inquiry, systematic thinking, innovative/critical thinking, reasoning, relating information,* and *memorizing* are some of listed sub-categories of the cognitive skills.

Social skills refer to learning through interaction with other players. According to Foster and Mishra (2009), computer games can help to develop interpersonal skills and identities. *Emergent culture, civic roles,* and *identity formations* are defined as some of the sub-categories of social skills.

Lastly, motivation defines the engagement abilities of computer games. Foster and Mishra (2009) argue that, developing *self-esteem, immersion, immediate feedback, control of player, exploration in the game* and *valuing ability* are the motivational effects of computer games.

FIGURE 3: Categorization of TPCK framework (Foster & Mishra 2009)



In summary, our literature review showed that the G/P/S and TPCK models reveal the distinct educational potential of computer games and suggest possible utilization methods of computer games in education. However, these models have essential limitations in addressing educational relevancies and determining scopes of classified games. For instance, while the TPCK model helps to evaluate games in order of their contribution to skill development, it does not provide any information regarding a game's relevance to educational demands. On the other hand, the G/P/S model divides educational games into thirteen application areas, however landscape architecture may correspond to multiple scopes, such as ecology, state & government, and scientific research. These classification systems do not provide any information regarding their visual, technical and instructional abilities, which are critical factors for pedagogical and feasibility determinations. For the purpose of employing computer games in landscape architecture education, a landscape focused evaluation system should be developed.

RESEARCH

According to the official website of Harvard University, landscape architecture is "a medium of design that engages urbanism,

environmentalism, and culture" (Harvard University, 2015). As a discipline, landscape architecture narrows the gap between architecture and urban and regional planning and explores creative solutions in built and rural environments through social, ecological and environmental resources. Therefore landscape architecture education requires three-dimensional thinking, management, analysis, critical thinking, decision-making and problem solving skills in addition to a thorough understanding of complex urban and ecological dynamics. In addition to knowledge and skill development, Gazvoda (2002) indicates the crucial role of teaching presentation techniques for design projects.

As mentioned previously, the latest scientific research indicates the instructional potential of computer games on developing knowledge and 21st century skills, such as critical thinking, problem solving, reasoning, collaboration, self-direction, information and communication technology, facility in using virtual workspaces, and computer programming, which landscape architecture students should have. However, landscape architecture pedagogy, as it currently stands, has not transcended beyond using computer aided design software for the visualisation of designs. On the other hand, recent gaming technologies present computer games as highly immersive, collaborative and customizable training tools. Students can learn plant material or landscape grading principles through well-designed learning tasks and receive informative feedback to solve complex problems. Moreover, students can become skilled in specific tasks through solving repetitive tasks in competition with other students. Consequently, this research introduces an evaluation system to assist educators in identifying potential computer games to be utilized in landscape architecture education.

Game Selection Criteria

In order to identify games related to the landscape architecture discipline, four criteria have been set for inquiries:

- Keywords used for database search: "landscape", "terrain", and "landform"
- Game release date: 2000 to 2014
- Operating systems: Games operating on Windows and Mac only
- Language: English was set as the primary language, but multi-language games were also included

Review of Game Databases

During the first round of game database review, a large number of computer games were retrieved from the *Serious Game Classification* (2014) database. This online database was developed as a result of Djaouti et al.'s serious game classification research published in 2011, which classifies games according to the G/P/S model. As of February 2015, the database contained 3088 games.

According to the aforementioned selection criteria, a search was conducted using the identified keywords, but did not yield many results. Therefore, the first criterion was changed, and a new search was

conducted using the following keywords: “ecology”, “education”, and “scientific research”. The second, third and fourth criterion were successfully applied.

During the second round of the game database review, the *Ecogamer* website (2014) was utilized. This website includes only a small number of games, however, due to its concentration on environmental health and sustainability issues, we thought it would be a worthy database to review. The website has an underdeveloped purpose-based classification system and search feature, therefore, a search was conducted through the review of game descriptions.

In addition to the games identified through these two online databases, more educational games were retrieved through the review of recent academic research papers that studied the educational use of computer games. This review directed us to the games such as *RiverCity* (Dade 2009), *Quest Atlantis: Taiga Park* (Barab et al. 2005), *Trails Forward* (Bell-Gawne et al. 2013), *Crystal Island: Uncharted Discovery* (Lester et al. 2013), *SecondLife* (Baker et al. 2009), *Open Simulator* (Perera et al. 2010), and *LeafSnap* (Kumar et al. 2012).

In order to further expand the selection pool, highly ranked commercial video games were also included into the selection. Finally, the *Entertainment Software Rating Board* (ESRB) (2014) and *Internet Gaming Network (IGN) Entertainment* (2014) websites were reviewed to identify more games that matched the selection criteria.

At the completion of our search, 22 games were identified from the Serious Game Classification database, 5 games were identified from the Ecogamer website, 9 games were identified from ESRB and 17 games were identified from the IGN Entertainment database. In addition, 7 games were identified through reviewed articles and research on educational use of computer games. A total of 60 games were identified for evaluation in this research (Table 3). The distribution of the studied games is shown at Figure 4.

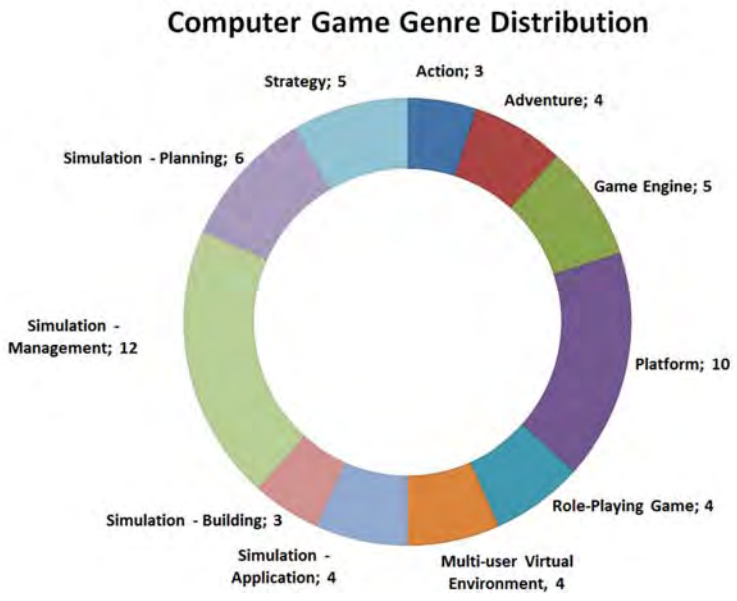


FIGURE 4: The distribution graphic of studied games based on genres

TABLE 3: List of identified games

Game Title	Game Genre	Release Date	Source	Usage Fee
2020 Energy	Simulation - Management	2012	Serious Games Database	Free
3rd World Farmer	Simulation - Planning	2005	Ecogamer Website	Free
Age of Empires 3	Strategy	2005	IGN Website	Paid
ASPIS Sustainable Game	Simulation - Application	2012	Serious Games Database	Free
Aurora Toolset	Game Engine	2002	IGN Website	Free
AWQA	Simulation - Application	2008	Serious Games Database	Free
BBC: Climate Change	Simulation - Management	2007	Ecogamer Website	Free
Bridge Builder	Simulation - Building	2006	IGN Website	Paid
Build-a-prairie (Ball Museum)	Platform	2000	Ecogamer Website	Free
Cap Odyssey	Simulation - Planning	2013	Serious Games Database	Free
Catchment Detox	Simulation - Management	2008	Serious Games Database	Free
Civilization 5	Strategy	2010	IGN Website	Paid
Clim' Way	Simulation - Management	2008	Serious Games Database	Free
Cry Engine 3	Game Engine	2011	IGN Website	Free
Crystal Island - Uncharted Discovery	Adventure	2008	Literature Review	Free
Disaster Watch	Platform	2006	Serious Games Database	Free
Dota 2	Strategy	2011	ESRB Website	Free
ElectroCity	Simulation - Management	2007	Serious Games Database	Free
EnergyVille	Simulation - Management	2007	Serious Games Database	Free
Enigmo	Platform	2003	IGN Website	Paid
FarCry 3	Action	2012	IGN Website	Paid
FloodSim	Simulation - Management	2008	Serious Games Database	Free
Forestia	Simulation - Application	2009	Serious Games Database	Free
Grand Theft Auto 5	Action	2013	IGN Website	Paid
GroenEiland	Adventure	2012	Serious Games Database	Free
IBM City One	Simulation - Management	2010	Serious Games Database	Free
Inside The Haiti	Adventure	2010	Serious Games Database	Free
Kodu Game Lab	Game Engine	2009	IGN Website	Free
Leaf Snap	Platform	2011	Literature Review	Free
League of Legends	Strategy	2009	ESRB Website	Free
Limbo	Platform	2010	ESRB Website	Paid
Machinarium	Platform	2009	IGN Website	Paid
Medal of Honor	Action	2010	IGN Website	Paid
Minecraft	Role-Playing Game	2009	IGN Website	Paid
My 2050	Simulation - Management	2011	Serious Games Database	Free
Neverwinter Nights 2	Role-Playing Game	2006	ESRB Website	Paid
Oiligarchy	Platform	2008	Ecogamer Website	Free
Open Simulator	Multi-User Virtual Environment	2013	Literature Review	Free
Plan Your Future Park	Platform	2004	Serious Games Database	Free
Plant it Green: The Big Switch	Simulation - Management	2013	Serious Games Database	Free
Plant vs. Zombies	Platform	2009	ESRB Website	Free
Quest Atlantis: Taiga Park	Multi-User Virtual Environment	2004	Literature Review	Free
River City	Multi-User Virtual Environment	2004	Literature Review	Free
Roller Coaster Tycoon 3	Simulation - Planning	2007	IGN Website	Paid
Second Life	Multi-User Virtual Environment	2003	Literature Review	Free
SimCity 4	Simulation - Planning	2010	ESRB Website	Paid
Sims 4	Simulation - Building	2014	ESRB Website	Paid
Smart Grids	Simulation - Management	2013	Serious Games Database	Free
Stop Disasters	Simulation - Application	2007	Serious Games Database	Free
The Riverbed Game	Adventure	2010	Serious Games Database	Free
Thisissand	Simulation - Building	2012	Serious Games Database	Free
Trails Forward	Simulation - Management	2013	Literature Review	Free
Ultima Online	Role-Playing Game	2000	ESRB Website	Paid
Unity	Game Engine	2012	IGN Website	Free
Unreal Engine 4	Game Engine	2012	IGN Website	Free
UWB Wetland Restoration	Simulation - Planning	2012	Serious Games Database	Free
Warcraft 3: Frozen Throne	Strategy	2003	ESRB Website	Paid
Windfall	Simulation - Planning	2009	Ecogamer Website	Free
World of Goo	Platform	2008	IGN Website	Paid
World of Warcraft	Role-Playing Game	2004	IGN Website	Paid

Evaluation System

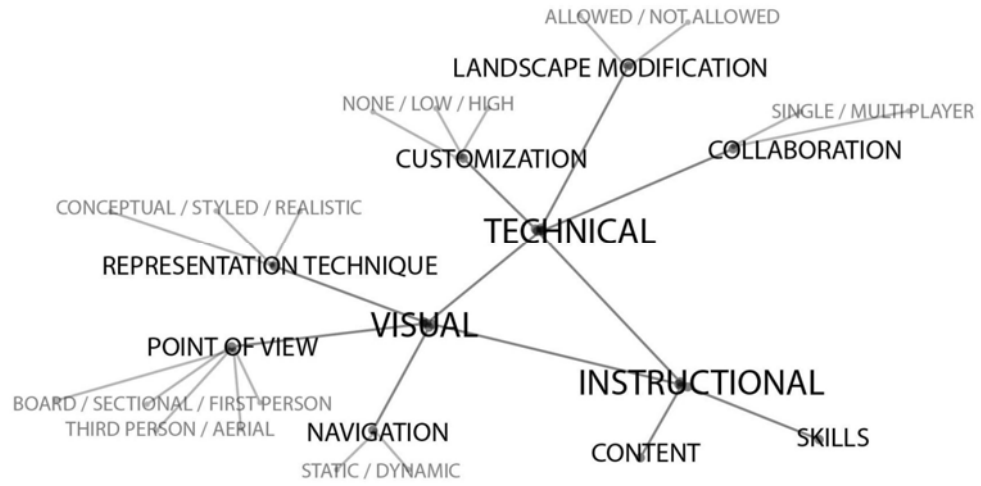
The identified games were evaluated based on their visual, technical and instructional aspects in order to reveal their educational potential. Each game was evaluated using the following questions:

- How does the game represent/portray landscape visually? How does the point of view affect the perception of players?
- How can players interact with the portrayed landscape? Can players shape the portrayed landscape?
- How can the game be customized for use in education?
- How can the game be utilized by students in collaborative projects? How does the game contribute to the skill development of the players?

An evaluation framework with three main criteria was developed according to the questions above.

The first criterion focuses on the *visual aspect* of games and evaluates the visual representation technique, the point of view (POV) of the players, and the navigation mode of the game.

FIGURE 5: Hierarchical scheme of the proposed evaluation framework



PRE-SELECTION

VISUAL

KEYWORDS	*Landscape/ Terrain/ Landform*
RELEASE DATE	*2010 - 2014*
OPERATING SYSTEM	*Windows/ MacOS*
LANGUAGE	*English/ Multi-Language*

TECHNICAL

REPRESENTATION TECHNIQUE	*Conceptual/ Styled/ Realistic*
POINT OF VIEW	*Board/ Sectional/ First Person/ Third Person/ Aerial*
NAVIGATION	*Static/ Dynamic*

INSTRUCTIONAL

CUSTOMIZATION	*None/ Low/ High*
LANDSCAPE MODIFICATION	*Allowed/ Not Allowed*
COLLABORATION	*Single/ Multiplayer*
CONTENT	*City Planning/ Survival/ Adventure/ ...*
SKILLS	*Creativity/ Management/ Problem Solving/ ...*

The second criterion focuses on the *technical aspect* of games and evaluates the customization, collaboration and modification of portrayal landscape capabilities.

The third criterion focuses on the *instructional aspect* of games and evaluates the educational context and skills that players may develop by playing the game.

Visual Aspect

Landscape is visually represented in computer games through varying quality levels from conceptual to realistic. Visual representation quality defines the cognitive experience of players during gameplay. To investigate the motivational effects of representation quality, Johns and Lowe (2006) conducted an experimental study on using computer games as a representation tool in a landscape design studio. The results of their study indicate that immersive game environments increase the sensory awareness and cognitive experience of the players with sound and animated surfaces. The motivational effects of visual quality were considered as part of the evaluation framework, and were identified at three levels: *conceptual*, *styled*, and *realistic*. Figure 6 displays different levels of visual representation techniques in three different games.

In addition to the visual representation technique, POV and navigation mode have an important impact on the visual perception of the players. In computer games, POV is variable according to the role of players in the gaming process. For instance, SimCity, a city planning and management game, requires players to take the role of mayor in a virtual city and to manage the complex urban dynamics behind the development of a city. In this game, the POV of players is set to aerial view. On the other hand, FarCry3, an action genre game, presents the virtual environment of the game to the players in first person or third-person view to provide more personal experiences. In reviewing the POV in games, five dominant types were identified: *board*, *sectional, first-person, third person,* and *aerial views*. In addition to POV, navigation mode refers to the stability of the point of view. Two types were identified: *static* and *dynamic*. Static navigation is a fixed view POV set by the game developer, while a dynamic navigation mode refers to an alterable view, which changes and can often be controlled by players.

FIGURE 6: Screenshots from Limbo, Civilization 5, and FarCry3

Technical Aspect

The second evaluation criterion is formed by three capabilities; customization, landscape modification, and collaboration capabilities. The customization capability defines the adaptation abilities, or features which players can modify. This capability is the most important factor in adapting computer games for use in landscape architecture education. While sandbox games enable users to make slight modifications through the use of built in tools, many computer games are not customizable at all. Furthermore, game engine software allows players to develop tailored computer games from scratch. The customization aspect of games was identified at three general levels: *none, low* and *high*. The computer games that are not customizable are marked as *none*. The *low* level defines the games that allow limited modification. The *high* level encompasses highly customizable games or software.

The second capability defines the modification ability of portrayed landscapes by the players. The landscape modification capabilities of games were identified at two levels: *not allowed* and *allowed*.

The last capability focuses on the ability of employing computer games for collaborative learning activities. Because of the interdisciplinary nature of landscape architecture, it is essential for students to work in a collaborative environment. For that reason, collaboration was included into the evaluation framework and was identified at two levels: *single* and *multiplayer*.

Instructional Aspect

Developed based on the TPCK model of Foster & Mishra (2009), the learning outcome criterion aims to evaluate games in terms of their contribution to the development of practical, cognitive, social skills and motivation. The evaluations of this dimension may help educators to design game tasks and goals for their curriculum. For that purpose, the game descriptions and claims made by game developers were reviewed to determine which skills are acquired. The descriptive information was obtained from websites and through instructions for the games. Due to a lack of available information on commercial games in published literature, the IGN Entertainment (2014) website was reviewed for descriptive information about the studied games. During the evaluation process, game purpose, the player's role and game actions were analysed for the relevance of the acquired skills in landscape architecture education. In addition, the authors verified findings by reviewing and playing the studied games.

FINDINGS

At the evaluation phase, the studied games were reviewed using the criteria to identify the most relevant games for employment in landscape architecture education. According to the findings, Simcity4, Leafsnap, Build-a-Prairie, UWB Wetlands Restoration, ASPIS Sustainable, and Thisissand games present opportunities for use in landscape

architecture education with little adaptation or modification. Another game, Minecraft, has several promising features but it needs significant tailoring to be useful in an educational environment.

SimCity 4, a city planning and management simulation game, was identified as the most promising game of this study. Although this game is developed specifically for entertainment purposes, it successfully simulates the complex dynamics between the built and ecological environments. In this game, the player becomes a decision maker and is asked to find optimum solutions for confronted problems and manage various parameters like time, resources, etc. Learning occurs by observing cause and effect relationships. *SimCity4*'s three-dimensional visualization capabilities can significantly help students to learn some important site engineering concepts, such as earth grading and cut-and-fill volumes. Many students struggle to understand such site engineering related concepts attributable to the use of traditional two-dimensional representation techniques, such as plan and profile drawings.

LeafSnap (Kumar et al. 2012) and *Build-a-Prairie* aim to foster the users' understanding of plant materials through clues on each plant. LeafSnap is a NSF funded project that focuses on developing a computer vision system for automatic plant species identification. To score points, users must guess plant names based on displayed plant parts. During gameplay, users focus on memorizing and matching more plants repetitively to increase points, helping users to build a systematic knowledge of plant species. Similarly, the Build-a-Prairie game specifically focuses on teaching convenient plant and animal species for

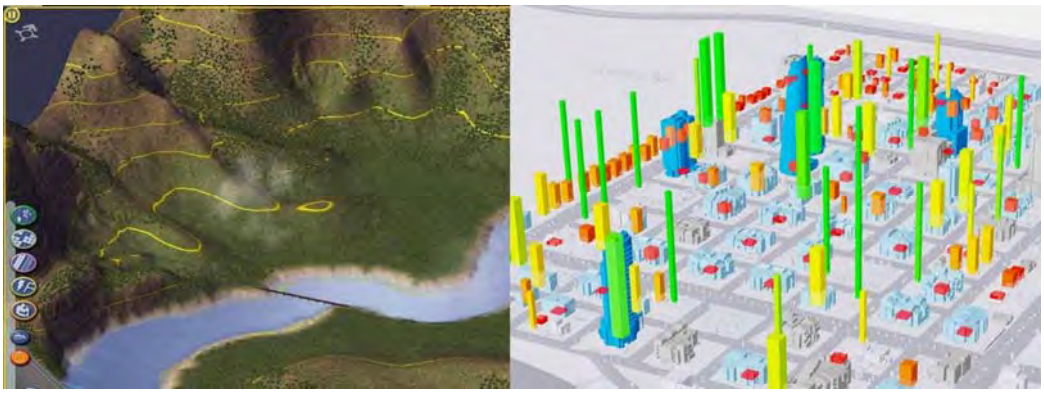


FIGURE 7: Screenshots from SimCity 4

FIGURE 8: Screenshots from LeafSnap, Build-a-Priaire and UWB Wetlands Restoration games

restoring a prairie area through the use of similar game mechanics to LeafSnap. Beside these, the *UWB Wetlands Restoration* game presents a wetland design environment based on the historical case of University of Washington Bothell. In this game, players are asked to maintain "*the biological diversity of the wetland by obtaining up to 30 species of plants, such as broadleaf arrowleaf, sitka willow and tufted hairgrass and planting them in areas to support biological diversity of the wetland, all while fending off invasive plants"* (Cook, 2012).

ASPIS Sustainable is an exploratory game, which aims to develop the user's knowledge of accessible park design through interviews with users. During gameplay, students can develop knowledge on convenient design solutions for urban park areas. Thisissand is another exploratory game that can be useful for explaining the stratification of land surfaces, the formation of landforms and the basics of landscape grading in a conceptualized way.

Minecraft is an open-world simulation game, which allows users to explore and modify random computer generated environments in order to survive against simulated environmental conditions and virtual characters. The game allows players to design and build in the virtual environment from a first-person viewpoint. Despite a pixelated style of visual representation, this game provides an immersive and creative design medium for players. It enables players to work collaboratively with other players by connecting to the same server over the Internet. Players can design using existing materials or "craft" new materials through following the recipes in the production web of the game. Many collaborative building events between users have been organized through the game, resulting in highly articulated replicas of existing cities. Due to its three-dimensional modelling and advanced material customization capabilities, Minecraft presents a potentially powerful digital platform for landscape design. However, it would require some tailoring to reach its potential as a tool for use in landscape architecture education.

At the Geodesign Summit 2015 Conference, Ulf Mansson (2015) presented a method that allows users to import GIS data into the Minecraft gaming environment and observe changes and modifications through time. This could potentially make Minecraft a great tool for generating new learning scenarios based on GIS data.

FIGURE 9: Screenshots from ASPIS Sustainable and Thisissand games

FIGURE 10: Screenshots from Minecraft

In addition, Minecraft could be more useful with a better method of feedback for landscape pedagogy. The inclusion of an on-screen dashboard could help students to take control of their design processes by observing parameters and managing resources, such as construction materials, budget and time, during the design. The game's production web could also be expanded in order to allow students to create new construction materials in their design alternatives. Such a feature could be used for assisting student understanding of complex concepts such as sustainability and embedded energy.

CONCLUSION

In conclusion, this research suggests using Simcity4, Leafsnap, Build-a-Prairie, Thisissand, ASPIS Sustainable and UWB Wetlands Restoration games in landscape architecture education to facilitate learning of specific topics such as sustainable city planning, plant materials, landform formation and the design principles of wetland and urban park areas. The research also suggests using the Minecraft game, albeit with modifications, as a tool for students to build their design alternatives collaboratively in a simulated environment, which is generated based on geographical information system (GIS) data. According to these findings, the proposed uses for the studied games are presented in Table 4.

In addition to identifying the pedagogical potential of the studied computer games, this research also suggests developing custom-made educational games using existing game engines, such as Unity, Unreal Engine 4, CryEngine, and Kodu Game Lab, and utilizing multi-user virtual environments, such as Open Simulator and SecondLife. These particular game engines have a significant potential to enable educators and researchers to create custom immersive learning environments without a high level of programming skill.

TABLE 4: The proposed uses for the studied games

Title of Game	In this game, player…	This game can be utilized ...
Simcity4	takes the role of mayor, planning and maintaining a virtual city. Player scores by producing sustainable solutions, increasing the economy and population, and satisfying the residents, etc.	to teach students the role of landscape architecture in the planning and development of a city in a sustainable way by allowing them to observe the effects of their planning decisions in a simulated environment
Leafsnap	matches the parts of plants with related plant species to score points	to engage students for learning plant species by distinguishing the species through matching their parts, such as seed, fruit, leaf and stem through presenting them a repetative training platform for constructing
Build-a-Prairie	matches the necessary plant and animal species for restoring a simulated prairie area	to assist students in developing knowledge about the necessary prairie plants and animals and their relationships.
Thisissand	creates landscape-like shapes through simulating the sand pouring on screen from the point of sectional view	to explain the formation of landforms, the concept of landscape grading.
ASPIS Sustainable	explores the virtual environment and interacts with other virtual characters to collect information about their ideas and suggestions about a simulated urban park area.	to develop knowledge on the design principles of accessible urban park areas and the special demands and necessities of different kinds of people which have disabilities.
UVB Wetlands Restoration	creates a wetland environment and maintains the biological diversity by considering the relationship of plant and animal species.	to teach students to create and maintain the biological diversity of wetland area by considering ecological relationships.
Minecraft	obtains/supplies resources from nature for crafting items, designing structures, and shaping landscape for surviving in a simulated wildlife environment	to allow students to build their design alternatives collaboratively in a simulated environment which is generated based on GIS data.

FUTURE WORKS

This research presents the evaluation of the studied games from visual, technical, and instructional aspects. We believe these games have more potential to be explored. This research could be expanded upon in future studies by incorporating games into real-world curricula and by studying their efficacy in meeting specific pedagogical goals.

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