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Game + Design Education

Proceedings of PUDCAD 2020

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Game + Design Education

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Preface

Project PUDCAD stands for *Practicing Universal Design Principles in Design Education through a Cad-Based Game*, and it is representing one of the foremost priorities of European commission: applying the inclusion and efficient accessibility for people with disabilities into everyday life.

The project was designed to work towards a major purpose through a minor addition in design education between September 2017 and 2020. PUDCAD deals with undergraduate design education to trigger the awareness of accessibility and let future designers and architects to develop accessible and innovative design ideas. It involves a design game on a CAD-based platform, allowing students to learn about basic and advanced universal design principles and train them with an entertaining context.

Istanbul Technical University proudly coordinated this project for 3 years. We developed this project with our partner universities and NGOs; Bahçeşehir University, İstanbul, Turkey; Institute of Design and Fine Arts, Lahti, Finland; Politecnico di Milano, Milano, Italy; University of Florence, Florence, Italy; University of Applied Science and Arts, Detmolder, Germany; The Association for Well-being of Children with Cerebral Palsy, Ankara, Turkey; and The Occupational Therapy Association of Turkey, Ankara, Turkey. In this term, we made lots of collaborations such as international and local workshops and conferences with our project partners to develop the main outputs of the project. We would like to thank to all of our partners for their valuable contributions. We would like to extend our thanks to the Rectorate of ITU and EU National Agency for their support in the administering works of the project and also special thanks to Efe Can Arslan. He and his friends, as brilliant young people with cerebral palsy, became the muses of this project.

As part of PUDCAD Project, the "PUDCAD Universal Design Practice Conference: Game + Design Education" international conference (E5) was organized by ITU-PUDCAD Team between 24 and 26 June 2020. Due to the global pandemic of COVID-19, the conference was held online through zoom. The conference, which was focused on the dissemination and promotion of the developed game and prelaunching of E-learning courses of the PUDCAD Project, aimed to open up to discussions the studies regarding the conference topics as "Universal Design", "Game and Design Studies" and "E-Learning in Design Studies".

Under these three main topics, the 33 papers under nine sessions were presented in three days. We would like to thank Hülya Kayıhan, Gonca Bumin, Güven Çatak, Birgül Çolakoğlu, Çetin Tüker, Barbaros Bostan, Çakır Aker, Veli-Pekka Räty and Aslıhan Ünlü Tavil for chairing the sessions in the specified order; "Universal Design and Education", "Universal Design and User Experience", "Games for Change", "Game Design Experiment", "Virtual Reality Experiment I", "Virtual Reality Experiment II", "Playful Experience Design", "Playful Spaces and Interfaces" and "Gamification and E-Learning in Design".

Besides, we hosted five keynote speakers from different disciplines and from a different expertise in each day. In the first day, Fiemmetta Costa from PUDCAD Partner University POLIMI spoke about "The Principles of Universal Design in PUDCAD Project Development" and Güven Çatak and Çetin Tüker from PUDCAD Partner University BAU introduced the PUDCAD Game in their speech about "Developing a CAD-Enriched Empathy Experience for Universal Design Principles: Journey of the PUDCAD Game". In the second day, Christopher Holmgård, who is co-owner of Die Gute Fabrik, spoke about "AI (eyay) Personas for Designing, Testing, and Optimizing Games" and Dylan Yamada Rice, from Royal College of Art, gave her speech about "Children and VR" sequentially. In the third day, Francesca Tossi as PUDCAD Partner University, UNIFI, gave her speech about "Asking Users: Questionnaires and Interviews as Indirect Observation Tools in Human-Centred Design Approach".

We believed that the "PUDCAD Universal Design Practice Conference: Game + Design Education Conference" has contributed to the creation of a discussion platform for academicians, students, relevant stakeholders and professionals from different areas of expertise for future research inquiries and relationships. Furthermore, we hope that the 32 studies presented at the conference and included in the proceedings book contribute to widen our perspectives in all senses.

Istanbul, Turkey — Özge Cordan
Istanbul, Turkey — Demet Arslan Dinçay
Singapore, Singapore — Çağıl Yurdakul Toker
Istanbul, Turkey — Elif Belkıs Öksüz
Istanbul, Turkey — Sena Semizoğlu

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Universal Design and Education

An educational path on Universal Design. Video Games as Learning Tools

Giorgio Buratti[1] [0000-0002-6882-0844], Fiammetta Costa[2] [0000-0002-5568-0061] and Michela Rossi[3][0000-0001-9860-0562]

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Abstract. PUDCAD (Practicing Universal Design Principles In Design Education Through A Cad-Based Game) is a project founded by the European Erasmus+ program for innovation and sharing of good practices in education. It provides, at systemic level, the modernization and activation of educational paths through cooperation with partners from different countries through participatory approaches based on ICT. The aim of PUDCAD is the creation of a playful computer assisted drawing application that allows interior architecture and design students to learn and use Universal design principles. This paper explains the different stages of research implementation. The first step was a workshop focused on a survey method developed to verify the compliance of educational environments with the principles of Universal Design (Checklist). Together with simulated direct experience (Empathy trial), it led the students involved to the creation of scenarios for school integration. In the second workshop the application of ad hoc parameter of universal design for spaces of learning led to the definition of Game Maps, where environments and characters of the game were identified. In the third, building on the second step material, table games able of sensitizing the user and supporting her/him in the design of inclusive environments were developed. In the fourth workshop the students developed and tested the videogame's Alpha version providing feedback and ideas for the ultimate version presented in the fifth workshop. Reviewing the process applied to build the application, the article explores educational experimentation and pedagogical aspects, emphasizing how the videogame, beyond entertainment, can support and promote new learning paths complementary to canonical teaching methods.

Keywords: Ergonomics, Universal Design, Gamification, Inclusion, Participation, Desing Education

1 Introduction

PUDCAD (Practicing Universal Design Principles In Design Education Through A Cad-Based Game) is a project founded by the European Erasmus+ program for innovation and sharing of good practices in education. It promotes, at systemic level, the modernization and activation of educational paths through cooperation with partners from different countries through participatory approaches based on ICT. The project

is related to one of the foremost priorities of the European Commission: to provide the inclusion and efficient accessibility of people with disability in everyday life. Regarding the European Universal Design Standards and the current state of universal design education in international networks, the aim of PUDCAD is the creation of a playful computer assisted drawing application that allows interior architecture and design undergraduate students to learn and apply Universal design principles through an empathic approach.

Universal Design [1] means a design method that provides for environments fruition and products use regardless of age, physical abilities and/or user social condition. This approach refers to Ergonomics, an essential discipline for the implementation of the social inclusion and non-discrimination targets set by the EU, but often not taught enough or considered a fringe element in future designers' training. The accessibility issue is not limited to just "compliance with the rules", but rather to the best avail-able solutions. An inclusive project goes beyond the concept of "Barriers free design", replacing the use of equipment dedicated to individual user profiles (disability aids, elderly furniture,…), by efficient solutions suitable to the widest possible range of population.

The project partners are: Faculty of Architecture, Istanbul Technical University, Turkey (leading institute); Bahcesehir University of Istanbul, Turkey; Institute of Design and Fine Arts, Lahti University of Applied Sciences, Finland; Detmold School of Architecture and Interior Architecture, Technische Hochschule Ostwestfalen-Lippe, Germany; Dipartimento di Architettura, Università degli Studi di Firenze, Italy; Dipartimento di Design, Politecnico di Milano, Italy; Association for Well-being of Children with Cerebral Palsy, Turkey; Occupational Therapy Association of Turkey.

2 Method

The project has been developed through the coordination of an international research group thanks to a transactional meeting program based on interdisciplinary conferences and workshops involving students from the five participating universities.

The first step was a workshop held in Politecnico di Milano, where the students applied a survey method developed by the project partners adapting the Americans with Disabilities Act (ADA) Checklist (Fig. 1) to verify the compliance of high school educational environments with the principles of Universal Design.

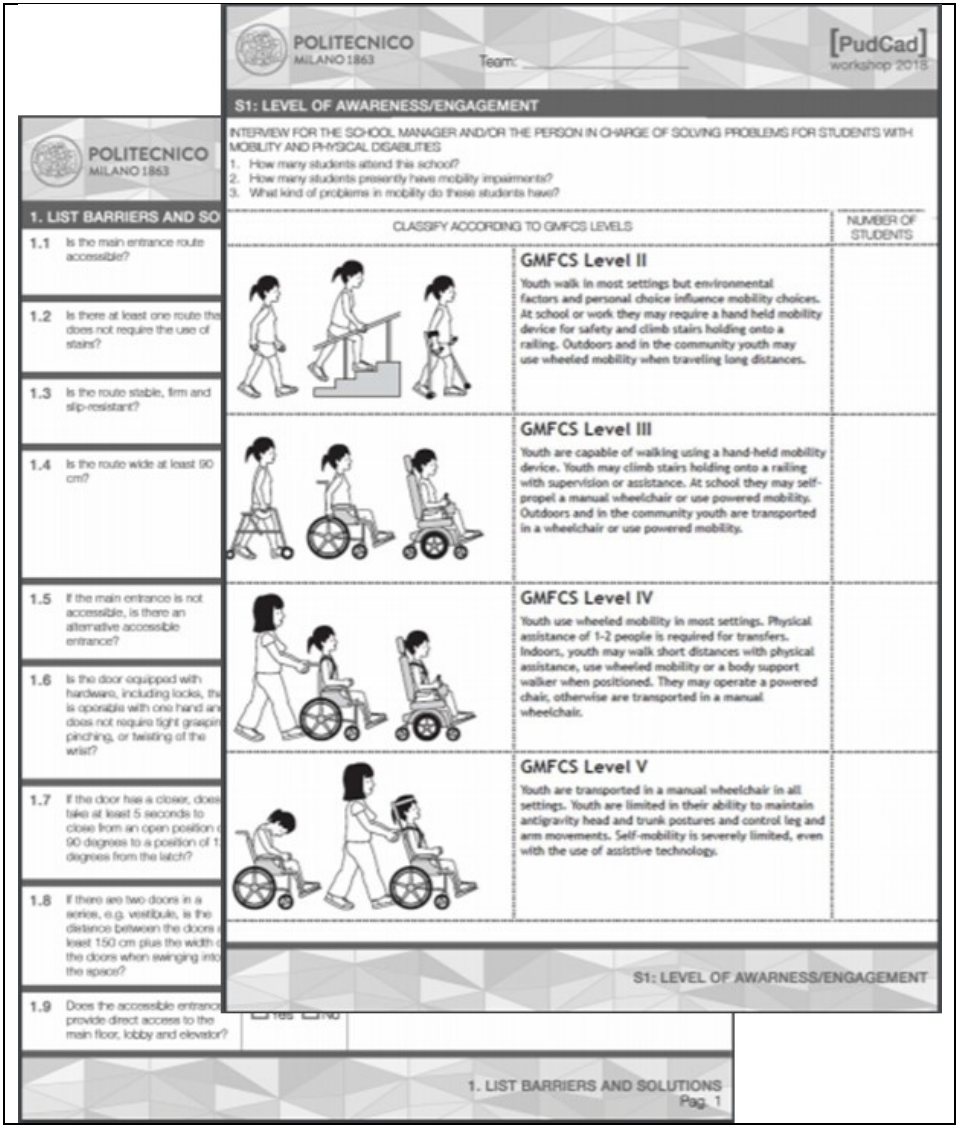

Fig. 1. Checklist for High school survey © Giorgio Buratti

Together with a simulated experience (Fig. 2), aimed at improving the direct perception of universal design problems, it was expected to lead the involved students to the creation of scenarios for school integration and proposals of innovative interior design concepts for school environments.

PudCad
Practicing Universa
C4- Students work

Team A

Monday 19th, h: 15:1

Impairments

- firm leg and f
- arm in a sling
- firm foot

Sample Activities

1. Go down usi
2. Go to the cof
3. Take the lift
4. Find Prof. Co
5. Make a copy
6. On the same
7. Take the stai

Change roles and tak

PudCad
Practicing Universal Design Principles in Design Education through a CAD-Based Game
C4- Students workshop

Team A

Monday 19th, h: 14:15-15:15

Tools

- Wheel Chair
- Corset
- Crutch

Sample Activities

1. Go to the toilet.
2. Go downstairs and to entrance A.
3. Take the lift to the 5th floor.
4. Find the emergency stairs.
5. Take the evacuation chair from the yellow package and go downstairs to the 4th floor using the evacuation chair (please, replace it in its package).

6. On the 4th floor, take a drink at coffee machine.
7. On the same floor, go to Marco Sedazzari in the administration.
8. Go down by lift to the 1st floor, reach class room C5.1.3 and work at pc workstation.
9. Come back to the classroom C5.1.6.

Change roles and take photos and notes about problems and unexpected situations.

Fig. 2. Empathy trial guidelines © Fiammetta Costa

The proposals were scored according to the 7 basic principles developed by the Center for Universal Design North Carolina State University, weighted as:

- Equitable use (15 points)
- Flexibility in use (15 points)
- Simple and intuitive use (10 points)
- Perceptible information (10 points)
- Tolerance for error (10 points)

- Low physical effort (20 points)
- Size and space for approach and use (20 points)

A second workshop, titled Universal Playground, took place at the University of Applied Science and Arts Ostwestfalen-Lippe. The application of ad hoc parameters of universal design for spaces of learning was planned in order to define Game Maps where environments and characters of the game should be identified.

The proposed Parameters of Universal Design for Spaces of Learning are:
1. Well-being
2. Organisation
3. Communication
4. Transformation
5. Creativity & Collectiveness
6. Action
7. Diversity

The third workshop, titled Game Jam, was hosted by University of Florence, students were asked to develop board games starting with the creation of characters, whose disability profiles and skills will affect the game design and mechanisms. Game themes and names were identified with the support of Bahçeşehir University Game Lab to face Universal Design principles in the games.

Game themes (and names):
- Escape From the Campus (Theme: Quake!)
- Match (Theme: What If?)
- Fire Alarm (Theme: Fire Alarm)
- A Short Daydream (Theme: Daydream)
- Tsialidybi (Theme: Alien Invasion)
- Campus Challenge (Theme: First Day)
- Crazy Granny (Theme: Holiday)

The decision to focus on brainstorming and paper prototyping was intended to let all the participants contribute in the short time, since most of them were not expert in digital game design. Focusing on the digital game itself would shift the emphasis from thinking on the design parameters to the tools. Whereupon the game design was finalized translating the findings to a first-person perspective digital game and he video-game's Alpha version was experimented in the fourth workshop, Designing and testing a game-based environment (Fig. 3), which was held at Lahti University of Applied Sciences.

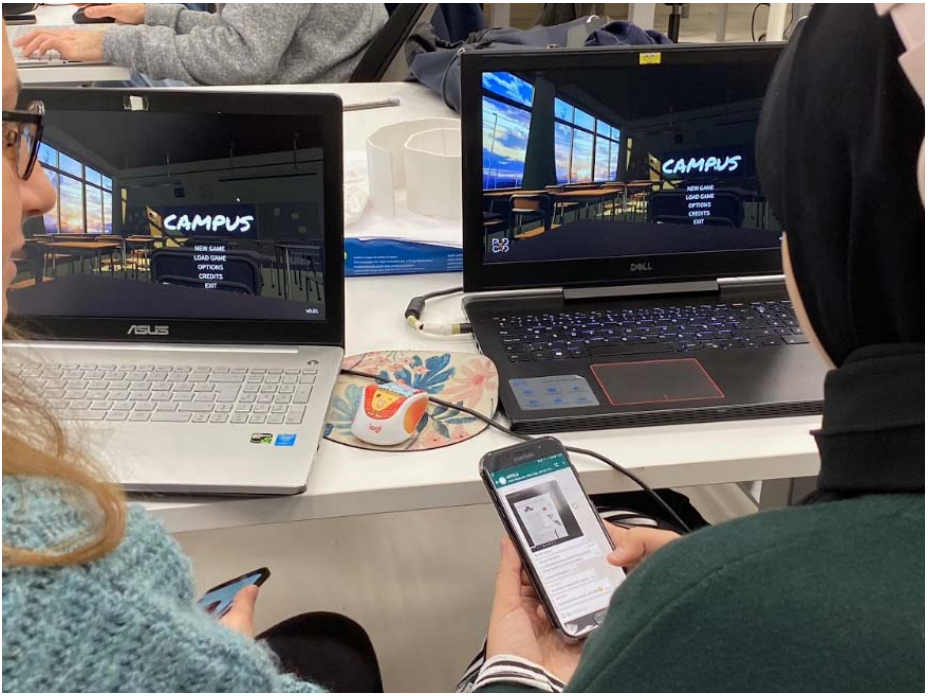

Fig. 3. Video-game's Alpha version trial © Ester Iacono

A Beta version of the game was then released and refined through partner's collaboration in order to present and promote the digital game in June 2020 at the final PUDCAD conference.

3 Results

3.1 Universal school environments

The five groups, composed by a student of each partner school, developed scenarios and designed an innovative school environment, namely the entrance and exhibition hall, a classroom, a laboratory, an auditorium and a library [2].

Each environment concept takes into account Universal Design principles and the library, conceived with modular furnishing elements that can be used by both able-bodied and disabled people (Fig. 4), obtained the highest Universal Design score.

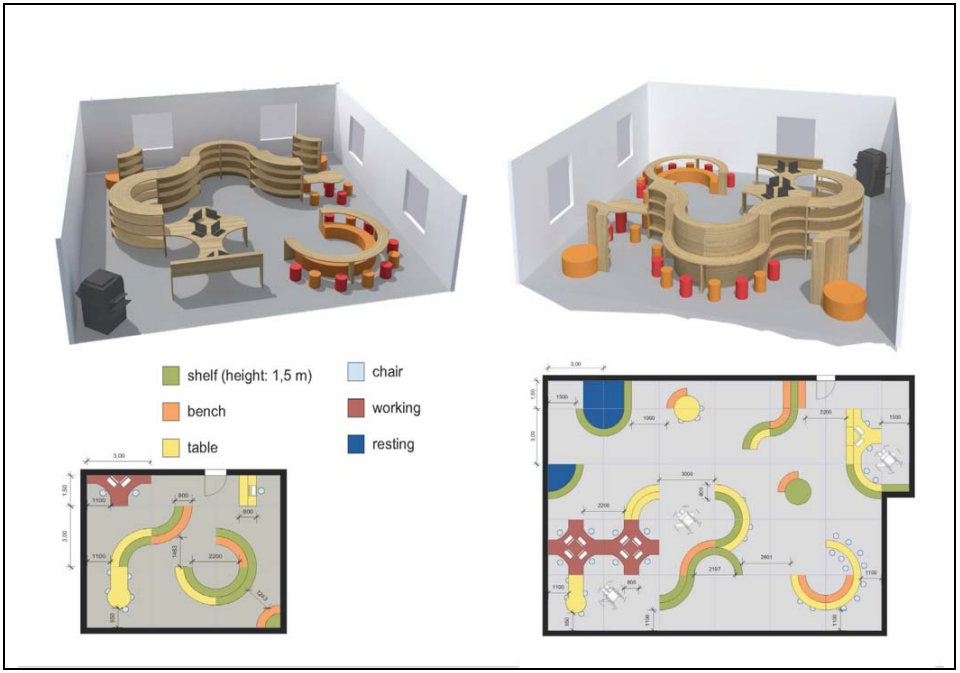

Fig. 4. Library environment designed by Andrea Zito, Anita Deckers, Rojda Edebali, Sabina Elena Quocchini, Mirka Pellikka.

3.2 Universal Playground

Applying the Parameter of Universal Design for Spaces of Learning as a starting point for the design process the students searched for corresponding locations and next included specific interactions and activities.

As a sample of profound results a group developed five design criteria for action: freedom, companionship, flexibility, fun and subtlety. The criteria were applied by the students in the outside space of the campus extended through Augmented Reality (AR) as "culturaction" (Fig. 5). "The object they designed was to give the opportunity to be a meeting and orientation point and a space for spontaneous lectures. By extending the physical object with a digital layer that can be activated through an AR application, a public sound library for teaching and an outdoor cinema and a place for music were implemented. Interesting about this process was that the exploration of the Parameter extended with the analysis of the chosen location helped them to even add to it in their way. The term "action" was enhanced with the social character of "culture". This guided them to come up with a distinct design language in their build object that enables the users' potential to create inclusive environments for multisensory experiences and social interaction" [3].

Fig. 5. Culturaction: Storyboard (5a) and AR-App (5b) proposed by Veronika Merlin, Christina Emilia Fager, Federica Ferrini, Michele Corna, Annabelle Brons

3.3 Universal Table Games

Table games able of sensitizing the user and supporting her/him in the design of inclusive environments were developed with the support of Bahçeşehir University Game Lab.

"Six of the proposed games are based on ad hoc boards (grids or paths), the seventh is a card game. Many of them involve dices and tiles representing rooms, architectonic elements or pieces of furniture (doors, stairs, shelves …). Characters are defined considering perceptive impairments (blindness, mono-chromatism …), specific anthropometric features (i.e. small person), physical temporary or permanent disabilities, specific characteristics like old age or skin disease" [4].

As a whole they can offer useful contributes in terms of game mechanism, win conditions and inclusion strategies for the digital game development. The Escape From the Campus game (Fig. 6) for istance has a high potential by its replayability, cooperation mechanics and the idea of creating design solutions to preventing disaster. It's a grid based board game where two characters try to escape from the school campus that just had an earthquake. The two has to cooperate due to their differences in disability and speed as quick as possible.

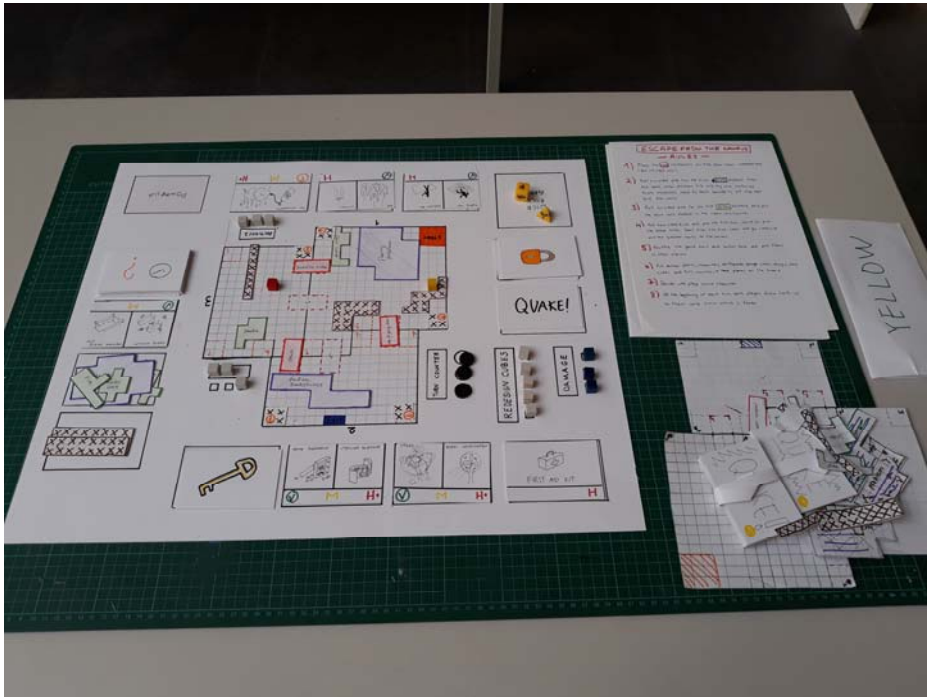

Fig. 6. Escape from the Campus table game by table Xin Xin, Saba Eraslan Sevin, Nikita Jelisejeff, Poyraz Ozer

3.4 Universal Digital Game

The game development targets a first-person perspective game run on a digital platform, based on the previous workshop delivered board games playable by multiple players. Feedbacks and ideas for the refinement where provided by students experimenting the Alpha version. The students advised to consider different disabilities for the characters comprehending also temporary and situational ones, other paths and environments inside the play field, further tasks to be accomplished also in interaction between players, alternative commands to move around and interfaces to choose between design solution, rewarding response for players.

In particular interesting hints were given by a group suggesting 6 distinguished characters with their features, the problems they should face and the possible solutions. Releated to their characteristics (dwarfism, age, blindness, color blindness, broken arm, paralysis) the students proposed different mouse and keyboard use mode, new paths and additional tasks, for example in the cafeteria or to reach the bus stop. Storyboards are used to exemplify the play scenarios and the shift from a the dark gloomy mood at the beginning of the game to colorful inspiring mood towards the end is planned to encourage the player progress (Fig. 7).

Fig. 7. Feedbacks and ideas for the game development by development by Anne Backus, Irene Bacherotti, Sinem Biçer

Bahçeşehir University Game Lab team enriched the digital prototype (Fig. 8) by CAD features and implemented several cases discussed and studied in the workshop, other, as the proposal to include blindness or visual impairments go beyond the project boundaries, but are promising ideas for future developments.

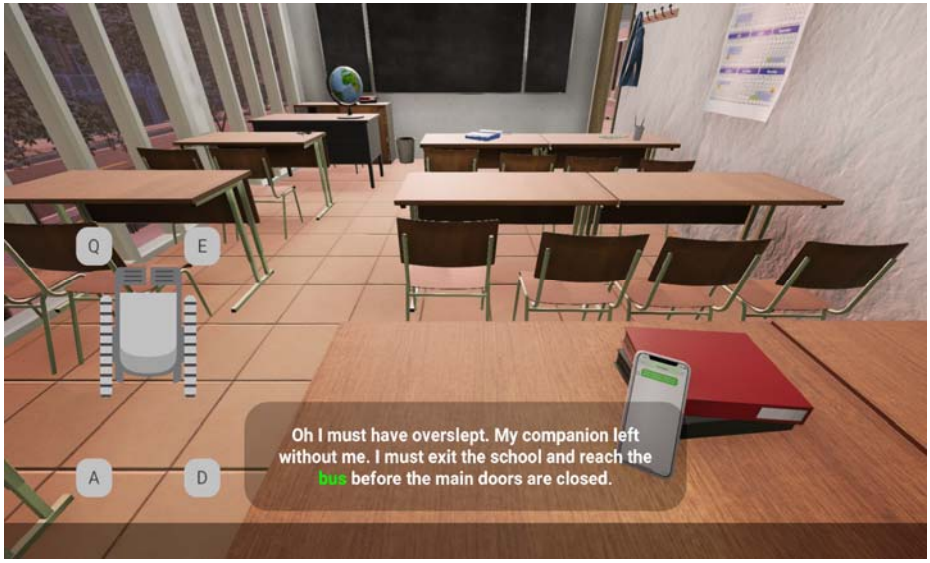

Fig. 8. Beta version startup screen © Giorgio Buratti

4 Discussion

Participants in the project had widely varied backgrounds (e.g., different nationalities, cultures, skills) and role (researchers, teachers and students). That made the interaction sometimes complex, but in the meanwhile has been a chance to share knowledge and experiences between partners and students, making it possible to produce a wide range of proposals all useful to build empathy and awareness on Universal Design principles and practice.

The game development part of the project started by an empathy trial and a field survey and arrived to a first-person perspective digital game through paper prototyped board games playable by 4-5 players. “Thinking of the game experience and presence perceived by the gamer, designing a board game for 4-5 players and translating the findings to a first-person perspective digital game for next step may cause some loss because not every game mechanic and case, even the feeling of the overal game, designed for the board game will work in the digital game.” [4] This kind of loss can be considered as a limitation, nevertheless it is compensated along the iterative design development process [5] through the contribution of students and experts experimenting and improving the Alpha and Beta versions of the digital game.

More in general the relationship between experimental learning [6] and gamification [7] opens up practices where learning is not based on the capability to remember and apply information, but on the ability to find information, evaluate and use it coherently. Through PUDCAD game teachers have the possibility to incorporate Universal Design principles in a narrative context, start the learning process by providing accessibility problems and solutions, beginning from an elementary level to achieve progressively more difficult tasks and finally evaluate the expected results.

Talking about video games in education and training today no longer arouses attitudes of mistrust or alert as a decade ago. Research and publications in various sectors [8, 9, 10, 11], underline how this media manages to synchronously stimulate different brain functions, improving those cognitive pathways that allow learning. The proliferation of new definitions such as *Gamefication, Serius Game, Applied Games, Edutainment*, to name a few, denote a consolidated research approach that goes beyond the function of pure entertainment and investigates the pedagogical and educational potential. The PudCAD research project, now at its final stage, confirms the qualification potential of the educational experience inherent in video games, inducing several critical reflections.

4.1 Designing a Serious Game

The need to develop a digital application led students to confront a computational process, developing a logical reasoning in developing systems and processes capable of solving a problem. The study of programming leads to the development of logic, through a path that uses analysis, the breakdown of problems, the verification of results and the organization of thought. This usually occurs in any design path, but the fact of creating a computer application leads to thinking in terms of sequence and rules that can be effectively performed by a processing agent, bringing the student from a "passive" user of technology to be a conscious subject, endowed with critical autonomy. The technology must be known, to be used effectively, and the only way to know it is to study it. Fluency with digital modeling software, together with the presence multimedia design students, who shared their knowledge with the rest of the working group, certainly facilitated the task.

4.2 Learning with a Serious Game

Interactive applications are rapidly leading from the distribution of content, to the construction of the same in a context shared by several individuals and which simultaneously involves different expressive codes. The immersion and interactivity components expand the learning experience, through "*immersion in a world simulated and regulated by technical laws in which the actions of the active user are theologically oriented*" [12].

The video game is in fact a playful activity that does not require prior knowledge of rules. The user discovers what he has to do by trial and error then, as the simulation progresses, he comes to understand the goal and decode the rules of the game. The space of the game is investigated and the information code creates the constraints, guiding the user who learns, studying, what the game allows you to do and how it responds to the inputs. This explains the link between learning and technology. Digitization offers the advantage of collecting data starting from the actions performed within the game, measuring user behaviour and allowing profiling and categorization. The outcome is a more efficient active participation, because it is personalized and because through the implementation of dynamic behaviours the meanings are connected to an action favouring experiential learning. This allows us to understand the effects of the particular case and anticipate its consequences, thus generalizing a prin-

ciple. The user is engaged in an empirical process that leads to "*learning by doing*" [13].

The gamification processes therefore promote the direct experimentation of ideas followed by immediate feedback, capable of evolving into innovative practices and theories. The ability to immerse yourself in correct consolidation activities through the simulation of real projects, while avoiding errors that in reality could have disastrous effects in economic and construction terms, provides the user with the freedom to experiment and conceive innovative approaches.

4.3 Empathy and Universal design

In the case of PudCAD, the didactic value of simulations lies not only in the manipulation of variables and in the evaluation of the consequences, but in a building knowledge process, which is expressed in the possibility of "putting oneself in someone else's shoes". The possibility of observation by immersive experience opens up to otherwise precluded realities, capable of assisting the formation of aspects of empathy, here understood as the assumption of the point of view of others regardless of a personal bond. The Empathy concept - from the ancient Greek "εμπαθεία" (empatéia, composed of en-, "inside", and pathos, "suffering or feeling" - is used to indicate the participation emotional relationship that linked the author-singer to his audience.

Already at the end of the nineteenth century the aesthetic theory of *Einfühlung* [14] theorized a mental simulation spatial process by which we project ourselves into another person. The etymological root (*ein*-inside, and *fühlen*-subjective sensory or emotional experience) suggests a dynamic interaction between the simultaneous experiences of one's own body and the other's body. More recent studies on mirror neurons [15] that are activated when an action is performed, when it is seen to be performed, but also when the action is only seen depicted, confirm the theory. It is therefore possible for the gamer to abandon the egocentric perspective to adopt an allocentric perspective. By avatar observation, the mirror neurons translate the shape into a motor program, allowing us to grasp the needs of different users in relation to space. Predicting the spatial prefiguration of a body, develops the functional capacity of representation and manipulation of space, it is a fundamental skill for ergonomically orienting designers.

According to Universal Design principles, designing must combine the different needs declining them in a real context of products, environments and viability based on the observation of anthropometric diversity, evolving needs and changes occurring in the course of a life. Exploring the space via avatar, the designer can infer the different human characteristics, using them consciously in the relationship between the user and the built environment and verifying them in terms of compatibility.

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References

1. Mace, R.L., Hardie. G.J., Place, J.P.: Accessible Environments: Toward Universal Design. AUED.9.96 (1996).
2. Buratti, G., Amoruso, G., Costa, F., Pillan, M., Rossi, M., Cordan O., and Arslan Dincay, D.: PUDCAD Project. Towards a CAD-Based Game for the Implementation of Universal Design Principles in Design Education. In Luigini, A: Proceedings of the 1st International and Interdisciplinary Conference on Digital Environments for Education, Arts and Heritage. Springer (2019).
3. Nether, U., Ley, J.P., Dorf, J.J., Herrmann, K.: Parameter of Inclusive Design for Spaces of Learning: New Methods in Design Education. In Tosi, F., Serra, A., Brischetto, A., Iacono, E.: Design for Inclusion, Gamification and Learning Experience. FrancoAngeli (2020).
4. Costa, F., Buratti, G., Serra, A., Brischetto. A., Francesca Tosi, F., Catak, G., Tukerg, C., Bostan, B.: A CAD-BASED GAME FOR INCLUSIVE DESIGN. In M. Bisson, M.: Proceedings (reviewed papers) of the IIIrd International Conference on Environmental Design. New Digital Frontiers (2019).
5. Norman, D.A., Draper, S.: User Centered System Design: New Perspectives on Human-Computer (1986).
6. Kolb, A.: Experiential Learning: experience as the source of Learning and Development. Englewood Cliffs, NJ: Prentice Hall (1984).
7. Desmet, A., Van Ryckeghem, D., Compernolle, S., Baranowski, T., Thompson, D., Crombez, G., Poels,K., Van Lippevelde, W., Bastiaensens, S., Van Cleemput, K., Vandebosch, H., De Bourdeaudhuij, I., Hospital, G., Street, T., Gard, T., Hoge, E.A., Kerr, C.: A meta-analysis of serious digital games. In Prev. Med. (Baltim) 69 (2014).
8. Bertolo, M., Mariani, I.: Game design: Gioco e giocare tra teoria e progetto. Pearson: Milano, (2014).
9. Bittanti, M.: Per una cultura dei videogames: Teorie e prassi del video giocare. Milano: Edizioni Unicopli (2002).
10. Amann, T.L.: Creating space for somatic ways of knowing within transformative learning theory. Mount St. Mary‟s Colleger (2003).
11. U., Ley, J.P., Dorf, J.J., Herrmann, K.: Parameter of Inclusive Design for Spaces of Learning: New Methods in Design Education. In Tosi, F., Serra, A., Brischetto, A., Iacono, E.: Design for Inclusion, Gamification and Learning Experience. FrancoAngeli (2020).
12. Accordi Rickards, M., Storia del videogioco: Dagli anni Cinquanta a oggi. Roma: Carocci Editori (2014).
13. Papert, S.: The Connected Family: Bridging the Digital Generation Gap, Longstreet Press, (1996).
14. Husserl, E.: Experience and judgment: investigations in a Genealogy of Logic. Evaston: Northwestern University press (1973).
15. Rizzolatti G., Craighero L.: The mirror-neuron system, Annual Review of Neuroscience. 27:169-92 (2004).