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Virtual Learning Scenarios for Qualitative Assessment in Higher Education 3D Arts

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Abstract: Using enhanced learning technologies (TEL) including immersive virtual reality environments, we are seeking to achieve a new way of assessing subjects of 3D arts. We have developed a project based on Scenario Centered Curriculum (SCC), where the students have to think, design, convey, validate, and build a civil project using new technologies that help in the assessment process. We have used gamification techniques and game engines to evaluate planned tasks in which students can demonstrate the skills they developed in the scenarios. The assessment is integrated in the creation of a 3D complex model focused on the construction of a building in a virtual space. This whole process will be carried out by gamification techniques to embed the assessment of the 3D models with the objective of improving students learning.

Keywords: Assessment, Digital Games, Multi-user Virtual Environments, Immersive Learning Scenarios, Scenario Centred Curriculum, Virtual reality, Gamification, Mobile technology
Categories: K.3.1, L.0.0, L.1.0, L.2.7, L.3.6, L.5.1

1 Introduction

In architecture and related studies, such as engineering construction and civil engineering, the process of project design and creation is usually complex. Often, the sketch of a design begins with 2D drawings, which lead to a 3D model, thus helping to validate each space and building component that is created. While 3D models have many functions, perhaps the most fundamental one stems from the effectiveness with which a model can communicate the design, helping both the student and the professional appreciate its complexity. In this communication process, the final outcome is usually a set of photorealistic renders from different perspectives, with occasional animation tours. However, this system is clearly not interactive. The final viewer of the project is not given options to view the three-dimensional model more closely, which can create a feeling of misinformation and a general lack of motivation in the final exposition.

The proposal presented in this paper starts from two initial premises. To begin with, the aim is to obtain a new way of presenting this type of projects adapted to various technological and visualisation systems, in a much more motivating way for both students and teachers. Furthermore, the proposed approach aims to monitor students' work and evaluate their progress constantly, with a completely adapted scenario that generates assessment aligned activities with the goals of the subject and an assessment embed with gamification techniques.

To achieve both objectives, we have proposed the use of various technologies and techniques, including virtual reality, 3D visualisation on web, mobile device usage, gamification and Learning Management Systems. These devices and tools will help the students improve the process of communication and presentation of complex 3D projects. It could be said that the uniqueness of the proposal is not in the display of complex 3D visualisation on new technology or devices, but rather stems from the evaluation of students' skills and abilities in line with every objective met [Biggs, 03]. However, in practice, exercises based on real examples adopted from their professions (Project Based Learning, PBL) and focused on the field of Civil Engineering and Building Engineering areas are usually much more traditional. Thus, in order to apply game mechanics and embedded assessments into the learning processes, and have a high level of engagement of the student, teachers need to follow some basic rules. More specifically, they should incorporate rewards, badges and points that encourage students to have fun and perform a learning activity as desired by the teacher. If the student's submission overcomes a minimum threshold, the student will continue the project to the next level or phase of the project. That level of embedding the assessment with gamification increases the motivation and decreases the anxiety related to the evaluation itself.

This paper introduces different methodologies related to Information and Communication Technologies (ICTs) and Technology Enhanced Learning (TEL) [Hwang, 11]. It also includes different research proposals in order to evaluate the benefits of using advanced technological solutions in education and provide new opportunities to assess learning. Some of them are also examining the use of diverse devices (not only computers) to support learning in different spaces (beyond the classroom) in order to create enriched online learning experiences [Oblinger, 06] and allow exploring new informal learning scenarios. We propose a qualitative assessment (using the Bipolar Laddering Assessment, BLA) to evaluate the motivation, satisfaction, and academic performance of building and civil engineering students using a gamified framework scenario. By employing technology, the teachers will use virtual reality to create interactive experiences, such as playing games and connecting for an ultimate immersed experience with Oculus Rift VR. This utilisation of immersed virtual reality will help in the final process of progress evaluation and will assist in conveying the entire project.

Section 2 of this paper provides the background of the main methods and techniques used for the case study explained in Section 3 that includes an overview of academic performance using Virtual Reality and gamification techniques and discusses how this type of technology can improve students' 3D skills. In Section 3, we also describe in detail the case study proposed based on the concepts explained in previous sections. The main concepts applied in the educational framework, such as qualitative tests, are described in Section 4 and provide the research results that are discussed in Section 5 and 6, which concludes the paper with final remarks on this study.

2 Background

The TEL research field has been profoundly involved with the development and application of collaboration apps. Computers and software tools play diverse roles at different times along the project lifecycle. The most common lifecycle comprises four distinct phases: design, implementation, approval and final assessment. Essentially, TEL seeks to improve the students' learning experience by:

- Supporting student engagement, satisfaction and retention;
- Helping to produce enterprising graduates with the skills required to compete in the global business environment;
- Encouraging inspirational and innovative teaching;
- Personalising learning that promotes reflection;
- Delivering and supporting CPD (continuing professional development) and internationalisation.

Focusing on Gamifying Learning Experiences (GLE) and Game Based Learning (GBL) concepts, there are a set of technologies based on game strategies that allow easier designs, generate self-learning activities, tracking exercises and self-assessment. Due to the constant monitoring and evaluations of these incorporated learning methods (questionnaires, delivery system practices, competitions, etc.), the teacher can ubiquitously validate students' progress. Another factor that determines the use of GBL and GLE is the easiness of adaptation and integration in Virtual Learning Environments (VLE). This approach provides further motivation and healthy competition among students, while allowing teachers to evaluate both the adaptation of requested content to multiple representation formats and the students' progress. The use of teaching strategies based on games is not only proven to increase student motivation but is also positioning itself as a good technology for assessment, facilitating the aligned and embedded assessments using virtual scenarios in which students can demonstrate their skills.

Recently, some researchers have started exploring the possibilities of using mobile phones to test students [de-Marcos, 10] [Trianfillou, 08]. The use of these devices allows not only access to online education and provides a system much more adapted to current criteria for mobility, but also provides the teacher with a more effective method of a dynamic assessment that is also direct and effective [Zhang, 10]. Boyle and Hutchison [Boyle, 09] stated that increased use of technological devices and applications generates an easier way to evaluate both complex tasks and specific student skills. According to the JISC report "Effective assessment in digital age" [JISC, 12], technology has to be used to create authentic assessment, serving as the foundation for effective incorporation of technology resources in classrooms, with the goal of increasing student motivation, and especially for the management of new evaluation methods.

2.1 Project Based Learning and TEL for Aligned and Embedded Assessments

As previously stated, one of the key issues in the current university teaching is the management of student motivation. The change in the educational systems of the past decade (which involved a reduction in the number of hours of teaching classes), along with a reduction in the number of university students, has caused a shift in the teaching paradigm, which is currently focused on how to improve student ability and skills. As previously proposed [Biggs, 99], the evaluation and control of the quality of student education and development is a key concept in the implementation of technologies utilised in the classroom. Thus, teaching and assessment practices must be aligned to the aims of teaching. In this sense one of the examples of aligned teaching most standardized is the work by SCC (Scenario Centered Curriculum) / Problem-based learning (PBL), a system that in fields of Civil and Building engineering, where the project is restricted explained in this paper, are perfectly suited. However, the experience shows a high rate of very subjective assessments (whereby the same project is deemed a success or a failure by different architects). For this reason, it is easy to find course tutors and professionals very reluctant to implement self-evaluative systems and / or clarify the evaluation of teaching / learning activities (TLAs). According to Biggs, this results in more damage than any other single factor in the process of assessment of learning. The defence of a subjective evaluation system is based on the negative effects that have explicit quantitative assessment on the student, where this time can be spent to follow a strategy that will help them learn, rather than simply achieve a pass grade.

Educational activities should be designed so that the students do not only for their final grade but to achieve their goals and thus their correct evaluation [Biggs, 99]. Hence, the gamification of educational activities appears to have potential to increase student motivation, while also motivating them to attain better scores in practical assignments (as well as higher overall score). It also has the capability to generate new virtual and embedded methods for assessing student learning. On the other hand, motivation is essential for the design and assessment is necessary aspect of student engagement [Dominguez, 13].

In contrast to traditional programs (passive and focused on subject matter), a SCC offers an experience equivalent to learning a trade, as learners must face a well-planned series of real situations (scenarios) in a significant and motivating role. Within these scenarios, they must carry out precisely those tasks, activities and reasoning processes that are best suited for building the desired skills [Higueras, 2013]. This way, learners facing a problem on their own will start to notice why certain skills are useful. This type of program is the most common PBL System used by civil and building engineering students. The SCC are defined as follows:

- A scenario: Simulation of an authentic situation that can motivate students by providing a coherent context for individual and collective learning.
- A sequence of planned tasks: Framed within the scenario, this allows the student to practice the key behaviours targeted in the training and, as a result, learn them.

- A structured suite of complementary learning resources: This includes work procedures, models to be used, job-aids, workplace tools, glossaries, etc.
- Access to a mentor: Online support or in-person communication, allowing students to obtain feedback and help precisely when necessary to reinforce learning.

In civil engineering and construction education, students are accustomed to using SCC and PBL strategies in the learning process. The combination of ICTs and TEL, is less common as the use of complex and self-evaluating systems. In practice, the students require the three-dimensional visualisation and compression, as these are skills and abilities where virtual and environmental systems show better adaptation to such content [Fonseca, 13, 14]. Additionally, in several studies, the authors have demonstrated the role of gamification and game-based learning (as a sub-model of PBL) in assessment within virtual environments [Wood, 13]. Examples of systems that can improve student assessment while increasing efficiency and providing new opportunities for educators to use motivation and ubiquitous systems are, however, rare [Villagrasa, 14].

The combination of three-dimensional models with urban information (especially when this information can be viewed and managed ubiquitously) will allow students to acquire skills related to historical knowledge, project development, and urban planning. Future architects and planners should be able to manage the proposed SCC from early stages, which is a great advantage, since in this particular field it is very difficult to work with abstractions and simplified models. The use of ICTs in education has a clear objective to promote an enhanced learning (TEL), in multiple form (assistance and semi assistance), generating much more motivation and improvement of academics for students, while allowing teachers to monitor and evaluate students' progress with greater ease. Literature on the use of explicit pedagogical strategies dedicated to the enhancement of creative problem solving is relatively scarce [Retalis, 2011].

This creates an opportunity for greater research and development effort in the context of learning strategies that could effectively promote creativity and innovation. The design-oriented pedagogy for TEL (for example, using exercises based on PBL) allows the students using collaborative environments to create and discuss new spatial proposals. This results in improving both general and specific skills that encompass both formal and informal educational environments [Vartiainen, 12]. Learning to collaborate and connect through technology is an essential skill and capability that future societies will expect from all individuals [Binkley, 11].

2.2 3D Models, Visualisation and Assessment

Historically, in the civil and building engineering education, visualisation and understanding of 3D space was typically accomplished via the classical view (physical models and drawings), necessitating complex 3D models and high computers specifications. This approach is changing owing to a generational change and continuous improvement and development of technology. The new systems based on VR / AR (Virtual and Augmented Reality), Geo-Referencing, and learning gamification, will gradually reduce the control imposed on the designed tasks and presentations scheduled. The well designed systems that allow the users to extract, store and manage various tasks, and provide easy to assess control at all times will enhance student learning and their ability to manage the tasks [Avouris, 2012].

Moreover, most extant analyses, both implemented or evaluated, have focused on VR models, while those that have used AR or gamification techniques are much rarer, and those that centred on students' access to tasks or projects in architecture or construction are almost non-existent. However, due to the potential of virtual systems, we can strengthen the spatial skills and abilities of students while also using the essential interactive and collaborative features of these processes. Students can work with peers and teachers and take part in multi-tasking / multi-user collaborative and instant tracking [Calongne, 08] [Rieder, 11].

Owing to digital processing, visual integration of students with the 3D environment allows for a fast and inexpensive improved understanding of space. The simplicity of completing the most basic models with the creation of new objects, light treatment, materials, textures, shadows, etc., allows a dynamic workflow that is much faster to complete than the actual physical scale models. Additionally, the versatility of virtual worlds [Ibañez, 12] and their use in social networking allows creation and work with heterogeneous groups from all over the world, who can collaborate synchronously in different virtual spaces. Virtual Worlds provide a combination of simulation tools, sense of immersion and opportunities for communication and collaboration that have a great potential for their application in education [Griol, 12]. However, as criticised in [Girvan, 10], many of the existing educative experiences in Virtual Worlds only replicate traditional approaches, such as for example recreating classrooms located in a Virtual World. Learning by designing [Hennessy, 99] has been regarded as an instructional approach that can be appropriate in knowledge creation, since it provides opportunities to work with complex design tasks within authentic and meaningful learning contexts [Seitamaa-Hakkarainen, 10].

In addition, we can find several assignments that were completed in recent years that required students to acquire spatial skills and use mobile technology. Antonio Gordillo [Gordillo, 13] proposed a generic model to support a new way of visiting the city. In this approach, instead of understanding it as a place for tourism, the students perceive it as a place for learning in which all necessary educational resources are available. The model has been conceived as a way to encourage the learners to create their own educational tours, in which Learning Points Of Interest are set up to be discovered using two models—formal (conducted by a teacher) and informal outdoor mobile learning (no educator is related to the learning experience). This system is nothing more than a basic model of SCC using gamification as a strategy to motivate students, as they work on solving a real task scenario as a POI display using elements of VR. The educational system is based on "developing scenario-based series games for complex cognitive skills acquisition" where we find previous work on all platforms [Slootmaker, 2014] [Herrington, 07] [Hummel, 11] [Nadolski, 12].

Taking AR/VR into account, these approaches share some common features, such as immersion, navigation or interaction. On one hand, AR allows collaborative experiences and tangible interactions in a real scene [Dunleavy, 2008]. By overlaying virtual objects in a real environment through markers, the students can modify and manipulate the scale, position and location of virtual objects. On the other hand, when VR is used with game engines (like Unity or Unreal) or immersion visualisation devices (like oculus Rift), it provides new collaborative experiences superior to AR, because all students will interact with each other and with the 3D models and spaces using Smartphones, tablets, 3D website or advanced devices, such as Oculus Rift. Therefore, we can conclude that VR technology, by providing new interaction possibilities, promotes students' participation in their own knowledge construction. For instance, through interaction with 3D models of environment, the entire construction sequence of a surface, in time and space, can be simulated for students, where a gamification approach facilitates better understanding [Ternier, 2012].

By using mobile devices in education, we can generalise this concept and refer to it as Mobile Learning, where the use of VR elements allows faster and better understanding of issues related to construction and technology [Redondo, 13]. Recent experiments have evaluated mixed assessments both quantitatively and qualitatively [Fonseca, 13]. Their findings support the conclusion that the use of these technologies generates high rates of student motivation and much greater involvement, leading to high satisfaction in monitoring, resulting in increased ratings. However, its integration into gamified learning systems and the difficulties of file exchange among CAD / CAM, 3D, VR / AR systems, leads us to conclusion that more development is needed before all systems can be successfully integrated in an informal learning environment, inclusive of capabilities for aligned assessment [Fonseca, 14].

2.3 Assessment of skills and competencies in Civil and Building Engineering Degrees

It is difficult to generate technological solutions that address the assessment of skills and competencies in a general way. The main abilities and digital skills described in Civil and Building Engineering programs include the following:

- General skills (Interpersonal, IP; Systemic, S; Instrumental, IT):
    - IP1: Team work.
    - S1: Ability to work autonomously.
    - S2: Ability to develop new learning strategies.
    - IT1: Information management skills.
    - IT2: Basic skills in computer use.
- Specific propaedeutic block, P (Competencies for the skill group on Ideation Space and Graphic Representation:
    - P1: Apply graphic procedures to space and object representations.
    - P2: Conceive and represent the visual attributes of objects and master proportion and drawing techniques, including computer.
- Block specific knowledge, Sb (Skills for Groups Systems and Restoration Graphic Representation):
    - Sb1: Spatial representation systems.
    - Sb2: Analysis and theory of form and laws of visual perception.
    - Sb3: Metric and projective geometry.
    - Sb4: Graphic lifting techniques at all stages.

Additionally, urban studies allow the students to acquire and improve their skills in other areas related to civil, urban (Ur), and building design, such as:

- U1: Acquisition of knowledge about urban analyses/project methodologies.

- U2: Identification, location and solution of problems in urban planning in a multidisciplinary context.
- U3: Understanding of the impact of urbanism in our society.
- U4: Use of new intervention techniques.
- U5: Urban planning, management and development control.

In our framework, it is still uncommon to use the now classic Assessment Technologies that we could call the first generation, such as online test with several variants (multiple choice, multiple response, etc.). Typically, these systems are integrated in VLE (e.g., Moodle); however, teachers in architecture are usually reluctant to adopt such technology systems, as many of them are already established in their profession and delegate the more technical tasks to their employees. Thus, in such educational scenarios, technology adoption is a challenge in its own right.

3 Context

Our case study presented allows the novice users in architectural education to generate a scenario in which students can demonstrate the acquisition of competences and skills using virtual environments and PBL with embedded assessment activities in the learning flows. For this reason, the challenge of this project is to change not only the educational method of a particular area, but also the evaluation of the proposal by the students themselves towards their improvement and future implementation in other subjects.

In order to assess students' competencies and their technology use in 3D, the following guidelines have been developed, to explain the topics students have to master and their relation to the aforementioned skills:

- General Skills:
    - IP1: Integration of the pavilion in the island according to the remaining pavilions. The work is conducted in small groups.
    - S1: Conceptual design, sketches and 3D modelling is evaluated.
    - S2: How to use tools of the model and its virtual environment.
    - IT1: Locate in the urban plan of the island, analyse the proposed master plan and enhance the work area. Propose timetable with period deliveries, and processes involved in creating 3D pavilion.
    - IT2: Creating 3D modelling, texture mapping, lighting, rendering, followed by final virtual presentation, which is formally assessed.
- Specific propaedeutic block:
    - P1: Drawing and conceptual design of the pavilion and the final render is evaluated. The objective of the course is to introduce the creation of 3D content, emphasising 3D modelling, texture and lighting 3D scenes, and basic knowledge of computer animation, model-driven design and audio-visual production.
    - P2: Work process is evaluated throughout the pavilion construction.
- Block-specific knowledge:
    - Sb1: Pavilion design with 3D models and virtual environments.
    - Sb2: Rendering and work in immersive virtual worlds is evaluated.

- Sb3: Working 3D model is evaluated.
- Sb4: It is assessed throughout the pavilion design workflow, from the idea to the final render or virtual experience.

- Urban design:
  - U1: Necessary for city planning.
  - U2: Individual and teamwork assessment. Continuous learning.
  - U3: Assessment of working in a professional context.
  - U4: IT and TEL uses in cities and land sites.
  - U5: Planning, management and urban development control.

3.1 Methodological approach of the subject Drawing Tools 2

The methodological approach of this work allows students to participate in the definition of the final product. The study was conducted during the 2013–2014 academic year, with students in their second year of a Building Engineering degree. The experimental framework will be completed in the course “Drawing Tools 2,” a six ECTS-credit course that is taught during the second semester of the school year. The subject is divided into 16 weeks (about four hours each week), resulting in an evaluated total of 64 hours of classroom time, although the overall workload equates to 150 hours. For the purpose of this study, 30 groups have been formed, with 65 students (35 women and 30 men) as study participants. The methodology used in the current study is based on exercises that students try to follow and understand while the teacher is explaining the work on the projector. This requires much more activity in the classroom and promotes collaboration and learning. During the practical classes of the course, which consist of monitoring assessments and evaluating activities, exercises, and practices, a total number of points is awarded to each item, applying the principles of gamification.

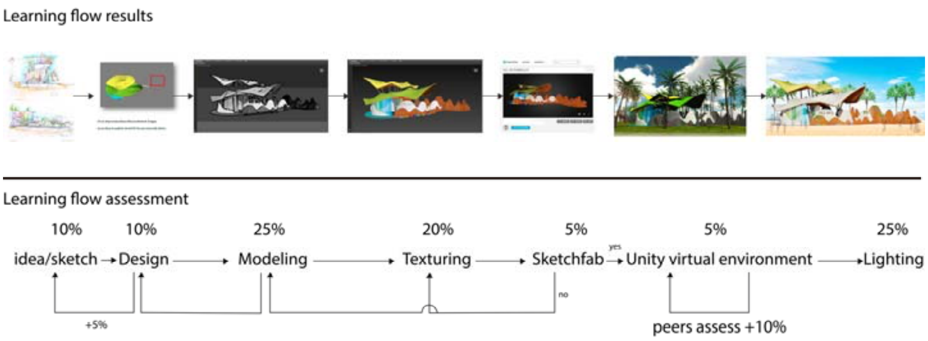

Figure 1: Learning objectives and assessments weights

The evaluation system shown in Figure 1 is balanced, with a percentage of points awarded for direct representation. However, given that the SCC and the creation of the island is gamified, it is possible to for students to achieve a higher level than usual. Throughout the course, students must earn a maximum of 10,000 points. We can divide the subject into two main groups. The first pertains to the house project, with a total weight of 70%, and the second project, the Virtual Island, carries a total weight of 30%. The latter is the SCC project, where we focus the case study specifically designed for a more aligned assessment using virtual reality and gamification. The assessment method applied to the first project comprises:

- Modelling: 1000 points
- Texturing: 1000 points
- Rendering and lighting: 1000 point
- Panel: 4000 points

This results in a maximum score of 7000 points, i.e., 70% of the total value that, when mapped to grades from 1 to 10, would correspond to a 7. The greater weight of the evaluation means that the student is in the phase dedicated to learning to use the tools, and the time devoted to their use is aligned to the value of the assessment. This first exercise is developed using Revit Architecture and Adobe Photoshop (Figure 1). Thus, students were required to search information, participate, and present their project before a digital architectural panel.

In an intermediate stage, teachers conducted a few exercises consisting of certain recreations and modifications of one of the buildings of the faculty using Adobe Photoshop. Finally, the teachers conducted exercises regarding the consistent improvement of the rendering of 3D example models with Autodesk 3dsMax. In this phase, students had to deepen their knowledge of texturing and lighting to recreate the house for panel presentations, this time in a physical and professional format (Figure 2). For this assignment, they could be awarded maximum of 500 points for the entire process of drafting, and further 1500 for the submission and staging of the final poster, which included night and day images.

The final stage of this process begins with the teachers conducting two exercises based on the original groups with different pavilions for a theoretical international exhibition (storyline gamification), which was also posted on a geographical space similar to an island (Figure 3). In addition, students had to look for information, and could thus receive points for correct research. Further points could be awarded for the entire process of design and delivery. In this phase, the applications used consisted of Autodesk Revit, 3dsMax, Adobe Photoshop, and Sketchfab. For programming the interaction, teachers used Unity and Oculus Rift for visualising a major immersion experience. The members of each group were instructed to carry out their work, despite encountering multiple difficulties in the completion of various tasks. Information regarding different evaluations carried out during the course has been reported through the Schoology system. This information included what the students learned systematically, including estimations of their exercises, which have been reviewed and tested if necessary, and the total number of points earned.

In the proposed scenario, both teachers and students act as evaluators, and are reviewing the design in real time and playing around the proposed scenario (a virtual island). They were also required to generate feedback reports to all users, which were both peer-based on the dynamics of game and provided by the teachers as resolved activities. TEL and the gamification techniques play a central role in the assessment, which tries to identify students hiding behind their classmates. It is designed to create positive interdependence within groups, while allowing individual accountability, thus promoting involvement of all students in learning activities.

3.2 The island: gamification and technology for assessment

The objective of the course is to introduce creation of 3D content, emphasising modelling, texturing and lighting of 3D scenes, and basic knowledge of computer animation, model-driven for design and audio-visual production.

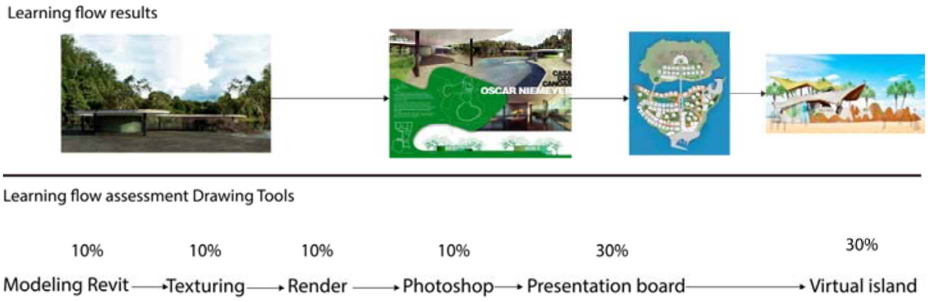

Figure 2: Methodology for embedding the assessment of the virtual island

For the SCC of the virtual island, 3000 points can be obtained, which are scored as shown below:

- Idea/sketch (10%): 300 points
- Design (10%): 300 points
- Modelling (25%): 750 points
- Texture (20%): 600 points
- 3D on web con Sketchfab (5%): 150 points
- Virtual island (5%): 150 points
- Render (25%): 750 points

The learning process will typically take place in groups, focusing on collaborative challenges and interaction with peers. The whole class is given the opportunity to work/play on a global project to build an exposition and design a pavilion with constraints. The name of the island will be decided by student voting, via a discussion created in Schoology [Friedman, 07]. This LMS tool displays the points earned and shows the progression with the aim to personalise the island and make it close to those that worked on it.

For the creation of the island, the parcels are numbered, marked and assigned. Initially, the island is undeveloped, and is only populated with trees, animated water and other natural features. By gamifying the process further, the design is constrained by minimising the ecological impact, for instance. This can be accomplished by limiting the number of trees that can be cut, or allowing a maximum 400 square meters of urbanised land, and enforcing a maximum building height of 15 meters. The model in terms of polygons should be lightweight and, as a minimum, there should be a texture applied to the model. Due to the size of the island, two high point accesses have been created—a lighthouse in the east and a tower in the west. Once the job is completed, students should transfer it to Sketchfab, as this allows visualising their work in a web browser in 3D, to make sure that the model meets the prerequisites. In addition, this allows them to show and share the model for further development.

In addition, when the full integration of the pavilion is completed, students will be asked to score the three best pavilions and explain why they made this particular choice. By creating competition, the goal is to engage them and motivate them to improve finishes and detail of their work. The groups that attain the first three places will receive extra reward points. In terms of technology, the pavilion is created with a combination of Revit and 3dsMax. In the classroom, the teachers will create discussions among groups, and form contests for each group. This island is an example of gamification techniques and the use of 3D virtual tools such as Unity. In addition, to increase student motivation, the teachers create the island that it is compatible with Oculus Rift for a real 3D immersive VR experience. With gamification as the topic for students in building engineering and architectural courses (and in order to use 3D tools to create architectural models), teachers encourage students to work collaboratively and actively participate from the beginning of the course to its end. The virtual exposition of the island will be showcased so that it can be seen via any platform, such as PC, tablet, mobile phone, with new touch screen technologies like Unity, and with Oculus Rift for a virtual reality experience.

Figure 3: Masterplan of the virtual island

Once the job is completed, students will upload their designs to Sketchfab, visualising it in a web browser in 3D, to ensure that the model meets the prerequisites and share the model for further development. When the integration of each pavilion on the island is complete, teachers will export the files to multiple outputs, such as a web browser, executable for PC or MAC (necessary for the Oculus version), and mobile iOS or Android.

In addition, students must present a rendering of their pavilion design (Figure 2). After uploading their models, students can share their work using Unity (Figure 4), whereby visualisation is achieved using immersive devices such as Oculus Rift. This type of devices represents a good VR technology for 3D model visualisation, especially in video games. In addition, VR devices promote immersive participation and, in this case study, the students and their classmates participate actively in this virtual world. The generation of practical exercises to develop 3D objects or spaces as a part of the course does not only permit the creation of static images for audio-visual productions but also facilitates an interactive and immersive visualisation.

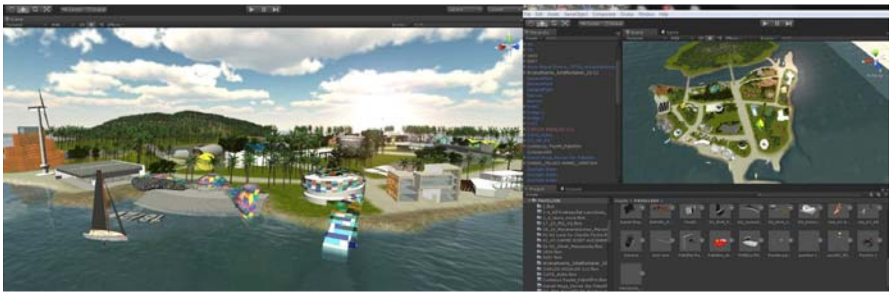

Figure 4: Virtual Reality of the island with the pavilions created by the students

For a more direct evaluation, we have used a LMS, which facilitates assessment in a ubiquitous system. Schoology enables integration of the assessment and helps develop gamified scenarios, by making quick fixes and obtaining immediate feedback. This is particularly valuable for students, as it helps them proceed to the next phase of the project. This system also allows the teachers to manage assessments obliquely, from a PC or a mobile and give students immediate feedback. Moreover, an API on the website allows the users to create their own applications or develop a web page, such as a gamified platform, which is in our case called GLABS [Villagrasa, 14].

On the platform, one can display multiple columns, each allowing evaluation of many activities, sometimes subdivided into many mini projects. This layout helps monitor the project progress and facilitates the final stage of the creation of a pavilion for the virtual island. Thus, at each stage, the student obtains immediate feedback from the teacher, thus embedding the objectives of the course and ensuring that the next phase can proceed, as the assessment is immediate and detailed.

4 Results

Qualitative methods are commonly employed in usability studies, inspired by experimental psychology and hypothetical-deductive paradigm, employing samples of users whose number is usually relatively limited. Nevertheless, the Socratic paradigm from postmodern psychology is also applicable and useful in these usability studies because it targets details related to the UX with high reliability and uncovers subtle information about the product or technology studied. This psychological model defends the subjective treatment of the user, unlike the objective hypothetical-deductive model [Guidano, 89]. Starting from the Socratic paradigm basis, we will use the BLA system (Bipolar Laddering) [Pifarré, 07]. BLA method could be defined as a psychological exploration technique, which points out the key factors of user experience. The main goal of this system is to identify concrete characteristic of the product that result in user frustration, confidence or gratitude.

BLA method focuses on the positive and negative poles to define the strengths and weaknesses of the product. Once the element is obtained, the laddering technique is applied to define the relevant details of the product. The object of a laddering interview is to uncover how product attributes, usage consequences, and personal values are linked in a person's mind. The characteristics obtained through laddering application will define what specific factors define an element as either a strength or a weakness. Using the results obtained, the elements are polarised based on two criteria:

1. Positive (Px) / Negative (Nx): The students must differentiate the elements perceived as strong points of the experience that helped them to improve the type of work proposed as useful, satisfactory, or simply functional aesthetic (see Table 1). The negative aspects are those that did not facilitate work or simply need to be modified to be satisfactory or useful (see Table 2).
2. Common Elements (xC): Finally, the positive and negative elements that were identified by several students (common elements), are identified according to the coding scheme, shown in Table 1 and 2:

	Positive Common (PC)	**Av Score (Av)**	**Mention Index (MI)**
1PC	Use of multiple edge technology	8,2	90
2PC	Learning by doing methodology	8,5	40
3PC	Gamification techniques and awards	7	40
4PC	Creativity modelling	9,3	70
5PC	Collaborative works	8,3	30
6PC	Professional portfolio	8	30
7PC	Use of Virtual Reality	9	90

Table 1: Positive Common (PC) elements

	Negative Common (PC)	**Av Score (Av)**	**Mention Index (MI)**
1NC	Little time for learning 3D	5	90
2NC	Use of Schoology points LMS	4	30
3NC	Lose track of contents	2	60
4NC	Group grades versus individual	5	40
5NC	Gamification: points & badges	6	30
6NC	A lot of retouching image tools	5	50
7NC	Use of vectorial software	5	10

Table 2: Negative Common (NC) elements

	Description	Mention Index
1CI	Small groups	20%
2CI	Unified web portal with a better gamification	60%
3CI	Starts with an easier exercise	10%
4CI	More 3D for design or films versus videogames	10%
5CI	At the beginning of the subject, clarify minimum specs	20%
6CI	More detailed grades. Rubrics for collaborative works	40%
7CI	Website with tutorials and maps for find the path again	50%
8CI	Better weight. Rounded numbers. Unified web portal	30%

Table 3: Proposed Common Improvements (CI) for both PC and NC

The common elements that are mentioned at a higher rate (MI) are the most important aspects to use, improve or modify (according to their positive or negative sign). The particular elements, due to their citation by only a single user, may be ruled out or treated in later stages of development.

Once the features mentioned by the students are identified and given values, the third step defined by the BLA can commence. It involves qualitative analysis, in which the students describe and provide solutions or improvements to each of their contributions in the format of an open interview.

4.1 Discussion

These results indicate that the adaptation of the content and the processes designed for the VR Island yielded student outcomes comparable to the average academic results that were historically achieved in this subject. The approach used also allows us to corroborate the qualitative data collected using the BLA (shown in Tables 1, 2). Although there was excess content regarding the time and the appeal of the VR system, the structure of the course was highly valued. The common elements that were mentioned at a higher rate are the most important aspects to use, improve, or modify (according to their positive or negative sign). The particular elements, due to their citation by only a single user, may be ruled out or treated in further stages of development.

The individual values obtained for both positive and negative indicators are shown in Table 1 and 2. Table 3 shows the main improvements or changes that the students proposed for both positive and negative elements. Only the “common” aspects, i.e., those mentioned by at least two students, have been included. At this point, before discussing the results, it is interesting to note the most relevant items obtained from the BLA, identified by high rates of citation, high scores, or a combination of both. Since work is carried out following an open-ended method, some of the elements above were not at the focus of the study (i.e., the evaluation of new visual techniques in the teaching field). Thus, only the elements most closely related to the motive of the study are highlighted.

Concerning positive remarks, the multiple use of edge technology (MI: 90 %, Av: 8.2) and the use of virtual reality (MI: 90 %, Av: 8.2) can be highlighted. In short, based on the ratings obtained here, the enhancements of methods for presenting architectural projects should not be modified in the redesign process.

This improved academic performance can be attributed to the course curriculum, the methodology of visualisation with VR, and enhancement technology provided by working with 3D, resulting in positive data yielded by the BLA. However, there are a number of negative aspects (Table 2) and solutions proposed (Table 3) by students that have had a direct impact, including the lack of time for practical realisation, VR explanations and techniques for rendering in 3D. Comparing the academic results with all the negative aspects and improvements that were cited in the BLA and those that can be drawn from the quantitative data, it is clear that the students appreciated this approach to learning and were highly motivated to work in 3D. Working in 3D is a very useful architectural technique; nevertheless, students become aware of the difficulty of establishing a domain when working with advanced models, which requires greater time for plans and details.

5 Conclusions

The use of TEL and gamification for assessment in 3D arts has demonstrated its usefulness as a system that can help align the assessed process and increase the embedded workflow of assessment. The Gamification has not only helped in student motivation, but has also allowed integrating the evaluation process in each of the phases of the project. The phase-by-phase 3D construction process of the pavilion has been very useful for students, allowing them to learn the basics in a completely practical way. The use of methodologies, such as PBL and SCC, is a valuable method to have as a guided development, from the idea itself to conceptual drawing, spatial concept, texture work, scale of the environment, etc. The use of gamification in the evaluation process has not only helped to create a better project but has also provided a way of seeing the self-evaluation as a well-aligned process to learn and develop the project itself. According to the final project results and personal interviews, the BLA model, due to the SCC proposed, appears to yield an essential improvement. Having the island exposed publicly in a VR from a computer or with an immersive device creates a sense of competitiveness among groups that worked on different pavilions. Furthermore, the use of SCC and gamified Virtual Reality offers students greater motivation to complete a project, thus creating complex environments to be urbanised. Technology such as immersive VR, devices like Oculus Rift, and advanced technology of videogames such as Unity or Unreal, are essential to achieve better results in the development of creativity, design of 3D modelling, lighting, rendering, and textures. Additionally, the use of 3D visualisation on mobile devices using 3D web services like Cl3ever or Sketchfab helps students achieve a more detailed project that can be integrated into their digital portfolio. All activities and exercises that help create the 3D design of the pavilion are assessed. Immediate feedback is provided on the Schoology platform, as a simple way to assess students' progress dynamically and rapidly, thus increasing their engagement and achievement.

This work focused on providing support through software technology in the first phase of the project lifecycle, or the design phase. The objective of the design phase is to create a design of the model that implements pedagogical methods suitable for the given learning objectives. This pertains to the preparation of the project for a particular learning flow, the understanding of the situation planned for the island, and finally the assessment of the pavilion, which might lead to changes for future applications. The use of gamification in a classroom is expected to increase student engagement and motivation, as it is more interactive and enjoyable compared to traditional classroom methods. It is important to engage the students with collaborative work in the classroom and develop a storyline (similar to a multiplayer game). This can be accomplished by competing with one another in groups, or developing a team that solves one goal together in a collaborative way. In the case of the island, students develop and urbanise an island as they wish, but also compete against each other to achieve the most visually appealing design. Their designs are displayed, allowing students and university faculty walk virtually into their pavilion.

The main advantages of this approach stems from the design process embedded with VR. The data is much more specific than that obtained through qualitative methods, which is usually the focus of studies that aim to address general questions.

The initial hypothesis proposed in Section 1 was based on the concept that, with a minor investment of time and with the use of visual mobile devices, students could obtain better results by having more motivating and satisfying experiences. This hypothesis has already been partly confirmed, as the use of mobile technologies and visual systems of the latest generation is more motivating for students. However, it has been demonstrated that these technologies do not reduce the investment of time because they require more hours dedicated to explanation, practice, and debugging to create the final projects. Nonetheless, neither the lack of time nor the need for more time to achieve the objectives of the course adversely affected the experience. Thus, it can be concluded that the motivational nature of the experience should be targeted for improvement in future iterations.

6 Future Work

Two possibilities have been identified for the experiments that should be conducted in the future, namely the adaptation of content and the assessment on individuals with disabilities, and automatic assessment within Virtual World according to their profile.

New VR devices that can increase the sense of immersion aimed for ordinary consumers of video games were recently introduced into the market. The project that will be developed is supported by two pillars, the VR and HCI. The first field is based on the immersion of the user in a virtual environment generated by a computer, while the second focuses on creating devices that allow the user to have fast, fluid and natural interaction with the computer. The idea is to develop a simulator that can move freely in a virtual environment (using, for example, Kinect), and interact with different VR elements. In this system, students can change some objects that were previously created by others, interact with them to move freely in 3D space and change materials incorporated in these objects (i.e., modify their visual properties).

This greater integration of immersive virtual worlds will help assess the work progress in an aligned way against the learning objectives of the courses using 3D. Thus, this initiative will build on the PBL foundation, as well as SCC and gamification, with the goal of attaining a greater embedment. The expected outcome is a more balanced project workflow and an assessment method that facilitates student learning.

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References

[Avouris, 12] Avouris, N., Yiannoutsou N. A Review of Mobile Location-based Games for Learning across Physical and Virtual Spaces Journal of Universal Computer Science, vol. 18, no. 15, 2120-2142. 2012.

[Binkley, 11] Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M. & Rumble, M. Defining 21st century skills. In Griffin, P., McGaw, B. & Care, E. (Eds.) Assessment and Teaching of 21st Century Skills (pp.17-66), New York: Springer, 2011.

[Biggs 99] Biggs, J., What the Student Does: teaching for enhanced learning, Higher Education Research & Development, 18:1, 57-75, 1999 http://dx.doi.org/10.1080/0729436990180105]

[Biggs, 03] Biggs, J: Aligning Teaching and Assessment to Curriculum Objectives, Imaginative Curriculum Project, LTSN Generic Centre, 2003.

[Boyle, 09] Boyle, A., & Hutchison, D. Sophisticated tasks in e-assessment: What are they and what are their benefits? Assessment and Evaluation in Higher Education, 34(3), 305–319, 2009.

[Calongne, 08] Calongne, C.M.: “Educational Frontiers: Learning in a Virtual World”; Educause Review, 43, 5, 36-48, 2008.

[de-Marcos, 10] de-Marcos, L., Hilera, J. R., Barchino, R., Jímenez, L., Martínez, J. J., Gutiérrez, J. A., et al. An experiment for improving students performance in secondary and tertiary education by means of m-learning auto-assessment. Computers and Education, 55(3), 1069–1079, 2010.

[Dominguez, 13] Domínguez, A., Saenz-de-Navarrete, J., De-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J. J. Gamifying learning experiences: Practical implications and outcomes. Computers & Education, 63, 2013, 380-392. http://dx.doi.org/10.1016/j.compedu.2012.12.020

[Fonseca, 13] Fonseca, D., Redondo, E., & Villagrasa, S. Mixed-methods research: a new approach to evaluating the motivation and satisfaction of university students using advanced visual technologies. Universal Access in the Information Society, 1-22. In Press. ISSN: 1615-5289 [Link Journal], Accepted 26/08/2013 Vol.13(3) 2014. [DOI: 10.1007/s10209-014-0361-4]

[Fonseca, 14] Fonseca, D., Martí, N., Redondo, E., Navarro, I., & Sánchez, A. Relationship between student profile, tool use, participation, and academic performance with the use of Augmented Reality technology for visualized architecture models. Computers in Human Behavior, 31, 434-445, January 2014, ISSN: 0747-5632 [DOI: 10.1016/j.chb.2013.03.006]

[Fonseca, 13] Fonseca, D., Villagrasa, S., Martí, N., Redondo, E., & Sánchez, A. Visualization methods in architecture education using 3D virtual models and augmented reality in mobile and social networks. Procedia-Social and Behavioral Sciences, 93, 1337-1343.Edited by Dr. Ferhan Osabasi, published by Elsevier Ltd, 1337-1343, 2013, [DOI: 10.1016/j.sbspro.2013.10.040]

[Friedman, 07] Friedman, J., Ryan Hwang, Tim Trinidad, and Bill Kindler. 2007-2008 Retrieve from https://www.schoology.com/home.php

[Girvan, 10] Girvan, C., Savage, T.: “Identifying an appropriate pedagogy for virtual worlds: A Communal Constructivism case study”; Computers & Education, 55, 1, 342-349, 2010.

[Gordillo, 13] Gordillo, A; Gallego, D.; Barra, E.; Quemada, J., "The city as a learning gamified platform," Frontiers in Education Conference, 2013 IEEE , vol., no., pp.372,378, 23-26 Oct. 2013 doi: 10.1109/FIE.2013.6684850

[Dunleavy, 08] Dunleavy, M., Dede, C., Mitchell, R.: Affordances and Limitations of Immersive Participatory Augmented Reality Simulations for Teaching and Learning. Journal of Science Education and Technology. 18, 7–22, 2008.

[Guidano, 89] Guidano, V. F. Constructivist psychotherapy: A theoretical framework, Cambridge: Cambridge University Press, 1989.

[Griol, 12] Griol, D., Molina, J. M., de Miguel, A. S., & Callejas, Z.A Proposal to Create Learning Environments in Virtual Worlds Integrating Advanced Educative Resources. Journal of Universal Computer Science, vol. 18, 2516-2541, 2012.

[Hennessy, 99] Hennessy, S. & Murphy, P. The potential for collaborative problem solving in design and technology. International Journal of Technology and Design Education, 9(1), 1–36, 1999.

[Herrington, 07] Herrington, J., Reeves, T.C., and Oliver, R. Immersive learning technologies: Realism and online authentic learning. Journal of Computing in Higher Education. 19 (1), 65-84, 2007

[Higueras, 14] Higueras, J., la Salle Open University, Scenario Centered Curriculum, el learning-by-doing de éxito en La Salle Open University, consultado 25 de julio de 2014, http://blogs.uols.org/mba/scenario-centered-curriculum-el-learning-by-doing-de-exito-en-uols/

[Hummel, 11] Hummel, H. G. K., Van Houcke, J., Nadolski, R. J., Van der Hiele, T., Kurvers, H., & Löhr, A. Scripted collaboration in serious gaming for complex learning: Effects of multiple perspectives when acquiring water management skills. British Journal of Educational Technology, 42(6), 1029–1041, 2011.

[Hwang, 11] Hwang, G., & Chang, H., A formative assessment-based mobile learning approach to improving the learning attitudes and achievements of students. Computers and Education, 56, 1023–1031, 2011.

[Ibañez, 12] Ibáñez, M. B., Rueda, J. J. G., Morillo, D., & Kloos, C. D. Creating Test Questions for 3D Collaborative Virtual Worlds: the World of Questions Authoring Environment. Journal of Universal Computer Science, *18*(18), 2556-2575, 2012.

[JISC, 12] JISC. Effective assessment in a digital age. Bristol, UK: <http:// www.jisc.ac.uk/digiassess> Retrieved March, 2012.

[Nadolski, 12] Nadolski, R. J., Hummel, H. G. K., Slootmaker, A., & Van der Vegt, W. Architectures for Developing Multiuser, Immersive Learning Scenarios. Simulation & Gaming, 43(6), 825–852, 2012.

[Oblinger, 06] Oblinger, D. G. (Ed.),Learning spaces. USA: EDUCASE. Pérez-Sanagustín, M., Hernández-Leo, D., Nieves, R., & Blat, J. (2010). Representing the spaces when planning learning flows. In Europeran conference on technology enhanced learning (EC-TEL) (pp. 276–291), 2006.

[Pifarré, 07] Pifarré, M., & Tomico, O. Bipolar laddering (BLA): a participatory subjective exploration method on user experience. In Proceedings of the 2007 conference on Designing for User eXperiences (p. 2). ACM, 2007.

[Seitamaa-Hakkarainen, 10] Seitamaa-Hakkarainen, P., Viilo, M. & Hakkarainen, K. Learning by collaborative design: Technology-enhanced knowledge practices. International Journal of Technology and Design Education, 20, 109–136, 2010.

[Slootmaker, 14] Slootmaker, A., Kurvers, H., Hummel, H., & Koper, R. Developing scenario-based serious games for complex cognitive skills acquisition: Design, development and evaluation of the EMERGO platform. Journal of Universal Computer Science, 20(4), 561-582, 2014.

[Redondo, 13] Redondo, E., Riera, A. S., Fonseca, D., & Peredo, A. Architectural Geo-E-Learning. In Virtual, Augmented and Mixed Reality. Systems and Applications (pp. 188-197). Springer Berlin Heidelberg. ACE (Architecture, City and Environment, vol. 8(24), pp. 100-132, February 2014. ISSN: 1886-4805, 2013 [DOI: 10.5821/ace.8.24.2714]

[Retalis, 11] Retalis, S., & Sloep, P. B.Virtual Environments for Collaborative Innovation and Learning J. UCS Special Issue. Journal of Universal Computer Science, 17(12), 2011, 1634-1637.

[Rieder, 11] Rieder, R., Pinho, M. S., & Raposo, A. B. A Petri Nets based Approach to Specify Individual and Collaborative Interaction in 3D Virtual Environments. Journal of Universal Computer Science, 17(2), 243-260., Journal of Universal Computer Science, vol. 17, no. 2, 243-260, 2011.

[Ternier, 12] Ternier, S., Klemke, R., Kalz, M., Van Ulzen, P., & Specht, M. ARLearn: Augmented Reality Meets Augmented Virtuality. Journal of Universal Computer Science 18(15), 2143-2164, 2012.

[Triantafillou, 08] Triantafillou, E., Georgiadou, E., & Economides, A. A. The design and evaluation of a computerized adaptive test on mobile devices. Computers and Education, 50(4), 1319–1330, 2008.

[Vartiainen, 12] Vartiainen, H., Liljeström, A., & Enkenberg, J. Design-Oriented Pedagogy for Technology-Enhanced Learning to Cross Over the Borders between Formal and Informal Environments, Journal of Universal Computer Science, vol. 18, no. 15, 2097-2119, 2012

[Villagrasa, 14] Villagrasa, S., Fonseca, D., & Durán, J. Teaching case: applying gamification techniques and virtual reality for learning building engineering 3D arts. In Proceedings of the Second International Conference on Technological Ecosystems for Enhancing Multiculturality (pp. 171-177). October 2014, ACM.

[Villagrasa, 14] Villagrasa, S., Fonseca, D., Romo, M., & Redondo, E. GLABS: Gamification for learning management systems. In *Information Systems and Technologies (CISTI), 2014 9th Iberian Conference on* (pp. 1-7). June 2014, IEEE.

[Wood, 13] Wood, L. C., Teräs, H., & Reiners, T. (2013). The role of gamification and game-based learning in authentic assessment within virtual environments, held at AUT University, Auckland, New Zealand, 2013-07-01 to 2013-07-04 Publisher: Higher Education Research and Development Society of Australasia (HERDSA)]

[Zhang, 10] Zhang, P., Wills, G., Gilbert, L., Warburton, B., & Bacigalupo, D. IMS QTI engine on android to support offline mobile learning. In Paper presented at the proceedings of the computer assisted assessment conference, Southampton, UK. Boyle, A., & Hutchison, D., 2010.