USE OF DELPHI METHOD IN OBTAINING REQUIREMENTS FOR THE GAME STRUCTURAL MASONRY

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ABSTRACT
The article presents the achievement of the project requirements for the development of learning material from the formulation of a game which simulates the management of a work in the building system in structural masonry. The methodology for obtaining these requirements goes through literature survey and application of the Delphi method with a group of 12 specialists (Professor, Researcher and Game Designer Professional) who develop their professional activities in this building system. The game will serve to qualify the students of civil engineering undergraduate courses, production engineering and architecture that will act as work managers in this system.

Keywords: simulation, education, Delphi method, requirements, serious games

1. INTRODUCTION

The quality of instruction of the civil engineer will have a positive impact on the success of his/her professional career, for this, he should use learning tools that combine theoretical training and professional practice.
One of the possible ways to get to this combination - theory and practice- is to use Serious Games in student training.
The term “Serious Game” is used to identify the games that go beyond entertainment and reach the learning and training level.
This paper seeks to develop a tool for qualifying undergraduate students in Civil Engineering as part of building system subject in structural masonry, serving to establish a link between the theories taught in the classroom and the practice of management.
The game will be developed to serve as a complement to the student training in the subject of work management in undergraduate courses of Civil Engineering, Architecture, Production Engineering and it will focus on constructive system in Structural Mansory.

The game setting is a simulation of a construction containing several buildings of two decks each, with four apartments per floor. The players are divided into teams containing one construction manager and the general supervisors in charge of operate the procurement of materials, plan the different stages of execution, and organize the building site.
The team which has a better cost/benefit development, planning and management wins the game.
The development of the research follows the steps shown in Figure 1, performing the stages to its conclusion with the implementation of the instructional design proposed, the development of the game Structural Masonry.

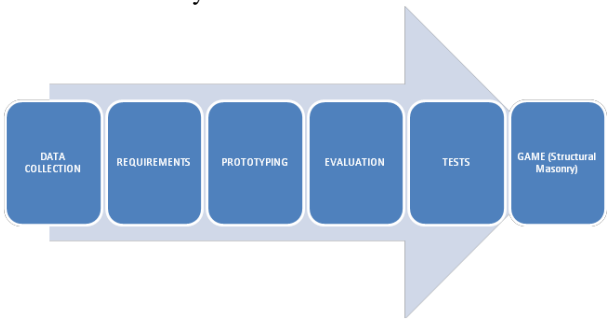

Figure 1: Logical scheme of the game development
Source: Adapted from Preece, Rogers and Sharp, 2007.

This article will present the steps taken to develop the first two stages, data collection and obtainment of the requirements.
The purpose of the data collection stage is to gather sufficient, relevant and necessary information for building a set of stable requirements for the game Structural Masonry.
"A requirement consists in a statement about an intended product that specifies what it should do or how it should perform" (Preece, Rogers and Sharp, 2007, p. 224).
To identify the requirements we used the Delphi method to experts, professionals working in the building system which is the focus of this work.

2. SIMULATION IN EDUCATION

Soldiers were the first to realize the great advantage of using simulation in the teaching - learning process. Besides them, this technique is also widely used in training in health and business areas.

Games and simulations are present in society in the last two centuries. It has been realized that the use of these techniques can go beyond simple fun and can add value to technical, scientific and intellectual education (Magee 2006).

Studies have shown several manners to use simulation in the educational environment. They range from the search for solutions to specific problems to the formulation of an environment that allows qualification for the accomplishment of more activities (Larréché 1987; Wolfe 1993; Curland and Fawcett 2001; Khaled 2001; Santos 2002; Van Der Zee and Slomp 2009; Pasin and Giroux 2011).

Simulation is understood as a technique that allows studying, predicting and understanding the behavior of a system in a simplified manner, enabling a "permanent representation of reality" (Ellington et al. 1981).

According to Salas *et al*. (2009) and Mahboubian (2010), learning from simulation takes the learner to build knowledge in a safe environment where he can make mistakes, understand them and get the correct results without the need of damaging equipment or changing the production flow of the activity to be learned.

Learning from the experimentation and simulation, along with the application of theoretical lessons results in a solid foundation for the students who need knowledge for decision making in real scenarios (Latorre and Jiménez 2012).

Developing competence in disciplines of undergraduate courses, from teaching methods that go beyond the traditional method already established of teaching, can be an alternative to achieve better results in education of the student. Among these alternatives we can mention; Latorre and Jiménez (2012); Bruzzone et al. (2013); Kazimoglu et al. (2012), Koops and Hoevenaar (2013), Cavalheiro, Freire and Jungles (2014) and Bellotti et al. (2012).

In Latorre and Jiménez (2012) it is possible to see the modeling, simulation and otimization application in a didatic tool which will help the training and constructionof competences in students, so they can become decision makers in a business environment.

Bruzzone et al. (2013), contributes in the training process in the health area inserting the MARIA (Model for Advanced and Realistic patient simulation driven by Intelligent Agents) a virtual model of a human being used as a patient in the game simulating the continual cares in the hospital environment to teach issues, such as the evolution of pathology, preventive actions and identification of clinical symptoms. Thus, the solution proposed becomes na inovation in the student training and requalification of professionals from new technologies.

In Kazimoglu et al. (2012), the Serious Game “Program your robot” is a didatic tool projected to enable the student in the subject of Introduction to Programming, seeking to develop mostly the proficiency related to the development of algorithms, data depuration and computer simulation. Divided into levels, the “Program your robot” gradually builds the necessary competencies to the student, expanding the knowledge required in each of the six levels of the game.

In the articles by Latorre and Jiménez 2012; Bruzzone et al. 2013; Kazimoglu et al. 2012 , the authors seek the training of the students and the development of the professional competencies, starting from the apllication of the serius games in the training environment.

Koops and Hoevenaar (2013) verifies the acquisition of concepts of Newtonian mechanics from the comparison of two students groups, the first one exposed to a traditional class and the second one using the simulation of learning games.

Cavalheiro, Freire and Jungles (2014), from the use of a table-top simulation with the application of serious game to a group (named A) of Civil Enginering students and apllication of the traditional teaching method to another group (named B), it is measured the acquisition of the competencies to the subject of programing techniques and construction work planning, coming to the results: (a) for the students , the acquisition of these competencies is more effective with the apllication of the serious games which simulates the reality of the building sites, (b) evasion is lower when applied this teaching method.Pode-se observar nestes trabalhos a utilização de serious game para a medição de aquisição de competências utilizando dois métodos de ensino diferentes.

Bellotti et al. (2012), part of the obtainment of the requirements thru the literature survey and consultation with entrepreneurs, students and professors to create educacional games which bring to students basic concepts of entrepreneurship and business management from this game practices.

According to Magee (2006), an approach to learning, from the use of simulation and games in adult education has worked well for the training paradigms, in which the educational objective has been to create a more homogenous workforce with consistent and predictable levels of competence.

3. METHODOLOGY

Preece, Rogers, and Sharp (2007) present some forms of data collection and determination of requirements for the construction of an instructional design, among these are: questionnaires, interviews, study group, natural observation and analysis of the documentation.

To Drenth (1984), the techniques of diagnostico of the requirements found in the literatura are in the figure 2 below:

Instrument or source	Level of method structuring	
	Structured	Unstructured
Instrument	Questionnaires with standardized scale Structured interview Objective test	Unstructured interview Projective test
Researcher	Sistematic observation Measuring scales	Register of impressions Participant observation
Specialist	Evaluations Structured interview	Brainstorm Delphi Method
Recording equipment	Indirect indications Experimental apparatus	Video, film, tape
Archive	Saved data	Personal documents Official documents

Figure 2: Main data collection methods
Source: Drenth, 1984.

Guimarães, Bruno-Faria and Brandão (2006) highlight that the utilization of techniques complementary to the principal one choosen auxiliate in obtaining the desired information, since it mantains the methodological rigor.
At the time of data collection, the starting point is the survey on the existing literature on the skills necessary to the professional manager of the building process on structural masonry and the main requirements for the development of learning materials for those skills.
The Delphi method will be used to determine the requirements creation of the game Structural Masonry as well as questionnaire and interview.
It is a method that serves to identify the objects requirement of this work, ant it is related with the literature as seen in the paragraphs above.
The method was developed by the Rand Corporation to study the impact of technology on war (Dalkey and Helmer 1962). With this method, it is possible to obtain a set of information on a specific topic from the consultation and consensus from specialists.
The research presents a qualitative, systematic and interactive method, for which specialists are selected according to pre-defined guidelines and are invited to participate anonymously in two or more rounds. The rounds are for collecting their impressions and providing impressions from the other specialists, in order to analyze, reflect and revise the points of view on the subject discussed.
The technique ends reaching the defined criteria which can be the rounds number or the reaching of the consensus (Hallowell e Gambatese 2010) and a statistical work provides the final result.
The procedure used to obtain the following requirements is shown through steps in Figure 3.

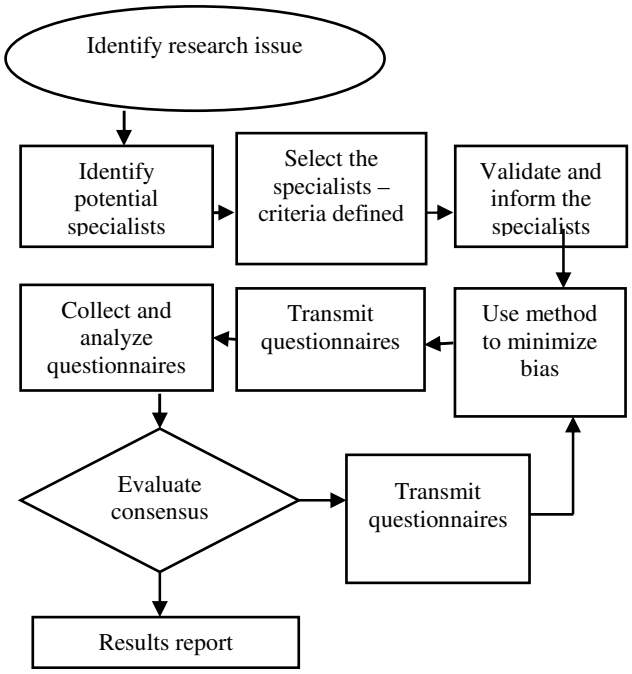

Figure 3: Procedure used in the execution of the Delphi method
Source: Adapted from Hallowell and Gambatese, 2010

For the identification and selection of specialists, there was an observation of Roger and Lopez's guidelines (2002), where the specialist must be or have been reached at least two of the following requirements:

- Primary or secondary author of two or more publications in the study area;
- Presenter in conferences of three or more publications on the subject covered in this work;
- Member and president of an institution or committee related to the topic of this work;
- Employee with at least 5 years of experience working with the practice of matters related to the subject;
- Professor at an institution of higher education within the field of study covered in this work.

Authors such as Brockhoff (1975), Boje and Murnighan (1982), Rowe and Wright (1999) and Hallowell (2008) recommend that the number of specialists to be selected for the application of Delphi method should be in a range of 9 to 15 specialists.
In this work the adopted number of specialists was 12, following Hallowell's recommendations (2008). According to him, this amount meets the study characteristics and the available number of potential specialists.
The choice of the specialists selected was for professionals who work on building sites, professors and researchers who use the building system in structural masonry in their work, divided into equal parts. It resulted in the professional staff as Figure 4.

Specialist	Experience (years)	International Experience	Professor	Researcher	Work Site Professional
01	09	x		x	
02	06				x
03	23	x	x	x	
04	12				
05	09	x	x	x	
06	18	x	x		x
07	05				x
08	06		x		
09	20	x	x		
10	11	x		x	
11	13				x
12	08	x		x	

Figure 4 – Characteristics of the participating specialists

Along with the definition of the specialists, a literature analysis for construction of the initial set of requirements was held.

To the specialists who expressed an interest in participating in this research, it was highlighted the importance of providing information, and the importance of working for the scientific and productive environment.

In the first round, there was an exposition of the theoretical conception on what would be the conditions required for the professional focus of the work and the skills these professionals needed to have in order to manage the production of a building in structural masonry.

Then, the following question was asked:

- "What are the requirements for the work manager in building system in structural masonry?"

The result of the first round was an ordinal enumeration of the requirements raised by the specialists, elimination of repetitions or similarities and the incorporation of the requirements observed from the literature, generating the matrix of initial requirements.

In the second round, the array of initial requirements was sent to the specialists, and they were asked about the approval or disapproval of each of these as a fundamental element for the professional of this area. In addition, there was the definition of values on the importance of each requirement reported. In this second round a consensus began to be drawn. It was possible to notice some changes of opinion compared to the responses from the first round. The feedback makes the specialists analyze and reassess the responses provided in the previous round. Thus, the views can be maintained, modified and changed according to the accomplishment of the following interactions.

To determine the required number of rounds, literature was consulted. According to studies by Dalkey et al, 1970, Brooks, 1979, Ludwig, 1994, Custer, Scarcella and Stewart, 1999, three rounds are enough to reach consensus. However, Pill, 1971, Delbecq, Van de Ven and Gustafson, 1975, Gupta and Clarke, 1996, indicate about three to six rounds as necessary to reach consensus.

For checking if there is consensus, literature recommends using a benchmark of Ca ≥ 60% agreement to be considered acceptable and validated, thus forming the requirements matrix.

The responses of the second round were used to determine the level of agreement. It was made from the expression below, creating a new matrix, named requirements matrix with agreement level.

$$\mathrm{Ca} = \left(1 - \frac{\mathrm{Vn}}{\mathrm{Vt}}\right) * 100 \qquad (1)$$

Where:
Ca = coefficient of agreement expressed in percentage;
Vn = amount of specialists in disagreement with the prevailing criteria;
Vt = total amount of specialists

Empirically when Ca ≥ 60% the agreement is considered accetable (Santos 2001).

4. RESULTS

Running the Delphi method, from the steps suggested by Hallowell and Gambatese (2010), has resulted in this work a total of three rounds. The compilation of the results is presented in Figure 5.

TYPES OF REQUIREMENTS	REQUIREMENTS
FUNCTIONAL	- The simulation will help in the development of planning and managing skills on execution and acquisition of materials for building in structural masonry.
OF DATA	- The system must have access to the database of the student skills required at different levels; - Data must be current and accurate.
ENVIRONMENTAL	- The sharing of data must be synchronous; - Players (students) should be in the same intranet system;
OF USER	- Targeted to undergraduate students in Civil Engineering, Industrial Engineering or Architecture; - Having knowledge in using technology; - Age should be less than 30 years old.
OF USUABILITY	- The game should have complexity divided into levels (beginner, intermediate and advanced)

Figure 5 : Necessary requirements for formulation of instructional design to be proposed

The requirements presented were the basis for the new stage of the creation of instructional design Structural Masonry, which is prototyping.

5. FINAL REMARKS

With this article, an absence of connection between classroom theory and professional practice could be identified. Thus, it is necessary to rethink the pedagogical practice of professors, trying to integrate

the classroom with the reality of the job market that awaits future engineers.

The proposal to obtain the requirements from the Delphi method makes the next steps a consistent work when gathering the information coming from specialists in the field.

This study contributes both for academia and for retraining by searching the theoretical knowledge, from the simulation techniques and associate it with the management process in undergraduate courses related to the civil construction.

It is worth to mention that the obtainment of requirements from the use of the Delphi method is a new element part of the practices and principles in the student training in the existing literature..

It is hoped that this article can contribute to expand the theoretical framework regarding the requirements for training of students who will act as experts and professionals in the construction system in structural masonry.

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