DAYLIGHTING RIVERS
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Daylighting Rivers: Inquiry Based Learning for Civic Ecology

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Ugolini F. & Pearlmutter D.

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Enhancing awareness to flood risk through hands-on models and serious games

Pileggi T.[1], Megale G.[1], Pampaloni M.[1], Caporali E.[1]

[1]*University of Florence, Civil and Environmental Engineering Department – DICEA, Firenze, Italy,* tiziana.pileggi@unifi.it, giulia.megale@stud.unifi.it, matteo.pampaloni@unifi.it, enrica.caporali@unifi.it

Abstract

The awareness of the population to the risk perception is an issue of growing importance in the mitigation of natural hazards. During a natural event, awareness of the dangers and self-protection behaviours can mitigate risk situations. In this context, the introduction of educational, informational, and public engagement tools that facilitate the understanding of the risk and improve its perception is certainly an effective way to contribute to mitigation.

The construction of physical models is traditionally a very good method to facilitate the understanding of complex phenomena, such as floods. Here, we propose the use of a physical model of flood scenario made with the famous LEGO bricks, to facilitate understanding and perception of hydraulic risk. Based on the LEGO model, recently a video game version has been preliminary designed. Using the Minecraft platform, produced by Microsoft, an actual serious game will be implemented on flood risk that has the city of Firenze as the reference scenario. The flood scenarios of the past and those resulting from the hydraulic models developed by the research group will be used to implement "role-playing games" related to the design of mitigation and hydraulic risk management measures.

In order to develop a method for the evaluation of effectiveness of the implemented serious game, a questionnaire was used, referring to some models available in literature. The elaborated questionnaire aims to provide a solid support to specific learning goals in terms of knowledge, skill and attitude, in order to assess the game quality and effectiveness as well as to contribute to its improvement and efficient adoption in practice.

Keywords: flood risk, awareness, hands-on model, serious games, evaluation, learning goals.

Introduction

Risk is a complex concept that is perceived by scientists and common people very differently. According to UNDRR (United Nations Office for Disaster Risk Reduction), risk is the probability of an outcome having a negative effect on people, systems or assets (UNDRR, 2020). Risk is typically described as being a function of the combined effects of hazards, the assets or people exposed to hazards and the vulnerability of those exposed elements.

The way in which the public perceive risk is heavily influenced by situational and cognitive factors. Risk perception can be considered as an individual's interpretation or impression based on an under-standing of a particular threat that may potentially cause loss of life or property (Bradford et al. 2012).

Risk perception is defined by Slovic (2000) as the intuitive judgement of individuals and groups, of risks in the context of limited and uncertain information. Raaijmakers et al. (2008) specifies this definition and defines perception through the relationship of a specific set of risk characteristics: awareness, worry and preparedness.

In the context of flood risk, the awareness of it could be defined as knowledge or consciousness of the flood risk that an individual or a group of individuals is exposed to. Flood risk awareness increases when a society is threatened by a hazard, when information and education about the hazard is more widely available, and this information has implications for appropriate actions (King, 2000). However, a society or a community tends to forget about risks associated with infrequent events and as a result awareness may decline (Arthurton, 1998). Provision of information to, or education of the public usually increases awareness. Worry depends on the awareness of the frequency of occurrence of certain hazards. Depending on the expected severity of the consequences of the hazard individuals may worry about socio-economic effects of flooding such as economic

damage, damage to ecology or health, the disruption of family life and loss of life (Tapsell et al., 2002). Preparedness is both the capability of coping with a flood throughout the inundation period, and post-flood recovery capability and strategies (Van der Veen and Logtmeijer 2005; Messner F. et al., 2006). Preparedness can be described in several dimensions as social, technical, economic and institutional.
As part of the university's third mission, aimed at promoting the cultural, social and economic development of the territory in which it operates, the Spatial Data Laboratory of the Department of Civil and Environmental Engineering, starting from its technical-scientific peculiarities, it is very much engaged in communication activities with the public in the field of natural hazards, with particular reference to natural hazards and floods.
To increase awareness of the flood risk and to facilitate the understanding of the complex dynamics of floods, a series of educational and dissemination tools have been developed and are in progress which refer to hands-on models and serious games. These tools are also useful in counselling activities during meetings with students of study courses and high schools and in multidisciplinary collaboration between various thematic areas. In order to consider the effectiveness of these tools, an evaluation questionnaire was implemented, referring to some survey models and investigation existing in literature.

Tools for enhancing awareness to flood risk

The LEGO hands-on model

The first flood risk model through which the activity in the field of risk communication to the public was started is the hands-on LEGO model [Figure 1]. The LEGO model built at the Department of Civil and Environmental Engineering of the University of Florence, represents a portion of territory crossed by a river. It is equipped with a water storage tank and a pumping system, for the simulation of water flow and fluvial floods. The LEGO bricks model is positioned in a container of Plexiglas for water collection. The base of the model (length 120 cm and width 80 cm) is made up of three layers of wooden material, useful for representing engraved riverbeds, floodplains and adjacent areas of the existing river segment. The surface of the model is covered with LEGO plates, so that the geometry can be modified through the insertion of preassembled external LEGO elements such as bridges, buildings, vegetation and barriers, as well as elements dedicated to the mitigation of hydraulic risk such as detention basins, weirs, dams, levees, embankments and spillways. In addition, in the model have been included small elements that represent non-structural measures in the context of hydraulic risk, such as rain gauges, instruments for measuring flow rate as well as emergency reception areas for the population. All elements are labelled, and their main purpose is explained during the carried on simulations.
The bricks are a real building material, simple and above all modular, which allows a tangible representation of reality, able to effectively communicate the connection between theoretical and practical aspects of risk and suitable for immediate observation of the effects resulting from design choices, planning or behavioural. The model can be used to organize Serious Games aimed at increasing interest and active participation, as well as soliciting competition and encouraging good practices in the field of hydraulic risk.
The definition of the characteristics of the portion of territory to be represented has been defined starting from the proposals emerged within the assignment given to the students of the Hydraulic Risk course in the academic year 2017/2018, which, using the software LEGO Digital Designer, have made design hypotheses about the preparation of the model surface, representing an existing or fictitious urban area adjacent to the river and prone to flood risk. To counteract the flooding of these areas following the flooding of the rivers, students have prepared appropriate risk mitigation measures, planning various solutions and scenarios.


Figure 1. The LEGO hands-on model

A serious game in Minecraft

Minecraft with his “digital bricks” is probably the most popular game among young people because it is an immersive interactive game where players can express themselves, build three-dimensional objects and play with others in a vast open world environment. Lately, a new version of Minecraft has been released: Minecraft Education Edition, that is specifically designed for educational purposes and provides educators with a game-based learning platform that promotes creativity, collaboration, and problem-solving.

Exploiting the potential of Minecraft Education Edition, a mini-game is being implemented composed of different scenarios in which the players are thrown into a reproduction of the city of Florence during a flood event [Figure 2]. The final goal of the players is to recognise possible risk situations and learn how to avoid them, in this way they can succeed and “win”. The first scenario that has already been structured is set at the Uffizi Museum: a group of children within a visit to the museum with their teacher during a weather alert are requested by the museum’s attendant to move some objects from the depot to the ground floor before the depot is flooded. The players must recognise that they are in danger and to “win” the game they need to take the stairs and go on the second floor, away from the flood.

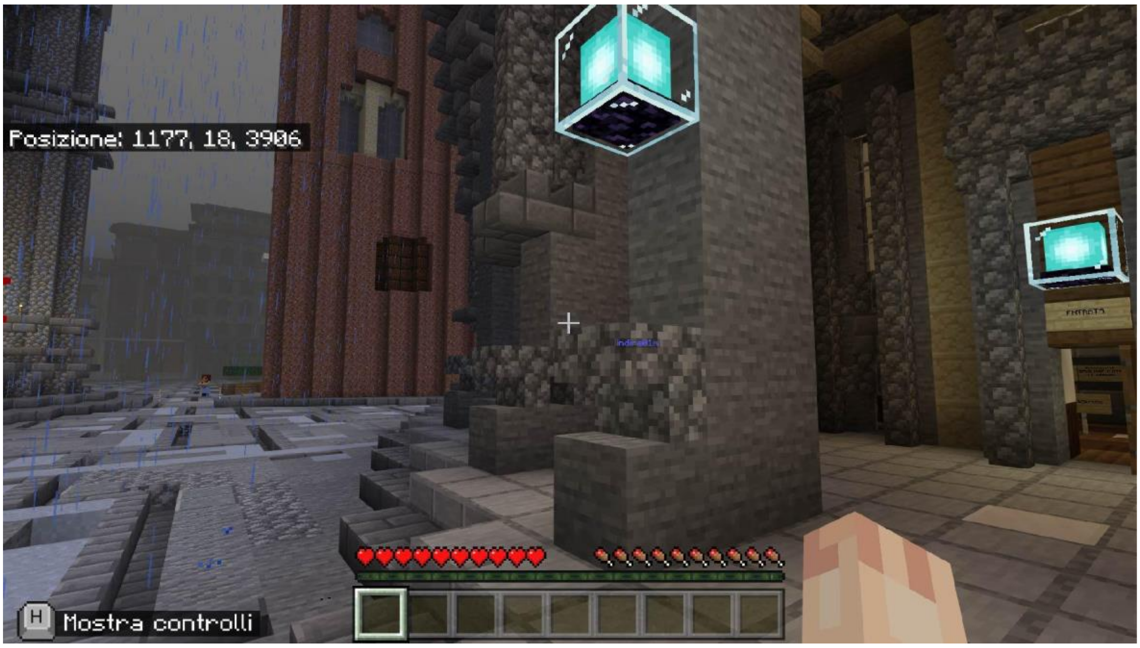

Figure 2. A screenshot of the Uffizi Gallery glimpse in Minecraft.

Evaluation of effectiveness

The use of serious games in the educational and public engagement field are becoming a common practice and are commonly considered effective educational tools in the various stages of growth (Petri et al., 2016). However, the definition of a method of evaluation for the applied approach is necessary. There are few studies in literature that have applied a rigorous method for evaluating serious games, some of them relate exclusively to e-learning. The MEEGA approach (Savi et al., 2011) is the most complete in terms of evaluation of effectiveness and it can be applied to both digital and non-digital game based learning. The considered quality factors are Motivation, User experience and Learning. The factors are decomposed into several dimensions and a questionnaire is constructed and distributed after the game experience.

The MEEGA+ (Petri et al., 2016) is an evolution of the previous method, focused mostly on computing education, evaluation goals are decomposed and a measurement instrument to evaluate the perceived quality of educational games in terms of player experience and perceived learning is defined (Petri et al., 2016).

Egame-flow (Fu et al., 2009) is another approach for the evaluation of effectiveness taken into consideration, it is meant to be applied on e-learning and it's the first method in literature with particular emphasis on fun, in fact, in an effective e-learning game, the learner's enjoyment acts as a catalyst to encourage his/her learning initiative. In addition, Serrano-Laguna (2017) is examined and readapted to provide simplified calculations to read the results of the questionnaire. In order to develop a method for the evaluation of effectiveness, a questionnaire has been implemented, with multiple sections, using the Goal/Question/Metric approach (Basili et al.,1994) to decompose Quality factors into dimensions and items. Its components are: Demographic Information, Previous Knowledge, Player experience, Usability, Learning, Comments and Suggestions.

With demographic information, the educator can outline the main aspects of the user. Previous knowledge is rather useful in defining a certain level of awareness the user has before playing the game. To answer, the player is confronted with multiple questions and a basic True/False (Yes/No) choice. These first two sections do not show into the final evaluation, nevertheless they are useful to give some context and increase the accuracy of the final assessment.

Player experience is a quality factor and it is decomposed in the dimensions of Fun, Satisfaction, Social Interaction, Immersion, Relevance, Focused Attention and Knowledge Improvement. This section is important because if the player experience is enjoyable, the user will remember more about his progressions in the game and acquired knowledge.

Usability is also an important dimension of player experience, but it was decided to place it in a separate section both because it contains others sub-dimensions and because it is easier to calculate the final result, in fact, in this way both Player experience and Usability have the same number of items. The sub-dimensions of usability are Aesthetics, Operability, Learnability and Accessibility, while the other dimensions of the player experience included in the usability section are Confidence, Goal clarity, Challenge and Feedback. The contents of the first two sections measure if the game is Fun and generally enjoyable (Player Experience) and if it is easy to use and accessible (Usability), with a response method through a 5-point Likert scale response from strongly agree to strongly disagree.
The Learning section contains 10 questions based on the LEGO model. This section serves to assess the effective learning of the user during the game and it's the crucial part of the questionnaire in regard to the contents of the game. The response method of the Learning section is through multiple choices, 4 statements for each question. This section is made to be easily modified in perspective of future developments of Minecraft's flood-risk game mentioned above.
The User's Feedback section can be found at the end of the questionnaire and it's a place where the user can express his opinions on the game openly and possibly give suggestions to improve it. After evaluating the player answers Demographic Information and Previous Knowledge are considered to extrapolate a complete analysis of the game regarding the target population it was tested on and to give a qualitative esteem on the player's perceived Learning.

The final questionnaire can be found at the link:
https://drive.google.com/file/d/1sTV04UHL0yOBkaNhEsJ3o5ItTq_zjjRf/view?usp=sharing.

Discussion and conclusions

In this paper we present two different flood risk models to enhance the awareness to flood risk and a questionnaire to evaluate their effectiveness.
The LEGO hands-on model has been shown in several risk awareness initiatives in the context of "Io non rischio – I don't take risks", a national communication campaign on best practices of civil protection. It has also been exhibited in scientific dissemination initiatives such as Bright-Night 2019 and at the Italian FIRST LEGO League regional selections. In December 2018 it was presented at China – Italy Week at the National Museum of Science and Technology "Leonardo da Vinci" in Milan.
Due to its characteristic of using the very famous LEGO bricks, it is aimed at the population of the little ones and reignites the passion of adults for "building bricks".
Each event was an opportunity for the facilitators to explain the dynamics of the floods and the importance of structural and non-structural mitigation measures. Adults and children were involved in risk scenarios set up in the model and the aspects related to the effects resulting from situations and decisions and the importance of good practices in the event of a flood were highlighted. The children may be involved in the scenario management by asking questions, suggesting interventions and virtuous behaviour.
Another way to promote flood risk awareness is through serious games, thus the second flood risk model to be presented is a serious game set inside the Minecraft Education world, that is under development with external collaborators, and it exploits the potential of Minecraft world to create an immersive role-play experience that will be submitted to a group of children of the school laboratory "Scuola-città Pestalozzi" in Florence.
In order to investigate the effectiveness of the proposed flood risk models a questionnaire, based on the MEEGA and MEEGA+ survey methods, have been implemented. In the questionnaire, some items from those methods were replaced with statements from EGame-Flow method and the number of questions was reduced to revise the results examination with the modified version of Serrano-Laguna method. The Learning section was structured on flood risk questions, that is the main object of our evaluation.
The questionnaire is shaped in such a way that it can be easily modified to meet future needs, so that it can be implemented after testing it, in fact, as the next step to this research, we are planning an application of this questionnaire to both the LEGO model from the University of Florence and the new digital game set in the Minecraft world.

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