SERIOUS GAMES: AN EFFICIENT TOOL FOR THE LEARNING ABOUT CITY RESILIENCE

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Abstract

Natural and man-made disasters are becoming more frequent lately and as a consequence, the relevance of resilience has increased significantly over the last years. Hence, there is a need for building city resilience yet there is a lack of guidance about what policies and steps should be followed in order to resist, absorb, adapt and recover from a crisis. In this context, Smart Mature Resilience (SMR) project, funded by the Horizon-2020 program, wants to develop a guideline for cities to improve their resilience level. The SMR project defines a Resilience Maturity Model (RMM) to determine the optimum path towards building the city resilience. In addition, the project develops a Serious Game (SG), aiming at presenting the RMM based on a system dynamics model that is encapsulated in a user interface. However, the benefit of using SG for didactical applications is not always clear, as there are examples that failed their purpose. Therefore, this paper presents the requirements the serious game should fulfil, explains the practical case of the pilot version developed in the SMR project and discusses how the pilot version achieves the established requirements.

1. INTRODUCTION

Cities continue to grow and as a consequence there is a need to build city resilience, not only theoretically but also in a more practical way. There are several researches that define resilience policies and actions in order to achieve higher resilience levels (Gimenez, Hernantes, & Labaka, 2016). However, none of these studies explain the inter-relations existing between the policies and their operationalization.

Therefore, recent crisis and catastrophic events have led to an increase of awareness regarding the necessity of developing tools which facilitate decision makers and crisis managers to deal with crisis and become more resilient. Decision makers such as local governments or involved stakeholders demand tools which enable to train and learn from past experiences in order to get prepared for future disasters. As a consequence, the use of serious games (SG) for didactical uses has augmented lately. Society has evolved into a more interactive and practical society (Kiili, 2005; Mayer et al., 2014) and, therefore, the way knowledge is taught and interiorized by learners has changed (Guillén-Nieto & Aleson-Carbonell, 2012). In some cases the literature shows that the use of SG have failed their purpose whereas in other cases it shows the high benefits of using SG for didactical application (Vogel, Bornhovd, Neupert, & AS, 2006).

This paper presents the practical case of a SG developed in the Smart Mature Resilience (SMR) European project, which aims to provide a tool for decision makers to train themselves. The SG presented in this paper is a pilot version of the one developed for the SMR project and therefore the complexity of the design is simplified yet the main characteristics are maintained. First, in Section 2, the context and necessities the decision makers have are pointed out followed by the description of the SMR tool (Section 3). Then, in Section 4, how the SG copes with the requirements is discussed and finally, in Section 5 the conclusions are made.

2. STATEMENT OF THE PROBLEM

The number of disasters has increased in the last decade with twice as many disasters and catastrophes than in the last decade of the 20th century. This, in turn, has augmented the awareness to improve the ability to manage and assess the cities' resilience. However, how to manage with already known risks and get prepared for unexpected ones is a complex activity as crisis management is unpredictable and it is not possible to know when disasters will occur and which the consequences will be (Coleman, 2004). In order to cope with this necessity a SG has been developed with the aim of providing decision makers with a tool to train, experiment and understand real life scenarios.

However, even if a SG is a tool which enables decision makers to better understand the concerning problem, to take more appropriate decisions and get to know the system under study there is not a consensus in the benefits and success of using them. In some cases the objectives when applying SG for interactive learning have not been achieved (Erhel & Jamet, 2013). The main cause for not developing a successful SG application is not having a clear goal during the design process (Greitzer, Kuchar, & Huston, 2007).

As a consequence, before developing the SG, the requirements the SG should have were pointed, taking into account the final user will be decision makers such as governments or involved stakeholders:

1. Training tool: Decision makers need to be able to train themselves with tools which represent real life scenarios in order to get prepared to face future disasters. To do so the SG should represent the reality and fulfil the following three characteristics:
    a. Holistic perspective: Users might be specialized in specific topics and might not be aware of other realities. Therefore, the SG should provide and encourage a holistic perspective that ends with the silo mentality users might have. This way, the decision makers who use the SG should end up with a broad perspective of crisis management not only being aware of their specific area but also understanding other sectors.
    b. Temporal order between policies: The policies chosen to get prepared and face a disaster do not have to be implemented at the same time but they should be applied in a specific order, since they are interrelated. However, decision makers might not know that the policies should be implemented following a temporal order in order to be more efficient. As a consequence, the SG should provide the user the opportunity to learn about which is the most efficient path to implement these policies.
    c. Relationships between policies: Decision makers use the SG in order to better understand how the policies are interrelated with each other and their effect. Therefore, the SG should interactively represent the existing temporal and interdisciplinary relationships between policies, as well as the impact of implementing the policies not taking into account these relationships.
2. Trustworthy: The SG should represent a city and show trustworthy results in order to provide decision makers a tool to study the impact of the implemented policies. Therefore, the SG should be parametrized with real cities' data with the objective of showing credible consequences after implementing a policy. As a consequence, the SG will make the decision makers aware of the counterintuitive consequences a decision could have.
3. Flexible: Disasters often happen unexpectedly and the context in which they could happen can be diverse. As a consequence, the SG should be flexible, enabling decision makers to adapt the game to different situations and contexts such as socio cultural aspects, economic structures or different types of critical infrastructures, as well as enable to choose the type of disasters the SG will simulate.

3. SMR'S TOOL: A PRACTICAL CASE

Smart Mature Resilience (SMR) is a European project funded by European Union's Horizon 2020 (H2020-EU.3.7., project ref. 653569) which develops a resilience management guideline based on a Resilience Maturity Model (RMM) that engages a growing number of stakeholders and multi-level governance in order for cities to become more resilient. In this context, the SMR project develops a tool; a SG which embodies the key aspects of the RMM.

3.1 Game description

The SMR's SG aims to develop a reflexive SG which assists decision makers to understand the structure of the RMM in order to enable doing experiments to study policies before implementing them in the real life. The RMM defines the path towards cities need to go through in order to improve their resilience level. It is composed of policies which are classified based on four resilience dimensions (Leadership & Governance, Preparedness, Critical Infrastructures and Cooperation) and five maturity stages (Starting, Moderate, Advanced, Robust, Vertebrate). Through the implementation of the policies, cities achieve higher maturity stages in a systematic and incremental way. The resilience policies defined in the RMM are inter-related and therefore, some policies are predecessors of others. Thus, depending on the order in which policies are applied, the efficiency of the implemented policies will vary and consequently the progress in the maturity stage will depend on that. Therefore, the SG targets to make aware decision makers about the policies' interrelationships, their dynamic behavior and the possible unintended consequences that may arise due to these precedence relationships.

Concerning its structure and design, the SG is composed of a System Dynamics model (SD), which defines the logic and the structure of the model based on the RMM and a user friendly interface that interacts with the user in order to obtain the input data and show the results. The SG can be used by any person, however it is oriented to be used by cities, specifically to by people who work on strategic levels with a holistic perspective and building resilience. Moreover, the SG is general and cannot be particularized to disasters. The results showed in the game represent a city of 800.000 inhabitants which would be similar to Amsterdam and a GDP of 35.500 similar to the city of Rome. This values are obtained after parameterizing the information and characteristics of the cities participating in the project (*Bristol*, *Rome*, *Riga*, *Glasgow*, *Vejle*, *Kristiansand* and *Donostia*).

Regarding the functionality of the game, the input of the SG are the policies defined in the RMM. During the game the user chooses the policy implementation order and how much to investment on each. As a consequence, the SG shows the impact of the taken decisions through time evolution graphs and indicators.

The SG is structured in three screens; initial state screen, decision-screen and result-screen. When the users enter the tool they go into the initial state screen where the purpose and functionalities of the game are briefly defined. In this screen the users need to choose the current maturity stage and the annual available budget (see figure1). Although the annual available budget is predefined, the budget can be changed at any moment in any of the three screens.

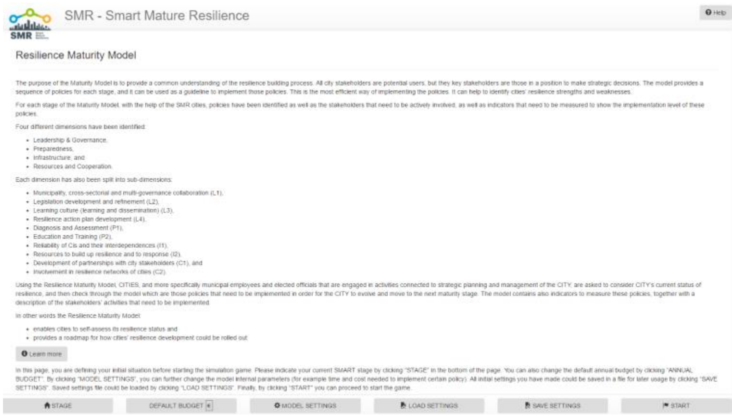
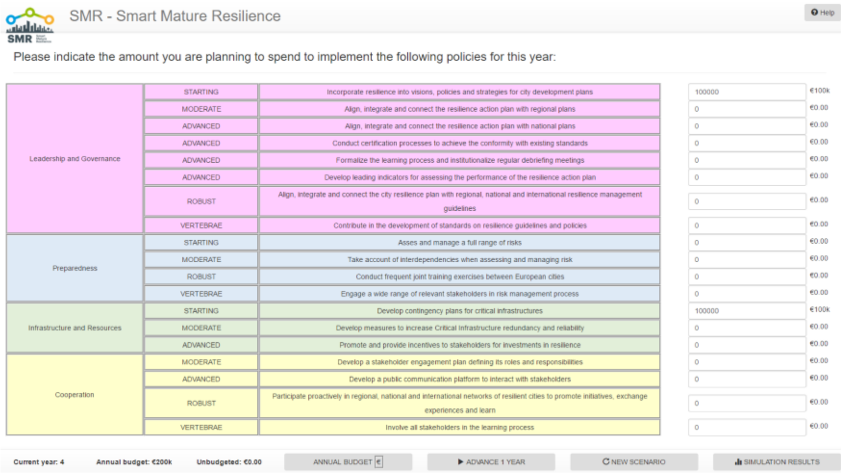


Figure 1 *Initial state screen*

Once the initial situation is established, the users move to the decision screen. In this screen, the users select how much money they allocate to each policy. The screen shows the list of resilience policies already defined in the RMM, classified by the four Resilience dimensions and five maturity stages (see figure2). Moreover, a short explanation of each policy appears when the mouse is put over the policy. Using the "Advance 1 year" button, the game simulates for one year, spending the available annual budget on the selected policies.

Apart from that, the indicators related to the current year of the game, the available annual budget and the budget left are showed as well as the buttons to change the available annual budget, to start a new game called "New scenario" and to go to result-screen called "Simulation results".



Leadership and Governance	STARTING	Incorporate resilience into visions, policies and strategies for city development plans	100000	€100k
	MODERATE	Align, integrate and connect the resilience action plan with regional plans	0	€0.00
	ADVANCED	Align, integrate and connect the resilience action plan with national plans	0	€0.00
	ADVANCED	Conduct certification processes to achieve the conformity with existing standards	0	€0.00
	ADVANCED	Formalize the learning process and institutionalize regular debriefing meetings	0	€0.00
	ADVANCED	Develop leading indicators for assessing the performance of the resilience action plan	0	€0.00
	ROBUST	Align, integrate and connect the city resilience plan with regional, national and international resilience management guidelines	0	€0.00
	VERTEBRAE	Contribute in the development of standards on resilience guidelines and policies	0	€0.00
Preparedness	STARTING	Asses and manage a full range of risks	0	€0.00
	MODERATE	Take account of interdependencies when assessing and managing risk	0	€0.00
	ROBUST	Conduct frequent joint training exercises between European cities	0	€0.00
	VERTEBRAE	Engage a wide range of relevant stakeholders in risk management process	0	€0.00
Infrastructure and Resources	STARTING	Develop contingency plans for critical infrastructures	100000	€100k
	MODERATE	Develop measures to increase Critical Infrastructure redundancy and reliability	0	€0.00
	ADVANCED	Promote and provide incentives to stakeholders for investments in resilience	0	€0.00
Cooperation	MODERATE	Develop a stakeholder engagement plan defining its roles and responsibilities	0	€0.00
	ADVANCED	Develop a public communication platform to interact with stakeholders	0	€0.00
	ROBUST	Participate proactively in regional, national and international networks of resilient cities to promote initiatives, exchange experiences and learn	0	€0.00
	VERTEBRAE	Involve all stakeholders in the learning process	0	€0.00

Figure 2 *Decision screen*

The result-screen shows the results of the simulation based on the taken decision (see figure3). At the top left hand of the screen the percentages of the current implementation, named “Actual”, and the efficiency of the implementation of the policies, named “Effectiveness”, are presented for each resilience dimension. The “Actual” percentage represents the implementation level of the policy and “Effectiveness” percentage represents the effectiveness of the implementation. These two percentages aim to represent the consequences of the relations existing between the policies. Therefore, if policies are not implemented in the correct order percentages will show low effectivity and implementation in comparison of what the user has decided in the decision-screen. Below this table, the speedometers are used to indicate the maturity stage the user has achieved in each resilience dimension. The speedometers start at 0 and go from the starting stage to vertebrate passing through moderate, advance and robust (S, M, A, R, T). Moreover, at the top right hand of the screen resilience dimension’s implementation level results are presented through time evolution graphs. The simulation ends at 40 years, therefore time cannot be greater than 40 and the level of implementation is complete when the 100% is achieved.

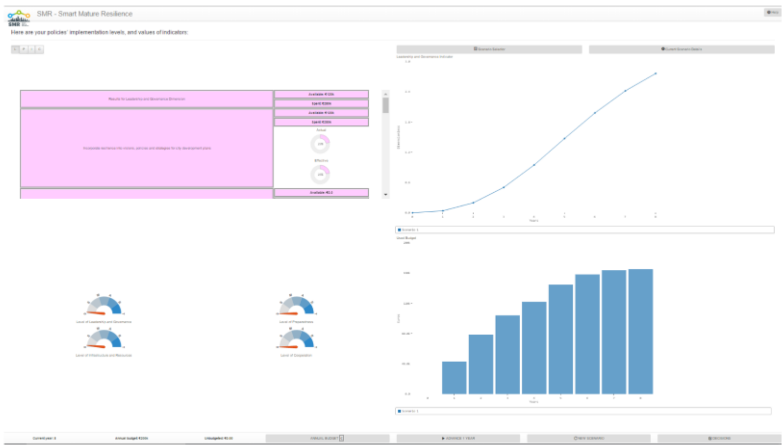


Figure 3 *Result screen*

Bellow the graph the evolution of the used total budget is represented through a time evolution graph where the time is represented in years and the budget in Euros. Furthermore, on the bottom of the screen the current simulation year, the available annual budget, the left budget and the button that gives the possibility to change the annual budget are shown. Furthermore, the buttons to step forward one year, to begin a new scenario and to go back to the decisions-screen are also represented.

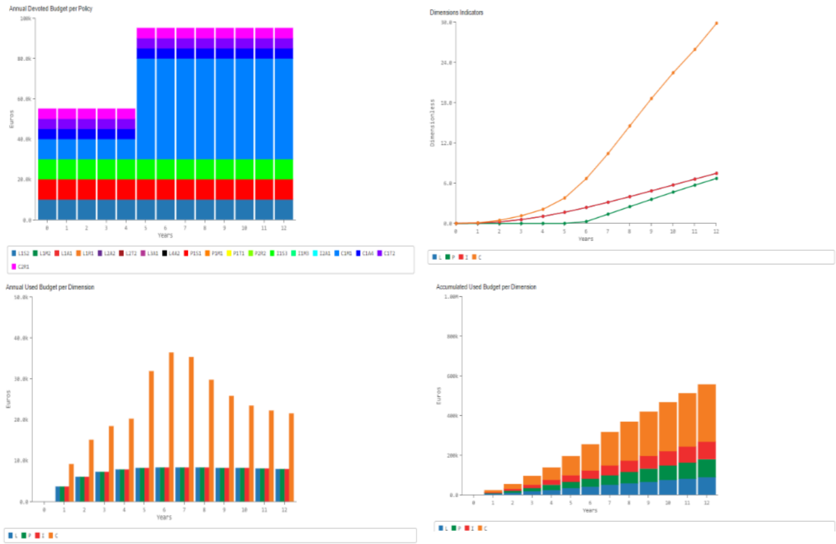


Figure 4 *Current scenario details graphs*

Apart from that, when clicking on the top right button called "Current scenario details" more detailed information concerning how the budget has been invested can be found (see figure4). In this additional result-screen, graphs regarding the level of implementation of the policies and the evolution of the spent budget are shown. The graph representing the implementation level resumes how the resilience dimensions have evolved over time per dimension. Below, the graphs concerning budget represent the accumulated budget per resilience dimension, annual devoted budget per policy and annual devoted budget per resilience dimension.

4. RESULT

Following, how the defined 6 requirements defined in Section 2 have been fulfilled in the SMR's SG is explained. In particular, the different functionalities that have been included in the tool in order to fulfill these requirements are explained.

1. Training tool: The developed SG enables the decision makers to try different policy implementation options and study their impact through indicators and graphs. Therefore, the SG provide decision makers a tool to train themselves.

   a. Holistic perspective: The SG developed in the SMR project encompasses the policies defined in the four resilience dimensions defined in the RMM. Therefore, all the fields (Leaderships and Governance, Preparedness, Critical Infrastructures and Cooperation) are represented. This means that the user who is playing with the SG should have a holistic view of the problem and not just a view of its particular area. Apart from that, there is no limitation regarding the user, any person from any particular area, specialization or background could use it. As a consequence, the SG enables the user to make aware that the decisions taken could influence not only in one resilience dimension but also in others. To do so, the SG shows how the resilience dimensions evolve over time and which is the direct effect of the taken decisions.
   b. Temporal order between policies: The SG is composed by different indicators and time evolution graphs that aim to make the user aware of the impact of the taken decisions. In order to make them realize how the implementation order affects, percentages per policy named "Actual" and "Effectiveness" have been used. The objective of these percentages is to show visually the importance in the implementation order as the decisions taken in the SG have to be what happens in reality.
   c. Relationships between policies: The developed SG is based on the RMM and it takes into account the precedence linear and transversal relationships between the policies. Therefore, in order to make the decision maker aware of these precedence relationships, every four years of simulation, the SG shows pop-up messages to the user explaining the errors he has committed. As a consequence, the SG enables the user to learn which are the

relationships existing between policies and therefore the optimum path towards resilience.

2. Trustworthy: The SG have been parametrized through a workshop in which 7 European cities have participated. Therefore, the showed results represent the impact of the taken decisions in all the resilience dimensions for a standard city. The resulting graphs indicate the level of implementation of the policies whereas the speedometer indicators indicate the maturity stage of each resilience dimension. Thus, decision makers will obtain trustworthy results which ensure the conclusions they get will help them achieving their resilience objective.
3. Flexible: The designed SG can be considered flexible due to several reasons. On the one hand, it is possible to stablish the initial maturity stage level aiming to represent different situations cities might be in. On the other hand, the SG enables to change the available budget during the game in order to be able to represent budget cuts or budget reductions. Apart from that, it is possible to adjust the critical parameters that define the characteristics of the represented city. This way parameters such as implementation cost or time for implementation can be adapted as they depend on the cities characteristics. Moreover, the SG enables to save and share the obtained results, therefore, it provides the opportunity to learn of other users' experience. However, the actual SG is not prepared to be particularized to specific disasters. Thus, next steps could be to develop an updated version which allows to particularize the disaster under study.

5. CONCLUSION

Recent natural and man-made disasters have led to the increase of awareness regarding the necessity of developing the resilience of cities. However, building resilience is a complex activity as disasters and crisis are unpredictable and difficult to manage. In order to reduce this complexity, recent studies have developed resilience frameworks, policies and actions which enable to achieve higher resilience levels.

In parallel, the use of SG has been a recent topic lately. SG have shown high benefits when applied for didactical objectives to better explain complex problems. However, a SG should accomplish some stablished requirements in order to ensure its success.

In this context, SMR European H2020 project develops a RMM which defines resilience policies that cities should implement in order to build their resilience level. In order to better explain the RMM and get a higher impact, a SG has been developed. The SG is based on the RMM and encapsulated in a system dynamics model and a user friendly interface. The game is divided into three screens: initial state screen, decision-screen and result-screen.

This paper discusses how the preliminary version of the SG developed in SMR fulfils the established requirements. As a conclusion, it can be said that all the requirements have been fulfilled and that as a future step the SG could allow the user to particularize the game to its specific situation and disaster problem.

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