SUSTAINABILITY LITERACY THROUGH GAME-BASED LEARNING

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Abstract

Sustainability and sustainable development have been recognized as the major challenges of the 21st century and to achieve this objective there is the need to think of education not as the traditional, analytic way of transferring knowledge, but as an experience that is centred on the student. Its purpose is to assist them in acquiring the necessary skills to constantly assess the environment, operate and adapt to it through a continuous and iterative process of revision from their frame of reference and finally equip them with the necessary material/tools that will help them comprehend and tackle complexity.

The objective of the current paper is to present an effort in the context of an E+ project on Higher Education to use serious games as a means to teach sustainability. To achieve the objective a board game will be designed and developed that will utilize the principles of Systems Thinking for the game mechanisms and design.

A systems thinking perspective implies the existence of interconnected elements to fulfill a function or a purpose over time. Those elements can be of physical or information composition. Modelling the system under study in this way allows policy-makers to make decisions based on scientific analysis of future scenarios and provide them with a supporting tool that could be used in synergy while planning and defining policies to get economic and socio-environmental benefits.

Causal Loop Diagrams (CLD) are qualitative representations of the system under study and illustrate in a clear manner the causal relations among the various elements. Furthermore, they can illustrate the feedback loops and nonlinearities that may be present in the system and give rise to dynamic behavior.

The SUSTAIN CLD is composed by different variables, that represent areas of interest in a general modern urban system. The model, in fact, considers general aspects as GDP and population, as well as environment, transport, urban planning and waste and water management.

As the CLD will be the basis for the future development of the game, the core of the model is represented by the most important parameter for deciding who will win the game, i.e. the Attractiveness of city. This variable is the synthesis of multiple variables that belong to many aspects of urban system, defining the “wellbeing” of the population who lives in it.

The most important effect due to variations in Attractiveness of city is a variation of the number of people who lives in the city; this generates many impacts on different urban levels, triggering as many feedback loops. In fact, the majority of feedback loops we identified passes through the “Population” variable. It's kind of natural that this happens as, in the end, urban systems exist because of its inhabitants, indeed.

The most important feedback loops were identified and then divided in three main groups. The first group is composed by loops belonging to the “core” of the model, that is the relation between population, GDP and Industries and Services. The second group is composed by loops which belong to the “environmental” part of the model. The last loop describes how traffic congestion has effect on usage of public transport and, in turns, effects on pollution.

The next steps of the research include the development of a quantitative model and the translation of the model’s variable to mechanisms and elements of a board game.

Keywords: Systems Thinking, Sustainability, Sustainable literacy, Game-based learning.

1 INTRODUCTION

Sustainability and sustainable development have been recognized as the major challenges of the 21st century and in that spirit the European Union has translated the notions into instruments of policy through the Sustainable Development Goals. However, interlinked with policies exists the need to raise awareness about sustainability and why it should be achieved; thus, acquiring a sustainability literacy in the form of a functional education that will provide the necessary skills and motives to tackle the complexity of and contribute to sustainable development.

To achieve this ambitious objective, we need to think of education not as the traditional, analytic way of transferring knowledge [1], but as an experience that is centred on the student. Its purpose is to assist them in acquiring the necessary skills to constantly assess the environment, operate and adapt to it through a continuous and iterative process of revision from their frame of reference [2] and finally equip them with the necessary material/tools that will help them comprehend and tackle complexity.

This experiential form of learning has been gaining traction in all levels of education [3] and its most prominent form is the one of game-based learning that has become an important aspect for the economy, society and research [4]. Games that combine entertainment with an explicit educational purpose are defined as Serious Games [5]; [6].

Serious games have increased their importance due to their advantages which include among others: they allow the players/learners to experience situation that are difficult to do so in the real world because of factors such as cost, time, safety etc. [7]. Moreover, they promote self-monitoring, problem identification and solving, decision making etc. [8]. Finally, they create the necessary conditions for communication, collaboration and a sense of belonging [9].

The objective of the current paper is to present an effort in the context of an E+ project on Higher Education (Project Reference No. 2017-1-EL01-KA203-036303) to use serious games as a means to teach sustainability. To achieve the objective a board game will be designed and developed that will utilize the principles of Systems Thinking for the game mechanisms and design.

The rest of the paper is organized as follows: Section 2 is devoted on presenting the principles of Systems Thinking and its operational tools of System Dynamics and Causal Loop Diagrams. In section 3, there will be a presentation of the basic model structure that will be used in the design of the board game. Conclusions and further project steps and research developments will be discussed on section 4.

2 METHODOLOGY

A systems thinking perspective implies the existence of interconnected elements to fulfill a function or a purpose over time. Those elements can be of physical or informational composition. While observing food systems, for example, we find interrelations among different elements carrying out the food production, supply, processing, distribution and consumption activities. Material flows constitute physical elements altering the state of stocks. Those accumulation processes determine the change of critical resources or drivers for production or distribution and are fundamental to assess their sustainability.

Modelling the system under study in this way allows policy-makers to make decisions based on scientific analysis of future scenarios and provide them with a supporting tool that could be used in synergy while planning and defining policies to get economic and socio-environmental benefits.

System Dynamics, proposed by Forrester [10], is a computer-aided approach to policy analysis and design that operationalizes Systems Thinking in a concrete manner. It applies to dynamic problems arising in complex social, managerial, economic, or ecological systems [11]. It is used to gain insights and improve the understanding of complex systems, often associated with complex problems. The System Dynamics approach faces the theme of interconnection with the creation of diagrams and models, in which information, that might be deduced from such methodology, are schematized.

These schemes are called Causal Loop Diagrams (CLD). They are qualitative representations of the system under study and illustrate in a clear manner the causal relations among the various elements. Furthermore, they can illustrate the feedback loops and nonlinearities that may be present in the system and give rise to dynamic behavior.

The outcome of a CLD is a combination of causal links between variables. Links can be of two types:

- Positive (S): when the independent variable (arrow tail) changes, then the dependent variable (arrow head) changes in the same direction.
- Negative (O): when the independent variable (arrow tail) changes, then the dependent variable (arrow head) changes in the opposite direction.

There are two types of feedback loops: reinforcing feedback loop and balancing feedback loop (indicated by + and – inside the loop). Also, it is possible to indicate a time delay between two variables (Figure 1).

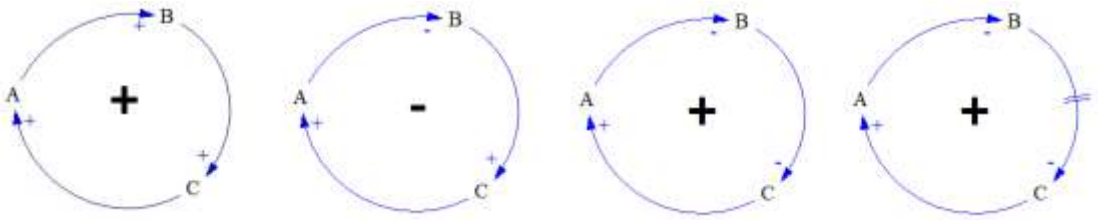

Figure 1. Starting from the left: Positive loop, negative loop, positive loop due to even number of negative links and delayed loop

Positive, negative, and delayed loops can give birth to a variety of systemic structures, named system archetypes, which can assist in taking a closer look at the problem displayed by a certain system and diagnosing the optimal solution [12].

In the next section, there is the presentation of the SUSTAIN CLD model.

3 SUSTAIN CAUSAL LOOP DIAGRAM

The SUSTAIN CLD is composed by different variables, that represent areas of interest in a general modern urban system. The model, in fact, considers general aspects as GDP and population, as well as environment, transport, urban planning and waste and water management.

As the CLD will be the basis for the future development of the game, the core of the model is represented by the most important parameter for deciding who will win the game, i.e. the Attractiveness of city. This variable is the synthesis of multiple variables that belong to many aspects of urban system, defining the “wellbeing” of the population who lives in it.

The most important effect due to variations in Attractiveness of city is a variation of the number of people who lives in the city; this generates many impacts on different urban levels, triggering as many feedback loops. In fact, the majority of feedback loops that are identified passes through the “Population” variable. While not surprising, this fact illustrates the importance of the urban population in any study/policy/analysis etc. with regards to urban studies.

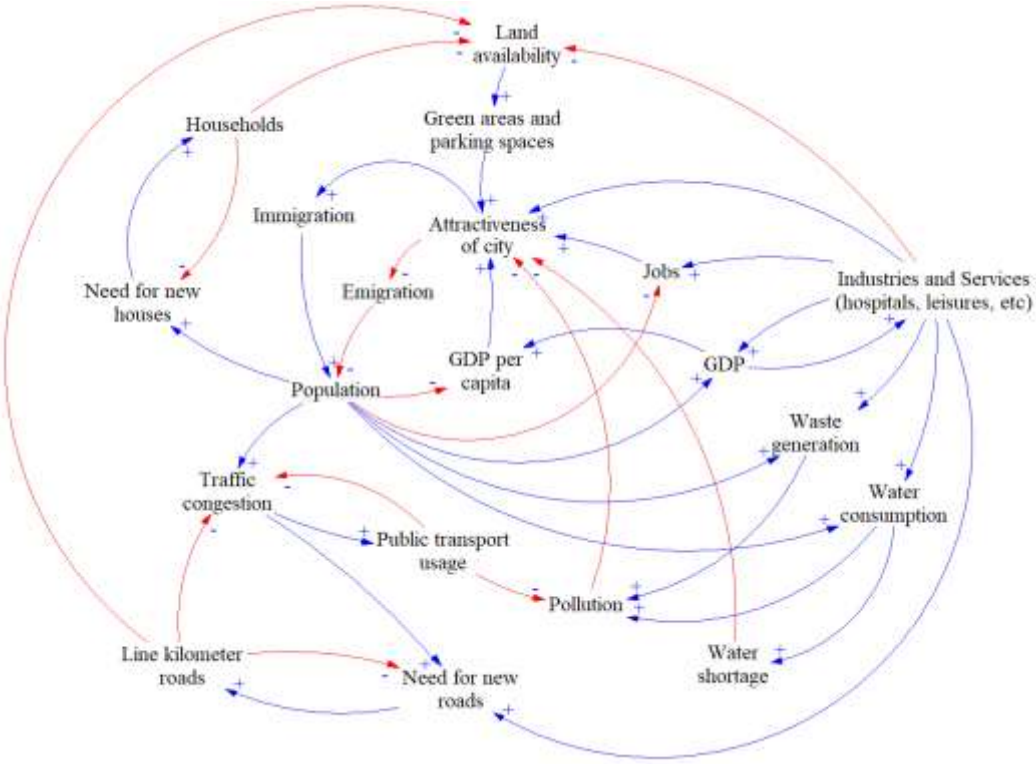

Figure 1 Overall CLD of the model

Analyzing the CLD, the most important feedback loops were identified and then divided in three main groups. The first group is composed by loops belonging to the “core” of the model, that is the relation between population, GDP and Industries and Services.

The first two reinforcing feedback loop (R1 – R2) are triggered when a variation in city’s attractiveness causes an increase in population, which generally has a positive effect in GDP; the higher the GDP the better the development of industries and services, which generates a twofold positive effect on attractiveness: on the one hand there is the availability of more services and developed industries; on the other hand more services and industries mean more jobs for inhabitants. The former is limited by the balancing feedback loop (B1), which depicts the saturation of jobs in the city. Finally, GDP and Industries and Services are coupled together by a simple reinforcing feedback loop (R3).

The second group is composed by loops which belong to the “environmental” part of the model. Water, waste and transportation have direct impacts on the total pollution and, in turn, on the city’s Attractiveness. Contrary to the reinforcing loops of the first group, there are two balancing loops (B2 – B3) that stabilize the attractiveness of the city through the possible increase in population which causes an increase in waste generation and water consumption, with consequences on pollution and water shortage phenomena.

The reinforcing feedback loop (R4) describes how traffic congestion has effect on usage of public transport and, in turns, effects on pollution. This loop is balanced by two loops (B4 – B5): on the one hand: the usage of public transport naturally reduces the problem of traffic congestion; on the other hand, external policies could increase the roads’ capacity and length addressing the same problem.

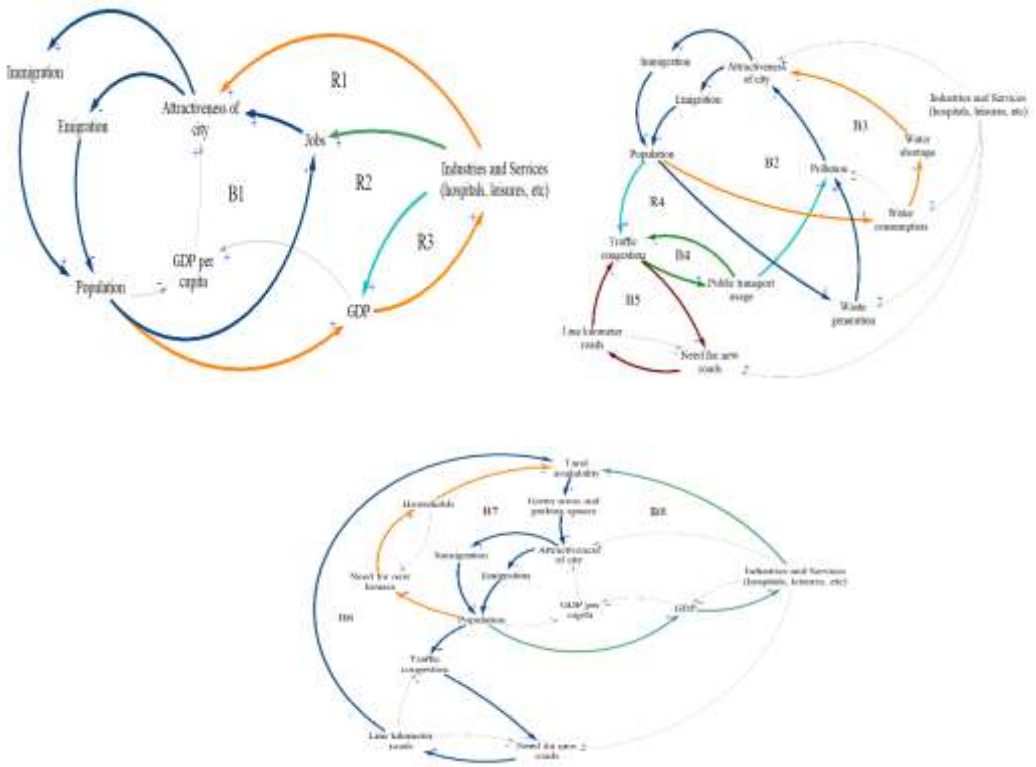

Figure 2 The three groups of loops: Part 1 (upper left), Part 2 (upper right), Part 3 (lower)

4 CONCLUSIONS

The purpose of the paper was to present the methodological mechanism behind the design of a board game that will be used as a teaching tool in the context of university educations.

The purpose of the model/game is to make education student-centered, experiential and non-linear, while at the same time admonishing the traditional analytical style of education.

The model uses the principles of Systems Thinking and Causal Loop Diagrams to create the system of a region/city and illustrate how the various elements are connected causally, how feedback loops are created and how these loops give rise to non-linear and complex behavior.

The next steps include the development of a quantitative model and the translation of the model's variable to mechanisms and elements of a board game.

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