

# GAME BASED LEARNING ON URBAN SUSTAINABILITY: THE "SUSTAIN" PROJECT

J. Papathanasiou<sup>1</sup>, S. Armenia<sup>2</sup>, F. Barnabè<sup>3</sup>, C. Carlini<sup>2</sup>, N. Ciobanu<sup>4</sup>, P. Digkoglou<sup>1</sup>, L. Jarzabek<sup>5</sup>, M. Kulakowska<sup>5</sup>, A. Lanzuisi<sup>6</sup>, M. Morfoulaki<sup>7</sup>, G. Myrovali<sup>7</sup>, C. Onofrei<sup>4</sup>, A. Pompei<sup>8</sup>, R. Scolozzi<sup>9</sup>, G. Tsaples<sup>1</sup>

<sup>1</sup>*University of Macedonia (GREECE)*

<sup>2</sup>*Link Campus University, Rome (ITALY)*

<sup>3</sup>*University of Siena (ITALY)*

<sup>4</sup>*Societatea pentru Consum Responsabil (ROMANIA)*

<sup>5</sup>*Stowarzyszenie Centrum Rozwiazan Systemowych (POLAND)*

<sup>6</sup>*Ergo Ludo Editions (ITALY)*

<sup>7</sup>*Centre for Research and Technology Hellas CERTH (GREECE)*

<sup>8</sup>*Sapienza University of Rome (ITALY)*

<sup>9</sup>*University of Trento (ITALY)*

## Abstract

SUSTAIN is an ERASMUS+ project with an innovative perspective on urban sustainability. Its target is to promote the importance of sustainability on the everyday problems of the cities among the students of higher education, which are the policy makers of tomorrow and the ones that will shape the future. In order to achieve its goals, the research team will develop a course that will be based on an interactive game with an analytical style of education. This game will allow students to learn about transportation sustainability and societal metabolism through playing. In addition, the research team will develop small and illustrative simulation models, which will make the definitions more concrete and allow students to experiment in a consequence-free environment. It is a quite innovative and hybrid perspective way of learning, in the sense that it will combine game-based learning with a cognitive and analytical style of education.

Keywords: Urban Sustainability, Board game, Edutainment, Decision making

## 1 INTRODUCTION

Sustainable development is among the grand challenges of the next decades. To come closer to achieving that state, the EU is committed to mainstream the Sustainable Development Goals (SDGs) in the European policy framework and current Commission priorities. Moreover, special attention is paid to means for the achievement of the SDGs, their universal application to all countries and the simultaneous address of the economic, environmental and societal dimensions of sustainability. Thus, there is the need of not only raising awareness, but acquiring a sustainability literacy, in the sense of a functional education that will provide the necessary skills and motives to cope with the challenges of and contribute to sustainable development.

The difficulty with sustainability arises from its abstract nature and the fact that these problems have long term horizons. However, the seeds for sustainable development lie already in the lives of millions of people, if we just think that two important facets of sustainable development are urban transportation sustainability (measures and solutions able to tackle mobility challenges that lead to uncontrolled growth of vehicles and downgrading of quality of life) and societal metabolism (models that facilitate the description of flows of material and energy within cities and provide a framework to study the interaction between human and natural systems).

Already in these aspects lies the implication of a need to fully comprehend the long-term horizon of sustainability problems and its backward relation with the present (how the choice of a transportation means affects the future status of an urban system), as well as the need to translate complex notions into concrete ones (what is the impact of citizens' consumption habits versus the local environment).

As a result, it is essential to provide an innovative pedagogy to students of higher education that will be the policy makers of tomorrow. In particular, their education should be exploring sustainability and the complexity among its different dimensions; moreover, it should provide the necessary means for

the students to experience processes of complex decision making, sharpen, their clarity of thought, enhance their communication abilities and help them develop critical thinking as well as key competences to address the complexities of sustainable development. This type of education needs to become a process that moves towards being transformed into a more experiential and student-centered way of learning: thus helping students to constantly assess the environment, operating and adapting to it through processes of revision from their frames of reference and provide the appropriate materials to comprehend systemic complexity.

The objective of the SUSTAIN project is to commence and promote sustainable literacy among students of higher education (and young people in general) through an innovative and student-centered education. To achieve this objective, the project will design, develop and implement a course to be taught in students of higher education; a course hybrid in nature, as it will combine game-based learning with an analytical style of education. In detail:

- 1) The course will deal with transportation sustainability, societal metabolism and decision making under those contexts. The purpose will be to teach students the definitions of those notions, how they are translated in everyday life, and formalize the mathematics necessary to make robust decisions.
- 2) The project team will develop small, illustrative simulation models that make the definitions more concrete and allow students to experiment in a consequence-free environment. The simulation models can be used to identify scenario exemplars on how we can achieve sustainable urban transportation and a balanced societal metabolism, while taking into account formal decision making process. Thus, greater insights will be provided to the policy makers of the future regarding the complexities of decisions in uncertain issues where many stakeholders are involved.
- 3) The approach of the SUSTAIN project is hybrid and as such the material developed so far, will be translated, in elements and mechanics of a Serious Game. The purpose is to create a board game that will allow students to learn about transportation sustainability and societal metabolism through playing. One important aspect of the design of the game it will be that it will avoid to be just an informational/fact-delivering game; the core design principle will combine delivery of facts with experiential elements that will allow students to explore their own sustainability goals and the means to achieve them.

Finally, the project is carried out transnationally because teaching students such an important issue requires the expertise of organizations that may be difficult to find concentrated in one country and secondly, it will promote to students the idea of cooperation for the achievement of a sustainable goal.

## 2 METHODOLOGY

The field of simulation and gaming has acquired a growing relevance for quite a long time [1,2,3] and certainly has evolved over that time span. Nowadays, simulation and gaming is recognized as a field of research that supports learning (both individual and organizational learning) and is employed extensively in educational and management training programs [4,5,6]. Notably, The field of System Dynamics has been traditionally close to the field of simulation and gaming, and various publications and special issues in the past two decades not only explored the interactions between the two streams of research [7,8,9], but also demonstrated the benefits stemming from their combination in favoring learning and improved decision-making [10,11,12]. So, within the SUSTAIN project, small illustrative simulation models will be developed allowing for experimentation in a consequence-free environment. The simulation models can be used to identify scenario exemplars on how it is possible to achieve sustainable urban transportation and a balanced societal metabolism, while taking into account formal decision making process. Thus, greater insights will be provided to the policy makers of the future regarding the complexities of decisions in uncertain issues where many stakeholders are involved.

Starting from these models, the project will develop an innovative and hybrid course. The course avoids the purely analytical style of education that is currently used in modern schools and universities and favors a more experiential, student-centered and hybrid approach. In fact, recently, there were more studies focused on experiential learning [13,14,15]. In this sense, the most known conceptualization is the Kolb's Experiential Learning Model [16], which is summarized in Figure 1.

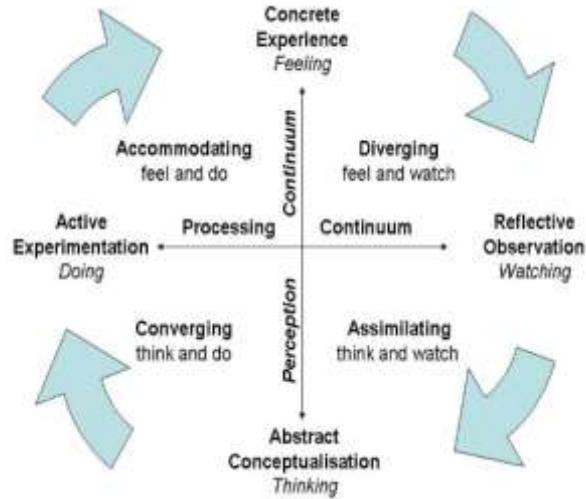


Figure 1. Kolb's Experiential Learning Model

Kolb speaks of a concrete experience when the subject is immersed in doing, experimenting and discussing an event. Learners are personally involved and influenced by their perceptions and reactions to the experience itself. In fact, experience produces sensations and behaviors on which the subject initiates an action of reflection and observation (reflective observation), examining the problem from multiple points of view and acquiring awareness of the lived experience. The understanding of events and the interpretation occurred through reflective observation, leads the subject to conceptualize working relationships and elaborate concepts that integrate observations in reference theories (abstract conceptualization). Intentionality and awareness are configured as fundamental elements in the next phase (active experimentation) in which theories and concepts are tested through action. This last phase in turn generates a new experience as the knowledge thus acquired can produce new ways of doing and thinking.

The experiential learning approach has been increasingly growing in importance at all levels of education [17] and in particular with game-based learning, which has become an important issue for economy, society and research. Game-based learning can provide educational enhancement along with the ability to:

- Allow the students to experience situations that are impossible in the real world for reasons of safety, cost, time etc.
- Engage the students in a pedagogical journey and have a positive impact in the development of a number of skills
- Enable improved self-monitoring, problem recognition and solving, decision making etc.
- Create a context of communication, collaboration and sense of belonging.

All these elements are essential for sustainability literacy, showing also the increasing importance of game-based learning as an innovative approach to higher education.

The course that will be developed within the project embraces all these aspects. The first part of the course will help students to learn about transportation sustainability, societal metabolism and the formal mathematics necessary to make decisions under those contexts. The material for this part of the project will be available in the form of interactive ebooks, available freely online, through the project's website. The interactive nature of the books will allow students to visualize the abstract notions in the form of videos, pictures and diagrams offering them the opportunity to gain insights into how these abstract notions are translated into concrete actions. Furthermore, it will show them best and failed practices that have been applied to other countries and gain insights into how sustainable transportation and a balanced societal metabolism can affect the urban environment. Then, the project team will introduce another innovative aspect in the education of students in the form of simulation models (already described in this section) that will allow for experimentation in a consequence-free environment. Finally, the students will be able to experiment through a board-game the notions they encountered during the previous studies and put them into practice considering also the interaction with other peer individuals and their course of action to meet their goals during the game.

Also, the SUSTAIN project will incorporate a framework for assessing the progress of learning and allow students to assess both the learning experience and themselves on what is they have learned, how they assess their performance in the game and how (and/or if) they have absorbed the information and experience at hand.

### **3 RESULTS**

The results of the project are still at an early stage, but there are three Intellectual Outputs that are complete:

The SUSTAIN Project will deliver four additional Intellectual Outputs, one for simulation models, one for the board game design, with game elements, mechanics and playing scenarios, one for the board game in its concrete form and finally the playing sessions with students.

#### **3.1 Output 1 – Ebook on societal metabolism**

The book describes the main definitions of societal metabolism and the formal theoretical models, their advantages and disadvantages and how the theoretical notions of flows of energy and material can be translated to elements of everyday life.

The innovative aspect of the ebook is that it contains links to videos, pictures and interactive exercises that clarify the definitions and elements with the purpose of helping students understand the complexities of modern urban systems. Being an interactive ebook the material can be transferred/translated to any context.

#### **3.2 Output 2 – Ebook on transportation sustainability**

The book describes the definitions of sustainable mobility/transportation, the theoretical models that describe its behavior and discuss on the state of the art from a theoretical point of view on the research conducted on the issue.

The innovative aspect of the ebook is that it will be interactive in nature by containing videos, pictures and links to describe best and worst practices in the field of sustainable mobility from around the world and how the theoretical models can lead to those behaviors. Finally, the material will demonstrate to students the dichotomy between political decisions to the higher levels of administration and the individual choice of daily commuters and how these types of (often contradictory) human behavior can shape the face of urban environments. Being an interactive ebook the material can be transferred/translated to any context.

#### **3.3 Output 3 – Ebook on decision making in the context of sustainability**

The book will provide the formal mathematics and foundations of decision making especially in the context of sustainability; meaning that a special emphasis will be placed in decision under uncertainty, the issue of time in decision making, decision making with multiple stakeholders etc.

The book will have a plethora of exercises that the students/readers can solve. Being an interactive book, these exercises will be available online and will attempt to incorporate and simulate actual decision making processes into the problem descriptions. For example, the student will attempt to solve the problem with imperfect information and the use of simple algorithms that will play "other" stakeholders with conflicting objectives.

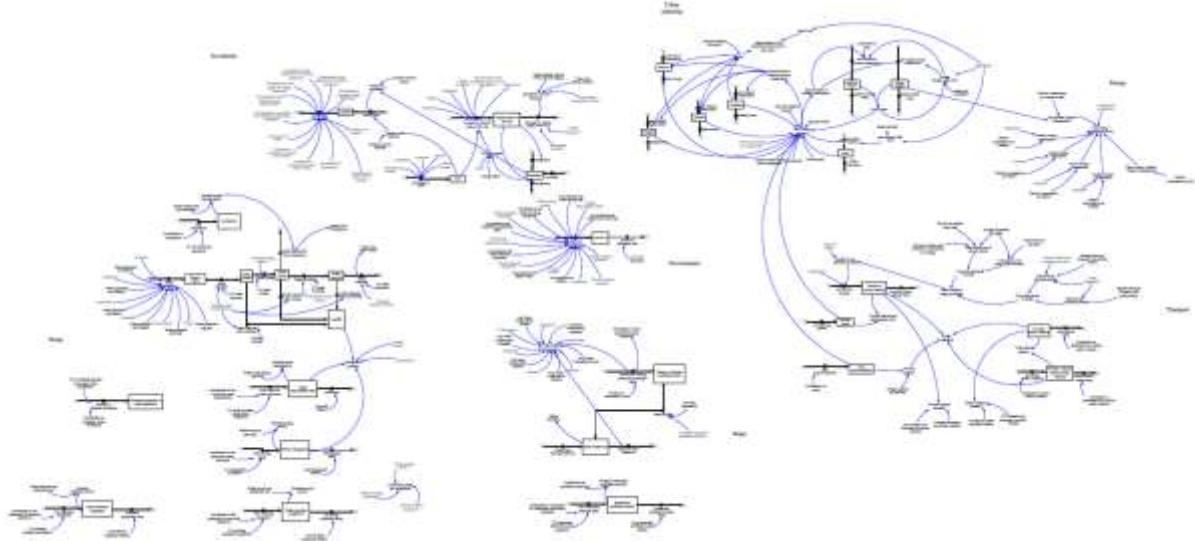
The expected impact of the output is to help students understand how the theoretical mathematics of decision making are translated into actual decisions.

#### **3.4 Output 4 – Simulation model**

The SUSTAIN model is a Stocks&Flow Diagram (SFD), one of the tools used by System Dynamics methodology. The model is already designed and structured, and it will be perfected by "quantifying" it, so that it can be simulated and experimented with. Probably, not all the aspects in the model will be implemented/accounted for also in the boardgame, but the model has been developed considering the elements that were already included in preliminary game designs as well as those found in the literature. The model is divided in several sections:

- Investment-general variables

- Urban planning
- Waste management
- Water management
- Transport
- Environment
- Energy



*Figure 2. SUSTAIN S&F model*

Each of them has its own variables and internal dynamics, but, from a systemic point of view, they can be seen as a whole big system which represents the concept of "city". In fact, there are many links and interconnections between variables belonging to different sections.

For example, building a new school have impacts not only at urban planning level (because it occupies a portion of available land), but also on waste and water management and energy (new activities, additional consume of resources, additional waste).

### 3.5 Output 5 – Game design

The project team will translate the simulation models to game elements, mechanics and potential playing scenarios. The book will show the logic of how abstract notions can be translated to simpler (gaming) elements without losing their meaning. Furthermore, the team will provide a state of the art on board games that deal with sustainability issues and urban environment, which ones have been successful and what were the elements that made them successful.

	My bus is never on time!		There aren't enough preschools		New preschool		Workplace development/retraining programme
Buses and other public transit often don't arrive on time with the scheduled arrival, making people late for work and other activities.		There are not enough early childhood education opportunities for children.		COST: 50	COST: 40		
MOBILITY -3	EDUCATION -3			EDUCATION +2	INDUSTRY +1	EDUCATION +1	PUBLIC SUPPORT +1

*Figure 3. Example of cards of SUSTAIN Board Game*

### **3.6 Output 6 – Board Game**

The final tangible output of the SUSTAIN project will be the board game (along with the guidelines on how to play it). The game design will be translated to an actual board game. The team envisages that the game will synthesize the knowledge of all the previous outputs into a gaming session that will inform, allow students to experience and be fun.

### **3.7 Output 7 – Course and playing session**

All the previous intellectual outputs and efforts by the members of the partnership will culminate in an intensive course that will help students understand the dimensions of sustainability, how decision making processes are applied under this context and play the board game that will help them develop critical capabilities and skills. The innovative aspect of the event is that the course will be hybrid, combining elements of traditional education (ebooks, the interactive nature of which brings another element of innovation in the course) with game-based learning (board game).

## **4 CONCLUSIONS**

The SUSTAIN project is in progress. The project teams are currently working in parallel on simulation model finalization and board game conceptualization. In a couple of months these two activities will be completed to move to the board game design and production. Finally, students from a partner's country will be engaged to try this innovative type of educational learning through playing the new game.

At the EU level, the project will provide added value in the efforts of the EU to disseminate the principles of sustainability (Sustainable Development Goals - SDG), while at the same time educating the future generations of policy makers to be better equipped to promote and achieve the SDGs. Furthermore, the project will pursue the effort for an enhanced education that will utilize and incorporate the principles of game-based learning and IC Technologies.

For the partners of the project, the impact will take the form of a strengthened cooperation and networking of different organizations among different European countries and with different scopes and experiences. At the same time, it will strengthen the role of the participating partners in their respective areas, as the project will bring cutting-edge research closer to students and citizens.

## **ACKNOWLEDGEMENTS**

This article/publication is based upon work from Game-Based Learning on Urban Sustainability (SUSTAIN) project (Agreement n° 2017-1-EL01-KA203-036303) supported by European Commission and funded under the ERASMUS+ Programme, Key Action 2 - Strategic Partnerships.

## **REFERENCES**

- [1] A.J. Faria, D. Hutchinson, W.J. Wellington and S. Gold, "Developments in Business Gaming A Review of the Past 40 Years," *Simulation & Gaming*, vol. 40, no. 4, pp. 464-487, 2009.
- [2] D. Crookall, "Serious games, debriefing, and simulation/gaming as a discipline", *Simulation & Gaming*, vol. 41, no. 6, pp. 898-920, 2010.
- [3] D. Crookall, "The founding of modern simulation/gaming: S&G and IASAGA four decades on," *Simulation & Gaming*, vol. 43, no. 1, pp. 5-14, 2012.
- [4] D. Crookall, R.L. Oxford and D. Saunders, "Towards a reconceptualisation of simulation: From representation to reality," *Simulation/Games for learning*, vol. 17, no. 4, pp. 147-171, 1987.
- [5] L. Sauvé, L. Renaud, D. Kaufman and J.S. Marquis, "Distinguishing between games and simulations: A systematic review," *Journal of Educational Technology & Society*, vol. 10, no. 3, pp. 247-256, 2007.
- [6] F. Barnabè, "Policy Deployment and Learning in Complex Business Domains: the Potentials of Role Playing," *International Journal of Business and Management*, vol. 11, no. 12, pp. 15-29, 2016.

- [7] P.I. Davidsen, "Issues in the design and use of system-dynamics-based interactive learning environments," *Simulation & Gaming*, vol 31, no. 2, pp. 170-177, 2000.
- [8] P.I. Davidsen, J.M. Spector and K. Morgan, Guest editorial: System dynamics and interactive learning environments in simulation and gaming. *Simulation & Gaming*, vol. 31, no. 2, pp. 169-169, 2000.
- [9] A. Alessi and B. Kopainsky, "System Dynamics and Simulation/Gaming: Overview," *Simulation & Gaming*, vol. 46, no. 3-4, pp. 223 –229, 2015
- [10] J.D.W. Morecroft and J.D. Sterman, (Eds.), *Modeling for Learning Organizations*, 1<sup>st</sup> paperback ed., Portland: Productivity Press, 2000
- [11] J.D. Sterman, T. Franck, T. Fiddaman, A. Jones, S. McCauley, P. Rice, E. Sawin, L. Siegel and J.N. Rooney-Varga, "WORLD CLIMATE: A Role-Play Simulation of Climate Negotiations," *Simulation & Gaming*, vol. 46 no. 3-4, pp. 348-382, 2015.
- [12] P.I. Davidsen and J.M. Spector, "Critical reflections on system dynamics and simulation/gaming," *Simulation & Gaming*, vol. 46, no. 3-4, pp. 430-444, 2015
- [13] A. Y. Kolb and D. A. Kolb, "Learning styles and learning spaces: Enhancing experiential learning in higher education," *Academy of management learning & education*, vol. 4, no. 2, pp. 193-212, 2005.
- [14] D. A. Kolb, R. E. Boyatzis and C. Mainemelis, "Experiential learning theory: Previous research and new directions," *Perspectives on thinking, learning, and cognitive styles*, vol. 1, no. 8, pp. 227-247, 2001.
- [15] J. A. Moon, *A handbook of reflective and experiential learning: Theory and practice*. Routledge, 2013.
- [16] D. Kolb, *Experiential learning: experience as the source of learning and development*. New Jersey: Prentice Hall, 1984.
- [17] J. B. Hauge, R. Berta, G. Fiucci, B.F. Manjón, C. Padrón-Nápoles, W. Westra, and R. Nadolski, "Implications of learning analytics for serious game design," In *2014 IEEE 14th international conference on advanced learning technologies*, pp. 230-232, 2014.