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Sunny Island. An interactive learning environment to promote systems thinking education for primary school students

Francesco Ceresia*

Department of Political Sciences and International Relationships, University of Palermo - Italy

Abstract

To make the process of learning easier for students, schoolteachers are increasingly using Interactive Learning Environments (ILEs) in classrooms. The paper presents a system dynamics-based ILE called *Sunny Island*. The ILE has been designed to promote Systems Thinking (ST) education for primary school students. Through a funny fantasy tale - described in detail in a book that accompanies the ILE - students have the opportunity to discover and become familiar with the basic principles of ST, such as feedback, positive and negative causal influences, limits to growth, short and long term effects, counterintuitive behaviors, causes of policy resistances and dynamic complexity. The proposed ILE has been designed through Powersim Studio 10, a simulation software that has been used to model the social phenomena described in the tale. A pilot project has been designed to test the effectiveness of the *Sunny Island* ILE. Six Italian primary schools have been involved in a pilot project, which is also supervised by a Regional Education Office, a public body that represents the Ministry of Education at a local level. The very first results show a positive impact of the *Sunny Island* ILE on ST education.

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1. Introduction

In the last twenty years, many scholars have shown that schoolteachers can effectively adopt Interactive Learning Environments (ILE) as a means to improve the quality of teaching. These new educational technologies are, in fact,

* Corresponding author. Tel.: +39-339-2324611.
E-mail address: francesco.ceresia@unipa.it

very useful to support the learning process, as they offer students a chance to simulate a phenomenon that is easily traceable in the real world and, therefore, they enhance a learning mode that is more connected to their personal lives (Ceresia, 2014; Foster, 2008; Papastergiou, 2009; Spires, Rowe, Mott, & Lester, 2011).

Although such new educational technologies have not as yet been well integrated into curriculum-based teaching and learning (Groff & Mouza, 2008; Levin & Wadmany, 2008), there is a wide awareness among scholars and teachers of how important it is to accelerate the process of integration among technology, pedagogy and content, which are considered as interdependent aspects of teachers' knowledge necessary to effectively teach content-based curricula.

A general framework, called Technological Pedagogical Content Knowledge (TPCK), has been suggested by Koehler & Mishra (2008) in order to highlight the positive effects generated by such integration among technology, pedagogy and content.

2. Systems Thinking and System Dynamics for K-12 students

Systems Thinking is an approach to analysis that focuses on the way that a system's constituent parts are interrelated and how systems behave over time. This approach is currently used in many scientific disciplinary sectors and has been applied to the study of environmental, economic, biological, medical, human resources, business and educational systems (Forrester, 1997, Sterman, 2000).

Scholars have also implemented educational materials and training activities designed for children aged 5 and older, with the aim of introducing at a very early age the basic principles of this new "way of thinking". The idea was that a young mind - being more flexible - could better internalize and acquire the basic reasoning mechanisms of systems thinking (Forrester, 1997; Roberts, 1978). As noted by Roberts (1978), dynamic feedback systems thinking can be effectively taught at the elementary and secondary school levels. In K-12 education, system dynamics modeling has been applied to mathematics, physics, social studies, history, economics, biology, and literature (Ceresia, 2016).

System dynamics - a computer-aided approach to policy analysis and design - is a methodology developed in accordance with a systems thinking perspective. In fact, both construct the same causal loop diagrams of systems with feedback and can be usefully applied to any social system characterized by interdependence, mutual interaction, information feedback, and circular causality (Forrester, 1961, Sterman, 2000).

However, system dynamics differs from systems thinking since it utilizes simulation to study the behavior of systems and the impact of alternative policies on it.

From a pedagogical point of view, the adoption of the *Sunny Island* ILE in the scholastic context can produce several benefits for the students derived from the possibility to:

- go beyond the limits of an educational approach based solely on an analysis of facts, allowing students to be leaders in the process of identifying the structure underlying the phenomenon being considered (Bruner, 1963)
- enhance the memorization of the details that characterize a phenomenon in light of their placement within a structure whose meaning is clear to the student (Bruner, 1963)
- gain a thorough understanding of a phenomenon without settling for a merely basic understanding, especially when the phenomenon is complex (Bruner, 1963)
- encourage the process of generalization of acquired skills by analyzing and investigating a phenomenon in order to understand the dynamics underlying other isomorphic phenomena (transfer of learning) (Bruner, 1963) through the identification of systemic archetypes (Senge, 1990).

The main aims of the paper is to present a system dynamics-based Interactive Learning Environment (ILE), called *Sunny Island*, designed to promote Systems Thinking education for primary school students. The *Sunny Island* ILE is designed for fourth and fifth grade primary school students.

3. The Sunny Island ILE

3.1. The Sunny Island ILE and Systems Thinking

The *Sunny Island ILE* is a simulation environment designed through Powersim Studio 10 that - through a funny fantasy tale - allows the student to discover the principles of Systems Thinking and become familiar with some of its basic concepts, such as cause and effect relationships, positive and negative feedback, limits to growth, short and long term effects, and counter-intuitive behavior generated by a social system.

One of the characteristics of the *Sunny Island ILE* is that the principles of systems thinking are presented through a narrative approach. From this point of view, these principles are gradually introduced whenever they are functional to helping the student understand why the facts described in the tale take place in that particular way.

Sunny Island ILE aims to help students understand that the illustrated tale represents only one of the all possible "event horizons". Students are encouraged to recognize that a single fact may generate countless "alternative scenarios", each of which is characterized by a particular "sequence of events" often deeply divergent from the one that really happened.

In summary, the *Sunny Island ILE* encourages the student to experience how a story - considered as a sequence of events - can change radically because of the decisions that its protagonists (agents) have made at every stage of its development.

3.2. The sections of the "Sunny Island" ILE

The *Sunny Island ILE* is divided into three main sections. The first section is an introduction of the ILE and its main aims. The second section shows the main feedback loops that characterize the underlying structure of the tale. The third section presents the cockpit used to simulate the alternative scenarios of the tale.

a. The introductory section

The introductory section is intended to introduce the ILE and its main objectives. Tab. 1 shows the text used to introduce the ILE to the students.

TAB 1. Introduction of the Sunny Island ILE

Did you ever find yourself in big trouble without even knowing why? Have you ever witnessed something that you would have never expected to happen? Have you ever stumbled upon such a complicated situation that you had to suffer a lot to get through it? If you answered yes, then this is the book for you! Through a funny fantasy tale, the Sunny Island ILE will propose an original method of analysis of the events, which could help you in understanding why sometimes things do not work to your advantage. You'll find that two people, because of the different observation methods they adopt, can interpret a single event in a radically different way. These observation methods will also influence the decisions people make in order to handle situations in the most satisfactory way. You will understand how important it is to identify the causes that have generated a problematic situation, as well as the different consequences that could be produced if it is handled in an improper way.

Working with the ILE you will exercise your mind to grasp the complexity that often hides behind phenomena that, at first glance, may seem very simple to understand. You'll find that at times, in the hope of dealing positively with a problem, you make decisions that not only do not produce the desired results, but also generate some opposite effects that, paradoxically, will further exacerbate the problem you wished to solve. You'll learn that - if you do not watch out for the complexity of the situation in which you end up - what initially may seem like a good decision, because of the positive results that are produced initially, will soon show its true face, unleashing on you a huge storm of new and unexpected problems. The Sunny Island ILE has the main objective of introducing you, in a simple but rigorous way, to the principles of Systems Thinking, helping you to understand some of its basic concepts such as: directly and inversely proportional relationships, causal circuits, limits to growth.

Once you become familiar with these principles, you will understand that within a social phenomenon it is possible to discover a hidden "structure" that is responsible for its evolution or dynamic over time. You'll find that a problematic situation can be analyzed through the elements that compose such a hidden structure, and that your ability to understand and anticipate the effects that it can generate depends on the manner in which you put those elements in relation with each other.

You'll learn what it means to build a mental map, and how much it could be useful to managing the complexity of the phenomenon you are facing. You'll understand that this mental map, being characterized by a complex network of relationships between variables, can be graphically represented by a set of causal circuits - called "feedback loops" - which, being interconnected, configure a "structure." Once you have understood this "structure" in all its aspects, you can forecast the effects that could be generated by the situation. You will learn the importance of being able to anticipate or forecast the effects of your possible decisions without having to really carry them out, thus avoiding to proceed by "trial and error."

The fantasy tale is described in detail in a book that is provided jointly with the Sunny Island ILE. The first section of the ILE shows a brief summary of the Sunny Island tale as described in the book. In addition, this first part also aims at stimulating interaction between the ILE and the students.

In a nutshell, the tale narrates the adventures of a community of monkeys and sheep who live together on an island in the middle of Caribbean Sea. More specifically, the tale starts off with an agreement signed by two monkeys (Bruno and Marco) and two sheep (Sara and Bea) in order to obtain the following benefits: on the one hand, the two sheep will produce cheese for the monkeys, of which the latter are wild about; on the other side, the two monkeys will trim and style the fleece of the sheep (“hairstyle”), allowing them to swim (they love to do it!) without the risk of drowning because of their thick fleece.

However, other monkeys and sheep decide to sign this agreement without taking into account the need to balance the number of monkeys and sheep. Several problems begin to arise, and the characters of the tale try to cope with them by making decisions that produce some good results in the short term but, dramatically, end up generating other problems in the long term. When the situation seems to slip away from anyone’s control, Marco decides to contact Mister Jack - an expert in solving complex problems - hoping he might help them solve the huge conflicts that have arisen between the monkeys and the sheep.

Mister Jack, in the end, is able to help the monkeys understand what triggered the conflicts between the monkeys and the sheep, illustrating the principles of systems thinking and using the methodology of system dynamics.

3.2.1. *The feedback loop section*

In the feedback loop section, the essential elements of the tale are presented to refresh the main causal loop diagrams - that is, the structure - underlying the considered system.

As an example of the feedback loop section content, Mister Jack, who - using the language of systems thinking - explains why, at some point, the sheep began to delay delivery of the cheese, making the monkeys unhappy for the supply service. The causal relationships between the variables of the two feedback loops are represented graphically with solid and dotted arrows, where the solid arrow represents a directly proportional relationship, while those dotted an inverse relationship.

3.2.2. *The cockpit section*

In the “cockpit” section the students can observe the simulation view presenting different outcome measures (behaviors) generated by the system. Based on the qualitative analysis of the system structure outlined in the previous section, the students can compare alternative decisions to evaluate their effects on the system behaviors.

For example, a cockpit can show the alternative scenarios generated by Bruno’s decision to organize the party with some of his friends and Luca and Gianni’s (two friends of Bruno) decision to sign a new agreement with Sara and Bea (the two sheep who have recently arrived at Sunny Island) and the level of satisfaction of the monkeys and the sheep for, respectively, the supply of the cheese and the hairstyle service. Otherwise, the cockpit can show how a decision (to invite more monkeys and sheep at Sunny Island to sign new agreements) made to solve the problem of the dissatisfaction for the delay in the supply of cheese and in the hairstyle service can produce a positive effect in the short run but a negative (unexpected and counterintuitive) effect in the long run (the reduction of the space in the forest and the beach for, respectively, monkeys and sheep).

4. Discussion

The *Sunny Island* ILE shows that introduces the principles of systems thinking through system dynamics methodology to primary school students facilitates their acquisition of important thinking skills, such as knowing how to represent and assess the complexity and the dynamics of a social system.

The working hypothesis of the Sunny Island ILE author is that engaging students in school activities focused on the adoption of systems thinking will stimulate the development of key thinking skills such as the ability to:

- analyze a phenomenon in a systemic perspective, considering the complex and often non-linear relationships between the key variables that define it
- understand how the behaviors displayed within a given system (phenomenon) are generated by a well-defined structure characterized by interconnected feedback loops and generally represented by a causal loop diagram or mental model.
- investigate the effects of decisions (policies) on the behavior of the system through a simulation model that also allows the students to identify the unintended and counterintuitive consequences of such decisions.
- underline the role of time delays in the cause and effect relations, understanding the impact of such delays on the behaviors of the system;
- recognize and overcome the limits of our mental models, understanding that these limits are often the main causes of wrong decisions we make while dealing with a complex situation.

In addition to these strategic thinking skills it is possible to identify more basic skills that are also stimulated through this ILE, including the ability to:

- create and interpret data-based graphs;
- tell a story through a chart that represents the dynamics of a social system;
- develop a basic understanding of probability, logic and algebra.

5. Conclusion

A pilot project has been designed to test the effectiveness of the Sunny Island ILE. Six Italian primary schools have been involved in the pilot project, which is also supervised by a Regional Education Office of Sicily (IT), a public body that represents the Ministry of Education at a local level. The ILE has been used at a classroom level of analysis. More than 200 students have been enrolled in this pilot project, which will be completed at the end of June 2016.

A training program for schoolteachers has been designed and implemented to allow them to utilize the Sunny Island ILE in their classroom.

The very first qualitative analysis conducted through semi-structured interviews of the teachers shows a positive impact of the Sunny Island ILE on System Thinking education.

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References

- Bruner, J. S. (1963). *The Process of Education*. Vintage Books, NY.
- Ceresia, F. (2016). Interactive learning environments (ILEs) as effective tools for teaching social sciences. *Procedia - Social and Behavioral Sciences* 217, 512 – 521.
- Ceresia, F., Aiello, V., Bottiglia, J., Ruffo, N., Ruggeri, S., (2014). Interactive Learning Environment as Innovative Teaching Method for Entrepreneurship Education. Proceeding of the International Conference on Social, Education and Management Engineering (SEME 2014), 154 - 159.
- Forrester, J. (1961). *Industrial Dynamics*. Waltham, MA. Pegasus Communications.
- Forrester, J. (1997). *System Dynamics and K-12 Teachers*. Lecture at the University of Virginia School of Education.
- Foster, A. (2008). Games and motivation to learn science: personal identity, applicability, relevance and meaningfulness. *Journal of Interactive Learning Research*, 19 (4), 597–614.
- Groff, J., & Mouza, C. (2008). A framework for addressing challenges to classroom technology use. *AACE Journal*, 16(1), 21–46.
- Koehler, M. J., & Mishra, P. (2008). *Introducing TPCK*. In *AACTE Committee on Innovation and Technology (Ed.)*, Handbook of technological pedagogical content knowledge (TPCK) for educators (pp. 3-29). New York: Routledge.
- Levin, T., & Wadmany, R. (2008). Teachers' views on factors affecting effective integration of information technology in the classroom:

- Developmental scenery. *Journal of Technology and Teacher Education*, 16, 233–263.
- Papastergiou, M. (2009). Digital game-based learning in high school computer science education: impact on educational effectiveness and student motivation. *Computers & Education*, 52, 1–12.
- Roberts, N. (1978). Teaching Dynamic Feedback Systems Thinking: An Elementary View. *Management Science*, (24) 8, 836-843
- Senge, P. (1990). *The Fifth Discipline: The Art and Practice of the Learning Organization*. Currency
- Spires, H. A., Rowe, J. P., Mott, B. W., & Lester, J. C. (2011). Problem solving and game-based learning: effects of middle grade students' hypothesis testing strategies on science learning outcomes. *Journal of Educational Computing Research*, 44, 453–472.
- Sterman, J. (2000). *Business Dynamics: Systems Thinking and Modeling for a Complex World*. The McGraw-Hill Companies, Inc.