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SimGreen: a serious game to learn how to improve environmental integration into companies

Feng ZHANG*, Peggy ZWOLINSKI

University of Grenoble Alpes, G-SCOP laboratory, 46, Avenue Félix Viallet, 38031, Grenoble, France
* Corresponding author. Tel.: +33 4 56 52 98 10; *E-mail address:* feng.zhang@g-scop.grenoble-inp.fr

Abstract

The aim of this paper is to present the implementation of a new serious game called “SimGreen” to optimize the systemic programming of environmental actions into a company. Today, there are numerous environmental methods and practices developed to allow companies improving the way they try to decrease their environmental impacts. But all the existing methods are not independent and it can be helpful to consider all of them to make decision when managing the way to answer environmental objectives for a company.
According to a cartography of environmental actions, which is a research result of a project named “convergence” funded by the French national research agency, we encourage the participants during the game to map all the possible environmental trajectories to answer an environmental objective. Then, we ask them to identify the most suitable environmental solutions depending on a specified context taking into account the different resources or competencies in the company.
This serious game has been experimented in 8 sessions. The main feedback demonstrated that this serious game provides a joyful game to support the learning about systemic environmental integration.

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Keywords: Serious game, systemic integration, eco-design, environmental management

1. Introduction

In order to improve the environmental performance of a product or a company, numerous methods and tools have been developed [1] [2] [3] [4] [5]. Nevertheless, the required competences and resources of each method are never uniform. Several operational conditions, such as the corporate strategic definitions, the availability of financial resources, the knowledge situation and the duration of methods application, directly affect the suitable method’s selection. Meanwhile, in practice, the company needs to deal with several strategic objectives and launch several related eco activities at the same time [6]. But each environmental method is not independent. Due to the operational data and the related knowledge could be shared and inherited; an implementable method affects the dynamic operational context when selecting another parallel method [7]. So it’s necessary to set up a systemic approach to summarize the existing environmental activities and their relationships (network of informational and decisional flows).

In order to answer this new problem, a French national research project, “ANR-Convergence”, was launched. As a part of this research project, a systemic cartography of environmental activities has been proposed. This cartography provides a systemic network of the informational/decisional flow between different environmental activities depending on the analysis about more than 300 existing environmental tools and industrial practices. This cartography collected 46 environmental topics, which include 20 topics for organization (i.e. the environmental management system, and the supplier management etc.) and 26 for product (i.e. the product’s life cycle analysis and the design for recycling, etc.). Depending on a depth analysis of the operational process of existing methods, a working process, with a chain of environmental actions is proposed for each environmental topic. The first version of this cartography includes 122 typical environmental actions. Meanwhile, there are more than 400 arrows to present the interactions and decisional

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flow among the different actions.

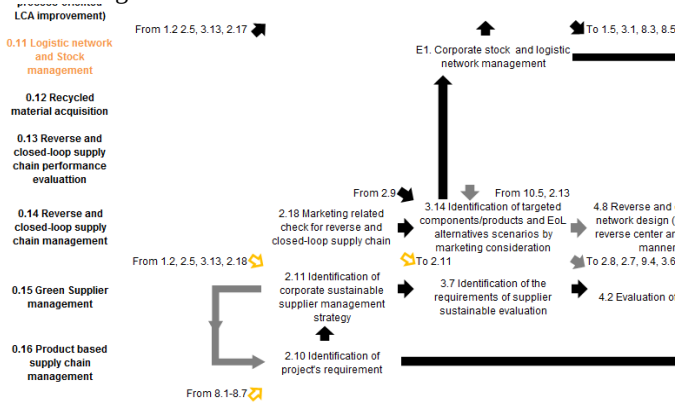

Fig. 1 The proposed systemic cartography of environmental actions (extract)

The first left column lists the environmental topics. The right part represents the operational actions chain for each topic (in the same line). The release of last action in the same line means the fulfilling of related environmental topic. The arrows indicate the informational flow and interactions among different actions. The previous action could drive the implementation of the next one. Depending on these interactions, there are several different trajectories could be explored for answering a last action (means an environmental topic) [Zhang & Zwolinski, in processing]

Several experimentations into the industry demonstrated that this cartography might optimize the program planning, especially establishing a systemic view of the environmental consideration. But, due to the large number of proposed environmental actions and complex interactions, the feedback indicated that it's not easy to explain the detailed relationships among different actions and to provide a global point of view about the relationship. Meanwhile, the feedback required also a simple and direct manner to indicate how this cartography treats the objectives within dynamic corporate context. So facing the growing number of existing methods and the collaboration between them, there is a new challenge to be treated: how to create a simple manner to optimize the comprehension of this systemic network.

So in this paper, depending on the scientific findings of "Convergence" project, we focus on the design and the implementation of a joyful serious game, named SimGreen, to encourage the participant to set up a systemic point of view about the environmental integration. A serious game is defined as "a learning tool that incorporates game technology for the purpose of achieving learning objectives rather than pure entertainment" [8], [9], [10].

2. Key points about serious game design

Learning and education via the play is the main objective of serious game. In order to provide a high level of education, Yusoff [8] summarized several perspectives for a serious game: the "Educational" and the "Psychology" perspective.

Yusoff [8] indicated that the serious game should support the knowledge transfer and the creation of a great relationship between the teacher and learner. Firstly, the contents of the serious game should be carefully designed according to the nature of serious topics [12]. Meanwhile, Paraskeva [11] presented that repeated reinforcement of the serious topics is necessary to encourage the learner to match the correct direction. Additional, Dieleman [13] summarized that the game rules need to allow the learner to obtain knowledge by his own actions; and to allow the learner to collaborate and negotiate in acquiring new knowledge when they learns with other colleagues.

According to the definition of Yusoff [8], this psychology perspective focuses on the attraction of the serious game. In fact, there are two inverse points to be treated: removing the negative emotions and encourage the positive values thus contribute the success of the game. Additionally, Yusoff [8] summarized several issues that should be highlighted.

Firstly, the learners, specially, the academic students, are not neither the master of the game, nor the serious contents [13]. So the win's knacks of the serious game could not be designed too difficult to be found. This bad design results in learner "losing heavily, becoming frustrated, remaining ignorant of what went wrong, unsure how to play or learn, finally this leads them giving up on the whole game". Secondly, the funny is important. But the funny is not a unique element of the serious game. The game design should ensure the learner could find out the serious topics and receive the related abilities or knowledge. Thirdly, the game design needs to demonstrate the received knowledge and skills are meaningful or usable. With the running of the game, a great design of game rules allows the learner to gain a win for part of challenges in next level or step by using these new abilities and knowledge. This sense of achievement could encourage the learner to continuously play this game. Fourthly, Yusoff [8] indicated that today, in the current world, because of the existing of so many different options, it's difficult to judge what is right or wrong, especially, when we teach the new concepts and principles. The scientific hypothesis and the limits of research sometime generate the disagreement. So the out comings of the game are not an arbitrary imposition of this predefined contents, it's necessary to provide some proofs to measure how well they are doing something right [13].

Finally, to resume, the design of serious game needs to consider these following points:

- The educational objective should be considered as a key element of the serious game. The game design need to clarify the purpose and the main objectives, such as the targeted contents and the new knowledge about some new conceptions [16], [8] and [13]
- The activities and the processing design need to make the learner feel more motivated and interested into the targeted contents [16].
- It's necessary to create the positive relationship between the playing success and the targeted contents or knowledge. Firstly, the targeted contents and knowledge should be easier found out. Sometimes, the game might be designed to generate some playing fails due to the lack of targeted contents or knowledge. But in next step, the learner might immediately resolve these fails by using the obtained new knowledge [15]
- During the play, the game doesn't judge if each decision is correct or wrong. Ideally, the game rules encourage the learner to find out the advantage and make a judgment by themselves.

- The final achievement need to be measureable to judge if the serious game achieves all predefined objectives.

3. Concepts of game rules

According to these above 5 key points, a serious game, which is named "SimGreen", has been developed. The "SimGreen", similar with the famous video game "SimCity" and "The Sims", means that this is a simulative game which provides a virtual context to plan a series of environmental activities.

The purposes of this serious game is to present a new conception to learner that "At the beginning of planning stage, a systemic view of the potential solutions and the summary of related required resources could optimize the decisional process about the integration of the environmental activities". According to the previous statements, some systemic considerations need to be represented into the game:

- Do the actual competences and implemented actions could contribute to the new needs? If yes, how to use them?
- How to decide the most suitable solution from all possibilities? And which indicator might be considered to make the decision?
- Is there an optimized solution that could be implemented to answer multiple environmental topics?

3.1. "SimGreen" Game Rules

The "SimGreen" is designed as a collaborative game by multiple players. All players are regrouped to represent several "companies". There is the competitive relationship between them to gain the final award - "Greenest Company". For animating the playing process, for each company, there is a "Game Master" who presents the rules, and pilots the rundown of this game.

In reality, the environmental success of a company could be evaluated by different manners. But in this game, the definition of the "Greenest Company" is simplified as *the company which integrates the maximum number of environmental topics (**Hypothesis 1**)*. So in order to obtain this award, each company needs to implement the maximum number of environmental topics within 10 rounds, each round = 1 year. These topics cover some hot-points of environmental related aspects which include the life cycle analysis, the carbon footprint and the environmental management, etc.

Table 1. Environmental topics need to be done (extract)

O1	Improvement of product-oriented life cycle performance
O2	Utilization of recycled materials in new product
O5	Responsibility of WEEE directive
O6	Green supply chain management
O8	Carbon footprint calculation
O10	Environmental management system

Each company is defined as it doesn't have any knowledge to resolve the required environmental topics. So the company needs to pay some "operational sources" to analyze and find out the solutions for treating them.

For each topic, a scenario card is prepared. This card (presented as below figure 3, 4 and 5) illustrates all potential solutions for fulfilling this topic. Each solution requires fulfilling a chain of actions that are registered into the environmental cartography. Once the company unlocks a topic (pay 3 resources to select a topic to be done), the game master provides a related scenario card to find out all possible solutions to answer it.

Meanwhile, some "operational sources" are required to realize all required actions. In real case, the implementation requires different resources, such as the knowledge, the time and the financial support, etc. But in order to simplify the game rules, these different types are unified as the "unit of operational sources" (***Hypothesis 2***). The multiple units required by an action represent the different complexity for implementation..

For representing the dynamicity of the resource, at the beginning of each round, the company needs to dice to identify how many resources are available in this year. These resources are used for buying the scenarios card and implementing the selected solution (actions in cartography). The company has also the right to unlock multiple environmental topics in a round, if it has enough resource.

Meanwhile, a completed environmental cartography is provided to each company to note the fulfilled actions and highlight them. Due to the different applicative domains and the human resources, in real case, it's not absolute free to re-use the actions that have been done. But in order to simplify the game, in this version, it presumes that the company doesn't need to pay any more resources to reuse these implemented actions (***Hypothesis 3***). This definition ensures that the company could profit the results from the existing achievements to simplify the new environmental implementation.

It's necessary to mention that all environmental solutions explored are considered as the equivalent solutions for answering objective topic (***Hypothesis 4***). The operational risks lied with thus solution (in real, this solution might not realizable) and the finale influence on marketing are not considered into the selection.

3.2. "EVENT" and "Chances" cards

Additionally, in order to present the influences from the external emergent requirements and the internal corporate changes, the "EVENT" and "Chances" card have been defined.

"EVENT" cards are to represent some new emergent requirements for all companies. These requirements ask all company to treat some new environmental topics which have not yet been planned into table 1, such as the enforcement of new directives.

Meanwhile, the "Chances" cards represent the internal corporate changes. These changes might include the new exigencies from main customers, the change of human resources (the entrance or retire of environmental expert, for example) or the financial crisis of company, etc. In this game, these influences are presented as the modification (increase or

reduce) of the quantity of “operational resources”.

3.3. Rundown of “SimGreen”

Finally, a rundown of this serious game is presented in table below. This rundown includes the roles of each actor and the playing process of 10 rounds.

Table 2: Rundown of “SimGreen” game

1. Players are regrouped as several companies
2. At the beginning of each year (round), the player throws both dices and gets the number of useable resources. Meanwhile, the players pick out one “EVENT” and one “Chances” card. These cards require some urgent new topics and modify the units of resources.
3. From the list, players select one or multiple environmental topics to be done and the game master provides them the related scenario map and card which summary the possible solution for this topic
4. Players analyze these solutions and identify a suitable one according to its context (urgent topics, number of resource, the found shortest way by combining the implemented actions of other topics have been done)
5. Players mark the selected solutions (the action chain) on the cartography. This highlight might simplify the reuse of them for following topics

Repeat step2 to step5 till all topics have been done

4. Implementation of game and discussion of feedback

In order to test the concept of this serious game and its applicability for optimizing the comprehension about the systemic environmental integration, 8 sessions of experiments have been organized.

Firstly, 3 sessions have been organized with environmental experts to validate the contents and the mechanism of this game design. On 14 January 2013, this game was presented during a seminar of G-SCOP laboratory. Twenty scientific researches about environmental management, eco-design and optimization of production process participated into this session. On 7 November, 2013, this game was experimented with three environmental experts from IFTH (French Textile and Apparel Institute). The objective of this session was to validate the pertinence of all proposed contents for industrial domain. On 4 April, 2014, this game was organized for a French National Scientific Conference: GDR 2014 at Paris. 18 scientific researchers participated into this session during 2 hours to validate the contents and game rules.

Next, in order to demonstrate if the game design might provide a joyful way to transfer the educational information to beginners, there are almost 40 students of master degree of Grenoble-INP (French national institute of poly-technology in Grenoble) have been organized for four sessions.

Lastly, on 11 April, 2014, this serious game was presented to 15 industrial companies and consulting cabinets. The principal purpose was to test if this game design could also answer the actual industrial needs. The feedback from the industries demonstrated that:

- The research of the convergence project demonstrated that the systemic view about the interactions among different environmental actions might optimize the decision of suitable program. The “SimGreen” provides a possible tool to exercise how this systemic view works. By this game, the industries found out how to use the environmental cartography and the scenario cards to explore, evaluate, rank and manage the potential solutions. The game rules encourage the player to find out the common way to treat the multi-topics. Meanwhile, the players learned how to consider the needs from the following topics to select the solution of actual topic.
- The simplification of the real situation allows the participants easily understand the rules, and then focus on the method to win: analyze and profit the relationship between actions to optimize the solution (reduce the action’s numbers)
- With the description of game master, the player indicated that they have a lesson about what details of each topic is. And the scenario cards bring a first impression about the potential solutions (action chain) for real environmental needs. With these supports, the players might learn them in just a few minutes.
- The environmental managers are interesting in this Game. They would like to integrate it into their corporate training package.

4.1. SimGreen ensures and encourages the players to find out different suitable solutions to answer multiple topics

Generally, from the feedback of eight sessions, the players pointed out that the “SimGreen” provides a simple tool to explain the interactions between different potential solutions. Due to these interactions, the player might set up a systemic view to treat the multiple topics under different operational context (the dynamic topic combination or the dynamic units of available resource, etc.). In order to evaluate this impact, during these eight sessions, the authors recorded every decision made by each person for each topic. And we found out even for a same topic, the different contexts always lead to the different choices. Meanwhile, the author recorded also the time required for each decision. The results indicated that the combination of different scenarios cards can support the player to find out an efficient solution to answer multi-topics in a very short time (15 minutes maximum for a decision). An example was observed directly during the first session and is descried as follow:. In the fourth round, the company “A” needed to finish the topic: “environmental management system” [14]. According to the scenarios cards, several potential branches could be selected (details presented as below Figure 3).

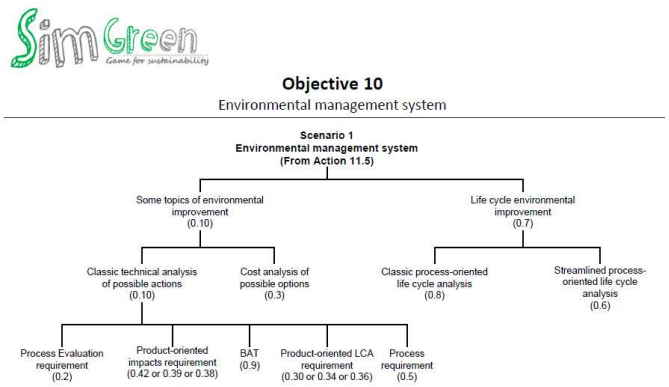

Fig 3. “Scenarios card” for topic: environmental management system

Meanwhile, the “EVENT” card required to provide an “environmental review of actual production process”, and its “Changes” card indicated that “the marketing requires an environmental declaration” for the customers.

According to three scenarios maps, the player found out that “the classic environmental management system” could directly answer three topics within the minimum resources. Firstly, this solution provides a review of actual production process which can answer both the needs from “EVENT”; secondly, the results of these activities can be integrated into the product’s environmental declaration, because any contribution at this phase affects the final results of product’s life cycle analysis.

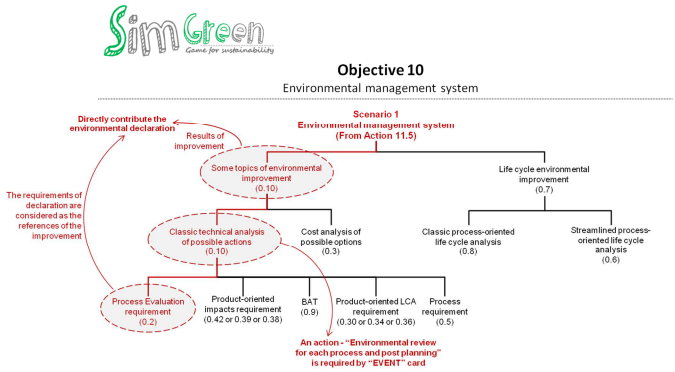

Fig. 4. Choice of company A to answer three topics at the same time

On the other side, the author observed that in previous phase, another company “B” has implemented environmental management via the approach of “Life cycle analysis” by secondary data. So the actual achievement couldn’t support the EVENT card. Finally, this company B realizes a different solution: “Process-oriented LCA” plus “production process review” which needs 2 supplementary operational resources. The real environmental data of the production could certainly help to validate and update the definition of LCA.

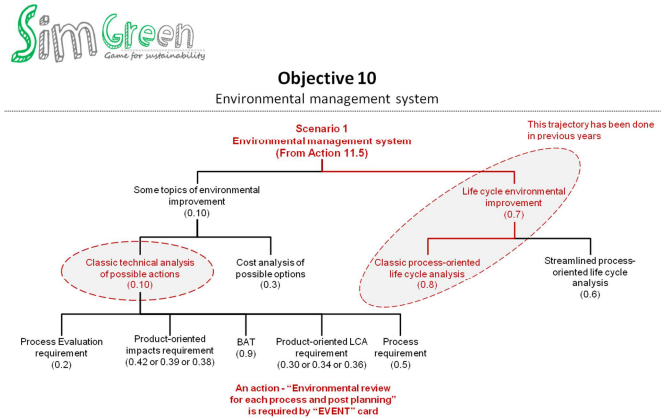

Fig. 5. The selection of company B to answer the needs from “EVENT” card

It’s interested to notice that although in this round, the company B could not profit the actions that have been done; these implemented actions are also usable for some last round. With the support of existing process-oriented LCA, the company B selected “to make some process-improvement” for contributing to the product-oriented LCA improvement. But on the other side, without this experience, the company A selected the classic solution for product’s LCA improvement.

The following summary indicates that the dynamic selections generate the different implementing results.

Table 3: The summary about the playing results of a session of “SimGreen”

Company A:	It realizes a classic environmental management system (such as ISO 14001) to manage the production process. For this company, the environmental declaration focuses on the improvement into production phase. Meanwhile, it realizes the classic LCA for product.
Company B:	It realizes the process-oriented LCA to manage the production process. An environmental review of each sub-process provides the primary data Meanwhile, it profits the implemented works for process-oriented to realize the product-oriented LCA (the improvement of product depending on the requirements of process improvement), and finally, the environmental declaration

This example demonstrated that the cartography provides several solutions to realize the environmental topics. The company can find out a particular solution according to its context (In this game, the context is presented as the number of available resources and the actions that have been done). Meanwhile, each new selection might also dynamically influence the next implementation. So finally, these different selections for each environmental topic lead to the dynamic results of implementation.

4.2. SimGreen improves a global review about the potential contributions from existing environmental practices to integrate new programs

In order to notice the actions realised, some color pens are provided to highlight them on the cartography. This highlight might simplify the reuse of these implemented actions for all following required topics. The game rule, the limited resource, encourage the players to reuse them for reducing the operational cost. Imaging the previous example in section 5.1, if “company A” has implemented the “classic environmental management by considering technical improvement”, when

the new “EVENT” requires an “actual process review”, the achieved environmental data could be directly profited. The second example was observed also during the internal seminar of G-SCOP laboratory. The above noticed “company B” realized the “management system” via “process-oriented life cycle analysis”. So when it faced the problem for “environmental efficiency (LCA+LCC)” of product, the pre-implemented process-oriented LCA can be directly used to prepare the reference of cost consideration. So it was different with the standard solution: answer the “environmental efficiency” of product via the “improvement of manufacturing process”, not via the classic product’s LCA.

This expertise and the examples demonstrated that the coupling of the solutions assures also profiting the existing environmental practices to integrate new programs.

4.3. SimGreen ensures the positive relationship between game success and the targeted educational contents

As the scientific findings of “convergence” project, the author presumes that the systemic view of all potential solutions could optimize the environmental integration within the dynamic operational conditions. This hypothesis is considered as the principal purpose of this serious game. The previous discussion demonstrated that the game rule and the cartography ensure the possibilities of selecting the suitable solution by considering the limit of operational resources. And then, step by step, this serious game tries to set up the positive relationship between the playing success and this main purpose.

Starting from the second round, the players need to consider the existing implemented action to reduce the cost of new integration. Once they find out this relationship, they can directly gain the advantage (reuse is free), and the game rule enforces nine times to strengthen this rule. The noticed player’s decision of each environmental topic demonstrated also this achievement. The examples in section 5.1 and 5.2 describe this achievement. Meanwhile, starting from the third round, the integration of “EVENT” and “chance” cards brings the mandatory consideration about the treatment of multiple topics. Based on the modified resources, the players have the opportunities to find out that common solution is better than two independent solutions. Meanwhile, they need to consider also the modification of suitable solution according to any change.

5. Conclusion

A serious game, named SimGreen, was developed to optimize the training about the systemic environmental integration. The principle purpose of this game is to push the player to identify a suitable solution by considering multiple dynamic topics and the limit of operational resources. So ten normal environmental topics have been selected and the game requires the players to realize them in 10 rounds with some constraints of resources. In order to simplify the game, the different types of operational resources have been regrouped in a unique type and the different company strategic needs are ignored in this game. Meanwhile, the “EVENT” and “Chances” cards system provide the mandatory opportunities to treat multiple topics at the same time and modify the quantity of available resources. In order to validate the pertinence of the proposed contents, 8 sessions of the game have been realized with environmental experts, industrial companies and several master degree students. With the numerous discussions about the action chains of each environmental topic, the environmental experts proved that the game design could correctly support the participants to take a more systemic view about the potential solutions. When participant faces multiple environmental topics at the same time, this serious game ensures the exploration of a suitable common solution with minimum consumption of operational resources. Meanwhile, the implemented actions and concerned knowledge are directly displayed on the cartography which ensures profiting them to further reduce the cost. Meanwhile, as a serious game, the competitive game rules and the real feedback demonstrated that the game design encourages the players to autonomously find out the educational targets into a joyful way and the game rules continuously repeat and strengthen the benefits of these new purposes.

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