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The WEBSIM FISHBANKS Simulation Laboratory: Analysis of its Ripple Effects

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In this article, we discuss the ripple effects of the WEBSIM FISHBANKS Simulation Laboratory held at Federal University of Sao Paulo (UNIFESP) in 2014, held as a result of a partnership between the Sloan School of Management of the Massachusetts Institute of Technology, the UNIFESP, and the Brazilian Chapter of the System Dynamics Society of Brazil (BCSDS). The simulation lab involved 100 people from 36 organizations. The aim of our research is to reveal the impacts of the laboratory two and a half years after it took place. We followed a mixed method approach, collecting data from questionnaires and documents. The main findings are as follows: 1) the laboratory helped spread the use of FISHBANKS software in Brazilian universities and consultancy firms; 2) the laboratory promoted systems thinking and environmental awareness, leading some of the participants to replace non-sustainable actions for more sustainable ones; 3) the laboratory fostered interest in the MIT LearningEdge initiative; and 4) the laboratory contributed to a rise in the motivation of the members of the BCSDS, which in turn led to the creation of symposia and other activities.

Keywords: systems thinking, environmental awareness, simulation laboratory, ripple effects, educational game

INTRODUCTION

In this article, we discuss the ripple effects of WEBSIM FISHBANKS Simulation Laboratory, a laboratory that used FISHBANKS, a free multiplayer, web-based simulation game provided by the Sloan School of Management of the Massachusetts Institute of Technology (thereafter Sloan MIT). The laboratory was a result of a joint effort of Sloan MIT, the Brazilian Chapter of the System Dynamics Society (thereafter BCSDS) and the Federal University of São Paulo, Campus Osasco (thereafter UNIFESP Osasco).

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The three organizations had complementary goals: Sloan MIT desired to publicize this free program to a diverse audience (faculty, students, K-12 teachers, officials from state education and others) and to foster reflection about sustainability while teaching concepts of system dynamics/systems thinking. UNIFESP Osasco wanted to host the laboratory in order to create educational opportunities for its professors and students and to establish meaningful academic ties with Sloan MIT, BCSDS, and the other participant institutions. The BCSDS wanted to promote and contribute to the development of system dynamics theory and its applications in Brazil.

The laboratory took place on September 12, 2014, from 1 pm to 4 pm, in UNIFESP's auditorium. It involved 100 participants (professors, graduate students, undergraduate students, consultants, officials from federal agencies), from 36 institutions (13 public universities, 9 private universities, 5 consulting firms, 2 k-12 private schools, 1 state government agency, 1 federal government agency, 2 foundations and 3 corporations (Table 1).

Table 1
The institutions involved in the laboratory (Source: Authors)

Federal University of São Paulo, Campus Osasco (UNIFESP Osasco)	Public University
Polytechnic School of Engineering of University of São Paulo (POLI-USP)	Public University
Faculty of Economy, Administration and Accounting of University of São Paulo (FEA USP)	Public University
Institute of Oceanography of University of São Paulo (IO USP)	Public University
Air Force Technology Institute (ITA)	Public University
Federal University of Paraná (UFPR)	Public University
Federal University of Viçosa (UFV)	Public University
Federal University of Santa Catarina (UFSC)	Public University
University of Brasilia (UnB)	Public University
State University of Campinas (UNICAMP)	Public University
State University of Maringá (UEM)	Public University
State University of Santa Catarina (UDESC)	Public University
State University of São Paulo, Botucatu Campus (UNESP Botucatu)	Public University
University Centre Faculty of Industrial Engineering (UNIFEI)	Private University
Catholic University of Campinas (PUC Campinas)	Private University
University Oswaldo Cruz (UOC)	Private University
University Centre Foundation for Osasco Education (UNIFIEO)	Private University
Getúlio Vargas Foundation (FGV)	Private University
Mauá Institute of Technology (IMT)	Private University
Paulista University (UNIP)	Private University
Foundation Armando Alvares Penteado (FAAP)	Private University
Institute of Education and Research (INSPER)	Private University
Bandeirantes School (ColBand)	Private K-12 school
Visconde do Porto Seguro School (CVPS)	Private K-12 school
Foundation for technology development of engineering (FDTE)	Foundation
Foundation Carlos Alberto Vanzolini (FCAV)	Foundation
Nokia institute of technology (IDNT)	Corporation
Siemens Brasil (Siemens)	Corporation
Brazilian Bank of Discount (Bradesco)	Corporation
Thoth Advanced Simulators (TAS)	Consulting firm
Simulate Technology of Simulation (Simulate)	Consulting firm

Flungler & Company (FlC)	Consulting firm
WeSee-Vision System Dynamics (WeSee)	Consulting firm
McKinsey & Company Brasil (McKinsey)	Consulting firm
Ministry of Environment (MMA)	Federal government
Secretary of Education of São Paulo (SESP)	State government

CONTEXT

The laboratory was conducted by the Director of Sustainability Initiative at Sloan MIT, Professor Jason Jay. Initially he talked about the FISHBANKS' simulation tool and how it fit into an array of different tools available from MIT Sloan's LearningEdge, a resource for universities to use in their curricula and for companies to use in their business. After that, he introduced the game and explained the mechanics of how it worked.

The participants were grouped into 20 teams, each team with five participants. Each team had a desktop with Internet access. All computers were connected to the FISHBANKS software stored on the Sloan MIT server. Professor Jason Jay explained that each team would play a role of a fishing company: the goal was to make a profit without decimating the fish population. He explained that the winner of the game would be the team that finished the game with the highest profits.

He also explained that each step of the game, lasting several minutes, would represent one year of fishing activities. Participants were informed that in each step the teams would have to make decisions such as whether to buy or sell boats and where to place them (in the harbour, in coastal zone or in deep water). Every decision had associated financial costs and consequences for the environment. The professor stressed that the teams should develop their own strategies in order to win the game. He also suggested that teams collaborate with each other, if they wished to.

After answering the participants' questions and helping participants interact with the software, he began the game. Professor Jay established a rhythm, allowing approximately three minutes per step. As the game progressed, he mimicked real world fishery events, introducing media and NGO alarms about the decimation of fish stocks. In secrecy, he chose three participants to act as his "spies." These participants were asked to collect phrases uttered by team members while playing the games that indicated how they were approaching the process. He asked his spies to take notes on the language the teams were using to find solutions to the problem. He wanted to record these phrases in order to expose the mental models of the participants, in the debriefing section later in the game, by means of qualitative analysis. After a determined number of steps, Professor Jason Jay paused the game and held a debriefing session with the whole group. He announced each team's profits and losses, presenting graphs of quantitative data obtained from the FISHBANKS software. He also presented qualitative data obtained by his "spies." Professor Jay identified the team who had won the game and the team who had obtained the worst results, inviting both teams to explain their strategies and the reasoning behind their actions. He then invited all other teams to reveal their strategies, bringing out the teams' mental models and promoting deep reflection among all participants. He then instructed the group on the basic concepts of system dynamics and sustainability related to the game. He explained the concepts of events, pattern of behaviour and systems' structures. Professor Jay explained the systemic structure of the game and the main feedback loops involved in fishing activities. He explained how the structure of the game reflected the structure of the real world with respect to fisheries. He discussed in detail the concept of the exploitation of common pool resources. The professor brought the participants into the discussion, asking them to give other examples of the exploitation of common pool resources. He made connections, discussing the similarities between the exploitation of fish and the exploitation of several other renewable resources. He pointed out that such exploitation could lead to the collapse of the resources, and provided examples of what people around the world are doing to solve some of these problems. He also mentioned scientific articles that address the issue. Professor Jay finished the laboratory by reflecting deeply on sustainability and cooperative governance of the commons.

Two and a half years after this laboratory, we were curious to learn of its ripple effects. Did some of the participants incorporate the game into their own teaching, in high school, college, graduate school or at the executive level? Did the laboratory promote a change in the participants' attitudes towards sustainability? Did the participants visit the Sloan MIT website in search of more information or to use other free games?

We decided to undertake research in order to assess the impacts of this laboratory. Our research question thus became:

"What were the systemic impacts of WEBSIM FISHBANKS laboratory?"

In order to collect quantitative and qualitative data, we sent questionnaires to all participants. We made a systemic analysis of the data following a convergent mixed method approach. In this paper, we present our findings related to the research question.

REVIEW OF LITERATURE

Throughout our lives, we interact with systems: economics systems, environmental systems, traffic systems, educational systems and so on. We affect them and are affected by them. Real-world systems can be very difficult to fully comprehend. We use our experience, our knowledge, and our beliefs (Jones, Ross, Lynam, Perez, & Leitch, 2016; Senge, 1990) in order to try to understand the complex and dynamic world in which we live. In other words, we trust our mental models to shape our comprehension of the systems (Cook & Wind, 2006). However, our mental models may fail to anticipate the results of our actions when we interact with complex systems; the behaviour of complex systems can be highly counterintuitive (Desthieux, Joerin & Lebreton, 2010; Sterman, 2002). We may fail to understand the interrelationships among the multiple components of the systems, we may overlook the multiple feedback, we may ignore the nonlinearities, or we may be unaware of the time delays involved (Frenseh & Funke, 2014; Sterman, 2000). However, in order to deal effectively with these systems, we need to understand their inner structures (Bossel, 2007a; Ghosh 2016).

Games can be useful tools for replicating the structures of the systems we are interested in understanding (Sweeney & Meadows, 2010). Games may be played with the support of computers, which can run models that replicate structures of real world systems. These kinds of games are called computer-based games. Computer-based games are valuable when they assist us in comprehending the complex dynamics of the systems they mimic (Ford, 1999; Yang, Jiang & Gary 2016). Computer-based games provide a controlled environment where the participants can learn by reflecting upon the consequences of the decisions made while playing (Forrester, 1961; Meadows, 2007; Pavlov, Saeed & Robinson 2015). Moreover, Sterman (2014a) points out that games based on computational simulation may allow the players to simulate years of life in several minutes of a game. In addition, computer-based games may facilitate the sharing of experiences among participants, and the game's dynamics may help to bring to surface their mental models (Dieleman & Huisingh, 2006). More than that, computer-based games can also make it possible to identify the flaws in the mental models of the players (Gary & Wood, 2016; Meadows, Richardson, & Bruckman, 1982). Therefore computer-based games may contribute to the improvement in the understanding of the complex aspects of real world systems (Elsawah, McLucas, & Mazanov, 2017).

In a typical computer-based game, the participants work in teams, competing to achieve a desirable goal. The most of the learning comes when the participants reflect together, in debriefing activities, about the structures of the systems they are interacting with (Bakken, Gould, & Kim, 1992; Crookall, 2014).

Researchers point out that computer-based games have been used successfully for teaching sustainable development (Katsaliaki & Mustafee, 2015). FISHBANKS is a well-known web-based multiplayer game, developed by the MIT Sloan School of Management; it has been used to teach the dynamics of the management of common pool resources (Sterman, 2014a). Researchers (Ryan, 2000) also mention that FISHBANKS allows the participants to reflect on the conflict of interests between fishing companies and conservational agencies.

Although several articles describe the mechanics of FISHBANKS and the results achieved by its utilization (Garcia, Dray, & Waeber, 2016; Ruiz-Pérez, Franco-Múgica, González, Gómez-Baggethun, & Alberruche-Rico, 2011), there is still a lack of information about the long-term ripple effects of its use in laboratories that bring together participants from different institutions and backgrounds. In this article, we aim to address this gap.

METHOD

In our research, we followed a convergent parallel mixed method approach as proposed by Creswell (2013). Following this approach, we first collected quantitative and qualitative data from electronic questionnaires and from documents such as emails and the minutes of meetings. After that, we analyzed the data separately. Finally, we compared the findings obtained by the analysis of both kinds of data in order to figure out if the findings were related or not, if they endorsed each other or not or if they were complementary or not.

We decided to follow this research approach because it would provide a rich way of understanding the consequences of the laboratory: the quantitative data would provide us numerical information about who had utilized the game. For example, it would allow us to know how many participants had made use of the game, and in which context. It would also allow us to know how in each degree the game influenced the participants to change in their actions towards more sustainable actions. The qualitative data would enhance our understanding of the quantitative data by providing us with the recurrent themes that would emerge from the discourse of the participants. It would allow us to have a better understanding of the reasons that led the participants to behave in the way they did.

Sampling technique

We selected the subjects using convenience sampling (Marshall, 1996). We sent questionnaires to all 100 participants in the WEBSIM FISHBANKS laboratory. We decided to use convenience sampling because, in our research, it was the only possible option for us; we had only the participants' email addresses, and participants came from a variety of cities, making other means of contact difficult.

Data collection tools

We created questionnaires using Google Forms©. The questionnaires had eleven questions. The first three questions were designed to identify the profile of the respondent (Table 2). The next four questions were closed-ended (Table 3); we asked the participants to agree or disagree with statements related to the laboratory and its effects. We used the Likert scale to measure their answers. We designed these questions because we wanted how if the participants understood the concepts taught and if these concepts had contributed to changing participants' way of thinking about and attitudes towards sustainability. In the next three questions, we asked the participants to agree or disagree with statements related to their interest in MIT LearningEdge (Table 4). We used yes/no questions to ascertain whether the participants had visited the MIT LearningEdge environment and made use of its resources. We also wanted to know if the participants were willing to participate in future laboratories. The final question was a broad, open-ended question (Table 5). We designed this question in order to give the participants the opportunity to give us additional information about their reactions to the laboratory and its effects.

Table 2
The questions regarding participants' personal information (Source: Authors)

Questions	Type of answer
Q1.- Please write your email address	The respondent should write a short sentence
Q2.- Please tell us where you work or study	The respondent should write a short sentence
Q3.- What is your main occupation?	The respondent chooses one answer of the following: □Undergraduate student □ Graduate student □ Professor/ Researcher □ Consultant/ Entrepreneur □ Government employee □ Corporation employee □ Other

Table 3
Questions about the laboratory and its effects (Source: Authors)

Questions	Way to measure the answers (Likert Scale)
Q.4-The laboratory contributed to broadening my vision about sustainability.	□Strongly agree □Agree □Neutral □Disagree □Strongly disagree
Q.5- The laboratory contributed to a change of some of my habits that were harmful to the environment.	□Strongly agree □Agree □Neutral □Disagree □Strongly disagree
Q.6- The laboratory fulfilled my expectations.	□Strongly agree □Agree □Neutral □Disagree □Strongly disagree
Q.7- I could clearly understand the concepts covered by the professor during the laboratory.	□Strongly agree □Agree □Neutral □Disagree □Strongly disagree

Table 4
Questions about interest in MIT LearningEdge and in participating in future activities (Source: Authors)

Questions	Way to measure the answers Yes/No)	
Q.8- After the laboratory, I visited the MIT LearningEdge website in order to find information and free software.	□Yes	□No
Q.9- After the laboratory, I used the FISHBANKS software in academic or professional activities.	□Yes	□No
Q.10- Are you interested in participating in future simulation laboratories that make use of MIT LearningEdge computational tools?	□Yes	□No

Table 5
Open-ended question (Source: Authors).

Question	Type of answers
Q.11-. Is there anything else you wanted to say about the laboratory?	The respondent should write a short paragraph.

Reliability and validity of the study

Questionnaires were sent by email to all participants two and half years after the laboratory. From the 100 participants, we received responses from thirty-seven participants. Thirty-seven is a sample size that represents the entire population with a confidence level of 90% and sampling error of 11%. Therefore, we may say that the sample size satisfactorily represents the population studied.

In relation to the validity of the qualitative data, it is reasonable to suppose that the data was collected from credible sources, since the questionnaires captured the answers from only those who had participated in the game.

Data analysis techniques

The quantitative data was analyzed by means of descriptive statistics. The qualitative data was analyzed following the five-phase analytic process proposed by Yin (2015): Phase 1-Compile the data, Phase 2- Disassemble de data, Phase 3-Reassemble the data, Phase-4 Interpret the data and Phase-5 Conclude.

First the data was compiled, and we collected the participants' answers to the open-ended question. After that, the data was disassembled: the fragments of the sentences were grouped into themes (groups of sentences with similar meaning). In sequence, the groups of themes were rearranged and recombined into lists. After that, the lists were interpreted and the recurrent themes (referred also as RT) were identified.

We compared the results of quantitative and qualitative analyses in order to see if the discoveries corroborated or refuted each other (Creswell, 2013). We use a causal loop diagram, a tool from system dynamics, to explain the connections within our findings.

FINDINGS

In this section, we present the participants' answers to the structured questions, the recurrent themes that emerged from the open-ended question, and the issues we collected from other documents, mostly emails.

Quantitative data gathered from questionnaires

Thirty-seven participants answered the electronic questionnaire. The respondents were from 7 public universities, 4 private universities, 5 consulting firms, 2 corporations, 1 government agency, 1 K-12 private school, and 1 Foundation (Table 6).

Table 6
Respondents' institutions (Source: Authors).

Institution´s Categories	Institutions names
Corporations	Siemens, Bradesco
Consultancy firms	Flunger, WeSee, Thoth, McKinsey, Simulate
Public Universities	UNIFESP Osasco, IO-USP, FEA-USP, UDESC, POLI-USP, ITA
Private Universities	FEI, UOC, FGV, PUC-Campinas
K-12 Private Schools	CVPS
Foundation	FCAV
Government	MMA

The respondents' main occupations are listed in Table 7.

Table 7
The respondents' occupations (Source: Authors)

Respondents' main Occupation	Percentage
Professor/ Researcher	35,1%
Consultant/ Entrepreneur	18,9%
Government employee (civilian or military)	10,8%
Corporation employee	10,8%
Graduate student	10,8%
Undergraduate student	8,1%
Other occupation	5,4%

The respondents' answers to questions 4 to 7 are shown in Table 8.

Table 8
Answers to questions 4 to 7 (Source: Authors)

Questions	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Q.4-The laboratory contributed to broadening my vision about sustainability.	56,8%	40,5%	2,7%	0	0
Q.5- The laboratory contributed to the change of some of my habits, which were harmful to the environment.	10,8%	35,1%	45,9%	8,1%	0
Q.6- The laboratory fulfilled my expectations.	70,3%	29,7%	0	0	0
Q.7- I could clearly understand the concepts covered by the professor during the laboratory.	70,3%	24,3%	2,7%	0	0

The respondents' answers to questions 8 to 10 are shown in Table 9.

Table 9
Answers to question 8 to 10 (Source: Authors)

Question	Yes	No
Q.8- After the laboratory, I visited MIT LearningEdge website in order to find information and free software.	64,9%	35,1%
Q.9- After the laboratory, I used the FISHBANKS software in academic or corporation activities.	27%	73%
Q.10- Are you interested in participating in future simulation laboratories that make use of MIT LearningEdge computational tools?	97,3%	2,7%

Qualitative data gathered from questionnaires

Four recurrent themes (Table 10) emerged from the analysis of the answers to open-ended question, the question number eleven (Q.11- "Is there anything else you want to say about the laboratory?").

Table 10
The recurrent themes (Source: Authors)

Number	Recurrent theme
RT1	The FISHBANKS software has been used in other universities by the participants of laboratory.
RT2	The laboratory fostered the development of systems thinking.
RT3	The laboratory was meaningful experience for the participants.
RT4	The laboratory raised the level of participants' interest in systems thinking and system dynamics.

RT1: The FISHBANKS software has been used in other universities by the lab's participants

Five respondents let us know that they had used FISHBANKS in their teaching activities. They reported that they used the software in five universities (FEI, Mauá, UNIFIEO, USP and UNIFESP). One respondent answered:

"I applied FISHBANKS in undergraduate and graduate courses of the Mauá Institute of Technology and in an UNIFIEO."

RT2: The laboratory fostered the development of system thinking.

Ten respondents let us know the importance of the laboratory in enhancing their understanding of systems thinking concepts. One respondent explained:

"The laboratory presented, in a clear way, the main concepts of systems thinking. We studied a good example of one system archetype, and I always use it when I want to make people aware of systemic problems."

Another respondent pointed:

"I liked the laboratory. The laboratory facilitated the understanding of concepts and its application by means of a practical example."

RT3: The laboratory was meaningful experience to the participants

Twenty respondents stressed the importance of the laboratory. Some pointed that the laboratory was well organized, relevant, interesting, useful and informative. One respondent explained:

"The laboratory was very dynamic and instructive and more initiatives like this would be very welcome."

Another respondent stressed the importance of the diversity of the people involved:

"The laboratory was one event where we had the opportunity to participate in an extracurricular activity, in an international model, inside the university. This allowed us to expand our social network because of the several different groups involved. It was a unique experience."

RT4: The laboratory raised the level of interest in systems thinking and system dynamics

Twenty-one respondents let us know that they would like to continue their study, participating in other laboratories, discussing the application of systems thinking in other contexts. One respondent explained:

"I would like to experience more computer models, related to other fields such as business games."

Another respondent let us know his interest in learning more about the simulator itself:

"It would be very interesting to have another laboratory, this time discussing the mathematics of the simulation."

Data gathered from documents (emails and websites)

The analysis of the email exchanges between members of the System Dynamics Society Chapter of Brazil revealed that the laboratory fostered the organization of at least one symposium (The Third Brazilian Symposium of System Dynamics). On the day following the laboratory, there was a meeting of the members of Chapter, and it was decided to take action to develop the symposium. The symposium was developed the following year, on November 16, 2015, in São Paulo. Some of the organizers of WEBSIM FISHBANKS laboratory participated.

DISCUSSION

The analysis of the data collected suggested that the WEBSIM FISHBANKS laboratory trigged at least five dynamics (Figure 1, feedback loops named "Promoting systems thinking," "Usage of FISHBANKS," "Interest in MIT´s LearningEdge tools," "Promoting change in habits," and "Spreading the word"). In this section, we will discuss each dynamic and the interconnection between them.

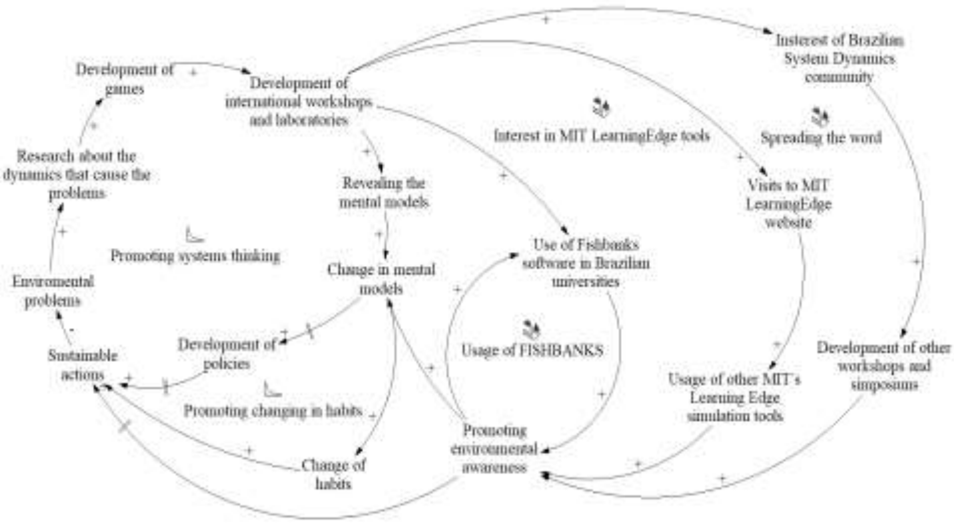

Figure 1
The dynamics that unfold due to the laboratory (Source: Authors).

Dynamic 1: 'Usage of FISHBANKS'

Data gathered (Table 9, line 2) revealed that 27% of the respondents had used FISHBANKS software in their academic activities or in professional activities. The qualitative data gathered RT1('The FISHBANKS software has been used in other universities by the participants of laboratory') reveals that respondents acknowledged that they had used FISHBANKS software in five different universities.

This quantitative and qualitative data thus leads us to conclude that Brazilian scholars have indeed been using FISHBANKS, promoting environmental awareness in their audiences. We suppose that their action may lead to an increase in the usage of FISHBANKS in other Brazilian Universities (Figure 1, loop 'Usage of FISHBANKS'). This led us to our first finding saying that "the laboratory helped spread the use of FISHBANKS software in Brazilian Universities."

This finding is not so surprising: it was somehow expected that the laboratory would increase the use of FISHBANKS. Indeed, other researchers have already pointed that the use of interactive web-based simulators is increasing nowadays in academia and in industry (Faria, 1998; Faria & Wellington, 2004; Sterman, 2014a, 2014b).

Dynamic 2: 'Promoting changes in habit"

Data gathered from quantitative analysis points that 97,3% of the respondents acknowledge that the laboratory contributed to broadening of their vision about sustainability (Table 8, line 1). In addition, 41,9% of the respondent (Table 8, line 2) recognized that the laboratory contributed to changing of habits they had that were harmful to the environment. Consequently, we may conjecture that the laboratory has promoted changes in mental models in some of the participants, which may have led to changes in habit and the development of sustainable actions (Figure 1, loop "Promoting changes in habit").

This finding is aligned with the findings of Pfligersdorffer (2002) who pointed that the use of FISHBANKS may improve the participants' understanding of the complex dynamics present in the exploitation of common pool resources. More than that, our finding is also aligned with the findings of researchers that point that computer-based games may enhance problem-solving skills of the participants (Meadows and Fiddaman, 2001), therefore contributing to changes in their mental models (Sterman, 2006) and behaviors (Gentile et al., 2009; Greitemeyer, & Osswald 2010; Saleem, Anderson, & Gentile, 2012).

Dynamic 3. 'Promoting systems thinking'

Quantitative data (Table 8, line 4) shows that 94,6% of the respondents acknowledged that they understood clearly the concepts presented in the laboratory. In addition, the RT2 ('The laboratory fostered the development of systems thinking'), from qualitative data analysis, reinforces the notion that the laboratory enhanced the systems thinking skills of the participants. Therefore, we may speculate that the workshop has contributed to the development of systems thinking abilities' of the participants (Figure 1, loop "Promoting systems thinking"). This supposition is aligned with the findings of researchers that point that computer games help the participants to develop system thinking skills (Homer, 1996; Sterman, 1994) since the participants may be able to reflect about the systems' structures and its patterns of behavior (Graham, Morecroft, Senge, & Sterman, 1992; Meadows, 2008).

The dynamics 2 and 3 led us to our second finding, "The laboratory promoted systems thinking and environmental awareness, leading some of the participants to replace non-sustainable actions for more sustainable ones."

This finding is aligned with the findings of other researchers that pointed that computer-based games may help the users to improve their understanding of systemic problems (Betz, 1995), to comprehend the interrelationships present in environmental systems (Costanza, Duplisea, & Kautsky, 1998; Deaton, & Winebrake, 2012; Ford, 1999) and to the change attitudes and practices toward sustainability (Bossel, 1998, 2007b; Dieleman & Huisinh, 2006).

Dynamic 4: 'Interest in MIT LearningEdge tools'

Approximately 65% (Table 9, line 1) of the respondents stated that they had visited the MIT LearningEdge website after the laboratory. In addition, 97,3% (Table 8, line 3) of the respondents affirmed that they were interested in using other MIT LearningEdge computational tools. More than that, the qualitative data (RT3-"The laboratory was meaningful experience to the participants" and RT4- "The laboratory raised the level of interest in systems thinking and system dynamics") point to the fact that the laboratory was a meaningful experience and raised interest in systems thinking and systems dynamics. Therefore, we may speculate the laboratory created a dynamic that led to an increase in the interest of the work developed by MIT LearningEdge (Figure 1, loop 'Interest in MIT LearningEdge tools'). This led us to our third finding: "The laboratory fostered interest in the MIT LearningEdge initiative".

Dynamic 5: 'Spreading the word'

Finally, we can say based on the analysis of the emails and data gathered from the Symposium's website that the laboratory motivated the development of other activities related to systems thinking and systems dynamics, such as workshops and symposiums (Figure 1, loop "Spreading the word"). This led us to our fourth finding: "The laboratory contributed to a rise in the motivation of the members of the Brazilian Chapter of the System Dynamic Society, which led to the creation of symposiums and other activities".

The combination of the five dynamics

In conclusion, we may consider that all five dynamics described contributed to the promotion and use of FISHBANKS software, to the development of systems thinking and environmental awareness, and to changes in the mental models of the participants. We guess that the ripple effects of this laboratory, which involved so many institutions, may have also contributed to the development of sustainable actions.

CONCLUSION

One may argue that it is not surprising that participants would report they had learned something from the game, or that they wanted to use it in their own teaching or consulting activities. What surprised us was that the laboratory triggered other dynamics. It was interesting to learn that this laboratory increased the motivation of the members of the Brazilian Chapter of the System Dynamic Society to create more symposia and other activities. This positive feedback loop is very interesting; one single event triggered the development of other educational activities, involving many other scholars and students. It is indeed a very important domino effect, promoting environmental awareness in Brazil and thus fulfilling the goal of Sloan MIT.

As Professor Jay has presented FISHBANKS in similar contexts in other countries around the world, we speculate that similar dynamics may have occurred in some of these countries.

It is important to notice that the participants stated that the laboratory contributed to the change of their mental models, promoting environmental awareness and leading to the replacement of non-sustainable actions for more sustainable ones. This ripple effect is also very interesting; showing that one single encounter with a simulation game can foster long-term changes.

We think this study may shed light on the importance of researching the medium-term and/or the long-term impact of the use of simulation games. We understand that a longitudinal study like this may be not very common in social research, but it should be. We consider that it is very important to understand the systemic impacts of the use of games and simulations.

Finally, we think the WEBSIM FISHBANKS laboratory fulfilled the goals of its organizers: the joint effort brought significant benefits to all involved and to the greater society. We hope this article contributes to further reflection on the ripple effects of a laboratory, and encourage other scholars and institutions to promote similar events.

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