International Journal on New Trends in Education and Their Implications
January 2014 Volume: 5 Issue: 1 Article: 08 ISSN 1309-6249

LEARNING OBJECT FOR LINEAR SYSTEMS: SCRATCH IN MATHEMATICS

Prof. Dr. Silvia Cristina Freitas BATISTA
Instituto Federal Fluminense
Campos dos Goytacazes – RJ, BRAZIL

Carlos Bruno Freitas BAPTISTA
Instituto Federal Fluminense
Campos dos Goytacazes – RJ, BRAZIL

ABSTRACT

The Scratch programming language was developed at the Massachusetts Institute of Technology (MIT) and allows the creation of games, animated stories and other interactive programs, through a simple and handy user interface. The use of this language for the Mathematics learning has been analyzed by educators in various contexts. In this scenario, this paper aims to present the learning object (LO) *2x2 Linear.S*, for the study of linear systems, developed using Scratch. Initially, the Scratch language is characterized and its use in Mathematics is discussed. Next, the LO *2x2 Linear.S* is presented. Finally, quality evaluation data of the LO, conducted with students of Information Systems, Bachelor's Degree, are analyzed.

Key Words: Scratch, learning object, linear systems, Mathematics.

INTRODUCTION

The proposal to use programming language to develop students' skills isn't quite recent. The development of the Logo language, in 1967, illustrates this well. Logo was developed for educational purposes, based on Piaget's theory (Valente, 1999). However, although experienced in many parts of the world over the years, the results obtained using Logo, generally, were below expectations (Resnick et al., 2009).

Analyzing what happened to the initial enthusiasm related to the initiatives for introducing programming for children, Resnick et al. (2009) emphasize that: i) early programming languages were difficult to use and many children didn't master the syntax of programming; ii) programming was often introduced through activities unattractive for young; iii) educational purposes with low interference of the teacher were generally adopted, therefore orientations were not provided in case of errors, as well as incentives for deeper analyzes did not occur in successful cases.

The developers of Scratch programming language, aware of this panorama, but confident in the educational proposal behind the educational use of programming language, established three core design principles for the same: make it more tinkerable, more meaningful, and more social than others programming environments (Resnick et al., 2009).

Thus, the Scratch language is very accessible. Its graphical user interface allows programs to be structured as stack of blocks. That is, all programming can be done from the predetermined command, to be grouped together. Although simple, the Scratch language allows the user to unleash their imagination, developing interactive programs (Teixeira, 2011).

Although the main focus of the educational use of Scratch is the development of programs by students, it can also be used for the development of learning objects (LO), by the academic community. These objects are resources that aim to support the construction of knowledge. The LO can be created in any media or format, and can be as simple as an animation or a slide show, or complex, such as a simulation (Macêdo et al., 2007). In

Copyright © International Journal on New Trends in Education and Their Implications / www.ijonte.org

this context, this paper aims to report the development of a LO in Scratch, for the study of linear systems, the *2x2 Linear.S*.

Aiming at the objective of this paper, Section 2 characterizes the Scratch language and Section 3 focuses on the use of the same in Mathematics. Section 4 presents the LO *2x2 Linear.S*[1] and analyzes results of the LO's quality evaluation conducted with students of Information Systems, Bachelor's Degree. Section 5 closes the paper with considerations on the theme.

SCRATCH

Scratch is a project of the Lifelong Kindergarten Group at the Massachusetts Institute of Technology (MIT) Media Lab. This programming language is designed[2] specifically for educational purposes, for ages eight to 16. However, it is used by people of all ages (Resnick et al., 2009). Scratch is provided free of charge (Massachusetts Institute of Technology [MIT], n. d.).

The Scratch language is object-oriented and uses a syntax common to many programming languages. Its development was aimed at encouraging the creative capacity of young people, the power of reflection and collaborative work (Resnick et al., 2009).

The Scratch programming environment, version 1.4, is still available for download from their website[3]. The LO *2x2 Linear.S* was developed in this version. Figure 1 shows the main screen of the Scratch environment version 1.4 in English.

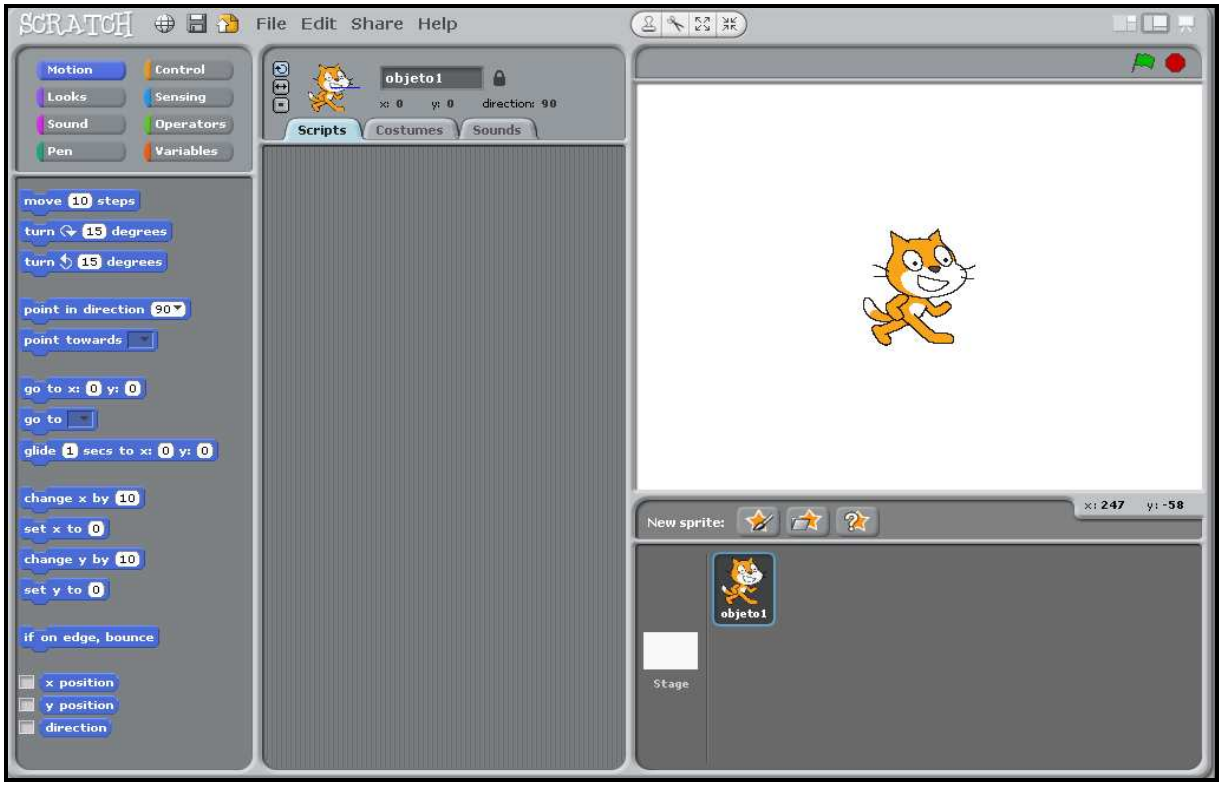

Figure 1: Scratch's Main Screen - version 1.4 – in English

[1] Learning object developed within the research project Information and Communications Technologies in the Process of Teaching and Learning of Mathematics, Instituto Federal Fluminense, Rio de Janeiro, Brazil. (http://www.es.iff.edu.br/softmat/projetotic/index.html).
[2] The first version of Scratch was released in 2007 (Resnick et al., 2009).
[3] <http://scratch.mit.edu/scratch_1.4/>.

Copyright © International Journal on New Trends in Education and Their Implications / www.ijonte.org

However, there is version 2.0, which has an on-line editor[4] and also has a beta version for download[5] (Figure 2), available in several languages. With the on-line version the user can create, edit and view projects directly from Web browser. Version 2.0 brings several improvements over version 1.4, such as: i) the users can set up their own programming blocks; ii) possibility of cloning (duplicate) a sprite (a sprite clone will be equal to the original sprite, but in a separate instance); iii) inclusion of vector graphics: images are resized without becoming irregular; iv) the *Backpack* option allows the user to copy and move sprites, costumes, backdrops, and scripts from any project to another. The *Backpack* can be opened inside any project; v) possibility to use the computer's webcam to interact with projects (MIT, 2013a).

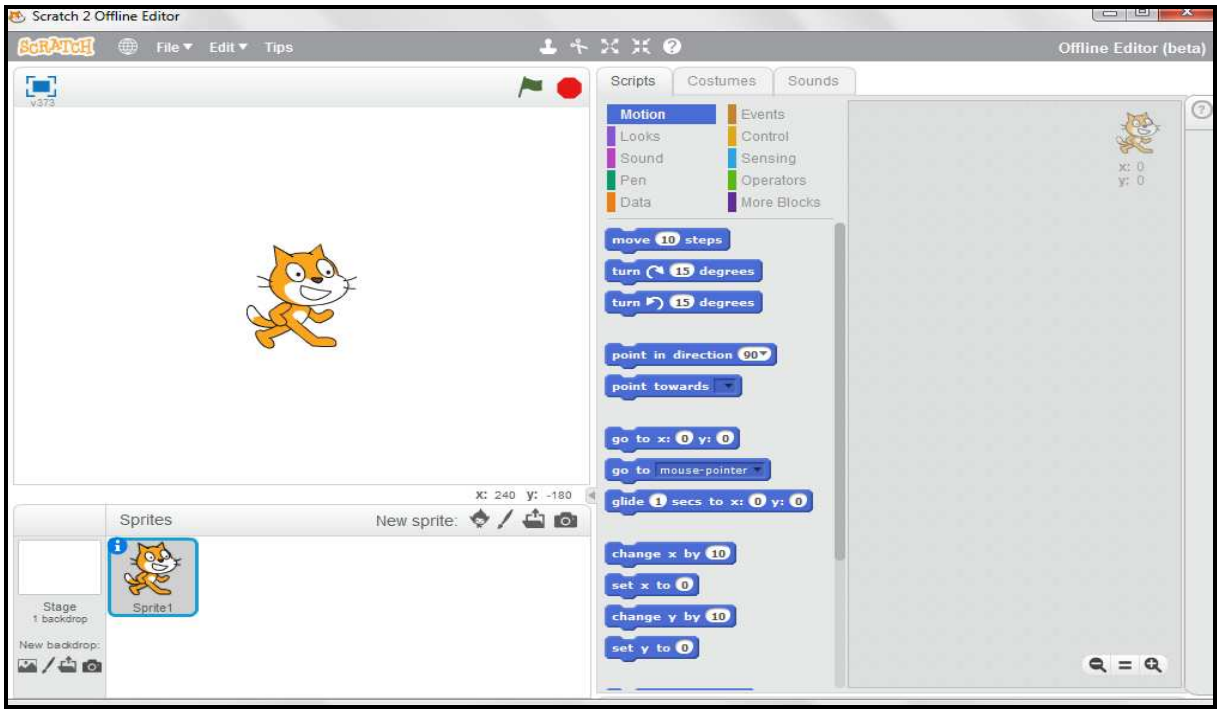

Figure 2: Scratch's Main Screen - Offline Editor - version 2.0 Beta – in English

After preparing a project in the offline version, the users can share their production, publishing it on the Scratch website[6]. For that, in version 2.0 beta, just click *File /"Share to website"* from the top menu of the program. But, it is important to note that before sharing the project the user must make a registration on the website.

The project includes the ScratchEd, Scratch online community educational in which educators from around the world share experiences and resources. There is also the Scratch Day, the day on which institutions promote events where people gather to share projects and experiences and learn more about this programming language (MIT, 2013b).
To conclude, the Scratch is a feature-rich environment and the educational possibilities are varied. Next section discusses the use of this environment in the Mathematics teaching and learning.

USE OF SCRATCH IN MATHEMATICS

Scratch, through its many features, can allow approaches that bring contributions to Mathematics learning. A very significant use of this environment is the proposal of situations in which the students prepare programs, with a view to solving problems. The use of this environment for this purpose can stimulate interest in

[4] <http://scratch.mit.edu/projects/editor/?tip_bar=getStarted>.
[5] <http://scratch.mit.edu/scratch2download/>.
[6] <http://scratch.mit.edu/>.

Copyright © International Journal on New Trends in Education and Their Implications / www.ijonte.org

Mathematics and help in understanding the issues involved (Pinto, 2010). This author states that the Scratch by allowing to represent and simulate problem situations, can contribute to the exchange between the formal and rigorous character of mathematical language and his character more intuitive and contextual.

As advocated by Resnick (2013), when using Scratch, people are not just learning to program, are actually programming to learn. In addition to understanding mathematical and computational ideas, people can develop problem-solving strategies, organize projects and communicate their ideas. From the analysis of a case study, Calder (2010) states that the Scratch is an engaging and relatively easy-to-use space for problem solving, and at the same time, an interesting and motivating programming environment to explore mathematical concepts.

In a survey, Quinn (2011) investigated how the use of Scratch could contribute to the development of mathematical thinking skills and to teach Key Stage Three Mathematics (KS3 - Northern Ireland Curriculum). The study indicated that there is a great deal of Mathematics involved in creating Scratch projects, even in basic projects. Scratch provides a fun way for the development of mathematical skills, to enable the creation of games, projects and animations. The author emphasizes that may occur some competitiveness among students in creating projects and it has to be well utilized in order to develop better projects and consequently the students' mathematical thinking. Thus, in the author's view, Scratch has the potential to contribute to thinking skills and personal capabilities (such as being creative, self-management, working with others, managing information). Furthermore, according to Quinn (2011), Scratch can be used in various ways in Mathematics classes (creation of new projects or alteration of existing projects, as alternative method of presentations and animations, lesson resource, storytelling with animations, among others).

There are many resources made on Scratch developed by the mathematical academic community and available to anyone. These LO can support the study of various mathematical topics. Many are targeted to early childhood education[7]; however, as shown in Figures 3 and 4 also are several LO for Mathematics, focusing on other segments of formal education.

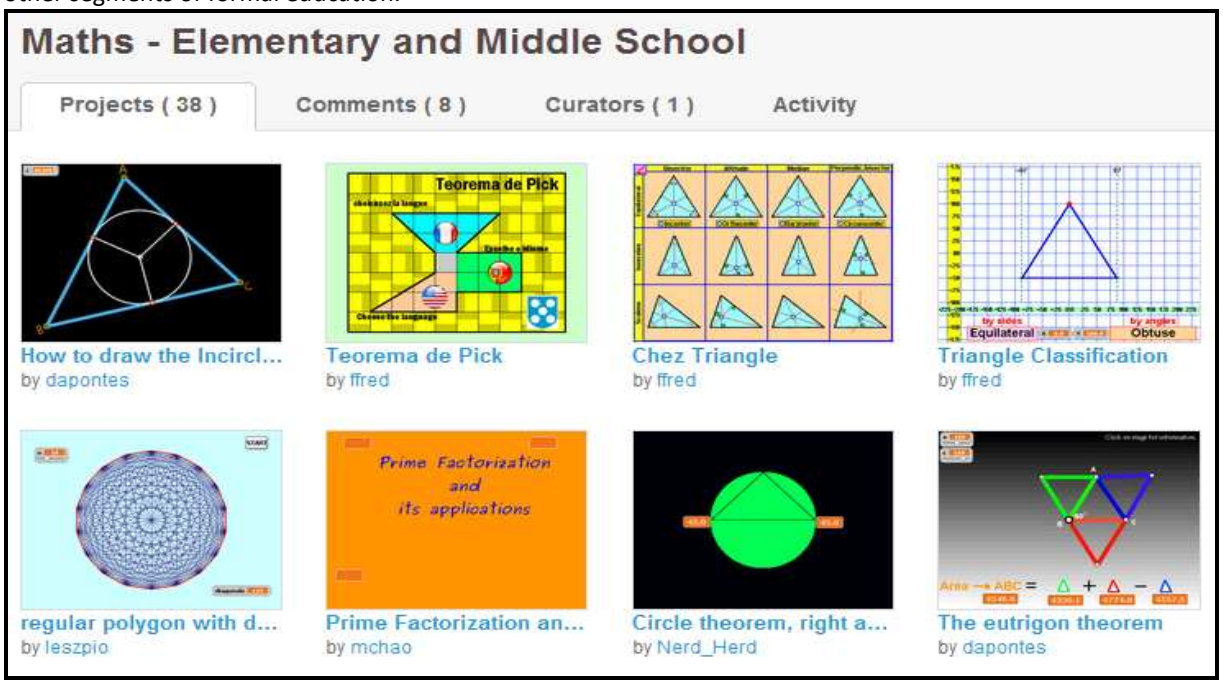

Figure 3: Gallery of resources – Elementary and Middle School
Source: http://scratch.mit.edu/studios/54584/

[7] For example, those available on <http://kids.sapo.pt/scratch/galleries/view/82> and on <http://scratch.mit.edu/studios/10733/>.

Copyright © International Journal on New Trends in Education and Their Implications / www.ijonte.org

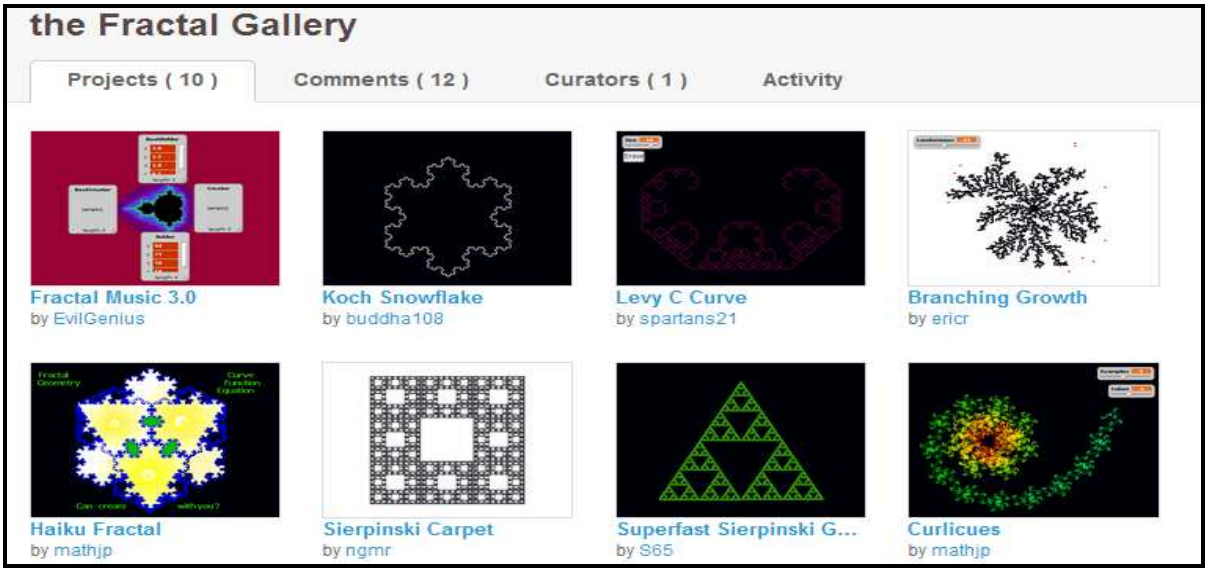

Figure 4: Gallery of resources - Fractal Geometry
Source: http://scratch.mit.edu/studios/33129/

Likewise, the LO *2x2 Linear.S* was developed for later stages of formal education (High School and early periods of Higher Education). Next section presents the LO *2x2 Linear.S*.

LEARNING OBJECT *2x2 LINEAR.S*

The LO *2x2 Linear.S* aims to support the study of 2x2 linear systems (two linear equations, two variables[8]), allowing to analyze the relationship between the coefficients of the equations (and also between constant terms) and the graphical representation of the system. The LO was developed using Scratch 1.4 and is available in Portuguese[9] and in English[10], on Scratch's website.

When starting LO, the user must input the system's coefficients of the two equations. Figure 5 shows the screen corresponding to the typing of the coefficient of the variable x, of the first equation.

[8] The coefficients of each linear equation are real numbers not both zero and the constant terms are real numbers. However, non-integer values must be entered as a decimal (exact or approximate).
[9] <http://scratch.mit.edu/projects/11688101/#player/>.
[10] <http://scratch.mit.edu/projects/13090813/>.

Copyright © International Journal on New Trends in Education and Their Implications / www.ijonte.org

International Journal on New Trends in Education and Their Implications
January 2014 Volume: 5 Issue: 1 Article: 08 ISSN 1309-6249

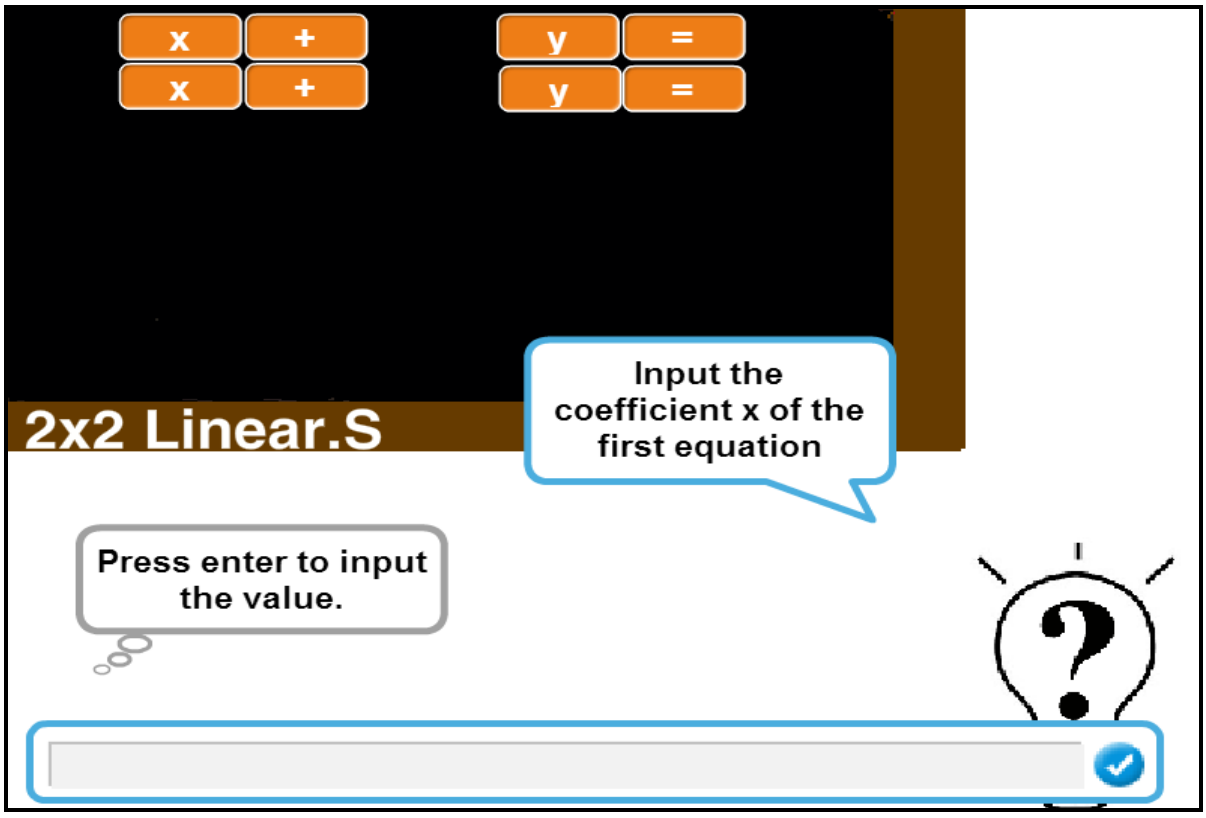

Figure 5: Input screen of variable x - first equation
Source: LO *2x2 Linear.S*

As *2x2 Linear.S* works with the relative position of two lines in the plane, it displays an error message if the user enters the coefficients of x and y simultaneously zero in any of the two equations (Figure 6). In this case, the user must restart the process of typing the coefficients.

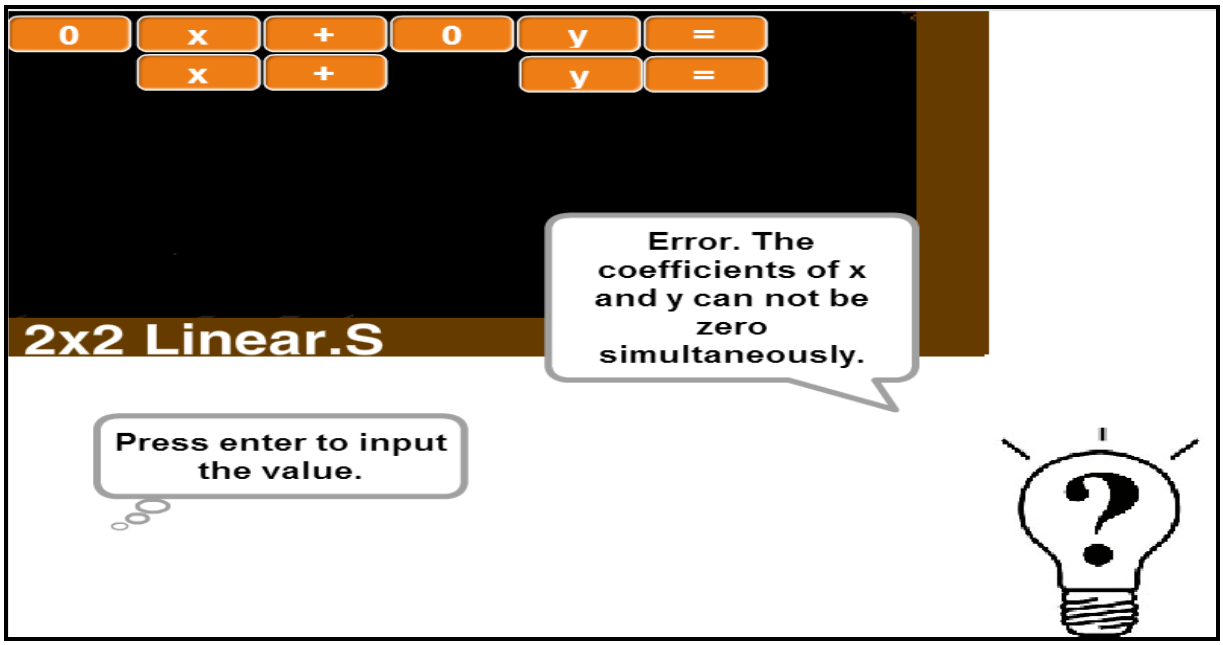

Figure 6: Error message - coefficients of x and y simultaneously zero
Source: LO *2x2 Linear.S*

Copyright © International Journal on New Trends in Education and Their Implications / www.ijonte.org

International Journal on New Trends in Education and Their Implications
January 2014 Volume: 5 Issue: 1 Article: 08 ISSN 1309-6249

When the user completes the two equations, the LO exhibits: i) the relative position of the two lines representing the equations; ii) the classification system in terms of the number of solutions; iii) the system's solution set. In addition, LO displays a merely illustrative image of two lines in the position mentioned. Thus, the image shown does not correspond, in fact, the graphical representation of the system considered, only illustrates such situation. Figures 7, 8 and 9 show three possible situations.

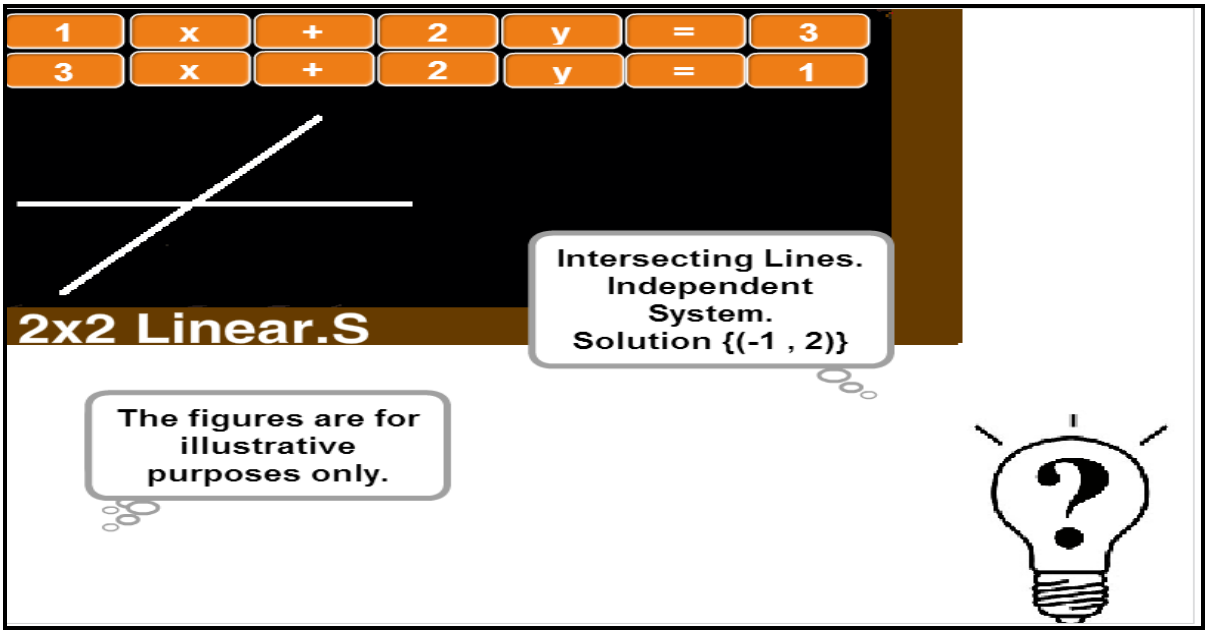

Figure 7: Sample Independent System
Source: LO *2x2 Linear.S*

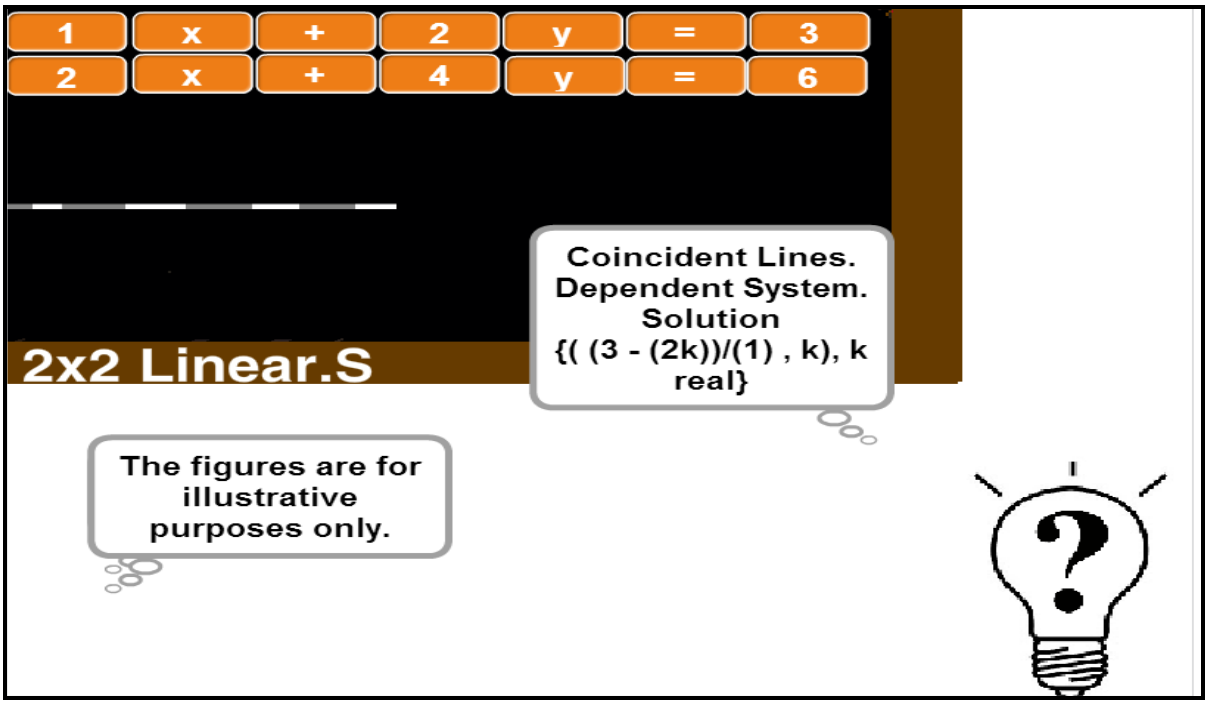

Figure 8: Sample Dependent System
Source: LO *2x2 Linear*.S.

Copyright © International Journal on New Trends in Education and Their Implications / www.ijonte.org

International Journal on New Trends in Education and Their Implications
January 2014 Volume: 5 Issue: 1 Article: 08 ISSN 1309-6249

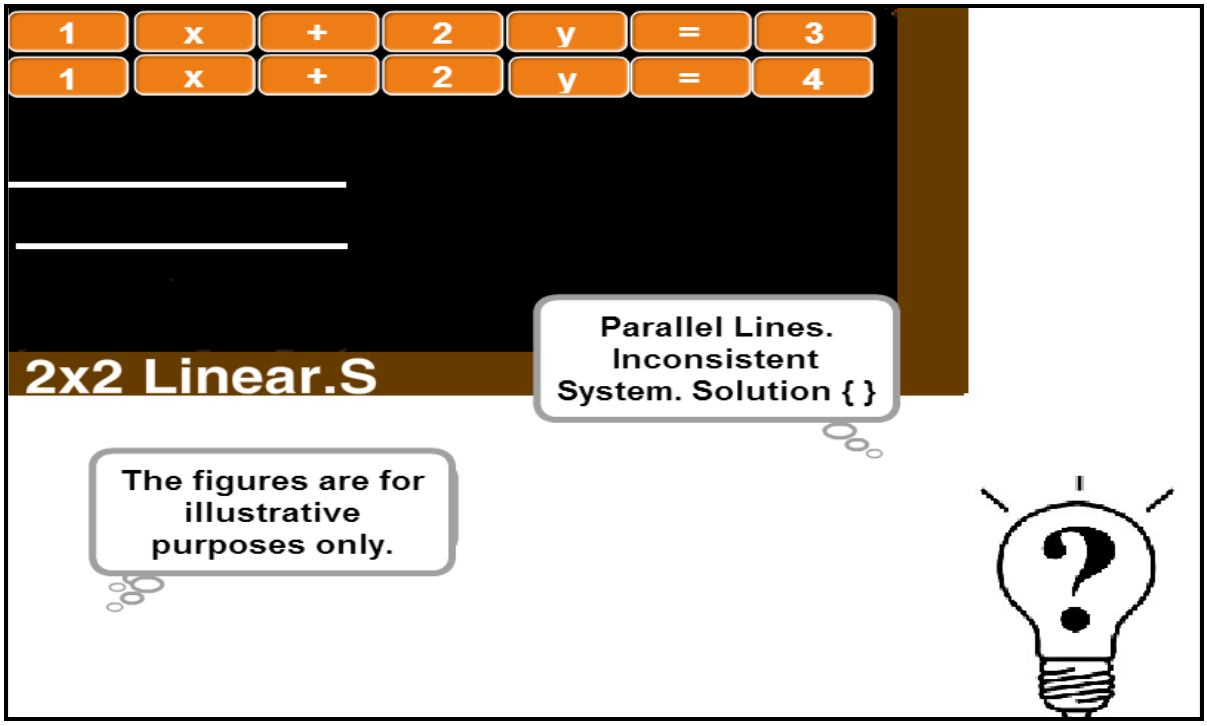

Figure 9: Sample Inconsistent System
Source: LO *2x2 Linear.S*

Due to technical limitations, non-integer coefficients should be entered in their decimal representations (exact or approximate). A note on LO's website alerts users to this fact. Also the results when there are non-integer numbers are given in decimal representations.

The LO was submitted to a first quality evaluation with six students of Information Systems, Bachelor's Degree, in a federal institution. These students had already studied graphic analysis of linear systems in the Linear Algebra and Analytical Geometry subject. Such subject is taught in the second term of that course. Of the six students, four were in the end of the second period and two in the third period. All had active participation and adequate performance when studying the topic addressed.

For the evaluation, a questionnaire containing statements about operational aspects, usability and content was used. In each statement, students should check one of the options: Strongly agree, Agree, Neither agree nor disagree, Disagree, Strongly Disagree. The results obtained are shown respectively in Tables 1, 2 and 3.

Table 1: Operational aspects

Statements	Students (%)				
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
The program worked correctly.	67	33	0	0	0
The functions available are sufficient to accomplish the tasks.	33	50	17	0	0
The processing time is adequate.	50	50	0	0	0

Copyright © International Journal on New Trends in Education and Their Implications / www.ijonte.org

Table 2: Usability

Statements	Students (%)				
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
The program is easy to use.	83	17	0	0	0
The instructions are clear.	83	17	0	0	0
The program is motivating.	33	67	0	0	0
The program is interactive.	67	33	0	0	0
Graphic design presented good quality.	0	83	0	17	0

Table 3: Content

Statements	Students (%)				
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
The program is clear and succinct.	33	50	17	0	0
The program addresses relevant content.	50	33	0	0	17
The concepts presented are correct.	33	67	0	0	0
The conventions and definitions related to Mathematics are used correctly.	33	67	0	0	0

In general, the LO *2x2 Linear.S* was positively evaluated in three criteria. Comments solicited in an open question in the questionnaire confirmed the good acceptance of students to the program.

However, some aspects of the content need to be improved, such as: i) coefficients and independent terms that are non-integer numbers must be typed in decimal representations, which implies to perform approximations, in various situations; ii) the results of the independent systems that are non-integer numbers or exact decimal are presented with many decimal places; iii) the solution set of dependent systems is given correctly, but the display form is, in some situations, a little confused, such as : {((1-(-3k))/(-1), k), k real}; iv) the graphical representations shown are illustrative only and do not represent, in fact, the linear system typed by the user.

CONCLUDING REMARKS

Scratch, using a graphical interface that allows the user to mount the programs' code as stack of blocks, makes the development process much simpler than in traditional programming environments. In developing *2x2 Linear.S*, version 1.4 was used, but version 2.0 will be analyzed in terms of possible improvements to the LO. With the proposal of the work described, the authors of this paper aimed to not only develop LO, but also to better understand the potential of Scratch, considering academic future actions.

The LO was assessed as adequate by test participants in the three criteria. However, *2x2 Linear.S* needs to be improved in some aspects, and subsequently experienced during real use, in the context of the classroom.

In general, the evaluation of digital resources is important. Such analyzes can provide feedback to the developers, with a view to enhancing the features. Additionally, the evaluators noted the evaluation criteria, as well as develop a critical sense. Students of Information Systems, Bachelor's Degree, as potential developers, should also learn to take into account the user and take care with certain quality criteria.

To conclude, it must be emphasized that a proposal for future research is the development of *3x3 Linear.S* (three linear equations, three variables), focusing on the eight positions of the three planes.

Copyright © International Journal on New Trends in Education and Their Implications / www.ijonte.org

International Journal on New Trends in Education and Their Implications
January 2014 Volume: 5 Issue: 1 Article: 08 ISSN 1309-6249

IJONTE's Note: This article was presented at World Conference on Educational and Instructional Studies – WCEIS 07- 09 November, 2013, Antalya-Turkey and was selected for publication for Volume 5 Number 1 of IJONTE 2014 by IJONTE Scientific Committee.

BIODATA AND CONTACT ADDRESSES OF AUTHORS

Silvia Cristina F. BATISTA is professor at Instituto Federal Fluminense, Rio de Janeiro, Brazil. In 1987, Batista has graduated in Science - Specialization in Mathematics, from the Faculdade de Filosofia de Campos. She received her Master's Degree in Engineering Sciences, focus on Production Engineering, in 2004, from the Universidade Estadual do Norte Fluminense Darcy Ribeiro, Rio de Janeiro. She received her Ph.D. in Information Technology in Education from the Universidade Federal do Rio Grande do Sul Federal – UFRGS, Brazil, in 2011. Her research interest is mobile learning, and digital technologies applied to Education.

Prof. Dr. Silvia Cristina F. BATISTA
Dr. Siqueira Street, 273,
Parque Dom Bosco, 28030-130.
Campos dos Goytacazes, Rio de Janeiro, BRAZIL
E. Mail: silviac@iff.edu.br

Carlos Bruno F. BAPTISTA is technical computing course student at Instituto Federal Fluminense, Rio de Janeiro, Brazil. In addition, he is undergraduate student of Mathematics Education at Universidade Estadual do Norte Fluminense Darcy Ribeiro, Rio de Janeiro, Brazil.

His research interest is digital technologies applied to Mathematics and subjects related to polytopes.

Carlos Bruno F. BAPTISTA
Padre Carmelo Street, 248,
Parque Califórnia, 28013-045.
Campos dos Goytacazes, Rio de Janeiro, BRAZIL
E. Mail: carlosbrunobapt@gmail.com

REFERENCES

Calder, N. (2010, Fourth Quarter). Using Scratch: an integrated problem-solving approach to mathematical thinking. *Australian Primary Mathematics Classroom* (APMC), *v. 15*, n. 4, 9-14.

Quinn, S. (2011). *An Investigation into the Use of Scratch to Teach KS3 Mathematics*. Dissertation (Maths and Science Bachelors Education Degree). St Marys Teaching College Belfast, N. Ireland.

Macêdo, L. N. de, Castro Filho, J. A. de, Macêdo, A. A. M., Siqueira, D. M. B., Oliveira, E. M. de, Sales, G. L. & Freire, R. S. (2007). Desenvolvendo o pensamento proporcional com o uso de um objeto de aprendizagem. In: C. L. Prata & A. C. A de Nascimento (Org.). *Objetos de aprendizagem: uma proposta de recurso pedagógico* (pp. 17-26). Brasília: MEC, SEED.

Copyright © International Journal on New Trends in Education and Their Implications / www.ijonte.org

Massachusetts Institute of Technology (MIT) (n.d.). About Scratch. Retrieved October 06, 2013, from http://scratch.mit.edu/about/

Massachusetts Institute of Technology (MIT) (2013a). What's new in Scratch 2.0? Retrieved October 06, 2013, from http://scratch.mit.edu/overview/

Massachusetts Institute of Technology (MIT) (2013b). Scratch Day. 2013. Retrieved October 06, 2013, from http://day.scratch.mit.edu/home

Pinto, A. S. (2010). *Scratch na aprendizagem da Matemática no 1º ciclo de ensino básico: estudo de caso na resolução de problemas*. Dissertação (Mestrado em Estudos da Criança. Área de Especialização em Tecnologias de Informação e Comunicação). Universidade do Minho, Portugal. Retrieved October 07, 2013, from http://scratched.media.mit.edu/resources/investigation-using-scratch-teach-ks3-mathematics

Resnick, M., Maloney, J., Monroy-Hernández, A., Rusk, N., Eastmond, E., Brennan, K., Millner, A., Rosenbaum, E., Silver, J., Silverman, B. & Kafai, Y. (2009, November). Scratch: Programming for all. *Communications of the ACM*, *v. 52*, n. 11, 60-67. Retrieved October 05, 2013, from http://web.media.mit.edu/~mres/papers/Scratch-CACM-final.pdf

Resnick, M. (2013). Aprender a programar, programar para aprender. Retrieved October 04, 2013, from http://www.eduteka.org/codetolearn.php

Teixeira, G. (2011). Scratch: a linguagem de programação para todos que auxilia o ensino e insere nerds no mundo de criação de games. Retrieved October 03, 2013, from http://www.plantaonerd.com/blog/2011/05/02/scratch-a-linguagem-de-programacao-para-todos-que-auxilia-o-ensino-e-insere-nerds-no-mundo-de-criacao-de-games/

Valente, J. A. (1999). Informática na educação no Brasil: análise e contextualização histórica. In J. A. Valente (Org.), *O computador na sociedade do conhecimento* (pp. 11-28). Coleção Informática para a mudança na Educação. Brasil: Ministério da Educação. Secretaria de Educação a Distância.

Copyright © International Journal on New Trends in Education and Their Implications / www.ijonte.org