TEACHING PHYSICS TO HIGH SCHOOL STUDENTS WITH JLINKIT COMPUTER MODELING TOOL USING THE IDEAS OF SYSTEM DYNAMICS AND EXPLORATORY LEARNING

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Abstract

It is of great matter for Physics teaching to identify new pedagogic practices that cause changes in the way students learn. In this work we present a semiquantitative computer modeling environment called JLinkIt, the main characteristics of this tool and its capabilities in the production of models to Physics teaching. An experiment with JLinkIt has been administered to 11th grade students in a Brazilian public school in Rio de Janeiro, about the use of the tool in the study of Kinematics, in the light of the abilities and competences presented in the Brazilian National Curricula, as a way of integration of the information and communication technologies to the exploratory learning in Sciences. The experiment has been conducted with students who have no previous experience in system dynamics nor modeling and the preliminary results presented in this work are relative to the study of the interaction and performance of the students during the use of the JLinkIt environment.

1. INTRODUCTION

Daily new possibilities for use of the Information and Communication Technologies arise, requiring from educators new skills and knowledge in order to insert these technologies in the school environment. The use of computational tools in the classroom context require procedures and methodologies that allow the appropriate inclusion of these tools and then cause changes in the way students learn and generate knowledge.

The use of modeling tools, such as the semiquantitative computer modeling environment called JLinkIt, in activities related to the content of the curriculum of Physics in high school will allow investigating the degree of influence of the use of computer modeling activities in the development the teaching-learning processes, considering the following:

a) Take advantage of lessons in present environments of learning;
b) Motivation of students to the development of learning;
c) Break with the conventional teaching.

Then, it will be possible to compare the performance of the students exposed only to traditional classes to students exposed only to laboratory classes.
In this perspective, this article presents the development of an instructional material using JLinkIt in the study of graphics of Kinematics with high school students from a public State School in Rio de Janeiro - Brazil in teaching physics integrating the discipline to the Information and Communication Technologies.

2. PRELIMINARY CONSIDERATIONS

This paper aims to examine the use of JLinkIt as a tool to help the teaching-learning process of Physics through the performance of students in the light of the Brazilian Curriculum Parameters (PCNs). The experiment will take place in the Dom Helder Camara State School with two classes of the second year of high school.

The development of this experiment will allow to examine and evaluate the strategies and the tool JLinkIt integrated to the teaching-learning process. Through the activities it is expected the following contributions:

- Development of an instructional material to be available in a web site in order to disseminate the possibility of its application in others teaching-learning situations with others teachers.
- Changes in the behavior of the students throughout the motivation of using the tool leading to externalize their mental models on the conceptions of the proposed system and lead to a discussion when comparing their representations with those of other colleagues, promoting a significant learning.
- Overcome the difficulties of learning graphics related to the uniform and uniformly accelerated motions.
- Change of attitude of the teacher due to the adoption of a new methodology in order to improve the quality of education.

The study of motion, object of this work, has been selected because it is a basic topic in the Physics curriculum of the secondary education and because the students demonstrate a lot of difficulties, such as interpretation of graphs, concept of functions and intuitive ideas of velocity and acceleration.

The students' weak performance in the mentioned items is widely known, not demonstrating the abilities and competences mentioned by the Additional Educational Guide of the Brazilian Curriculum Parameters of Secondary Education (MEC, 2002) of Physics:

- Read and interpret correctly tables, graphs, schemes and diagrams, presented in texts;
- Interpret and use of explanatory models, recognizing their application conditions;
- Elaborate simplified models of certain situations, from which may be possible to elaborate hypotheses and forecasts.

Therefore, it is necessary to investigate the use of resources that could bring positive contributions to the teaching/learning process. What is proposed in this study is that the students discuss and experiment with daily situations emphasizing the understanding of qualitative concepts, allowing them to think in a critical way about scientific concepts.

Those activities are developed in exploratory and expressive ways, according to Bliss & Ogborn (1990).

In the exploratory activities the students are asked to use, observe, analyze and interact with the computational environment, with a model developed previously by a teacher, for instance a model/simulation presenting a graph of uniform motion.

In the expressive activities the students are asked to develop their own model in the suggested tool, for instance a model of a uniformly accelerated motion situation, following the steps of construction of models proposed by Camiletti (2001):

- Identify the motion;
- Classify it;
- List the variables;
- Build the causal diagrams with cause-effect pairs;
- Foresee the behavior of the variables in the graph;
- Rebuild the causal diagram built with the inclusion of feedback links;
- Foresee the behavior of the variables in the graph;
- Represent the causal diagram in the JLinkIt environment;
- Simulate the built model;
- Foresee the graphic behavior from the animation of the variables;
- Compare the graphic exit and the forecast for the causal diagram rebuilt with the inclusion of feedback links.

Along those steps it is possible that several subjects be explored on the problems treated, being asked to the students *what* happened and *how* the phenomena happened.

3. THE JLINKIT ENVIRONMENT

JLinkIt environment (http://labase.nce.ufrj.br/JLinkit10/) lets you create, manipulate and simulate dynamic models on the web using a semiquantitative language to represent the variables and the relationships of the phenomena to modeled. In other words, the user does not need to work with mathematical (differential) equations to construct models.

The simple vocabulary used in the construction and simulation of models tries to correspond to an intuitive way the language is used usually when talking about those phenomena, allowing representing certain aspects of the real world.

JlinkIt was developed in Java and was based on another modeling system called WlinkIt (Sampaio, 1996; Pedro 2006).
The initial screen of the JLinkIt environment is shown in Figure 1. The screen is subdivided in 3 parts:

- Toolbar – this is the area that contains the necessary tools for the construction and simulation of the model.
- Work Area – this is the white area below the toolbar. It is used to the construction of the model by the user.
- Graphs Area – this is the area of the screen below the Work Area reserved to the visualization of the graphic exit of the variables that compose the model.

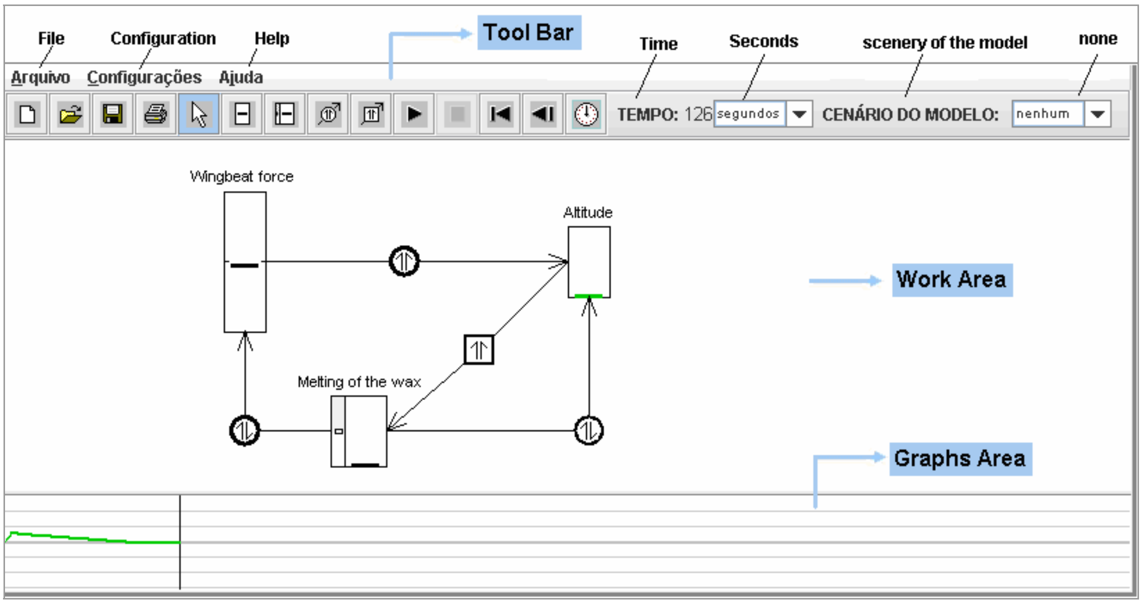


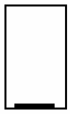
Figure 1 – Window of Jlinkit with a model on Icarus

The functions of the JLinkIt environment are classified in four types: manipulation of models, manipulation of objects, model configuration and simulation of the model.

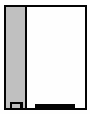
The functions related to the manipulation of models are presented in Table 1. Such functions are evoked through the option *files* in the Tool Bar.

Function	Description
Create Model	It allows the user to create a new model in the system.
Save Model	It allows the user to store a model for subsequent use.
Open Model	It allows the user to visualize a model already created in JlinkIt.
Print Model	It allows the user to print a model and its respective graph.

JLinkIt provides a direct manipulation interface with two main building blocks : variables and links. Variables are used to represent objects, events and variables of the system to be modeled. They can be of two types: Continuous Variable and On-Off Variable.

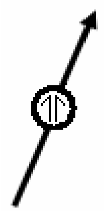


Continuous Variable – Stays active during the whole time of simulation. It influences their dependent variables, being influenced by the independent variables linked to it.

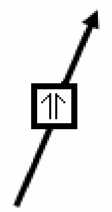


On-Off Variable - Activates the dependent variables only when it crosses a certain value stipulated by the user (trigger), being influenced by the independent variables linked to it during the whole time of simulation.

The links, connect variables allowing to represent the cause-effect relationships among them. In the JLinkit environment, the relationships can be of two types: Gradual and Immediate.



Gradual - Presented by a circle, it indicates that the mathematical relationship between a pair of variables can be defined as a variation rate between them. In this kind of relationship, the value of the independent variable is a variation rate of the dependent variable (affected variable). Once defined the value of the independent variable, the value of the dependent variable will grow or decrease gradually in time.



Immediate – Presented by a block, it indicates a linear relationship between the variables that are being related. In this relationship type, the value of the affected variable is calculated immediately from the values of the independent variables.

Variables and links have different attributes that can be changed by the user in order to construct more realistic models.

It is also possible to include comments regarding to a variable of a model. The comments can have buttons which points to web pages through the internet or other comments in the model.

4. THE INSTRUCTIONAL MATERIAL

The material have been organized in a 15 hours course, divided in three modules: **Module 1 (3h 20min)** - Introduction to the study of System Level Thinking (cause, effect and cycles of feedback) and to the manipulation of JLinkIt; **Module 2 (5h 50min)** - Physical Systems Modeling and Representation: study of the Uniform Motion Graphs; and **Module 3 (5h 50min)** - Physical Systems Modeling and Representation: study of the Uniformly Accelerated Motion Graphs.

Module 1

The purpose of this module is to develop the following skills of the students:

- Identify the Cause and Effect pairs in nature and the relationship of dependency between them for questioning about the effects that an action can cause and thus promoting interactivity.
- Recognize the behavior of the positive feedback link as a continuous growth or decay of the variables reinforcing their initial behavior and the behavior of the negative feedback link characterized by balance and search for solutions to problems, denying its initial behavior.
- Represent relationships of cause and effect found in nature through the construction and simulation of dynamic models in the JLinkIt modeling environment.

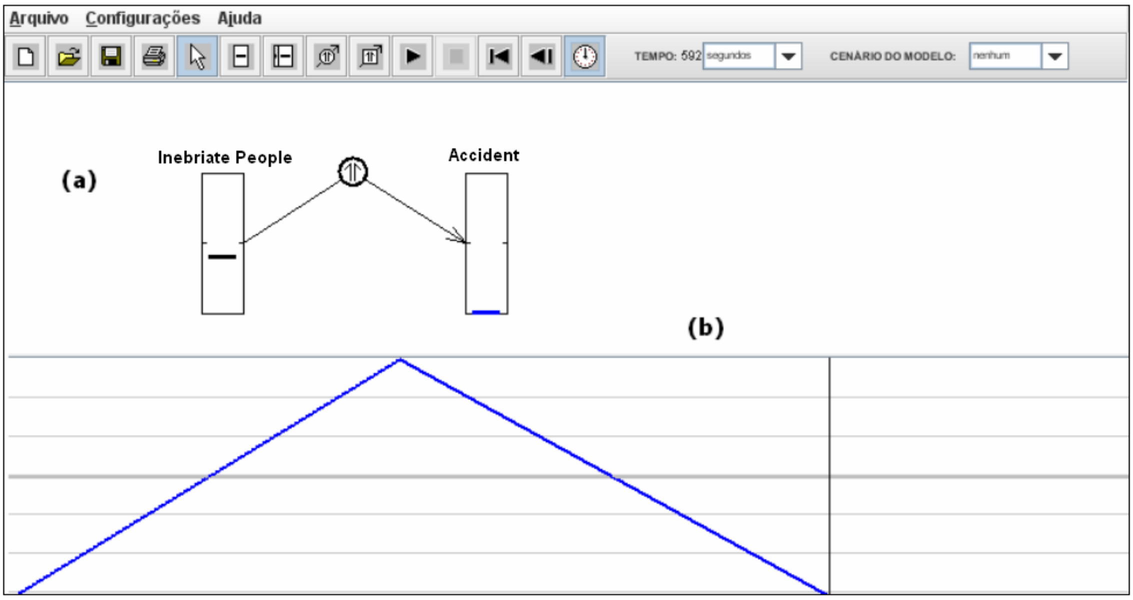


Figure 2 – model 2. (a) structure e (b) behavior. Linear Growth and Decay.

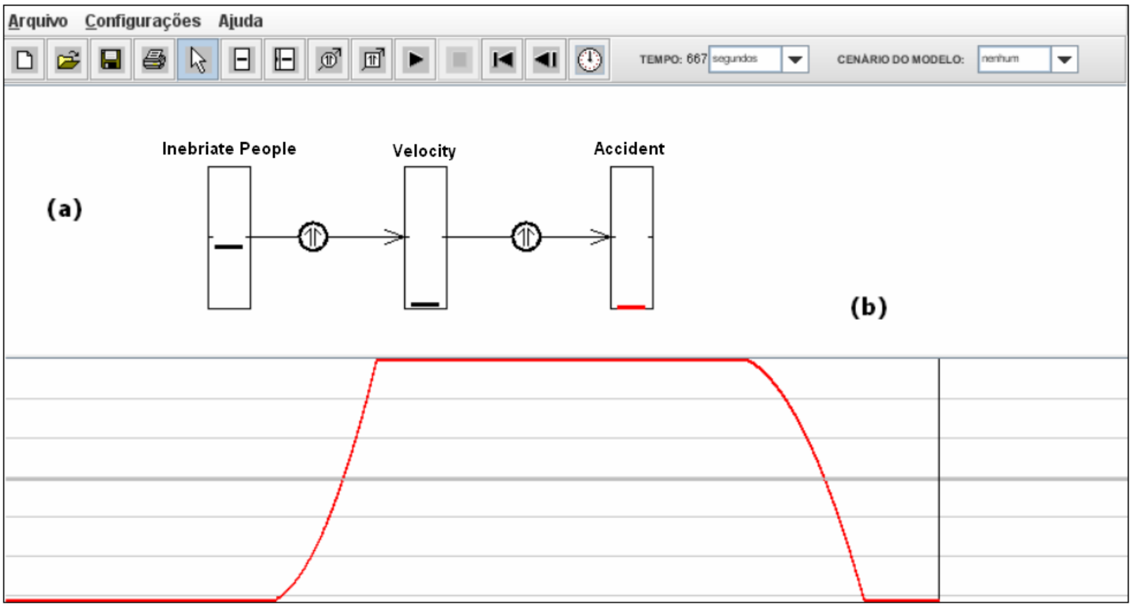


Figure 3 - model 3. (a) structure e (b) behavior. Exponencial Growth and Decay.

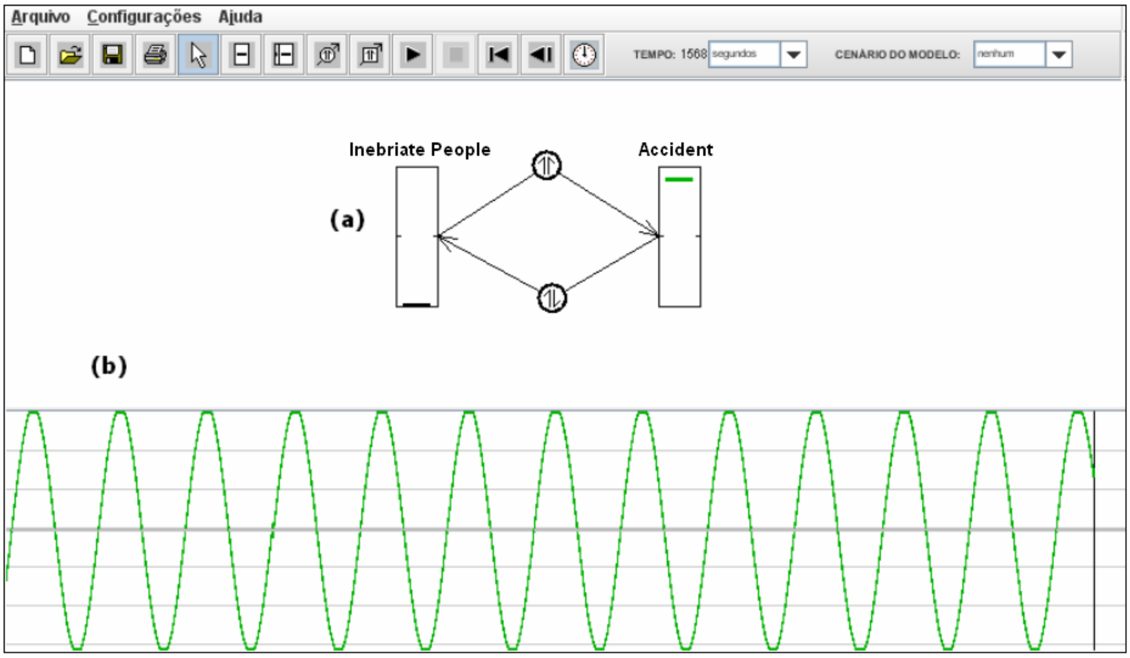


Figure 4 – model 4 . (a) structure e (b) behavior. Oscillatory Movement

Module 2 – Study of the Uniform Motion Graphs

The purpose of this module is to develop the following skills of the students:

- Identify in a specific problem-situation the relevant information or variables involving a movement in a graph and understand its graphic relationships recognizing the relation between different magnitudes, or cause and effect relationships, in order to be able to establish forecasts.
- Interpret graphics, changes in height and changes in the inclination.
- Identify relevant variables in a text, the relationship of dependency between them, variations in growth and decay, and model the phenomena.

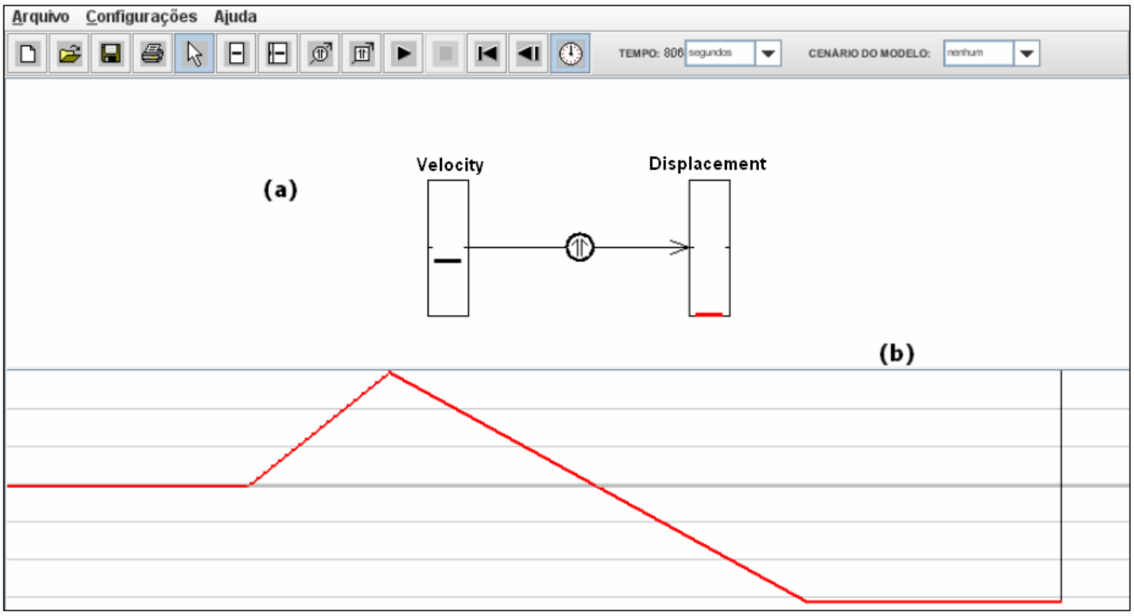


Figure 5 – model 5 . (a) structure e (b) behavior. Displacement x Time Graph when velocity is changed.

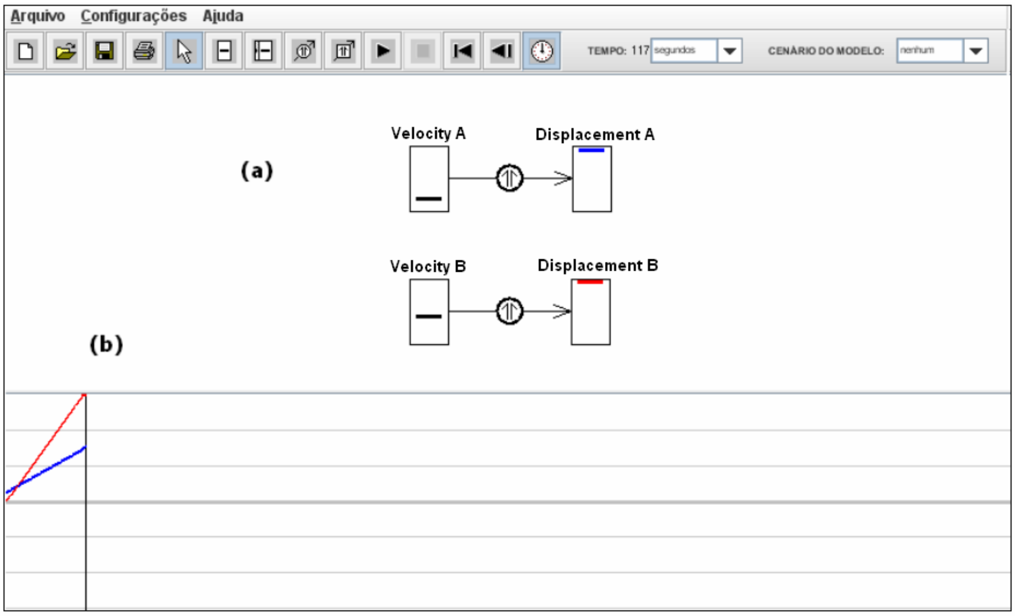


Figure 6 – model 6 . (a) structure e (b) behavior. Displacement x Time Graph of two cars A and B in a same direction movement.

Module 3 – Study of the Uniformly Accelerated Motion Graphs

The purpose of this module is to develop the following skills of the students:

- Identify in a specific problem-situation the relevant information or variables involving a movement in a graph and understand its graphic relationships.
- Try to eliminate the confusion between height and inclination and the mistakes related to inclinations that do not cross origin.
- Graphs interpretation of photographs of movement trajectory and differentiate height and inclination.
- Identify relevant variables in a text, the relationship of dependency between them, variations in growth and decay, and model the phenomena.

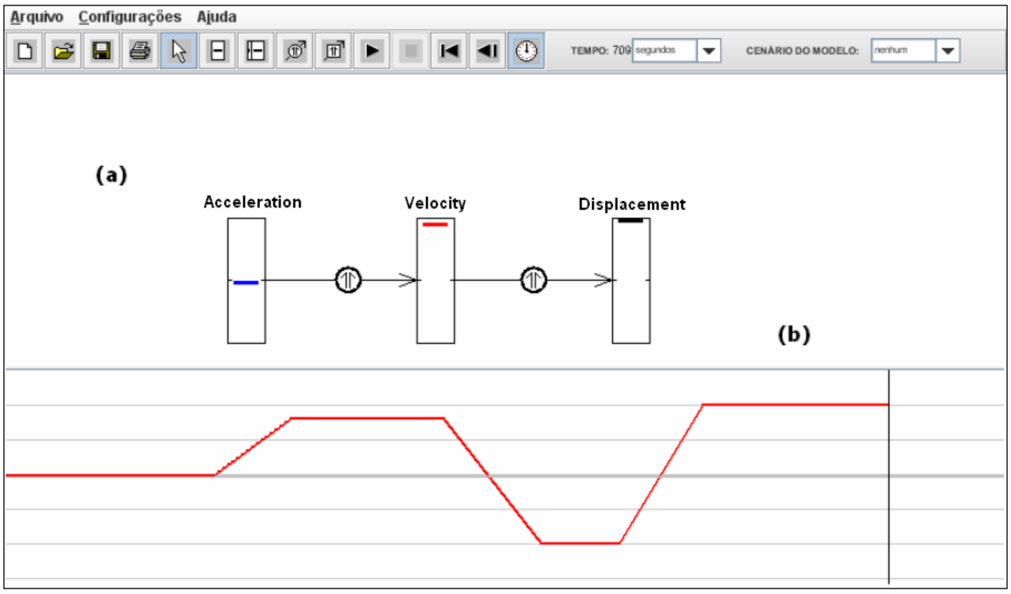


Figure 7 – model 7. (a) structure e (b) behavior. Displacement x Time Graph of a Formula 1 runner that starts from rest.

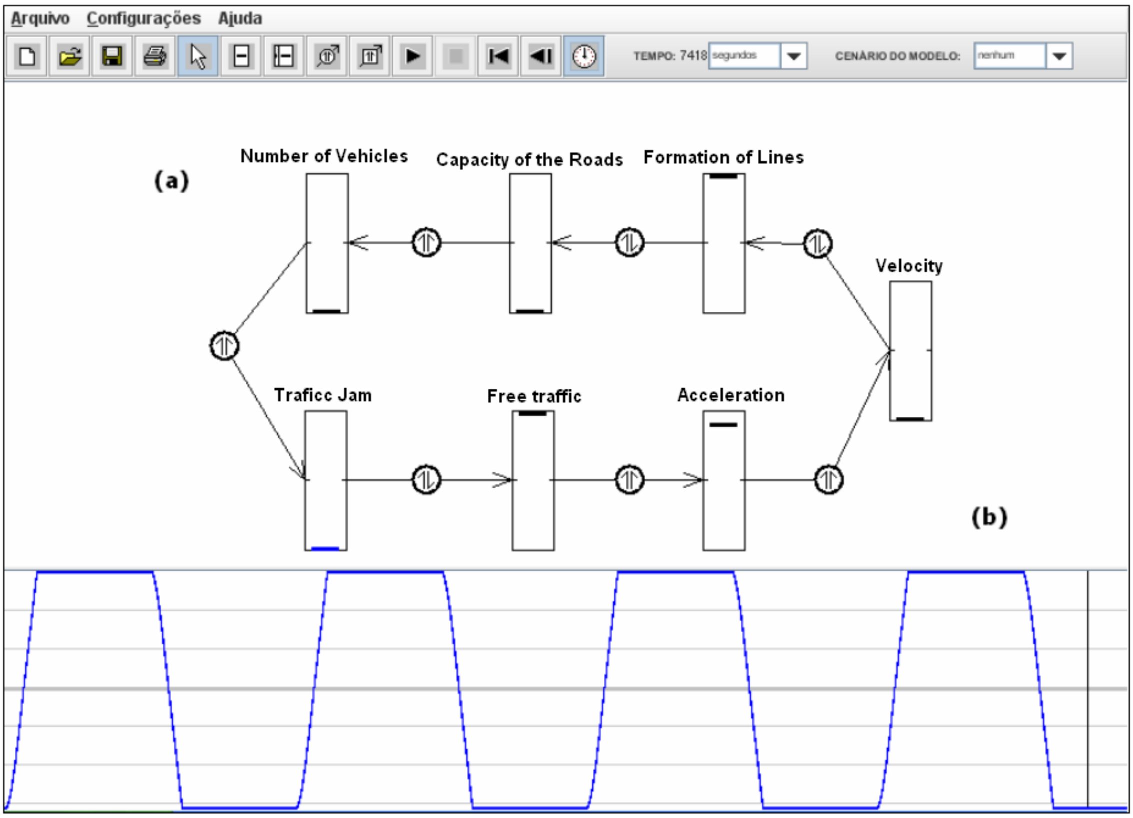


Figure 8 – model 8 . (a) structure e (b) behavior. Growth and Decay of traffic jam.

5. DATA ANALYSIS

Data analysis will be based on the dialog recorded, the written responses of the students to the instructional material during the activities of modeling, tests and questionnaires and the modeling log provided by the system. The main aspects of the data collected to be considered for the analysis are:

- Identification of the cause and effect pairs in nature and the relationship of dependency between them;
- Recognition of the behavior of positive feedback link as a continuous growth or decay of variables reinforcing their initial behavior and the behavior of the negative feedback link characterized by balance and search for solutions to problems, denying its initial behavior;
- Representation of the cause and effect relationships found in nature through the construction and simulation of dynamic models both on paper as on the Semiquantitative Computer Modeling Environment JLinkIt;
- Identification in a specific problem-situation the relevant information or variables involving a movement in a graph and understand its graphic relationships recognizing the relation between different magnitudes, or cause and effect relationships, in order to identify if the student is able to establish forecasts;
- Interpretation of graphics, changes in height and changes in the inclination;
- The interaction between a pair of students through conversations and arguments;
- The interaction between a pair of students and the JLinkIt;

- The development of students in the light of skills/abilities proposed by PCNs;
- The evaluation of the computational and educational aspects of the insertion of JLinkIt and computer modeling in the classroom activities will be made through the application of questionnaires.

With the questionnaires will be possible to propose improvements in the JLinkIt environment and complete the construction of the web site of modeling to be available to Teachers of the Education Network with Internet access.

6. CONCLUSION

The investigation about the contribution of the use of modeling environments in the student's learning process in the secondary education, connected to the Brazilian Curriculum Parameters and its real application possibilities in the teaching-learning process is of great importance.

It is expected that the use of this computational tool together with an exploratory approach to the topics of the physics secondary curriculum will bring the students to a better understanding of the physical concepts involved in the activities proposed.

It is also expect that the availability on the web of the material produced in this (and other) researches

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