A computational model to help teach the topic of earth as a cosmic body

Um modelo computacional para auxiliar o ensino da temática de terra como corpo cósmico

Jefferson Oliveira do Nascimento
Doctor in Computational Modeling and Industrial Technology
Institution: Universidade Federal do Pará (UFPA)
Address: Rua Augusto Correa, 01, Guamá, Belém – PA, CEP 66075-110
E-mail: jeffersonascimento@gmail.com

Italo Gabriel Nede
Doctor in Physics
Instituição: Universidade do Vale do Taquari (UNIVATES)
Address: Avenida Avelino Tallini, 171, Universitário, Lajeado – RS, CEP: 66075-110
E-mail: italo.neide@univates.br

Sônia Elisa Marchi Gonzatti
Doctor in Education
Institution: Universidade do Vale do Taquari (UNIVATES)
Address: Avenida Avelino Tallini, 171, Universitário, Lajeado – RS, CEP: 66075-110
E-mail: soniag@univates.br

Marcelo Albano Moret
Doctor in Biophysics
Institution: Universidade do Estado da Bahia
Address: Rua Silveira Martins, 2555, Cabula, Salvador – BA, CEP: 41180-045
E-mail: mamoret@gmail.com

ABSTRACT
To facilitate the process of teaching and learning in physics, through the use of computers, avoiding to learn numerous programming languages, several software was developed, among them Modellus. The nuances in its use focus on processes that aim at activities that basically require the concepts of Science, Mathematics and basic computer studies. This article aims to present a computational model developed for use in Software Modellus and to assist in teaching the Earth thematic as a cosmic body. This approach to Earth means to study it through its form, its gravitational field, its movements and the astronomical phenomena arising from these movements and the configuration of the Sun-Earth-Moon system, that is, its interaction with other cosmic stars. Initially, the method of construction by means of an algorithm is presented, and also, how its implementation in the software should occur. The respective interactions with the functions in Modellus are also indicated. Finally, the computational model of the Sun-Earth-Moon system is presented in an
executable form, aiding the learning process of the Earth Thematic as a cosmic body.

**Keywords:** physics teaching, computer modeling, *Software Modellus*, Earth as a body cosmic.

**RESUMO**

Para facilitar o processo de ensino e de aprendizagem em Física, por meio da utilização de computadores, evitando-se aprender inúmeras linguagens de programações, foram desenvolvidos diversos softwares, dentre eles o *Modellus*. As nuances na sua utilização se concentram em processos que objetivam atividades que necessitam basicamente dos conceitos de Ciências, Matemática e estudos básicos de computação. Este artigo tem por objetivo apresentar um modelo computacional desenvolvido para utilização no *Software Modellus* e, auxiliar no ensino da temática de Terra como corpo cósmico. Esta abordagem à Terra significa, estudá-la por meio de sua forma, seu campo gravitacional, seus movimentos e os fenômenos astronômicos decorrentes desses movimentos e da configuração do sistema Sol-Terra-Lua, ou seja, a sua interação com outros astros cósmicos. Inicialmente, o método de construção por meio de um algoritmo é apresentado, e também, como deve ocorrer a sua implementação no *software*. As respectivas interações com as funções no *Modellus* são também indicadas. Ao fim, o modelo computacional do sistema Sol-Terra-Lua é apresentado de forma executável, auxiliando o processo de ensino de aprendizagem da Temática de Terra como um corpo cósmico.

**Palavras-chave:** ensino de física, modelagem computacional, *Software Modellus*, Terra como corpo cósmico.

**1 INTRODUCTION**

The last few decades have been characterized by a technological revolution, one of the main consequences of which is the dynamic evolution of information technology and computers. By occupying the various spaces of society, in domestic use, influencing man’s lifestyle, technology also appears in the various work relationships in the industrial sector. In relation to the educational field, one can be present through the process of acquiring knowledge.

Technological advances result in a greater possibility of access to information, considerably increasing the number of people who now have this
access, as we live in a society in which speed, movement, image, time and space prevail with a new conceptualization (NASCIMENTO; NEIDE, GONZATTI, 2017)

Faced with this new reality, the use of computers in teaching and learning processes is increasingly common, thus making it possible to expand the use of this tool and when we add the importance of internet access, according to the aforementioned author, this combination becomes makes it essential for the construction, dissemination and advancement of knowledge.

In this logic Nascimento et al. (2017) by using Information and Communication Technologies (ICT) applied to Physics teaching, makes us reflect on current teaching and learning processes, in which by finding alternatives to make Physics classes more enjoyable and motivating. This way, we will be able to provide better learning for students, which is a constant challenge in teaching practice. Araújo (2002), Araújo (2005) and Nascimento et al. (2016) confirm the use of technological tools in the teaching of Physics, such as computational modeling, through didactic proposals involving the use of computers, in which increasingly elaborate software has been created in an attempt to facilitate the construction of knowledge by of the student. Following this thought, in order to facilitate the teaching and learning process and obtain a real gain in time in front of the computer, software such as Dynamic Modeling System, Stella, Easy Java Simulations and Modellus were developed, which concentrated learning in activities that fundamentally required the concepts of Science and Mathematics (TEODORO; NEVES, 2014). Therefore, our option in this research is to present a computational model, for the study of astronomical phenomena, in the Modellus Software.

This work is organized into 6 sections. In the second, we will present the Modellus Software. In the third, the materials and methods used to build the computational model. On Wednesday, the results and discussions. In the fifth section, the final considerations and then, the acknowledgments.
2 THE SOFTWARE MODELLUS

The Modellus Software, according to Teodoro, Vieira and Clérigo (2014), is a computer tool that provides the possibility for students and teachers to carry out conceptual experiments on mathematical models. Mathematical representations can be functions, derivatives, rate of change, differential equations and equations through differences, simply writing them in a simple and direct way in a text box called "Mathematical Model". Multiple Representation and Direct Manipulation are important features in Modellus. The first consists of the fact that it is possible to create, see and interact with analytical, analogical and graphical representations of mathematical objects (ARAÚJO, 2002; ARAÚJO, 2005; NASCIMENTO et al., 2016).

The second, direct manipulation, already mentioned above, means that the user can work directly with all types of objects that appear on the computer screen, without the need for knowledge of a specific programming language, that is, the objects can be directly manipulated by following the mathematical model worked on (TEODORO, 2014). Modellus is a tool that also allows graphical output, because, as the computational model is executed, and the objects acquire movements, the graphics are plotted instantly. At the same time as the plotting, it monitors the development of the equations, which represent the mathematical model that is being solved, according to the initial conditions assigned.

3 MATERIALS AND METHOD

The tool used for computational modeling was the Modellus Software, which can also be found for download at www.modellus.fct.unl.pt/, (website of the Faculty of Science and Technology Universidade Nova de Lisboa), from where the user can do also download manuals and tutorials in different languages.

There are also registrations for courses, different versions of Modellus, articles, brochures in “pdf” file extension and modeling examples for Mathematics and Physics. The version used for the computational model presented in this research corresponds to the Modellus X Software, found on the aforementioned website, which presents the following initial screen, as shown in Figure 1:
On the home screen shown in Figure 1, menus and submenus are available (like any software) and some windows that deserve our attention. Numbered 1 is the mathematical model window, where the equations must be arranged in a logical and direct way. Number 2 corresponds to the screen whose graphics, which correspond to the animation movements that obey the mathematical equations inserted on the mathematical model screen, are plotted. In window 3, the values resulting from the calculations performed by the equations inserted in the mathematical model window are presented. Window 4 features a notepad or comment notes function. Region 5 indicates the animation area, where objects will be inserted and associated with mathematical equations for the development of the computational model.

4 RESULTS AND DISCUSSION

In this research, modeling the Sun-Earth-Moon system in the Modellus Software basically means building a computational model of the ellipse equation associated with the movement of the stars involved with the possibility of translating the axes, according to the equations below:
\[
\frac{(x-h)^2}{a^2} + \frac{(y-k)^2}{b^2} = 1
\]  

Eq. 1 and the following equations use the condition \(2a > 2b\), with axis \(a\) being horizontal and \(b\) being vertical. Therefore, Eq. 1 can be written as follows:

\[
x = h + a \cos \theta
\]  

and,

\[
y = k + b \sin \theta
\]  

The terms \(h\) and \(k\) represent the translation factors in the ellipse equations, in parametric form. To build the computational model in Modellus Software, we suggest the following procedures below:

1. Run Modellus and, in the Animation Menu (Figure 2), choose Particle:

   ![Animation menu](image)

   Source: From the software.

   1. Click on the Animation Area and insert the Object;
   2. Return to the Animation Menu and change the inserted Object to the one that represents Planet Earth;
   3. In the Animation Menu, insert a Geometric Object and change its Type to Line Segment;
   4. Leave the Geometric Object with an inclination of approximately 23.5°, in relation to the horizontal direction;
   5. In the Animation Menu, insert the Source Object;
6. Select the Geometric Object and in the Properties menu, make its connection - Connect to - with the Source Object;
7. Join the Earth to its "tilt axis", the Geometric Object linked to the Origin Object;
8. In the Animation Menu, insert a new Particle Object, changing its Color to yellow. Also change its size with the mouse, in order to represent our Sun, for the present model;
Note: Inevitably, the Sun and Earth model will be out of proportion, for teaching purposes;
9. Bring the Sun and Earth closer together, leave the perihelion and aphelion differentiated by an average of 3% apart, in the model;
10. Zoom in on Objects in the Animation Area;
11. For the Mathematical Model window, we present the following algorithm in the form of a flowchart in Figure 3, based on and derived from the works of Nascimento, Neide and Borragine [9] and Nascimento, Neide and Gonzatti [10]:

...
Figure 3 – Algorithm for developing the computational model.

1. Select the Earth Object;
2. In the Properties Menu (Figure 4), assign the coordinates $x = x$ and $y = y$;

1. The choices for $x$ and $y$, assign one unit to each. Select to view – View - Trajectory and Axes;
2. In the More Menu, Select Angle and within angle, theta;
3. Select the “Earth's inclined axis”, in its Origin and in the Properties tab, assign x and y coordinates;
4. In the positions corresponding to the Solstices and Equinoxes, insert the Text Object, adding the corresponding information;
5. Click the play button and check the Modeling development.

The resulting computational model for the study of astronomical phenomena is shown in Figures 5, 6, 7, 8 and 9:

Figure 5 – Start of modeling execution - December Solstice. Source: From the software.

Figure 6 – Model with emphasis on the position of the March Equinox.

Source: From the software.
Figure 7 – Model with emphasis on the position of the June Solstice.

Source: From the software.

Figure 8 – Model with emphasis on the position of the June Equinox.

Source: From the software.
Figure 9 – End of modeling run for a period of one year - December Solstice.

For example, the result of applying the computational model through a psychopedagogical intervention is presented in research on Nascimento (2015), Nascimento et al. 2016 and Nascimento et al. (2017). For example the result of applying the computational model through a psychopedagogical intervention is presented in the research by Nascimento (2015), Nascimento et al. (2016) and Nascimento et al. (2017).

5 CONCLUSIONS

Astronomical phenomena such as days and nights, succession of years and seasons, lunar phases are common phenomena in our routine and are associated with the cosmic nature of the Earth, which involves both its shape, location, and its participation in gravitational interactions. Therefore, when we consider the Earth as a cosmic body, it does not mean characterizing it as a perfectly spherical shape, blue in color, almost cloudless, commonly shown in various media, or in didactic models such as terrestrial globes and world maps, present in school environments, where visual enchantment is inevitable, as well as dissociation from the real world. Treating the Earth as a cosmic body means approaching it through its shape, its gravitational field, its movements and the astronomical phenomena resulting from these movements and the configuration
of the Earth-Sun-Moon system, such as days, nights, seasons of the year, lunar phases and eclipses, that is, its interaction with other cosmic stars.

In this way, and with the help of the works cited in this research on the application of the computational model presented in this article, through the presentation of its construction method, we hope that computational modeling can be used as a technological tool for the Teaching of Physics and related areas. The model can either be built with apprentices from the beginning or delivered ready for use and study of astronomical phenomena, intersecting and in line with a learning theory.

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