

Pedagogical Design for Teaching Physics Using Virtual Reality

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ABSTRACT: *This article describes a tutorial system prototype using virtual reality as a means for learning physical phenomenon. This prototype was developed by a multidisciplinary team (Education and Electrical Engineering departments), in order to stimulate undergraduate research in the area of information technology in education. The pedagogical design was developed in accordance with constructivist principles of teaching-learning, as such cognitive-computational tools were utilized to stimulate active and intentional processes of learning, VRML, JavaScript and HTML languages were used as technological support.*

1 INTRODUCTION

This article is the result of a joint effort to motivate undergraduate student research in teaching methodologies which was undertaken by the Education and Electrical Engineering Departments at the Federal University of Uberlândia, in Brazil. One simulation model, that of horizontal propulsion, was chosen from several developed to serve as a prototype for the virtual reality learning environment.

A number of studies describe the development of software programs which simulate phenomena that are difficult to demonstrate in the classroom and that provide support to the teaching process. However, it is important to note that many of these teaching technologies are not based on cognitive and pedagogical models, and, thus, do not stimulate active learning processes [(Diehl, 2002); (Good and Berger, 1997)]. Simply simulating real phenomena doesn't develop and direct learning processes. For this reason, our goal was to create an instructional prototype based on new information technologies in conjunction with cognitive and pedagogical theories.

We chose a pedagogical design supported by constructivist learning principles, such as action, intentionality, reflection, contextualization, and interdisciplinary qualities (), and by models of meaningful learning, as described by Novak (1984) to create a cognitive ergonomics in virtual learning experiments. Further, the learning environment was developed based upon Lowyck's pedagogical design model (2002).

With regard to the technological aspects, we used the more interactive means which are available through virtual reality to enable the user to immerse himself in the learning environment. To this end, we use Virtual Reality Modeling Language and JavaScript to simulate the physical phenomena.

2 DEVELOPMENT OF THE PROTOTYPE

The content focus of our study was Physics as it relates to Classical Mechanics in secondary education. More specifically, we chose to create a virtual learning environment which reproduced the effects of gravity (in the form of projectile propulsion) and examined the motion involved, including uniform and varied motion, and especially cinematic vectorial motion. The teaching method thus employed emphasized the interdisciplinary aspects of understanding motion as it is affected by gravity, by using mathematical equations to understand and represent the physical phenomena.

The learning setting created consisted of all the elements necessary to simulate the propulsion of a projectile toward its target. These elements together with a set of educational objects, included a canon, a panel with the variables that influence the oblique propulsion phenomenon (speed, angle, coordinates of the bullet, and the target). These educational objects were developed to effect an interaction with the

user, such that the user could change the parameters and visualize the results immediately through the behavior of the virtual objects available in the setting.

With the goal of stimulating active and intentional learning, we developed a control panel which created a sense of immersion in the scenario, that is, the user simulates a real action by virtue of the data on the control panel. Further the panel was developed to permit the user to operate on the variables of the system without losing this sense of immersion. There is also the ability to interact directly with the elements of the virtual environment by directly manipulating the objects.

The control panel allows the intentional choice of angle and speed of the shot (input). After specifying these factors, the software program offers an answer (output) that determines the period of time of the experiment and the coordinates of the cannonball. The panel also provides the option of stopping the experiment at any time. This process allows for an opportunity to observe the experiment, for example, to analyze the position of the projectile (height and reach) at a given time and to verify the accuracy of the equations in reference to the oblique motion.



Figure 1 – Virtual Reality Setting

Another attribute of the panel is the help function icon which links the user to a tutorial system so that he can understand the mathematical and physical concepts related to the phenomenon in question. For this purpose, we used concept maps to organize and distribute the ideas in an interdisciplinary way and to eliminate the linear and uni-dimensional organization common to traditional teaching methods. The organization of the content in this way allows the students to perceive the relation between the mathematical and physical concepts as well as offer an integrated overview of the concepts involved in the phenomenon of oblique propulsion. In addition, we created a system of hyperlinks in HTML for each concept. The goal of this procedure was to manage the learning support service so that the students could identify the concepts they didn't understand and click on the hyperlinks to correct their conceptual errors.

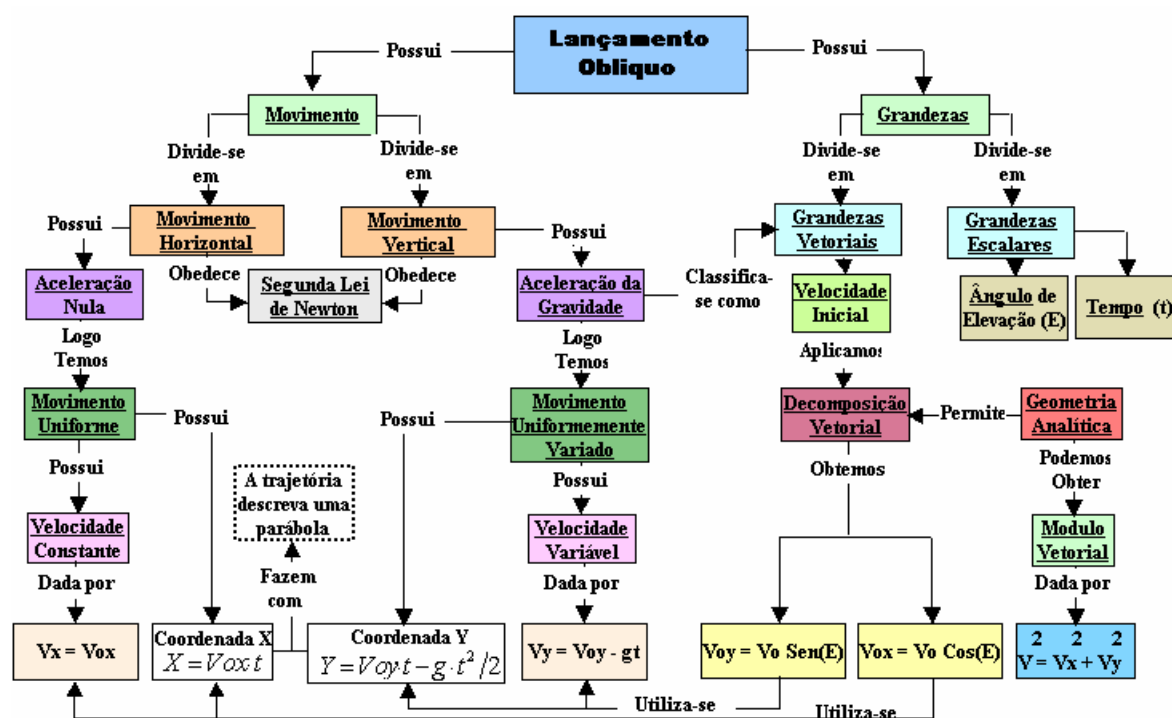


Figure 2 – Conceptual Maps for the Tutorial System

As technological support, primitive geometric figures were developed to model the solid geometric objects and, later, to attribute to these objects physical properties, such as transparency, reflection, texture, motion etc. The goal of these processes was to generate files small enough to be easily integrated into the Web. Further we used JavaScript to attribute movement to the virtual environment.



Figure 3 – Learning Setting of Virtual Reality

3 CONCLUSION

The development of this virtual environment prototype, through an interdisciplinary process, enriched both the project and the educational software product. This observation can be exemplified by the Engineering College which had previously developed educational software without pedagogical input. On the other hand, the Education College was able to put into practice cognitive and instructional fundamentals in a more innovative and far-reaching way due to this collaboration. Furthermore, we observed through this project the need to develop new immersive environments which guide the learning process toward problem resolution and cooperative action in a synchronized way.

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