TATI - A Logo-like interface for microworlds and simulations for physics teaching in Second Life

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Abstract
Student difficulties in learning Physics have been thoroughly discussed in the scientific literature. Already in 1980, Papert complained that schools teach Newtonian motion by manipulating equations rather than by manipulating the Newtonian objects themselves, what would be possible in a 'physics microworld'. On the other hand, Second Life and its scripting language have a remarkable learning curve that discourages most teachers at using it as an environment for educational computer simulations and microworlds. The objective of this work is to describe TATI, a textual interface which, through TATILogo, an accessible Logo language extension, allows the generation of various physics microworlds in Second Life, containing different types of objects that follow different physical laws, providing a learning path into Newtonian Physics.
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Extended summary

Student difficulties in learning Physics have been thoroughly discussed in the extensive scientific literature on the subject, accumulated since the 70's. Of particular interest to this work, is their general difficulty in distinguishing between the concepts of velocity and acceleration. See (Rosenblatt & Heckler, 2011) for a recent review.

Papert discusses how students trying to develop Newtonian thinking about motion have no direct experience of pure Newtonian motion (1980, p. 123), that is, of real objects that are totally free of forces so that they continue to move forever at a constant speed and in a straight line. The best thing schools can provide is the ubiquitous piece of physics laboratory equipment known as *air track* (or *air table*) where compressed air is used to exactly *compensate* friction and gravity forces providing a situation of *no net force*, what is not the same as being *free of forces*. Papert then emphasizes that, in the absence of *direct* and *physical* experiences of manipulating Newtonian objects, schools are forced to teach it by manipulating equations, a practice that lacks immediacy (1980, p. 123-124).

Displeased with this inefficient learning process, Papert proposed his *physics microworlds* (1980, p. 120-134), computer-simulated worlds where students would not only have direct access to Newtonian motion but also have the opportunity of playing with different alternative laws of motion, and even with laws of motion they could invent for themselves (1980, p. 125).

Far from being an unfulfilled promise attached to a specific ageing technology, Kynigos (2012) discusses how Constructionism is essentially an epistemology creating continual need for an evolving theory of learning in collectives and individually and at the same time a theory of design of new digital media. During these 30 years after Papert's proposal, the Logo language has been much discussed and there are various 3D virtual environments based or inspired on Logo among which SLurtles (Girvan, Tangney, & Savage, 2013) is probably the most recent one. However, while the emphasis in all these implementations is on Mathematics Education, mathematical representations are given very low priority by media designers (Kynigos, 2012) and, to our knowledge, there is no other microworld implementation which allows the experimentation with physical laws, as conceived by Papert.

While Second Life (SL) is a huge simulation of an Earth-like world and definitely cannot be seen as a mere game, there is a considerable learning curve in mastering its Linden Scripting Language (LSL), without which one cannot add interactivity features to the objects. This surely discourage most Physics teachers which probably will not be willing to invest so much time learning LSL only to build simple educational simulations.

Aware of these shortcomings, it was decided to build TATI, *The Amiable Textual Interface for Second Life*[*], which would translate simple Logo-like commands into the sometimes cryptic LSL commands that would generate objects following alternative physical laws. Papert (1980, p. 128) proposed a sequence of four types of objects: geometry, speed, acceleration and Newtonian Turtles. For compatibility, TATI should also be able to generate the two standard types of SL primitives, resulting in a total of six types of objects which are summarized in Table 1.

Table 1 - Correspondence between TATI objects and Papert's turtles and Second Life objects

In the same way as Papert extended the basic Logo language to add new commands for the new types of turtles (1980, p. 122), TATI offers its user *TATILogo*[*], an accessible Logo language extension to manipulate each one of the above objects. Being SL a 3D environment where rotations around all three axes are allowed, the commands *UP, DOWN, CLOCK*, and *ACLOCK* were included in TATILogo in addition to *LEFT* and *RIGHT*. For Newtonian objects commands such as *APPTORQUE* and *APPROTIMPULSE* to apply a torque (a rotational analogue of force that causes a change of angular momentum, usually in the form of angular accelerations) and an rotational impulse (the result of the application of a torque during a certain, usually short, time interval, such as in a collision or stroke), respectively, were included. Table 2 presents the application of each TATILogo command to the various types of object, according to their properties.

Table 2 - TATILogo commands allowed for each type of object available

TATILogo syntax, part of which is exhibited in Figure 1, has been intentionally made as simple as possible to make it easier for the user to interact with TATI.

Figure 1 - Part of TATILogo syntax

Besides creating objects following different physical laws, by using the parameter *object_shape*, the user can choose their shapes as well, from a set of *shape-objects* previously defined, such as cube, sphere, cylinder, cone, apple, and airplane. Other shapes may be easily included by the user in the *shape_object* list. The user can change their color through the *COLOUR* parameter or with the command *SETCOL*, from a predefined set of eight basic colors.

Examples of objects created by TATI are shown in Figure 2: a blue CUBE of NOROBJECT type, a PLANE of VELOBJECT type, and a yellow CONE of PHYOBJECT type, which is lying on the ground as it is subject to gravity.

Figure 2 – Examples of objects created with TATI

An interesting exercise is to try to do closed trajectories with the non-geometric objects VELOBJECT, ACCOBJECT and NEWOBJECT. In the first case, for example, the user will soon discover that geometric commands like *FORWARD* or *BACKWARD* are ineffective and in addition to having to use a 'velocity' commands like *SPEEDUP* to assign some speed to the object, she will also have to use *SLOWDOWN* to stop it before turning it over with *SPINUP* and also to stop it from turning, repeating the entire process as many times as necessary (Figure 3).

Figure 3 - TATILogo commands for a green VELOBJECT *plane realizing a square trajectory*

In the case of ACCOBJECT, successive accelerations will be necessary to put the object in motion and to stop it, thus approaching the concept of centripetal acceleration until the case of NEWOBJECT, in which a centripetal force will be needed.

TATI and TATILogo are in alpha test and final developments now, but will soon go to beta test by being released to a limited and selected group of volunteer users to perform usability and acceptance tests.

We believe that our sequence of object types accomplishes Papert's learning path and that TATI is the first microworld implementation which allows the experimentation with physical laws, as conceived by Papert, helping to alleviate students' difficulty in learning Newtonian motion. At the same time, we expect them to reduce the SL learning curve, enabling users to build simple simulations and microworlds in an easy way without being forced to enter into the depths of LSL programming and making such an interesting tool as SL available to a greater number of teachers.

[*] http://www.tatilogo.com/

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