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Theory Practice and Impact

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Preface

Constructionism 2012 in Athens carried on the tradition of the bi-annual meetings of the Eurologo community in Dublin (1987), Gent (1989), Parma (1991), Anavissos (1993), Birmingham (1995), Budapest (1997), Sofia (1999), Linz (2001), Porto (2003), Warsaw (2005) and Bratislava (2007) and Paris (2010). Our highly successful meeting in Paris in 2010 was characterized by the change in our title to 'Constructionism' in order to delineate our head - on addressing of and reflection on our constructionist epistemology on learning and using Logo-like digital systems.

It was also remembered for the broadening of learning domains from mathematics and programming to the arts. Permeating our discussions was the feeling that in 2012, it is time to look at and to question Constructionism in the future, to discuss the associated learning theory in a world where connections and integration is sought in a landscape of fragmented theoretical frameworks and constructs. What has constructionist learning theory to offer in our understanding of how and what we learn? It was felt that it is equally time to reconsider constructionism as a theory of pedagogical design and practice.

In a world where educational reforms and wide scale initiatives are becoming more pertinent and where curriculum materials and management systems crop up at unprecedented scale, availability and variety, how can constructionists have an impact? How can we make use of new media and how can we describe our designs and our practices to be convincing and relevant? The theme of our 2012 conference, 'Theory, Practice and Impact' was thus meant to reflect our on-going discussions and provide challenge for our meeting in Athens which we hope you all enjoyed.

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Creating motion models by manipulating parameters that correspond to scientific conventions

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Abstract

The literature in Science Education offers insights on how students' intuitions and everyday experiences interfere with their understandings when they attempt to interpret simulations of scientific phenomena. However, there is no much data about students' strategies when they work with simulations for which there are scientific conventions. Those conventions are likely to be outside the students' everyday experiences and far from common intuitions like the ones about force and velocity. Designing a microworld for simulating phenomena in 3d space, the conventions made are human inventions and don't make a one-to-one mapping to the language the students use in their everyday life. In this Report we describe students' activities as they attempt to create models in a microworld called the "3d Juggler". Two of the main parameters that control the behaviour of the models created in 3d Juggler are "shot azimuth" and "shot altitude".

Keywords

Meaning generation, students' strategies, models and simulations, conventions

Introduction

The Science Education literature offers insights on how students use their intuitions and real life experiences to interpret simulations of scientific phenomena (diSessa, 1993; Sherin, 1996, 2001; diSessa & Sherin, 1998). Designing, however, a microworld for simulating such phenomena, several scientific conventions are made. These conventions are highly possible not to adhere to students' intuitions and everyday experiences, just because they are human inventions, specifically made for the software's purposes.

3d Juggler (Kynigos, 2007) is a microworld (Figure 1) within which the students may create models for simulating motions and collisions in 3d space (Smyrnaiou et al., 2012). Apart from controlling parameters like Sphere Mass, Gravity Pull and Wind Speed, the students may also give their models behaviours that are defined by the "shot azimuth" and the "shot altitude" parameters. Shot azimuth and shot altitude are conventions, as they exist only inside the microworld and just because this is a 3d microworld and motion inside it can be defined in the X, Y and Z direction.

We asked students to create a model within 3d Juggler that would make one of the Juggler's balls hit a specific racket. As they addressed this "challenge", we focused on the strategies they devised for making sense of the "shot azimuth" and the "shot altitude" parameters and the effect these two parameters had on the models they were creating. Our aim was to evaluate our design choice to include in the microworld parameters that correspond to scientific conventions.

The 3d Juggler Microworld

3d "Juggler" is based in a game-like half-baked microworld (Kynigos, 2007). It is designed to offer students opportunities to explore and build models of 3d motions and collisions inside a Newtonian 3d space while playing a juggling game (Figure 1).

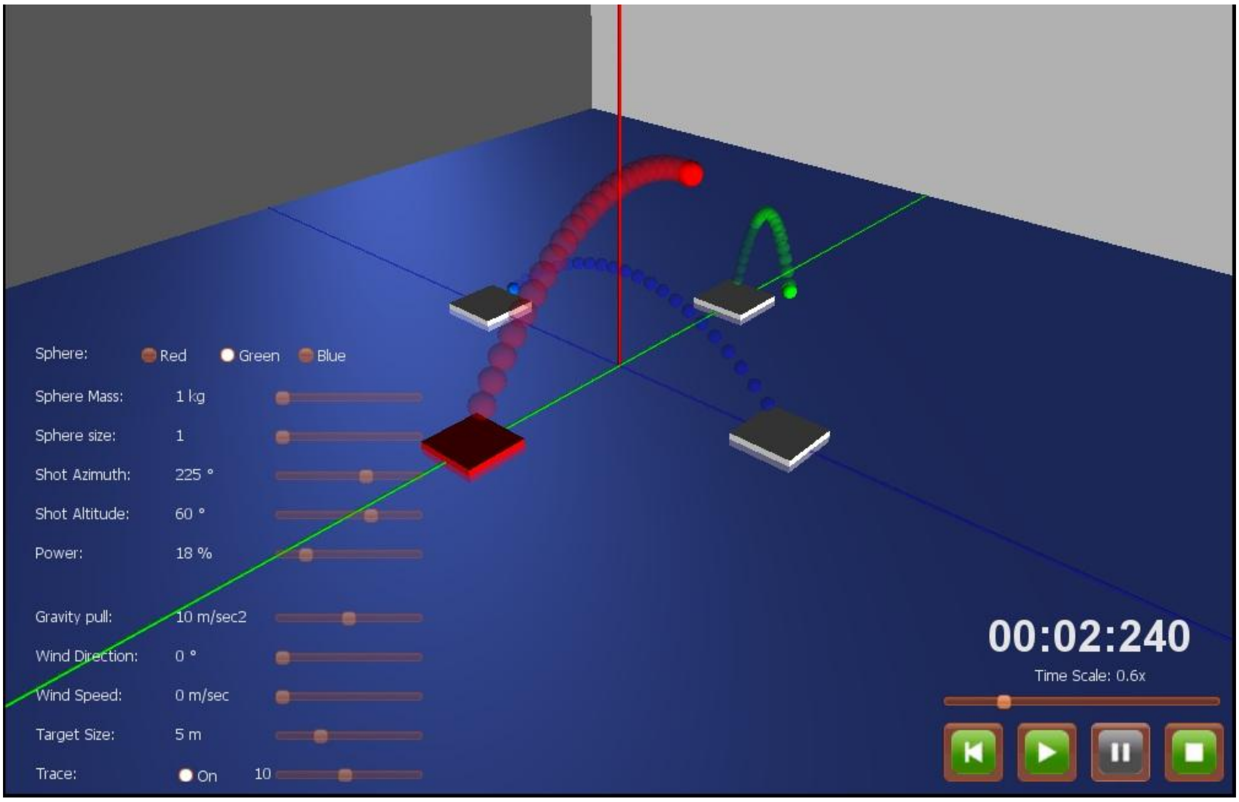

Figure 1: The 3d Juggler microworld

In order to play the game, the students need to first define the initial conditions for running the model that underpins the game. To do so, they have available: a) nine sliders - the sphere mass, the sphere size, the shot azimuth, the shot altitude, the power (corresponds to initial speed), the gravity pull, the wind direction, the wind speed, the target size, b) three balls - red, green, blue, and c) three different camera views for observing the simulation. The students set the values for each of the physical quantities involved by dynamically changing the sliders' values. Once the 3d Juggler game starts, the simulation of the model shows the balls launching in the air according to these initial conditions. If there is no wind (direction and speed), and the gravitational pull is set to 9.81 m/sec2, the balls move in projectile motion trajectories.

Research Design and Context of Implementation

The design-based research method (Cobb et al., 2003) that we employed, entailed the 'engineering' of tools and tasks, as well as the systematic study of the forms of learning that took place within the specific context defined by the means of supporting it.

The study was performed at the 2nd Experimental School of Athens (Ampelokipi) with four 7th grade Secondary School students (2 girls and 2 boys). At this grade, the students haven't been taught at school about motion in 3d space and haven't yet worked with projectile motion.

The three researchers that participated in the session collected data using a screen-capture software (Hyper-cam), a camera and tape-recorders. One of the researchers was occasionally moving the camera to all the Subgroups of students to capture the overall activity and other significant details as they occurred. Background data, like students' worksheets and observational notes were also collected. All audio-recordings were transcribed verbatim.

The students which participated in the Study were divided into two Subgroups. To get familiar with the 3d Juggler Microworld, we initially gave them a warm-up challenge and then proceeded to the main challenge. At the main challenge phase, the students were asked to create a model so as to make "the red ball hit the blue ball's base and stop its motion right there".

In analysing the data, we first looked for instances where meanings generation processes seemed to emerge as the students worked with the 3d Juggler microworld, creating, running and observing models of motions. In addition, we paid attention on how students manipulated the variables that correspond to scientific conventions made for the purposed of the software and used them to create models of motion in 3d space. Specifically, we looked at an excerpt of the students' work with the microworld in which they try to make sense of how the "shot azimuth" and "shot altitude" parameters affect the behaviour of the models they create.

Results

Students' strategies and meaning generation processes

After the introductory activity in which the main point was to get familiar with 3d Juggler, the students -working in Subgroups of two- were given a new "mission" to accomplish. As in 3d Juggler one may control the motion of three different balls starting from three different "bases", the students were asked to make each one of these balls hit another ball's base so as to gain game points. In this process, the students of Subgroup B come to build and experiment with an overall number of 18 different models.

Running and observing their first models, the students seem not to be able to extract any reliable conclusions as for which physical quantities they need to change or for what values to give so as to make their ball hit the racket. This confusion seems to appear as they students manipulate too many variables at the same time and fail to observe the outcome of their actions in the simulation generated. A novice researcher's intervention, leads them towards the direction of manipulating first the "shot azimuth" and "shot altitude" parameter.

The students' attempts to make "the red ball hit the blue ball's base and stop its motion right there", focus around giving specific values those two physical quantities. Still, however, the students' explorations seem not to focus on a systematic process of creating a model, observing and interpreting the outcome and rebuilding it according to the visual feedback.

After a while, they try out giving the exact same value to both shot azimuth and shot altitude. As this doesn't really work, they start giving characteristic values (such as 90°). The student's explorations at this point focus more on giving different values to the shot azimuth and shot altitude parameters and observing the changes in their simulation generated. Being more and more confident after each try out that this is the way to achieve the goal, they come to a first conclusion about the role of the shot azimuth and shot altitude in the represented phenomenon ("the shot altitude is about the height").

In the next models the students create, they seem to move away from characteristic values -like 90 degrees- and try out random values for shot azimuth and shot altitude (206° and 63°). Running models with random values, one of the students describes in detail the simulation generated and explains how the changes they made to the values caused the ball to "move to the left" (phenomenological description).

Since the goal of hitting the racket still hasn't been accomplished, the other student decides to increase the value of the “Power” quantity. “Power” is a parameter that -up to this point- the students have left completely intact. The first student, observing the simulation once again, disagrees with manipulating the “Power” parameter so as to achieve the goal and asserts that "it has nothing to do with the force".

Giving random values for only shot azimuth and shot altitude continues, but now it seems that the students consider that this is not enough, as they haven't managed to accomplish their goal. Having rejected the Power quantity, they try out the effect of the gravitational pull parameter. Reducing the value of the gravitational pull, the students run the model and observe the outcome. The researcher intervenes and reminds the students that “the experiment takes place on the Earth's surface and therefore the gravitational pull is constant and equal to 9.81 m/sec^2”. Similarly, when they attempt to change the wind direction and wind speed, the researcher reminds them that the challenge is not affected by “air conditions”. Searching for parameters the values of which they haven't changed yet, they decide to also test how the ball's size may help them achieving their goal. Once again, the interpretation they give to the simulation generated leads them to exclude the ball's size quantity from the set of parameters they need to manipulate to make the ball hit the racket.

As the researcher suggests once again that they should try to modify one physical quantity at the time, the students focus on shot azimuth and create several models changing the values for only this parameter. While building these models, the students come across the issue of increasing or decreasing the value of the shot azimuth for hitting the racket with the ball. Observing systematically, model after model, the simulation generated, they come to an understanding on what needs to be done to send the ball on the racket, implement it and explain how increasing the value for the shot azimuth brought the desired outcome.

However, as the ball doesn't stop on the racket, but falls over, one of the students suggests that they need to throw the ball applying less “Force”. As the new value for the Force parameter doesn't make the ball go as far as they had predicted, they increase it once more, eventually making the ball reach the racket and stay on it without rolling over.

In this excerpt, coming from the students' interactions with the 3d Juggler microworld, we attempted to identify episodes in which the students come to generate meanings about moving in 3d space. We focus on their strategies when it comes to controlling and manipulating parameters that don't apply to their intuitions and don't use them in their everyday lives to explain scientific phenomena. These strategies are revisited again and again as the students build models to test their ideas, run them to observe the visual outcome and rebuild them according to their understandings. Thus, it seems that those strategies feed meaning generation process as the experience the students gain from working with their models leads them to reconsider and gradually reshape the theories according to the new situations that rise.

Conclusions

The two Subgroups of students, both members of a common Group, are asked to work together so as to make in the 3d Juggler microworld “the red ball hit the blue ball's base and stop its motion right there”. Analysing the students' interactions as they work with the 3d Juggler microworld, we focus on their strategies for making sense of the “shot azimuth” and the “shot altitude” parameters and the effect these two parameters have on the models they were creating. In this process we identified strategies such as: “change one physical size at the time and observe its effect”, “give the exact same values to both parameters”, “give characteristic values, such as 90°, the two parameters”, “give random values to the two parameters”, “change the value of a third parameter”, “change/keep constant the gravitational pull on the Earth's surface”, “change/keep constant the wind direction and wind speed”. These strategies seem to feed students’ meaning processes, as the students test their ideas by running the models they create and observing the outcome of their actions and reshape their understandings accordingly.

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