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Inquiry based learning and meaning generation through modelling on geometrical optics in a constructionist environment

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Abstract
The central roles that modelling plays in the processes of scientific enquiry and that models play as the outcomes of that enquiry are well established (Gilbert & Boulter, 1998). Besides, there are considerable similarities between the processes and outcomes of science and technology (Cinar, 2016). In this study, we discuss how the use of digital tools for modelling geometrical optics supports meaning generation. More specifically, it tests: a) the role of educational software "Law of Light Reflection" in the generation of scientific meanings, b) the factors affecting this meaning generation and c) the extent to which integrated physical concepts, strategies, cooperation and verbal interaction affect scientific meaning generation. The research methodology adopted for the purpose of compliance with these three dimensions is design-based research which enabled us to investigate the effectiveness and the dynamic interaction of the tool with the specific cognitive skills. In this study, we used a specially designed of open-software for modelling on geometrical optics phenomena. The use of digital tools for modelling is studied from two perspectives: inquiry based science learning and scientific meaning generation of the interactive dialogic interaction among 6 students who were assigned to two focus groups, in a public elementary school in Athens, Greece. In this context, we focused on 5 dimensions of analysis that concern inquiry and meaning generation, based on dialogic instances during the described episodes.

Keywords: Digital Tools, Meaning generation, Modelling, Inquiry Based Learning, Microworld

Theoretical framework

Interconnections among Constructionism and Modelling
In this study, we focus on interconnections of constructionist approach and modelling in science learning. The constructionist model of teaching should start from the emergence of ideas of students, which is a familiarizing phase progressing to amend or reinforce them, the introduction of new knowledge and its' application to new situations and ends with metacognitive procedures (Kariotoglou et al., 2013). Various researches' results, based on constructivist model, showed positive impact in the reconstruction of student representation in a large number of science cognitive areas such as energy, forces, light, electrical and thermal effects, the kids, etc. (Koliopoulos & Argyropoulou, 2012; Osborne, 1983; Solomon, 1982).

Moreover, computer is a tool to build a world between the experimental and theoretical approach (Smyrnaiou et al, 2013). This idea is supported by the rapid evolution of ICT that not only expands greatly towards the available modelling opportunities for science learning, but dramatically transform traditional learning environments (Shen et al., 2014). Already, more than two decades before, Papert (1991) was arguing that students will have to develop complex mathematical problem-solving skills and physics, via computer use.

In this context, model construction is directly related with the constructionist theories of learning (Papert & Harel 1991), because in order to build an internal mental model for a phenomenon, students will have to construct an external representation or an artifact of the studied scientific phenomenon. Thus, by creating external representations, the individual is able to process internal representations or mental models of the phenomena (Papert, 1980). In this case, modeling activities provide an opportunity for teachers to have a better overview of the transition of students from an initial and perhaps "naïve" understanding of a scientific phenomenon to a more comprehensive and epistemologically acceptable understanding (Evagorou & Avraamidou, 2008). Moreover, as reported by Shen et al. (2014), teaching based on modeling is an innovative way of teaching and learning of science that encourages students to use, create, share and evaluate models, represent and explain scientific processes and phenomena.

In a constructionist environment, characteristics of teaching based on modeling which shows the following advantages: a) science learning based on modeling involves students actively participate in learning as they build, test and modify their own models (Schwarz et al., 2009), b) adopts means of representations and alternative models -including physical models- of digital visualizations, graphs, of mathematic formulas and models with human "role play", which creates a variety of choices for students with different learning styles and c) provides peer-learning community, as students build models together and evaluate alternative models in order to understand complex scientific issues (Gilbert & Boulter, 1998; Papert, 1991).

Considering to these characteristics, we tried to associate Constructionism and Modelling approaches (Figure 1). We see that these two approaches have much in common, since they are based on the idea of building an artifact (model) from the students themselves, which encourage group collaboration learning through the provision of various representations, which students have the ability to modify and reconsider exchanging views among themselves on the hidden elements of the natural phenomenon of examination. As therefore observe, building models paralleled by creating microworlds through peer work, while the variety of models are shown with rich representational environment microworlds in meaning generating and understand complex scientific topics from modeling side.

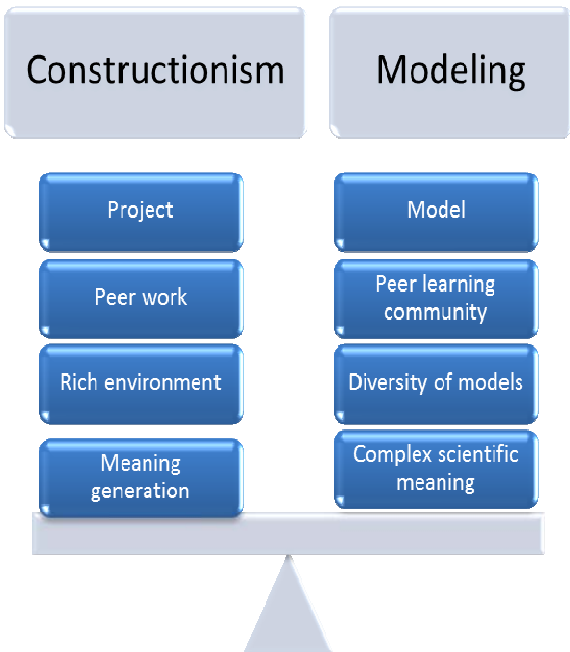

Figure 1. Association among Constructionism and Modelling approaches

Modelling and Inquiry Based Science Learning

Inquiry is the way in which scientists work, and the activities through which students learn both the scientific concepts and scientific processes (Barrow, 2006; Bybee, 2006). On science learning inquiry has two versions. Firstly is a means for learning of science content and secondly a learning objective, which requires the exercise of skills of scientific inquiry and reflection for scientific meaning generation (Waight & Abd-El-Khalick, 2007).

As far as science learning is concerned the "Course of Inquiry", can be used as introduction and utilization under the Information and Communication Technologies in teaching - learning process, focusing on the promotion of alternative forms of experimentation, investigation, building knowledge, expression and communication for students and teachers (Glezou & Grigoriadou, 2009). For that reason, primarily microworld open exploratory software and database management systems are writing and application environments tools for the development, management and investigation of a digital microworld (Glezou & Grigoriadou, 2009). In this case, the E-slate software package works as investigative software with which students have the opportunity to engage in introductory exploratory activities on Geometrical Optis phenomena. In addition, while carrying out the inquiry activity, students were divided into groups of 2-3, actively participate in the teaching - learning practice, collaborative working in front of their computer screen. Consequently, students learn to work as scientists; they learn to ask questions, observe, plan investigations, collect information, analyze and interpret data and to construct explanations which communicate to the community.

In this study we aim to the following skills that students will need to develop during an effective science teaching based on inquiry: Firstly, the ability to design and interpretation of experiments to draw conclusions in relation to the role of a variable in the behavior of a system, which is standard procedure of Science (Boudreaux et al., 2008). For example, through the digital artifact "Law of Light Reflection", students are involved both in the design and the interpretation of geometrical optics. Secondly, learning how to use scientific models or construction and revision models and therefore, understanding of the science is removed from initial/ hypothetical aspects (Chinn & Samarapungavan, 2009). In this case, we see that through construction and review activities of the original models made by students there is a creation of inductive aspects, which contribute to scientific meaning generation. Consequently, the combination of investigation and data modeling activities in science learning can significantly enhance the achievement of such objectives. The use of models and modeling activities support inquiry in the educational process, since in this way the students are able to cope with the model as a research tool, and introduced to the scientific method (Psillos, 2011).

Modelling in science learning

An essential part of scientific activity consist the modification, the validation and the reconstruction of a model (Dimitracopoulou & Komis, 2005). The cognitive process followed by the design principles of a theory in order to produce a model that represents a physical object or a phenomenon, a system or a process called "development of a model" or "modeling" (Hestenes, 1987; Papaevripidou, 2012). The role of modeling as an inquiry learning process has proved very important, because it strengthens the reasoning process of students and improves the understanding of scientific concepts (Smyrnaiou & Dimitrakopoulou, 2007). This process is further enhanced by the use educational software (Smyrnaiou & Evripidou, 2012).

Justi and Gilbert (2002) described four characteristics which should be present in each model: a) be partial non - unique representation of an object, event, process or idea, b) can be changed, c) enhance visualization, to simultaneously develop creativity and understanding, to make predictions about what behaviors and properties and d) be acceptable to many and what behaviors and properties and e) be acceptable to several social groups.

Apart from these features, the new conceptual change models have emphasized over the cognitive factors that influence the conceptual understanding, emotional, social/environmental and motivation factors. In particular, recent models for conceptual understanding emphasized the students' motivation and their epistemological beliefs about the edification of knowledge (Pintrich, 1999). To develop interest and motivation of students, researchers have proposed a number of new teaching practices that incorporate creative actions to motivate students by motivation theories such as the theory of self-determination (Dede, 2004). In addition, modeling as a kind of inquiry, enables research in science to "escape" from the attachment to achieve conceptual change for its own sake and to consider extensive cognitive and epistemological aspects related to learning through modeling (Papaevripidou , 2012).

Modelling in Science Education is considered a very important learning process and the subject of study in educational research. In teaching practice, modeling is an approach when used as a platform through which students are helped to develop an understanding of the content, procedures and epistemology of science through manufacturing, control, review and research validation models for phenomena or complex systems (Evagorou & Avraamidou, 2008). Windshitl et al. (2008) report that successful teaching contexts that use modeling as a teaching approach should involve students in a variety of activities including:

- Dealing with a problem or question
- Develop of a model or test case for relations identified in the studied phenomenon
- Carry out systematic observations to examine the accuracy - the validity of the assumptions made
- Create models for the phenomenon which is consistent with prior observations
- Evaluate model with criteria of usefulness, the predictive power and explanatory adequacy
- Revision of the model and applied to new situations.

In this study, we attempted to design and implement a synthetic model (Vosniadou & Brewer, 1992) which is a special category of a constructed mental model, which attempts synthesis between alternative self-perception (intuitive model) and scientific models proposed by the instructor. The premise of this theory is founded through the combination of both cognitive structures of Piaget and symbolic interference of Vygotsky, who led Vergnaud (1994) to propose a general theoretical framework that relies on the ability of a person to understand and interpret the situation, to communicate, to make predictions and interventions (Smyrnaiou & Kynigos, 2012). In this theory, mental representations are cognitive structures underlying meaning generation. These mental representations guide the subject's activities. Accordingly mental representations have dual origin: activity and cognitive structures of the subject (Weil - Barais, 2001). Therefore, through the interaction with suitable modeling software mental representations of students turned into action, which enables them to interpret, understand, communicate and eventually generate scientific meanings (Vosniadou, 2009).

Designed Microworld – E-Slate Platform

For the purposes of this study, we designed a special software using the development platform - E-Slate, which is an authoring package for construction of exploratory educational software for different subjects. By using software units as building blocks (generic components), the designer can move onto the coupling reasoning of the two axes approach: 'Black-and-White Box' approach (Kynigos, 2007). In this research, we used as main component the “Turtle World”, which is a symbolic expression tool for mathematical activity through planning to build and tinker dynamic graphical models (Yiannoutsou & Kynigos, 2013).

The Microworld "Law of Light Reflection” is an attempt to link science learning through the interactivity of new technologies which enhances the role of the teacher. In this series of activities, students are involved with the programming component of Turtle World, trying to connect optical phenomena with geometry (geometrical optics). During these activities, students have the opportunity to determine the environmental capacity, through reflection, discussion, negotiation and initiative. In this way, students are involved in long access to the software structure and generate scientific meanings on geometric optics. The software “Law of Light Reflection” (Figure 2), focus on the capacity to move from general to specific scientific meanings. The activities of the software correspond to the function of a "half-baked Microworld" created in a constructionist environment which is offered for investigation and argumentation (Kynigos, 2007).

The pedagogical value of the software design is that it is the construction tool adapted to students needs primary emphasis both in initial students’ ideas and the epistemological knowledge promoted through modeling. As reported by Dimitrakopoulou & Komis (2005), the interaction with a computer model, which is clearly structured and practical, providing the opportunity of clarification and crystallization of scientific concepts. Also, educational software should correlate multiple representations to support scientific learning through a semantic knowledge network staff (Smyrnaiou et al., 2014). In this study, we developed multiple modeling software that combines many types of model building.

The general characteristics of the " Law of Light Reflection” are the following:

- Initial modeling to express personal representations.
- Setting "situations - problems" that contains training scenarios to be simulated - modeled (in this area the teacher can modify the scripts).
- "Notepad", which is available to the student to record notes from the initial modeling, simulation until the final stage used as a tool that fosters metacognition.
- Information - Material, associated with the ideas, concepts and the scientific research conducted in the "Light" phenomenon, from ancient times until today.
- Special links multimedia content and collaboration sites, where students will have the opportunity to exchange views on the situations - problems encountered in modeling conditions. (In this case, due to the chip connection failure of the "Navigator", has created a special area for cooperation in a specific site in which students alongside the microcosm) will interact.
- Planning Area in the language Logo in the "Microworld", which allows the creation of a graphic model potential associated with the laws of geometrical optics, namely the "law of reflection".

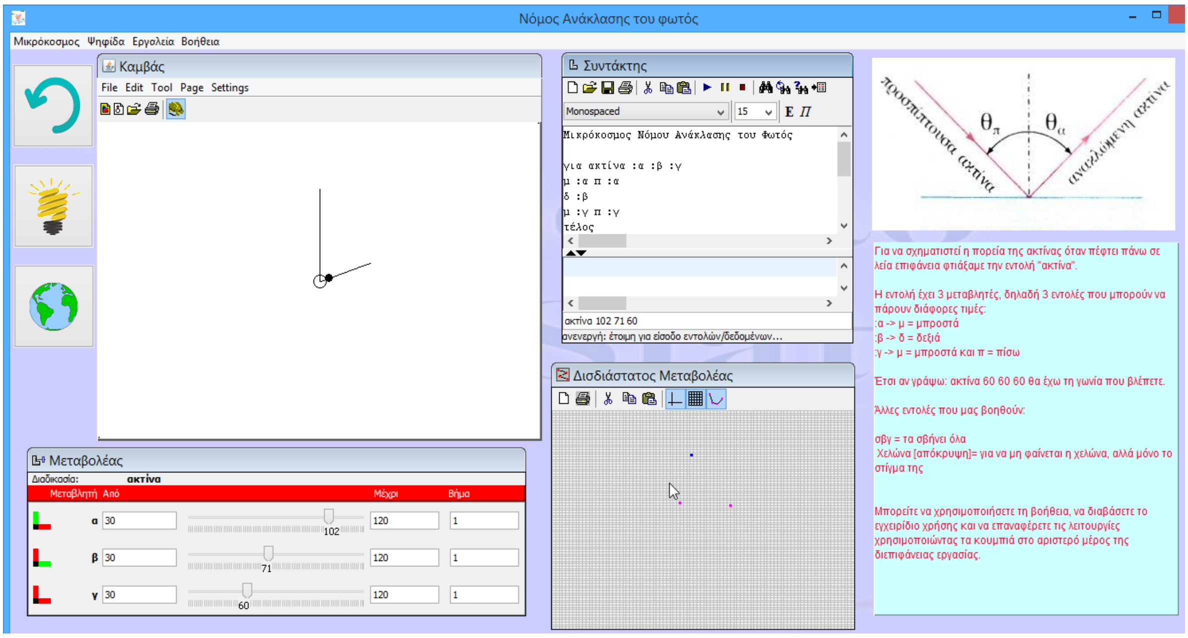

Figure 2. Microworld "Law of Light Reflection"/ E-Slate Platform

The Study

Research design

In this study we use methodological tools of 'designed based research', which is a relatively new research approach that lies between the empirical research and design experiments of human activity in real settings. According to McKenny & Reeves (2013), the Educational Designed Based Research (EDBR) is a kind of research in which the scientific research field based on iterative development and practical solutions to complex educational problems. The solutions can be educational products, processes, programs or policies. However, EDBR not only aims to solve major problems of education professionals, but also trying to discover new knowledge that can be communicated to other professionals with similar problems (Kelly et al, 2014).

This research framework is suitable in the classroom because during the implementation of the research, students were engaged in interactive activities with the use of digital tools. Based on the general methodology of EDBR, this study mainly focused on the difficulties faced by students to generate scientific notions about the phenomenon of geometrical optics phenomena. Fundamental steps of this research are described in figure 3. The first step concerns the identification of the problem, which is about the difficulties of scientific meaning generation in primary school education. For that reason, the design of technological tools that are aimed at creating conditions for the expression of initial views of students to the transformation of scientific knowledge through involvement in modeling activities.

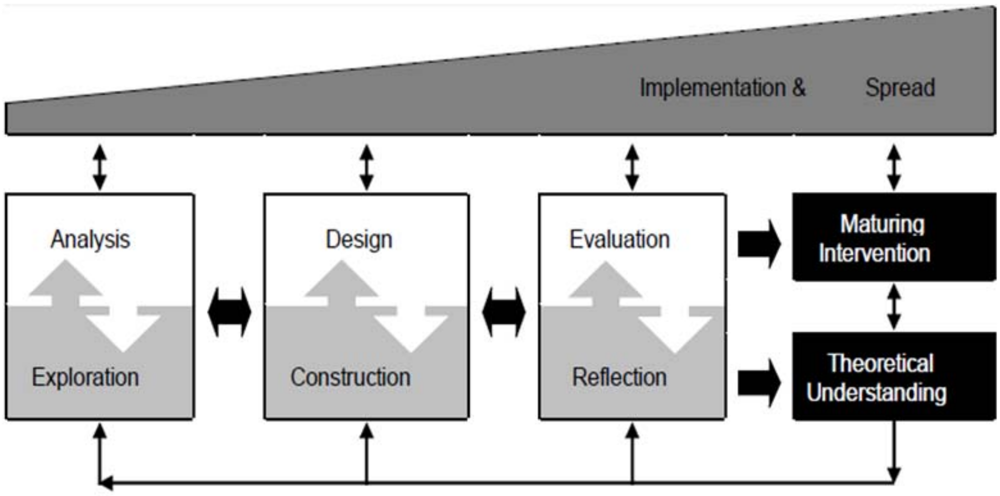

Figure3. Educational Designed Based Research Diagram (McKenny & Reeves, 2012)

Researcher and six 6th grade students, the teacher of the classroom of a public elementary school in Athens participated in the study. The implementation took place in the school pc lab during school science activities, for 3 sessions of two teaching hours each. Students were not novice users of logo like environments, such as E-Slate, so a preparation session was needed. In the time of the study, students had been taught about light, but not geometrical optics. They were separated in two groups and they had the opportunity to communicate with each other too.

Task Analysis

The survey was conducted in the school computer lab and class of students and lasted about 6 hours of teaching. During the first hour of the first session there was plenty of time on discussion in order to create a more intimate atmosphere between the participants and the researcher. The second teaching hour, the researcher gave explanations on the activities to be followed by the students, and a brief description of how the use of software. At the end of the introductory phase, students had time to engage with the software and ask some questions about the functionalities of use of tools, while researcher was able to give a detailed report about the processes. In this way, students - participants were aware of the purpose of this research, as well as for selecting the particular sequence of activities, which differ greatly from the traditional way of teaching the lesson of physics at primary school.

Then, in carrying out the second phase of the activities, students had the opportunity to initially engage with geometrical optics simulation software "Law of Light Reflection", which is an introduction of students to mathematical formalism of physics through planning activities using logo language.

Data Collection Method

The method used is the "triangulation" of research data. The triangulation is a technical research and basically it is a way of ensuring the validity in qualitative research and can be described as the use of two or more methods to collect the data. The triangulation may have several benefits for the research results. More specifically, by utilizing multiple methods found different, additional questions or enhanced interpretive ability. They can be used and quantitative methods are combined with quality will give the best possible result, "by controlling a qualitative method with results of the quantitative method or vice versa» (Wellington, 2015).

For these reasons, for the collection and consolidation of data, which will enable support for research questions of this study were used three tools: a) the products of the interactions with the educational software "Law of Reflection of Light", b) technological Hypercam support, through which recorded verbal interactions, and pupil reactions these articles and c) specially designed research protocols on evaluation of the software, the learning process and the creation of meaning on the test field.

Complementary to these tools, participatory observation is an important dimension for the collection of data, since the observer is able to collect "live" data from real situations. The researcher, ie, able to spot see what happens and not as secondary data (Cohen & Maagen-Nagar, 2016). This allows researchers to understand the context of its activities, to open and operate inductively, to see things otherwise unconsciously would escape them, to discover information about which participants would not speak freely in an interview, to go beyond from data on perceptions and access to personal knowledge (Munir & Prem, 2016).

In this research, special focus is given on the students' dialogue interactions throughout the sessions, as well as the interface of students with artifacts of computing environment which involved. For this reason, we used the following means for collection of survey data:

- Participant observation as a literal recording and analysis method directly accessible externalizing behavior data.
- Screen-capture software Hypercam 2, for filming verbal information and movement at the interface of the computing environment.
- Three research protocols, structured on the basis of the theoretical framework and the three research questions raised.
- The resulting composite-products produced by the interaction of students with the use of software and the researcher's field notes on them.

Analysis Categories

In this study, we present a sample analysis of data gathered from both focus groups and correlated with the analysis sub 5 basic dimensions. The dialogic interactions include data from inquiry based learning, constructionism, collaboration skills, scientific content, scientific language of science and scientific argumentation. The analysis categories were based on the theoretical framework, as well as from empirical data of this study. For each of the dimensions mentioned above there are the following categories:

1st Category: dialogic interactions affected / expressed by Inquiry Based Science Learning [IBSE]. In this dimension, the analysis categories are: Question [QUEST] Solution [SOLU] Test of a solution and improve it [TESTSOLU] Results Analysis [RESU] Conclusion [CONCLU] Share Information [SHARE].

2nd Category: dialogic interactions affected / expressed by constructionism [CONSTR]. In this dimension, the analysis categories are: Create Microworld / model [CREATEmcw] Degradation of Model [DEGRmcw] Change the value of a slider [CHANGEvalue], change the measure and the angle [CHANGangle] Modification of Concept [MODconcept] Modify Object [MODobject] modification of a correctness Instrument [MODcor], Feedback Rating [FEEDrate] Help Search [SEARCHelp].

3nd category: Dialogic interactions affected / expressed by scientific content [sciCONT]: In this dimension, the analysis categories are: intuitions / initial representations [INrepresant] actions description [DESCact] concepts [CONC] relations [REALAT].

4th category: Dialogic interactions affected / expressed by the scientific language [sciLANG]: In this dimension, the analysis categories are: scientific concepts (verbs, essentially, objects) [SCIconsc], everyday words instead of scientific [EVwords].

5th category: Interactive interactions affected / expressed by argumentation [ARGU]: In this dimension, the analysis categories: argument [Arg] explanation [EXPL] question [QUE] claim [CLAIM] duties [DUT] connection [CON] support [SUP] opposition [OPP].

Results

The activities focus on modeling interactions within the software: "Law of Light Reflection" in E-Slate Platform which is a half-baked Microworld for modeling geometrical optics. In the following episodes, students argument through their engagement with the software.

Episode 1: Interactive/dialogic interactions affected / expressed by the inquiry.

S2: We have to try making the angle as in the picture?
S1: We must create them equal to each other, but have to find how...
S2: Let's move them (sliders) to see what is right?
S3: To make them one by one, to see what happens.
S2: Correct... We can write them in the right side, as before...
S1: Yes certainly, but let's look at this [...] with these two sliders we can wiggle both sides
S3: We want to open the corner, so...
S2: We should move it (slider variable angle). [...]
S1: This will probably create the proper angle; the other two do not play any role.

In this episode the three students of the first group interact with the software "Law of Light Reflection". They try to model the path of the beam which is incident on a smooth surface. The inquiry based learning category [IBSE] of this project begins with the creation of question [QUEST], as to the steps to be followed for the construction of the model: "We have to try making the angle as in the picture?" "We must create them equal to each other, but have to find how ". It becomes clear, therefore, that students wish to explore this subject in an attempt to find the correct method. Then a solution proposed [SOLU], which constitutes the first step of their actions: "Let's move them (sliders) to see what is right?" followed by a second case where an alternative appears to intervene in orders of Logo language: "Correct... We can write them in the right side, as before..." Followed by testing of this solution and improve it [TESTSOLU] by moving sliders representing the three variables and analyze the results [RESU] saying: "Yes certainly, but let's look at this [...] with these two sliders we can wiggle both sides". Finally, they conclude [CONCLU] and share the information [SHARE] that slider that moves the variable of angle will lead to the desired result: "This will probably create the proper angle; the other two do not play any role".

Episode 2: Interactive/dialogic interactions affected / expressed by constructionism

S4: We have to make the angle as shown us here...
S6: We have to write: [radius 60 60 60] and carried through.
S5: If you put something else; for example [Radius 45 0 45]
S4: It is better firstly to put the mouse here to display the sliders.
S6: We can write here if you want ... Let's see what happens ... [...]
S4: No ... it is wrong, let's do it again! Press [svg (= delete)], then again [radius 60 60 60].
S5: Yes, okay. Now;
S4: Dangling the sliders... change one, the other (sides) and it opens.

S5: We need the slider that opens angle ... to create the proper angle.
S6: So we found it; the same width of beam should be on both sides.
S5: See what next ... one angle should be equal to each other… but on the side.
S6: Can we turn it?

In this episode, students of the second group are engaged with the activities of the software "Law of Light Reflection" by interacting with the working interface of the particular constructionist environment of Logo Language. In this dimension, special focus is given in both creation and degradation of the model by changing the price of sliders which represent sides and angle. In particular, we see that students are attempting to create this model as a microworld [CREATEmcw], according to the given image of the Law of Reflection: " We have to make the angle as shown us here..." [...] "We have to write: [radius 60 60 60] and carried through", while, simultaneously, there is an attempt of degradation [DEGmcw] of the model by changing the values of the variables and the angle [CHANGEvalue]: "If you put something else; for example [Radius 45 0 45]". Besides, we observe important interactions on changing the value of a slider, and change of the measure and the angle [CHANGEangle], because students seem to vary quite often these variables in order to create the desired model: "It is better firstly to put the mouse here to display the sliders." They also result in the modification of the object through the dimension of the angle [MODconcept]: " Dangling the sliders... change one, the other (sides) and it opens", but modifying the correctness of a relationship [MODobject] after unsuccessful application: " No ... it is wrong, let's do it again! Press [svg (= delete)], then again [radius 60 60 60] ". Then, through the feedback they receive when moving sliders, they have feedback [FEEDrate]: " So we found it; the same width of beam should be on both sides" Finally, in this dimension, students seem to search for help [SEARCHelp] on the left part of the working interface where imaging of light reflection law is shown: " See what next ... one angle should be equal to each other… but on the side”.

Episode 3: Interactive/dialogic interactions affected / expressed by scientific content/ language

S2: Is that shape, we have done a triangle?
S1: We have to draw an angle as we it is shown in this the image ... right?
S3: Yes, the first angle is an angle of incidence and the other one is the reflection angle and they are equal.
S2: So if we have to adjust the width of the angle, in order to be equal.
S3: Yes, they have equal degrees, I guess.
S1: Sure, you will just have to figure out that there is a dichotomous line that separates them…

In this episode we can distinguish a short dialogue of three students of the first group at the end of the activity. Students are at the end of this phase and they discuss about the interactions they had with this software in connection with the scientific content of the specific scientific content of the digital tools they used. We can distinct that, due to the young age of students, they have difficulties in accurately record the scientific dimension of the studied phenomenon, students engage in interactive their interactions affected by intuitions or their initial representations [INrepresant] which are related to geometry, which leads to a first introduction to the mathematical formalism with respect to the phenomena of geometrical optics "Is that shape, we have done a triangle?". Then, they describe their actions concerning the scientific content [DESCact]: " We have to draw an angle as we it is shown in this the image ... right?”, while there is and a clear statement of basic concepts [CONC] when S3 says: "Yes, the first angle is an angle of incidence and the other one is the reflection angle and they are equal”. In this statement S3 presents the relations [REALAT] of two forms of rays in a scientific manner. This scientific context is complemented by the statement of S2: "So if we have to adjust the width of the angle, in order to be equal”. At this level, based on the analysis category "Interactive interactions affected / expressed by the scientific language, we distinguish both scientific concepts and scientific language [sciLANG] like "dichotomous, incidence, reflection" which are including in the common everyday language [EVwords] they used during the activities.

Episode 4: Interactive/dialogic interactions affected / expressed by argumentation

S1: This slider you moved before […] Maybe we need it now. What do you think?
S2: In order to make the right angle we have to think about how to turn it vertically.
S3: I don't think that you need that, because we did before and it went wrong. We have to create equal angles.
S2: How can we understand it?
S1: From the numbers we have here ... it needs half of 60, so 30.
S3: Let's try it.
S1: Ok, I did it ... After showing that falls on the surface; on the other hand there is a radius with equal angle. What we said before, right?
S2: Well, let's check it out again. Okay…

In this episode, students of the first group, after many tests and feedbacks, end up discussing and arguing over the creation of incidence and reflection angle of the beam engaging with the software. In this dimension, we find that S1 created the query [QUE] about which variable they should choose to create the model of the beam impinging on a smooth surface: "This slider you moved before […] maybe we need it now. What do you think?, followed by the explanation [CLAIM.] in how to move properly the slider in order to model the beam: " In order to make the right angle we have to think about how to turn it vertically". In this proposal S3 interferes and opposes [OPP] that the incidence and reflection angles should be equal and they should follow a different approach: "I don't think that you need that, because we did before and it went wrong. We have to create equal angles". After this fruitful contrast, S1 supports [SUP] this by saying: "From the numbers we have here ... it needs half of 60, so 30". Finally, it is very important that in this aspect students manage to connect various meanings through their mutual engagement in dialogue interactions argument: "Ok, I did it ... After showing that falls on the surface; on the other hand there is a radius with equal angle. What we said before, right?"

Discussion

This study objectives are focus on scientific meaning generation, while interaction of students with open-software of modelling. Through the analysis of the episodes above, we are able to discuss the main dimensions of the creation of scientific meanings:

In the first episode students were engaged with inquiry based method (questioning, create a solution and test to improve) during their interaction with the computing environments due to use open-software, which cause users to negotiate within the team. This gives more emphasis on the learning process rather than the final result.

In the second episode, it appears findings concerning the constructionist elements of the software use, as children strongly focus on degradation interactions, change and reconstruction microworlds / models. It should also be noted that these digital tools are not configured on a linear and specified process. Therefore, students should follow a process which has no clear-cut right or wrong steps but it upon communication and negotiation -with digital tool in mediating role- to co-decided rationally steps that will lead to the successful completion of activity.

During the third episode, we see that students are able to build cognitive content with an interactive way while their trying to create the model "Law of Light Reflection". Scientific language is combined with strategies, cooperation and verbal interaction between students motivating the creating scientific meanings on the scientific phenomenon. Finally, in the fourth episode interactive interactions expressed by argumentation are declared through students' discussions, which, after many tests and feedbacks, drive to arguing over the creation of scientific meaning of the Law of Light Reflection.

The results of this study demonstrate that the interaction of students with modeling software was instrumental in our main objective in creating scientific meanings on geometrical optics. The engagement with a open-software which is based on different representation manage to involve students in conducting research while they build original scientific models. Besides, students groups showed great interest for the expression of their individual opinion through argumentation, which worked well in the factors of collaboration and interaction with the digital tool. At this level, it should be noted, that the main motivation and enhancement factor as the original ideas of students and exported scientific meanings was the engagements with the software "Law of Light Reflection".

In conclusion, we can see that the use of the constructionist environment of "Law of Light Reflection" which associates modelling in logo-based open software, contributed significantly to scientific meanings generation on geometrical optics. They also proved particularly important concepts negotiated through the cooperation of the students during their interaction with the modeling and simulation software based on assumptions through inquiry based learning approaches.

At this level, the qualitative results of the analyzed episodes strengthened the assumptions to determine the factors that influence meaning generation (physical concepts involved in software, strategies followed by the students, cooperation between them, verbal interaction of students) and the importance of the built-cognitive content of software and mediation and interactive way of viewing, concerning the creation of scientific meanings. Finally, we could also support the learning efficiency of the use of computer constructionist for modelling environments, as an enhanced, pedagogical and cognitive, supporting framework of the teaching practice of Science Learning in Elementary School.

The limitation of this study is that the implementation of these activities should be further explored as a pilot in various schools to confirm the resulting findings as to the possibilities of using modeling software to create meanings of primary school students. It would also be helpful to intergrate other theoretical and research approaches of New Technologies in teaching science that starts from the town or even in kindergarten and ending in secondary education, even in Higher Education.

Concluding this study, we point out, therefore, that it would be very interesting the implemented research study to be associated with similar future studies in order to improve and complete under most objective, weighted criteria, focusing in-depth on the parameters that motivate learners a creative cognitive penetration of linguistic structure, through the computing environment of the Microworld to fully understand the size and dynamics of this manipulation of information.

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