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IMPROVING THE EDUCATIONAL PRACTICE USING SIMULATIONS IN SCIENCE EDUCATION: THE CONTRIBUTION OF ALTHUSSER'S THEORY ON THE COGNITIVE PROCEDURE

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Abstract:
This article discusses the relationship between the theory of Louis Althusser concerning the subjectivity of knowledge and the cognitive process and the effective use of educational computer simulations during Science Education and Science Teaching. Our first aim is to highlight the aspects of the cognitive process – according to Louis Althusser's theory – that should be considered by teachers when they opt to utilize computer simulations in their classroom teaching in the subject of Science and Physics. Our second aim is to suggest ways in order to overcome the conceptual ambiguity, the misunderstandings and the misconceptions that sometimes students form while using simulation models on the computer. The research question being investigated here is the following: "What kind of learning outcomes might the use of computer simulations have concerning the acquisition and construction knowledge by students in the course of Science and Physics in the light of L. Althusser's theory and *what* could teachers do so as to eliminate the potential risks of their use and to achieve better outcomes in the learning procedure?". The utilization of computer simulations in Science Teaching sometimes make students think that the simulated object or phenomenon is identical in nature with the real one. However, the simulations do not constitute the "real objects" themselves; in contrary, they are the means to come closer to reality in order to study it thoroughly.

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1. Introduction

The utilization of computer simulations in classroom within Science Education has come to a great development the last decades (Chandler, 2004· Mnguni, 2014· Thisgaard & Makransky, 2017· Thurman, 1993); now also in Greece (Jimoyiannis & Komis, 2000· Kalkanis, 2010· Komis, 2004). However, there is little research on an international and national level investigating the effects of utilization of computer based simulations during Science Education and Science Teaching to the personal construction of knowledge (Chandler, 2004· Jimoyiannis & Komis, 2000· Mnguni, 2014· Thisgaard & Makransky, 2017); even smaller is the amount of research that is concerned of the philosophical aspect of idea development as regards to the acquisition of knowledge, the subjective perception and the complex nature of cognitive processing of information which relates to the field of cognitive psychology (Dunnington, 2014· McKinney, 1997).

This paper is being constituted under the framework of Louis Althusser's theory concerning knowledge and cognitive process (Althusser, 1996). The first purpose of this paper is to point out the aspects of the cognitive procedure –according to the theory of Louis Althusser- that teachers have to take in consideration during the use of computer simulations in the classroom and, particularly, in Science Education. The second purpose is to suggest educational solutions so as to overcome the obstacles that simulations sometimes have. The total overview of Althusser's theory concerning knowledge and cognitive procedure results in certain conclusions that are discussed. The way by which Althusser's theory is applicated in Science Teaching and, especially, while utilizing computer simulations is analyzed; particularly, we focus on the interplay between simulations as educational tools and educational-learning process, on the interpretation and the subjective perception of students concerning what simulations represent. This paper does not present primary data but having an interdisciplinary approach between Cognitive Psychology, Pedagogy, Science, Science Education and Philosophy of Science; it combines the recent and older data leading to a multilevel understanding of the issue. The research question that arises is: "What kind of learning outcomes it is possible that the computer simulations have on students' knowledge acquisition and construction of knowledge in the lesson of Science in the light of Louis Althusser's theory and what can be done to eliminate the danger of their use in order to lead to better learning outcomes?".

2. Louis Althusser theory about knowledge and cognitive procedure

The theory that was developed by Louis Althusser regarding the cognitive procedure is referred to the relationships that are developed between the individual and the real object which is under processing. Althusser claims that the "possession" of a real idea, namely a belief by an individual brings on the following outcomes:

a) The production of other ideas (according to the rule of the first one);
b) The certainty of the real being of this idea;

Consequently, the idea itself constitutes a drive lever and a generating force that determines what it may follow: the idea is the starting point so as to put forward other assertions (Althusser, 1996). The individuals are already ready subjects to acquire knowledge before they understand the subjectivity of their perception, because their formation as individuals is former to their perception (Bazzul, 2014: 425· Middleton, 2005). Afterwards, the individuals acquire knowledge for themselves (Batens, 1996).

In order to elaborate on the nature of knowledge, Althusser uses part of Marx's theory about knowledge "production", proposing as such the "idea of knowledge as production" (Althusser, 1996: 465). According to Marx, knowledge moves on from abstraction to specificity and in no ways conversely, because knowledge resides "in thought", whereas the real object that gives the stimulus is outside of the thinking process (Lewis, 2014· Vratsalis, 2002: 210). The real object has a precedence comparing to the object of knowledge and "the [cognitive] procedure from abstraction to specificity does not produce the real object"; instead, it **produces** knowledge about the real object (Althusser, 1996· Makrakis, 2014). Based on Marx, Althusser concludes to a segregation of great importance, namely between **"real object"** and **"object of knowledge"** (Hirst, 1976· Makrakis, 2014· Sotiris, 2006). This segregation comes to an agreement with the perception of imaginary-symbolic function of being, according to which, man started to express a new world, differentiated from the "real" one that is perceived with senses: the world of fantasy, this one of the "object of knowledge", which has been transformed into it after the real object has been processed by the subject (Kechagias, 2009: 88· Makrakis, 2014).

The fact that the real object exists regardless to the thinking process, namely the conceptual procedure of knowledge production (Garagounis, 2013: 92), is opposite to the "special feature of learning procedure", where while it is being processed, there is a production of ideas, drawing on representations and senses (Makrakis, 2014· Vratsalis, 2002). The result of this cognitive procedure is the **"knowledge of the specific real object"** (Althusser, 1996), therefore there is a clear distinction between the real object and the cognitive procedure (Hirst, 1976). Althusser deduces that the produced knowledge concerning the real object remains independent of the spirit (the knowledge is embedded in a transformation that is not related to the real objet but to the subjective experience) and the thinking process "before and after", namely the cognitive procedure. The produced knowledge which is originates from the human mind, therefore the spirit, cannot be characterized as natural, it does not exist, that is "the meaning is not identical to the referenced objects but refers (potentially) to them" (Kechagias, 2009: 88). This point of view contradicts that one of the existence of "ideal/mental/imaginable objects" (the objects of knowledge); the second one claims that the objects of knowledge possess their own existence and participate into the formation of the world (Kechagias, 2009). In conclusion, since the cognitive procedure does not change the real object, and since it is done entirely in the thinking process– and not in the real object- this means that the thought of the individual is working on another "raw material", the real object itself. The cognitive procedure and its subject influence the real object that is under investigation (Kechagias, 2009: 215), incorporating the produced knowledge, resulting in a newly real object that "radiates this incorporated knowledge as it is actually its own" (Garagounis, 2013).

It is rather obvious that the cognitive procedure is not characterized by passivity; instead, it is an **active relationship** (Batens, 1996: 14). Since the individual interacts with the real object so as to produce knowledge and it acts inducing changes in the reality, a relationship is formed between them that affects the individual's perception of reality, which of course ends up being subjective (Batens, 1996· Vratsalis, 2002). In this way, the concepts are formed ("the specific of the thinking process", namely the object of knowledge that is not related to the real one) (Kechagias, 2009· Kokkotas, 1998). The "object of knowledge" is formed by the way that the individual makes their own the real object (Makrakis, 2014: 69). Althusser claims that the cognitive procedure is a living organism in a perpetual cyclical procedure (Vratsalis, 2002: 208), only if it is continuously reproduced, seeing that "only the production of new knowledge keeps the old knowledge alive" and only in this way we come closer and closer to the objective reality as exactly it is (Kokkotas, 1998), without ever being able to reach it completely (Batens, 1996). Finally, it is obvious that the relationship between the individual-observator and the real observed object is dynamic and under continuous transfiguration and evolution (Kechagias, 2009: 119).

2.1 Use of simulations in Science Education

Before we deal with the utilization of simulations, it would be useful to make a distinction between the terms: visualization, simulation and modeling. The term "visualization" is used to generally state the development and use of media (e.g. graphic representation, images) in order to make something visually **understandable** (Komis, 2004· Mikropoulos, 2011). An is widely used example of visualization is Google Maps. Essentially, within visualization, the data we want to be transmitted are represented in pictures through which comprehension is easier (Komis, 2004). The noticeable difference between visualization and simulation is that, in the first one, it is possible to represent data through images, but it is not possible to manipulate and change these data, as it is possible is simulations. (Kalkanis, 2010· Komis, 2004).

According to Kokkotas (2004), simulations are the result of man's attempt to interpret their environment, but also to be able to predict the evolution of phenomena being studied, especially when he cannot gain direct access to them (Mnguni, 2014· Komis, 2004). In this way, man creates mental representations or mental models, whose fundamental characteristic is that they are artificial but simultaneously realistic (Dunnington, 2014: 15· Husain, 2010: 2) and they visualize the reality approximately. Simulation models' main purpose is the ideal imitation or representation of aspects of reality with the greatest proximity that can be given to it (Burbules & Linn, 1991· Crapo, Waisel, Wallace & Willemain, 2000· Komis, 2004). The static character that simulations initially had is avoided by creating and using more dynamic and interactive simulation models, broadening the educational potential for their use (Chandler, 2004· Jimoyiannis

& Komis, 2000: 185· Mikropoulos, 2011). The noticeable difference between simulation and modeling –even though sometimes they get confused (Jacobson & Wilensky, 2009: 21)- is that, in the first one, there are some variables of a constructed model which can be handled and modified, whereas in the second one, the individual creates the model on its own (Eskrootchi & Oskrochi, 2010: 238· Komis, 2004· Komis et al., 2011). Consequently, the term "simulation model" comprises of the constructed models on which the student-user is urged to act by using lots of possibilities and choices on offer (e.g., see Huppert, 2002).

As new and open educational environments (Jimoyiannis & Komis, 2000: 185), simulations enable the user to understand the functions of the system which is studied, to discover new aspects and to study the gradual evolution of a phenomenon, to apply measurements of from real experimental data and see the results, to change the variables and make comparison between different situations but also to evaluate their effects in comparison with reality, and to develop initiatives for the evolution of the simulated system, not by responding to a set of closed-type questions but to their own questions (De Jong & Van Joolingen, 1998· Eskrootchi & Oskrochi, 2010· Huppert, 2002: 803· Husain, 2010· Jacobson & Wilensky, 2009· Kalkanis, 2010· Kokkotas, 2004· Komis, 2004). Simulations' basic characteristic is the possibility of the individual who learns to use the model to interact with the system (e.g. device, process) under study (Mikropoulos, 2011). Computer simulation models of the natural world constitute methods of studying a system (Komis, 2004), support exploratory and discovery learning (Eskrootchi & Oskrochi, 2010· McKinney, 1997· Komis et al., 2011· Soulios & Psillos, 2013) and help the student understand functions of the world that which are not accessible through direct experience and observation but only using computer (Husain, 2010· Jacobson & Wilensky, 2009: 21· Komis, 2004· Mikropoulos, 2011: 290· Chalkia, 2008: 165), for example, the composition of matter at microscopic level or are very complex, time-consuming or expensive for a laboratory environment (Dunnington, 2014· Husain, 2010· Moore & Thomas, 1983). The above advantages contribute to the connection of the educational tool of simulations with the constructivist approach, which sees the student as an active individual during the process of building their personal knowledge (Husain, 2010).

In addition, we have to point out the inherent advantage of simulations as regards to the safety they offer to the user, which in a real system is not fully assured, for example in chemical experiments, in the learning of handling an airplane (Husain, 2010· Komis, 2004· Mikropoulos, 2011: 286) or during the familiarization with the human body under clinical conditions (Dunnington, 2014: 16). Apart from the cognitive content, educational simulations enable the user to acquire specific skills such as academic and scientific skills, 21sr century skills and visual literacy skills (Mnguni, 2014). Computer simulations enrich the educational procedure and allow the user to experiment on a system or phenomenon which approaches the real world without actually having real contact with it (Thurman, 1993· Komis, 2004· Chalkia, 2008).

Simulation programs have two possible versions (Kalkanis, 2010· Chalkia, 2008):

a) **Reproduction:** Using animation techniques, procedures and phenomena (whose evolution is determined randomly on the basis of the natural laws that have been defined in the program and is statistically predicted) of the natural world are reproduced on the computer (reflective processes-relationships, see Kalkanis, 2010: 113· Komis, 2004). The result is the creation of a "virtual reality" (Kalkanis, 2010) which approximates the objective reality. The reproduction version of the simulations is often referred to as a "model" (Komis, 2004).
b) **Representation:** Again, using animation techniques, processes are represented through the copying of the reality, as it is introduced in the computer program (non-reflective processes-relationships, since they are simple visualizations).

2.2 Cognitive procedure and use of simulations in Science Education

According to Vratsalis (2002), sometimes the use of simulations in Science Education brings on students' impression that what is simulated as real (the "homonym") is identical in nature and importance to the real object itself, resulting in a kind of regeneration of the reality or the creation of another, new, hardly questionable reality (Dunnington, 2014· Turkle, 2009). Moreover, students may consider that the simulation is the reality on a much smaller scale (Chalkia, 2008). Such a belief can make students believe that the simulation has the ability to accurately reflect the reality and that, since they can alter the variables of the simulation (Komis et al., 2011: 120), they can therefore control and possibly reconstruct the real, natural data (Vratsalis, 2002). By focusing on the identification of variables and the relationships created between them, the student is disoriented from the educational purpose and fails to construct the concept of the simulation model as an exploratory learning tool (Soulios & Psillos, 2013). Under these circumstances, the student identifies the real object with the object of knowledge (namely, the simulated object that is processed by the student). The simulation model ends up in being the real object-target of knowledge that is simulated and constitutes the main scheme of the formed experience (Baudrillard, 1983: 149· Dunnington, 2014: 16· Chalkia, 2008: 165). Thus, the process of acquiring knowledge is hindered, since students have difficulty in accurately interpreting and evaluating the various simulation models presented to them (Kuriakopoulou & Vosniadou, 2013). The result of this process for students is the difficulty in understanding, the superficial comprehension which also disorientates the teacher, as they think that the student has acquired the required knowledge, and the creation of misconceptions which do not correspond to objective reality (Mnguni, 2014). In the long run, the student consequently goes away from real knowledge; the simulation model is established in the individual's perception as a "fait accompli" (Turkle, 2009).

However, the simulation is ultimately just one –the more reliable and approximate to reality- controlled representation of the real object to which students have to focus (Eskrootchi & Oskrochi, 2010· Husain, 2010· Kalkanis, 2010· Chalkia, 2008). Simulations simplify reality as much as possible, omitting or changing details of the real object (Husain, 2010: 3). This is obviously the case, because we necessarily have to focus pupils' attention on some key concepts of the knowledge, which we want them to acquire and are clearly and adequately presented (i.e. as a "good condition"[ii]) in the simulation model. Yet, while the fidelity of human body simulations has increased significantly (Zygogianni et al., 2012), the complexity and authenticity of human reactions that are qualitatively different from the simulation system cannot be presented totally and reliably (Turkle, 2009 in Dunnington, 2014). The manipulations the student can make on the simulated human body and the representation of its reactions are subject to mathematical laws; they are the product of predetermined and mechanical feedback and they do not correspond sufficiently to the more unpredictable and demanding reality (Dunnington, 2014· McKinney, 1997: 600). Automatized reactions reduce the sensitivity and flexibility required so that the simulation model corresponds to reality (Waks, 2001). In addition, when students handle the variables of the simulation model, they manipulate the model itself and the "potential" world it contains, but not the real object (Komis et al., 2011: 120· McKinney, 1997: 600). The fact that a simulation may not accurately describe the situation studied (and this is logical because reality is always at least a bit short) and that no simulation model can be totally concise (Komis, 2004· Komis et al., 2011) should be taken into account by the teacher who has to try various methods in order to inform students about the nature of the simulation, so as to avoid confusion with the reality (Mikropoulos, 2011: 291).

According to Batens (1996: 220), the place of interest in the educational procedure is the mental process the student followed to get to a certain result. This mental process is of major importance (Tzani & Kechagias, 2009: 37), because only if we understand it, we will approach the personal knowledge construction of the individual, to which we will aim in order to achieve the desirable cognitive change (Chalkia, 2008). Furthermore, if students come to understand their own learning process, then they develop their metacognitive skills, and therefore they are introduced in the learning pillar of "learning how to learn" (Tzani & Kechagias, 2009: 41). Thus, we cannot justify (and evaluate) the cognitive process based on the result produced; in contrast, we should justify the outcome, looking back on the cognitive process.

However, what kind of knowledge is constructed when during the cognitive process there is a misidentification of the individual and what kind of results in their perception of reality, thus what kind of relationships do individuals finally build when they have embraced this distorted perception of reality (Baudrillard, 1983· Dunnington, 2014: 17)? If students perceives the simulation as an absolute reflection of real object (surreal, according to Baudrillard, 1983), that is, as if seeing the real one, it is possible that any desire to approach the real object of knowledge during life course be reduced, because they consider they have acquired it through the presented simulation. It is also equally likely that the student form misconceptions for the real object of knowledge and, especially, for these features that were not of great importance in the lesson, because they were not key-concepts so as to understand the phenomenon (Chalkia, 2008: 166). In this case, the teacher and the student have to look back on the cognitive

[ii] Kechagias C., 2016.

process that the second one followed in order to reflect on the ways the simulation relates to reality.

The learning procedure is not just a mental process where the individual processes their original ideas, based on reality, and aims at the conceptual formation of this reality. On the contrary, the learning process involves an increased degree of complexity displaying the "production of the object of knowledge" (Vratsalis, 2002), the building of communication relations between individuals and material learning objects as well as the redefinition of the individual itself after the production of new knowledge and the adoption of new ideas that differentiate the individual's cognitive state from its previous one. Therefore, the subjective perception of the individual –as a complex biopsychosocial system (Mylonakou & Kekes, 2011)- is co-transformed by the communication relations that develops with the other individuals who possess the knowledge and the other elements of the learning environment each time (Batens, 1996). The individual generates the required knowledge but also produces social relations that inevitably determine it in a way unique (Charlot, 1999˙ Vratsalis, 2002). The fact that we do not perceive reality –in our case, what is said to be the "real object" is the simulation- all in the same way creates this momentum in the cognitive process (Batens, 1996).

Finally, according to the categorization of kinds of "mixed" reality by Mylonakou & Kekes (2011: 308), we could say that the computer simulation models belong in the category of absolute "virtuality", where "physical reality assigns its place to a fictitious state" in which the student-user submerges. That is, simulation models posses a potential (virtual) character, since they are placed within a "potential" environment. In the light of a historical-philosophical approach, we could say that the nature of the simulation models is closely linked to the Aristotelian but also the exactly opposite Platonic approach concerning the representation of the reality (Dunnington, 2014: 16· Mylonakou & Kekes, 2011). Just like in the Platonic myth of the cave, as in the context of a simulation model, students can plunge into an adequate and misleading reality experience, whereas they actually experience the reflection of the reality (Dunnington, 2014: 16). On the contrary, Aristotle's[iii] point of view is that the representation is an absolute expression of the process of *mimesis*, which leads to the acquisition of the true knowledge and experience of the reality (Dunnington, 2014: 16).

2.4 Suggestions for an effective educational procedure in the use of computer simulations in Science Teaching/Education

It is evident from the above that the design of suitable dynamic computer simulations can only be carried out by examining closely the knowledge process that takes place in human mind (Chandler, 2004). Research has shown that an overly interactive environment can ultimately be dissuasive for the learner because the cognitive load that needs to be acquired is too much (for working memory and as well as the transport and

[iii] The Aristotelian approach is the main philosophical influence that led to the creation of simulation models (Dunnington, 2014: 16).

storage of information in the long-term memory). Thus, when selecting a simulation to be utilized in the classroom, the teacher should consider whether it meets the following **conditions** (Chandler, 2004):

- having a specific target, a skill the student needs to acquire
- taking into account the student's previous knowledge and build on it gradually
- enabling the user to control the amount of information (cognitive load), being flexible
- taking into account the normal limitations of working memory (Crapo et al., 2000), especially for students with weak working memory (Papadatou-Pastou, 2015)
- taking into account and integrating the findings and research data of cognitive psychology, according to which computer simulations in the classroom are suggested to be used in combination with other teaching methods and educational tools. A starting point for this should be the need to develop critical skills and the ability to understand the reality, with the ultimate goal of holistic approach to knowledge through a dynamically evolving cognitive process (Tzani & Kechagias, 2009: 41).

Of course, we do not claim that the use of simulations in the educational procedure and, especially in Science Education, has no benefits for students. Instead, we argue that their utilization can enrich traditional teaching (Thisgaard & Makransky, 2017· Rutten, van Joolingen, & van der Veen, 2012) and bring on better learning outcomes (Akpan, 2001· Dunnington, 2014: 19) and a better understanding of reality, helping students to overcome their cognitive barriers and change constructively their misconceptions (Jimoyiannis & Komis, 2000), as long as their role, purpose and nature are determined and their use is clarified to students from the beginning in order to avoid misunderstandings (Kokkotas, 2004). In particular, students' interaction with simulations regarding complex phenomena may reveal any misconceptions and misbelieves created and, thus, multiply the opportunities to modify and cope with these misconceptions (Jacobson & Wilensky, 2009· Rutten et al., 2012). Therefore, the teacher has to focus on students' epistemological awareness of simulation models (Dunnington, 2014· Snir, Smith & Grosslight, 1993· Soulios & Psillos, 2013).

The comprehension of a phenomenon can be supported by simulation models (e.g. the microcosm model for teaching the concept of matter, see Gkikopoulou et al., 2016), provided that the teacher explains to students that each model and every simulation is characterized by some conventions, such as the fact that it does not fully reflect reality; it simply approaches it in a much more complete way than the use of traditional methods such as static representations, and that it is an effective method in order to develop their critical skills (Chalkia, 2008· Soulios & Psillos, 2013). Science Education can be substantially supported when the teacher uses simulations as educational equipment or as a means of verification of a phenomenon the class is studying, allowing for additional interaction with the teacher and direct feedback (Komis, 2004). The use of a single educational medium for the study of a variety of different phenomena is not a one-way course: depending on the phenomenon being studied, the simulation might or may be the appropriate or inappropriate way for its investigation (Komis, ibid).

Educational computer simulations should not replace or substitute **direct observation** of the reality and **experimentation**, where possible (Eskrootchi & Oskrochi, 2010: 243· Kalkanis, 2010· McKinney, 1997· Tzani & Kechagias, 2009: 42). Simulation models are not the actual "real objects" we want to know but only the means to come closer to them so that we can study them thoroughly (Chalkia, 2008). The way scientists perceive models is very different from the way models are perceived by students, who have not yet developed totally their ability to visualize abstract concepts; students -due to age and maturation- think more statically and concretely, while they have not yet developed their critical skill so as to evaluate alternative approaches (Dunnington, 2014: 18). That's why children possess alternative ideas (misconceptions) concerning natural phenomena that are inconsistent with scientific principles and current scientific knowledge (Jimoyiannis & Komis, 2000). Children sometimes ignore the feasibility of a simulation –namely, the fact that it serves the human need for discovery- and the probability of reversion and change of the simulation model if new research data arise or even the possibility of simultaneous existence of two different models for the same phenomenon due to different views within the scientific community (Chalkia, 2008· Kuriakopoulou & Vosniadou, 2013· Soulios & Psillos, 2013).

Teachers have reevaluated their role so as to continue to constitute an irreplaceable factor in the educational process (Tzani & Kechagias, 2009). Consequently, teachers have to ensure that they do not put their faith in only the use of computer simulations for effective teaching and learning (Eskrootchi & Oskrochi, 2010). On the contrary, they have to utilize them logically with certain educational purposes, designing structured students' interactions (Eskrootchi & Oskrochi, 2010) and also utilizing other various educational media and teaching methods to ensure that knowledge is acquired by the students and to get as closer as possible to reality (e.g. through experiments, see Kokkotas, 2004).

The clear description of a natural phenomenon or a process is more familiar to the student when the teacher has the ability to approach gradually the issue of Science the classroom is studying without having set from the beginning as an 100% positive answers to everything" (Batens, 1996), because not all the students have the same starting points concerning their conceptions or misconceptions (Chalkia, 2008). Contrarily, it is suggested that the teacher use a variety of frames and media so as the students get to the desirable educational goal and the knowledge is not fragmentary and detached from reality (Dunnington, 2014: 20). In this way, the clarity and preciseness as regards to the explanation and the mental representation of a phenomenon are increased. Additionally, the teacher can incorporate in the educational procedure hands-on activities which offer direct feedback in relation to the learning outcome (Chandler, 2004). The incorporation of hands-on activities keeps up to the need of experiential learning which has to be enhanced (Stefanopoulou, Tsatiri, Koumzis, 2017: 47) in all school lessons. During the use of simulations, the teacher could become the facilitator who encourages the constant effort of the student to get a little bit closer to the real knowledge (Tzani & Kechagias, 2009: 36).

Furthermore, the teacher has to ensure that students have adequately understood the differentiation between:

a) objective reality ("real object" according to Althusser's theory);
b) simulation that seems to incarnate the "real object" (reproduction or representation) but by all means it is not, it just approaches it;
c) conceptual framework with which we result in constructing so as to reach true knowledge (cognitive procedure according to Althusser's theory).

In the end, what is qualified concerning the learning outcome is that the students have appropriate experiences in order to build concepts rather than just the use of computer simulation (Soulios & Psillos, 2013). That is, the production of substantial learning experience is not due to the simulation itself but due to the critical and analytical thinking, the advent of cognitive conflict in students' minds and the discussion guided by the teacher who uses the appropriate teaching questions (Chandler, 2004). In order to surpass the reservations regarding the uses of computer simulations in Science Education, the teacher may take into account the guidelines proposed in the international literature concerning their effective use (Chalkia, 2008· Kiriakopoulou & Vosniadou, 2013· Soulios & Psillos, 2013):

- emphasis on the limitations of the simulation model used in the classroom
- a holistic approach to knowledge
- enhancement of students' ability to reflect on different scientific beliefs about the same phenomenon or the same situation
- utilization of the historic-genetic method in Science Teaching
- conscious development of reflective and metacognitive skills of students

According to the above, it is suggested that the teacher should pay particular attention during the educational procedure in teaching the "strengths and weaknesses" of the simulation model used when pupils study a natural phenomenon (McKinney, 1997: 599· Soulios & Psillos, 2013: 724· Turkle, 2009). Epistemologically informing students about the limitations as well as the perspectives of the simulation model will help them fully understand that the simulation simply duplicates reality and is not identical to it. In addition, the use of various and/or alternative models, each of which presents and focuses on different aspects of the same phenomenon, reflects the holistic approach of the knowledge we want students to acquire and enables them to address the whole issue under study (McKinney, 1997: 599). The integration of the historic-genetic method during Science Teaching involves the contact of students with the development and evolution of all theories, interpretations or mental models (simulated or not) that are proposed to date so as to explain a phenomenon (Soulios & Psillos, 2013). More specifically, the utilization of History of Science in Science Teaching has already given positive results so that students achieve the learning objectives and be aware of the fact that a scientifically acceptable theory about a natural phenomenon is apt to change if new research data that overturn the older scientific assumptions arise (Bliss, 1994· Skordoulis, 2008). In conclusion, the teaching methods concerning the development of metacognition and skills of cognitive regulation of students, for example the observation and evaluation of the practices used by simulations and are related to their nature, function and purpose, contribute to the conscious development of reflective and metacognitive skills (Komis et al., 2011: 122). These metacognitive skills will also help students to comprehend the theoretical nature of simulations (Kiriakopoulou & Vosniadou, 2013). Stimuli for the development of metacognitive skills can be discussions through teaching questions like "How do we know that this is a good model?" (a model that corresponds adequately the reality), "What if the model [the Newtonian force laws] is finally incorrect?" and "Are there alternative competing models?" (McKinney, 1997: 598). In this way, students develop their critical thinking, using information from the field of Philosophy of Science and Epistemology (McKinney, 1997).

3. Discussion

The conjunction of the suggestions for integrating the computer simulations in Science Teaching with Althusser's theory as regards to how knowledge is acquired, how it is subjectivised through the ideas, as well as the possibility to use the research data of the cognitive information processing (from the field of psychology) can have extraordinary learning outcomes to the acquisition and construction of knowledge by students in Science Education. The "production" of the knowledge for the "real object" is radically separated from the cognitive procedure, since this process is dynamic, potent and energetic through constant interaction with the individual. Teachers' contribution is crucial since they firstly have to intervene during the learning procedure by clearly distinguishing the simulated model from the "real object"; secondly, they have to control "what" and "how" students understand contributing in this way in the clarification of their interpretative approaches. We suggested specific criteria of utilization (or not) of simulations in the educational procedure, as well as milestones which can practically help teachers be effective in their educative function in Science Teaching. In order to actually achieve a substantial educational outcome, we have to take into consideration many further elements, as there is a need for an appropriate content regulation and adaptation to the cognitive ability of students of each class, appropriate teacher training and careful designation of a program that will give clear directions through structured, creative and critical activities that will frame the simulation techniques used in the classroom.

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