USING A SOCIOCULTURAL APPROACH IN TEACHING ASTRONOMY CONCEPTS WITH CHILDREN OF PRIMARY SCHOOL

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Abstract

This paper describes the use of a social collaborative learning approach to teach astronomical concepts. We used a repeated measure design to test the effectiveness of a teaching intervention aimed at improving basic concepts of Astronomy. Results show that children after the didactical experience were able to give a detailed explanation of the acquired knowledge. These results suggest that the approach adopted is fruitful and helps children to learn and understand scientific concepts, revisiting their pre-existing knowledge, often influenced by naïve explanations.

1. Introduction

Several studies highlighted that primary school age children often build their scientific concepts of the physical world on the basis of their own everyday experiences (Brewer et al 2000; Ehrlén 2008; Miller & Brewer 2010; Plummer 2009; Stathopoulou and Vosniadou 2007; Vosniadou et al 2004; Vosniadou 1994; Vosniadou and Brewer 1992). Some of children's Astronomy ideas are (Kallery 2010; Skopeliti and Vosniadou 2007): the "Earth is flat" (children imagine the Earth shape as a disk); the "Earth is hollow" (the earth is similar to a rectangle or to a sphere). Yet, children think that some natural phenomena can represent negative events. They consider, for example, the passage of comets as negative events or premonitory signs that warn people about possible dangers or disasters. Another common children misconception concerns the day/night cycle, which they attribute to the Sun anthropomorphic quality (Kallery and Psillos 2004). The authors claim that children have the idea that during the day the Sun "lives" like a normal being and then, in the night, it "goes to sleep" (as ancient people believed).

A deep understanding of scientific concepts requires that children significantly learn and share both theoretical and practical skills. Hence, to encourage this conceptual attainment, teachers should design educational settings able to stimulate the students' mental activity to analyse problems and then to apply "creative thinking" strategies. The main idea of this approach is to stimulate children to learn from direct experience without restricting the didactical potentialities of the scientific exploration. Furthermore, learning is more productive when children are exposed to the socials interactions, where language, group discussions, collaborative and cooperative work, and tools' use play an important cognitive function (Vygotskij 1986). There enhances reflection and helps learners to build well-grounded and shared scientific concepts.

Although the research on children's ideas remains an important field of inquiry into the astronomical education as a whole, many questions associated with the cognitive processes involved in knowledge acquisition and concept learning are still unanswered. We can summarize these aspects as follows: 1) is it possible to restructure the pre-existing children's misconceptions regarding Astronomy concepts? 2) What is necessary in order to improve the traditional educational settings to teach Astronomy concepts in a productive way? A common aspect of the aforementioned factors concerns teacher modalities to deliver scientific concepts.

In this study, made in a recent academic year, we tested the effectiveness of teaching intervention, which was based on "sociocultural learning" (Vygotskij 1986). We used a repeated measure design to compare teacher and investigator treatments. The last one emphasizes the role of "social learning theory" as a good didactical strategy to teach Astronomy topics. The instructional material was organized with the intent to motivate children learning interest, facilitating their mental elaboration of the information presented. Specifically, we argued that Astronomy concepts are not difficult to learn. Nevertheless, it is important to identify appropriate didactical methods that help children to better understand scientific ideas. Therefore, we also argued that children astronomical knowledge before treatment session was affected by naïve ideas. We expected that when applying the sociocultural learning approach to the treatment session, children would improve their astronomical understanding.

This paper is organized as follows: in the next Section we describe the aim of the current study; then, in the "Procedure" Section, we present the design and the procedure adopted in developing the current research. "Results" of the pre- and post-tests assessments follow. Finally in the Section "Conclusion" we present the outcomes of the study.

2. Aim of the Study

The purpose of the present investigation was to examine the effectiveness of a sociocultural didactical approach with the support of cognitive tools, aimed at teaching Astronomy concepts. Children and teachers were actively involved during the educational and didactical sessions. The main idea was to create a productive learning context, where teacher and children work cooperatively. It is widely agreed that "learning" is not merely an individual process, since a more complete cognitive result can be achieved when social and cultural aspects are taken into account (Iiskala et al 2010).

We designed and used traditional didactical materials and multimedia contents oriented to attract students' attention and interest. By applying this didactical approach students were able to share ideas, make inferences, and they identified relationships among concepts, rather than exchanging information without a concrete direct experience.

3. Method

3.1. Participants

The participants in this study were twenty-two Italian children (10 males and 12 females), aged between 9 and 10 years (M = 9.8; SD = 0.35), took part in this study. They attended two fifth-grade classes of a Primary School in San Lucido (Cosenza, Southern Italy). For the study purposes, all the didactical activities took place in each single classroom, respectively. We did not use a preliminary test to measure children's cognitive abilities. Students participated in this study after having obtained a written consent of the School Director. The children sampling took into account the previous studies that showed different examples on how children learn Astronomy concepts (Brewer et al. 2000; Kikas 2003; Vosniadou & Brewer 1992).

3.2. Study Design

We used a repeated measure design to test the effectiveness of the sociocultural didactical approach (Vygotskij 1986). In this study, pre-test session represents the control condition and the post-test the experimental one. The proposed study design includes the Mathematics and Physics schoolteacher's suggestion, which wished that all children received the same astronomical concepts delivered through the proposed didactical approach. This educational approach was also coherent with the objectives and the guidelines of the Italian Primary School curriculum. In order to control the student's learning progress, we used different evaluation methods, such as graphical representations, questionnaire and social learning activity. Participants were individually tested except for the cooperative educational activity.

The twenty-two-grade students, attending the primary school, received the same basic teaching on the shape and rotational movement of the Earth and Sun, the day/night cycle, the seasonal changes, gravity, meridians, and parallels. We introduced these concepts in the fifth-grade primary class since during the research children have already completed the educational programme (according to the Italian Education Minister curriculum) that included the learning of astronomical concepts.

Before starting with the direct educational activities children were pre-tested by using a multiple-choice questionnaire, in order to evaluate their initial knowledge about specific astronomical phenomena. Schoolteachers examined the students' learning by using this type of test. Thus, we avoided to introduce new didactical constraints in the classroom. The investigator administered again the same questionnaire immediately after the treatment session, aimed at examining children learning progress, and again one month later, in order to evaluate how children maintained the acquired knowledge over time.

We assumed that after the treatment session children would better understand the astronomical concepts. In this study, the treatment included educational activities based on "social learning theory". All the didactical activities were presented to children with appropriate information along with conceptual tools and practical collaborative activities. This approach should help children to

improve their scientific understanding, avoiding at the same time the learning of astronomical concepts in a naïve way. Specifically, it is rather effective when children learn scientific concepts in a non-monitored context (e.g., family environment, and so on).

3.3. Materials and Data Collection

A geographic map of Italy, two globes, a lamp with swing arm, equipment for drawing (a black marker), a blackboard, balloon and a flashlight, a thermometer, two manuals of Astronomy and a laptop were adopted during the whole period of the treatment activities. We also selected a series of multimedia lectures notes that the investigator used in the classroom during the lessons, to explain the Astronomy concepts to children. In addition, to support children's learning, we arranged simple hands-on Astronomy exercises in the classroom.

To assess children's Astronomy concepts and to easily introduce them we designed a questionnaire, taking into account the previous studies conducted by other researchers (Vosniadou et al. 2004). The questionnaire consisted of twelve items, and each one included two answer modalities: dichotomous (Yes or No) and open-ended. We used the open-ended modalities to collect a richer source of information about children's astronomical knowledge. The open-ended questions aimed at identifying the meaningful utterances used to explain some astronomical events and indicating the learning of new concepts. Therefore, we were able to understand as children explained scientific concepts they learned. The questionnaire items examined the Earth's shape, the day/night cycle, the Earth's rotation, the concept of gravity, meridians, parallels and others concepts regarding the Solar System.

3.4. Procedures

Two classrooms of students participated in this research carried out during in the 2009 academic year. According to the study design, the investigator delivered the same educational contents in each classroom, separately. Children were told that the proposed educational activities were not a test and that they could say if they did not wish to answer a question or did not know an answer. The same instructions were given for the graphical representations. In addition, schoolteacher of Mathematics and investigator gave no support to children to perform all the designed educational activities. One month after the end of the educational activities, we evaluated children's learning again.

Initially, students were individually tested administering them a pre-test questionnaire. Each participant was invited to read carefully the questions statement and then to pick out the correct answers, providing an explanation of it (open-ended modality).

During the second session (called treatment) we delivered target Astronomy concepts. Each educational activity consisted of two parts. In the first part of the lesson the investigator introduced theoretical concepts in Astronomy to children. Afterwards, the investigator designed some simple experiments in the classroom, in order to actively involve the children. The aim of this approach, based on "social learning theory", was to explain to the children the basic astronomical phenomena, making use of their own conceptual knowledge. The duration of each lesson lasted approximately 45 minutes. The research was carried for five and half weeks and the educational activities were delivered twice per week (Tuesday and Saturday). Finally, the third session included second and third observation, respectively.

The schoolteacher of Mathematics in one year earlier (April-May 2008) taught to the children basic astronomical concepts by adopting a normal textbook. These concepts included the shape of the Earth and the day/night cycle. The textbook included theoretical description of astronomical phenomena and practical exercises to improve the students' learning. For instance, the textbook displayed the position of the Planets by using images, chart and other materials. Finally, it provided a list of questions to evaluate the children learning. The duration of each lesson ranged from 35 to 45 minutes. It depended by the lesson organization and by the topics of the didactical activities scheduled, as well as by the students' attention.

According to the research purposes, we performed a classroom pre-test aimed at assessing the initial children's knowledge about Astronomy. We administered the questionnaire in the classroom and each student had to reply it individually. Children had approximately 50 minutes to fill it out. They knew that this was not a test, and that they could say if did not wish to answer a question or did not know one. In addition, subjects completed the task without receiving any support.

After this preliminary assessment, investigator started with treatment activities. The research

design included both theoretical contents and simple hands-on Astronomy exercises. We designed the educational material to be flexible, taking into account children's ideas that emerged during the class discussions. It included multimedia resources (e.g., videos, animations, images, and sounds). During the educational sessions children were stimulated to apply a social-cooperative strategy aimed at enhancing the learning of astronomical concepts. Other activities included discussions in a whole-class session. For example, a child asked the following question: "*If I move, I go to the other side of the terrestrial globe, for example, in China, here will I walk to head down and therefore could I fall from the Earth?*" Hence, the investigator introduced the concept of gravity, explaining to children that it is an attractive force, which causes all bodies to move towards the centre of the Earth. In the next educational meetings the investigator introduced other astronomical concepts like: day/night phenomenon, Earth rotation, seasonal changes, meridians and parallels. Most of these concepts were delivered with the support of multimedia materials.
At the end of the treatment session, the investigator administered the post-test questionnaire. The setting was the same of the pre-test. One month later, we repeated again the questionnaire administration, without modifying the school setting.

3.5. Data Analysis of the Results

First, we assessed the internal consistence of the designed questionnaire performing a Cronbach alpha reliability test. We obtained a good reliability result. The Cronbach alpha value was 0.72. Nunnaly (1978) has indicated 0.70 to be an acceptable reliability coefficient, but lower thresholds are sometimes used in the literature.
Preliminary pre-test analysis showed that all participants had similar prior astronomical concepts ($F_{dichotomous}$ (1, 21) = 1.53, p >0.05; $F_{open\text{-}ended}$ (1, 21) = .13, p >0.05). Children acquired these backgrounds on Astronomy during their previous educational activities carried out by schoolteacher. Vice versa, the differences between pre-test and post-test condition were significant ($F_{dichotomous}$ (2, 65) = 16.50, p < 0.01; $F_{open\text{-}ended}$ (2, 65) = 35.73, p <0.01). Secondly, after pre-test 68% of the 22 assessed children answers correct to the dichotomous items, whereas 32% gave a wrong answer. Analysing the results of the post-test, we obtained that 98% of the answers of 22 assessed children were correct and only 2% of them answered wrongly. 1 month later, we have observed a short difference in comparison with post-test. In particular, 97% of the assessed children answered correctly, while the remainder 3% of them answered wrongly.
Results show that the mean number of correct answers to the questions after the treatment (M = 11.79, SE = 0.10) and 1 month later (M = 11.63, SE = 0.10) was greater compared with pre-test results (M = 8.18, SE = 0.32). Although all children had the same initial knowledge about Astronomy concepts, an active, social and collaborative participation improved their scientific understanding.
To examine the significance of the students' learning changes occurred over time and in connection with the treatment, we have performed a series of two-tailed paired *t*-test. The results indicated that there was an overall significant improvement from pre- to post-test scores for the dichotomous questions (t21 = -10.62, p <0.01) regardless of treatment condition. However, the difference between the two outcome measures was not significant (t21 = .70, p >0.05). We obtained the same result for the open-ended questions. A significant improvement from pre- to post-test scores indicated that the children language showed more details to explain Astronomy concepts (t21 = -15.82, p <0.01). In contrast, we did not find significant differences between post-test and one month late measures (t21 = .70, p >0.05).

4. Conclusion

The aim of this study was to experiment the social learning approaches to teach Astronomy concepts. After training treatment, children understood astronomical notions and in particular the behaviour of the Earth system, and they clarify their knowledge about day/night cycle, and other concepts introduced during the treatment session. For instance, children understood that day/night phenomenon is the result of the Earth rotation on its own axis. The pre-test results showed that few children answered correctly to the astronomical questions, but in many cases they gave an incorrect description of the phenomenon. On the contrary, post-test results showed that children increased their conceptual acquisition. As expected, the results of the current study provide meaningful evidence that children retrieved easily the Astronomy concepts learned during the classroom activities. In particular, this social learning astronomical experience shows that certain

didactical strategies have a greater potential to improve scientific knowledge in children. After the treatment, children showed not only the ability to learn new astronomical knowledge in their memory, but also to retrieve it easily by using scientific language and avoiding naïve explanation.
These results support our expectation, indicating how social learning strategies and use of tools can improve children understanding of scientific events and, in particular, of astronomical concepts. It means that children's learning is more productive when teaching involves both social educational and interaction strategies among pairs with the support of tools that increase the scientific learning. Clearly, the level of acquisition of the new knowledge reflected the treatment carried out during the investigator activities. Children verbal descriptions and/or explanations represent important aspects to evaluate their scientific conceptual learning. For this latter aspect, examining children's open-ended statements, we found significant similarities in both theoretical and practical educational content delivered in the classroom. In addition, reading the children's descriptions it is possible to find also a narrative thinking that show the cognitive association between scientific concepts and quality of the learning (Boutler 2000).
The current results indicate also that the integration of social learning methodologies and use of multimedia contents create a didactical environment, in which children are stimulated to extend their own scientific mental skills. This learning setting encouraged children in an active exploration of ideas affording their opportunity to learn Astronomy concepts in a new and dynamic way. However, the role of the schoolteacher is crucial. Schoolteachers should be able to experiment new didactical approaches to reinforce children interest, designing classroom laboratory to teach astronomical phenomena. The social learning approach gives to schoolteachers the possibility to fascinate children, and capture their attention and stimulate the imagination.
Overall, this study demonstrated the successful use of the theory of social learning and tools for engendering playful astronomical learning. The didactical settings were designed to include theoretical and practical activities that mediated different astronomical concepts and phenomena. This enabled students to actively think on scientific concepts, thus providing their new way to explore scientific concepts and then to improve the learning outcomes. This combined use of social learning approach and tools means that the students themselves become a central part of the educational activity rather than just watching something in an inactive way.

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