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Experiences and teaching physics with the IBSE method in primary school

I. Confalonieri(1), M. C. Onida(1) and D. Di Martino(2)

(1) *Department of Human Sciences for Education, University of Milano-Bicocca - Milan, Italy*
(2) *Department of Physics, University of Milano-Bicocca - Milan, Italy*

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Summary. — We present the methodologies used, the main activities, the documentation and evaluation methods used in an astronomy activity proposed to children in a 5th grade class of an Italian Primary School. The main objective was to test whether the approach used (based on the IBSE method) could develop meaningful and long-lasting science skills in children and could increase their interest in disciplines such as physics and science. The methodology, based on Inquiry, involved moments of experimentation, hypothesis formulation, model building, discussion and comparison with peers. The Inquiry course lasted about 40/45 hours and had as its main focus the Moon and the main phenomena concerning it: light and shadows, lunar phases, eclipses, and space-time dimensions of Moon-Earth.

1. – Description

The main objective of the present research is a comparison between two different approaches used for teaching astronomy: a traditional approach and a laboratory based approach, whose methodology, based on Inquiry [1], involved moments of experimentation, hypothesis formulation, model building, discussion and comparison with peers. For this reason, it was necessary to compare two different groups (classes), using only and exclusively a laboratory approach in one of them. In this way, it was possible to determine which cause-and-effect relationships led to a certain result in one class rather than the other. The research strategy used, the experimental one, involved collecting data at the first stage, and then analysing them at the end of the course, subsequently comparing them between the group that used the experimental teaching approach and the group that did not experiment with it. Starting from a shared multidisciplinary design (from physics to mathematics, Italian, English, and education science), the activities designed for the two fifth-grade classes at "S. Pellico" Primary School in Gallarate, Varese, were aimed at comparing two different teaching approaches, to subsequently determine which of the two had developed more scientific skills for pupils. One class (5A), the experimental group, took a laboratory-type course based on the IBSE approach [2], during which children developed more and more autonomy in investigating problems of a physical-astronomical nature. The other class (5B), the control group, on the other hand, tackled the exact same topics but with a more traditional teaching approach based on the study from the textbook. For both classes, a questionnaire was proposed at the end of the course to observe and compare the knowledge acquired by both classes and the motivation and interest developed toward science topics. In addition, two authentic tasks were administered which, on the other hand, made it possible to verify and evaluate whether and how the development of scientific skills in the classes was effective or not.

2. – The project-research in the teaching of astronomy

The project-research in the experimental classroom was designed following Inquiry-based principles, and the various stages of the teaching itinerary followed the five different moments of the Learning Cycle approach based on the 5Es (Engage, Explore, Explain, Elaborate, Evaluate) [3]. In addition, the level of Inquiry changed in the different phases, moving from more confirmatory/structured Inquiry at the beginning of the itinerary to an open-ended Inquiry level at the end [4]. At the heart of this approach lies precisely the development of scientific Inquiry *i.e.*, the set of all those processes that pupils put in place to give themselves explanations to phenomena around them and, in doing so, gain rich understanding of concepts, models and ideas, just as scientists do [5]. Pupils have, in this case, had a lot of freedom in proposing solutions to the problems posed to them. In the traditional approach, on the other hand, pupils had to deal with structured materials (textbooks and worksheets) and explanations that guided their thinking in a linear way. In addition, the path of the experimental class included collaborating with a section of a Kindergarten, whose children carried out, thanks to the collaboration of a colleague, the same path (obviously with modifications and variations considering the age of the children). Both classes started the path with a collection of pre-knowledge, after which the two educational paths had completely different activities but involved the acquisition of the exact same knowledge and the same kind of knowledge but completely different skills. Class 5A gained knowledge through experimentation, discussion, observation and comparison [6], all of which contributed to the formation and consolidation of both scientific and non-scientific skills. Class 5B, on the other hand, assimilated knowledge by listening to the teacher explanations and by underlining and studying from the textbook. The design in the experimental class was divided into five major phases, where the type of Inquiry involved changed in each of them. In the first phase, where structured Inquiry was used, children divided into small groups experimented with the phenomena of light and shadow using flashlights and different objects. Then the children involved, divided into large groups and under the guidance of their teacher, transferred what they observed experimentally to what happens in reality between the Sun and Moon, coming to talk about primary and secondary sources. The second phase, where the Inquiry involved was structured-guided, was the longest. Initially, children observed the moon in the sky for a month by filling out a personal lunar calendar. Then the phases of the moon were reproduced experimentally in the classroom; first, children observed their bodies, and particularly their faces, illuminated by a flashlight inside a darkened room. From this situation, children began to observe how face illumination changed according to the reciprocal positions of observer, flashlight and illuminated face. Next, a new situation was proposed using a Styrofoam sphere illuminated by a flashlight; this allowed for a better observation of the three-dimensionality of the object and allowed children to collect data (through drawings) as the observation position was changed. As a final exploration activity, children were offered the "Moon phase box" specially constructed by their teacher in this way (see fig. 1): a Styrofoam ball representing the moon was placed in the centre of the box, illuminated by a flashlight, and placed on one of the two

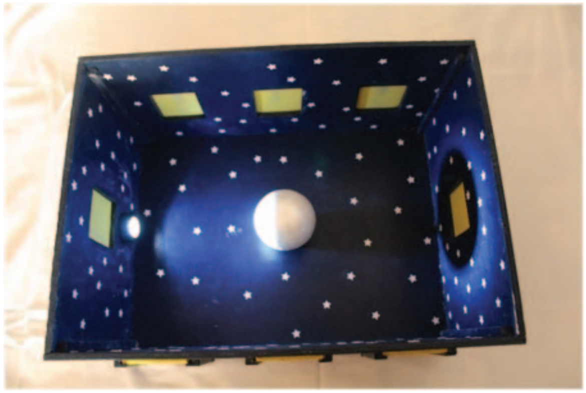

Fig. 1. – The “Moon phase box” used for the study and observation of moon phases.

short sides of the box (rectangular in shape). On each side of the box there are small windows that can be opened and closed: three windows on the long sides and one on the short sides. On top of the box there is a lid that makes the inside of the box dark and only the beam of light coming out of the lit flashlight can be seen. Depending on which window is opened, a different moon phase can be observed. In the third phase, in which the eclipse phenomena were discussed, the type of Inquiry involved was a guided Inquiry. Children were shown two videos (one about the solar eclipse and one about the lunar eclipse) and were then asked to try to formulate hypotheses in groups about the mutual positions of the Earth, Sun and Moon in the two different cases. Then their hypotheses were taken up with the teacher and compared with the accredited scientific theory. The last phase was the most difficult to handle, as the distances between the Earth and the Moon were discussed, and an open-ended Inquiry was involved. Children made assumptions about the relative distances and thought, after much reflection, about scaling down the actual size and real distances to reproduce the situation to scale in the hallway (using a basketball to represent the Earth, a tennis ball for the Moon, and the foot as the unit of distance measurement).

3. – Results and conclusion

The evaluation of the pathways, of both classes, was proposed through questionnaires that aimed to test the knowledge and interest developed for astronomy in children and through authentic tasks with the purpose of assessing the skills developed by both groups. In the first authentic task, children were asked, using the material prepared for them (a flashlight representing the Sun, a Styrofoam sphere representing the Earth, a Styrofoam sphere representing the Moon and a little man) to recreate the situation whereby the little man, placed on the Earth, could observe four different phases of the Moon. In the second, however, using the same materials, children were asked to place the little man on the Earth so that he could observe first the solar eclipse phenomenon and then the lunar eclipse phenomenon. From the data collected for the questionnaire, it can be seen that the experimental class developed more knowledge than the control class. This result should raise a reflection: one method (the traditional one) focused on developing knowledge proved to be less effective in children than another method whose main purpose was not to impart knowledge. Children, by experiencing and “touching” real phenomena, develop more knowledge as they are able to relate it to real facts. Mnemonic study from the textbook keeps children away from reality and does not give meaning to what they are doing. This is not to discredit study from the textbook altogether; on the contrary, sometimes it is even useful. However, this must be accompanied by examples, photographs and videos that simulate reality and modelling that can provoke questions, activate reasoning, and finally arrive at being able to transpose theoretical knowledge into reality situations, that is, building real skills. It is also possible to observe that both classes developed interest in the topics covered, and this was greater in the experimental class. Children come to school with lots of questions, interests and curiosity; it is up to us teachers not to extinguish their enthusiasm and to nurture it through educational paths that engage them and can provide answers to their many questions. This has been one of the goals of the experimental approach: to arouse the interest to be able to find explanations to what surrounds them, to put themselves at stake in first person to understand the phenomena in question, without finding the solution from the teacher or as written (sometimes incorrectly and/or incompletely) in textbooks. From the results of the authentic tasks, the difference between the two classes is even more evident. In solving the tasks, both classes showed that they had the correct knowledge concerning the phenomena they dealt with, but at the time of application it was possible to observe that only class 5A managed to complete the task correctly and showed that they had developed many scientific skills that we had set out to develop when designing the task. In order to observe and compare the competencies developed in both classes, special tables were constructed, in which the following were entered: the final competency to be achieved, the competency indicators, the evidence collected and the assessment by levels [7]. Thus, one can conclude by answering the question for which the research project was carried out: does the IBSE method develop skills in children? The answer, after analysing the available data, is definitely affirmative, and this can be noticed particularly by comparing the collected data of the experimental class with that of the control class.

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REFERENCES

[1] Smith John K., *The Nature of Social and Educational Inquiry: Empiricism versus Interpretation* (Norwood, Ablex) 1989.

[2] National Research Council, *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning* (National Academy Press, Washington D.C.) 2000.

[3] Pascucci A., *L'Inquiry Based Science Education – IBSE nella formazione docenti e nella pratica didattica* (INDIRE, Firenze) 2014.

[4] Bell R. L., Smentana L. and Binns I., *Simplifying Inquiry instructions*, in *The Science Teacher*, 2005.

[5] National Research Council, *The National Science Education Standard* (National Academy Press, Washington D.C.) 1996.

[6] National Research Council, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (National Academy Press, Washington D.C.) 2011.

[7] Confalonieri I., *Confronto tra l'approccio didattico tradizionale e l'approccio basato sul metodo IBSE per lo sviluppo di competenze scientifiche in ambito astronomico nella scuola primaria*, Master's Degree Thesis (University of Milano Bicocca) October 2022.