Understanding thermal phenomena and developing formal thinking in primary school

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Abstract How does formal thought develop in the perspective of scientific education in primary school? A group of 30 students divided in two group (experimental and control) who attending 4° class of primary education in Pordenone, Italia, reflected on this thermal Phenomena by Problem Solving and Inqury Based Learing using *Termocrono* the research lasted 22h developed in 4 months. After this pupils developed formal thought about thermal phenomena and the date collected evidence the needs for a transversal perspective in primary education.

Introduction

The construction of formal thinking is one of the main goals in the international guidelines for primary education to be reached by the contribution of the scientific areas [1]. Pisa surveys highlight the need to strengthen the role of scientific education in primary school and to start as soon as possible in operative ways with children [2]. Scientific competence enable child to interpret reality and act on it [3], making informed decisions. Physics education research investigates how to offer opportunities for understanding what science is [4], what it deals with and how it works, through direct personal experience by means of scientific explorations [5]. Physics Education research analyzed educative activities in terms of active construction of knowledge and skills [6], because international inquiry [2] and EU studies [7] evidenced the lack of scientific education in primary school and a tendency to address primary learning by memorizing sentences and information in a dogmatic way, without help in understanding the concepts involved. An interdisciplinary and transversal perspective in classroom activity is required in the curricular guidelines, but it is not present in Italian books and teachers follow what appear in the books, which are the written support for children. The lack of scientific competences of teacher, in addition, do not favorite initiatives or innovation in scientific activities.The main goal to integrate, for example math and physics learning or to use ICT to enhance learning remain a need for teachers and their request is for examples of innovative activities based on active role of children in learning processes. In this research Physics, Math and Technology are analyzed in terms of their contribution to the operative epistemology of subjects and to the mutual fertilization of different subjects to understand thermal phenomena. Computer on line measurements by means of sensors of temperature and real time plotting of measurements, integrated in the teaching/learning module implemented, offer new opportunity in overcoming learning knots, in favorite learning processes and in exemplify physics research methods on experimental plan.

The theoretical background

The theoretical Model of Educational Reconstruction [6] guided the research work, including the educational reconstruction of the topic, the study of conceptual knots on thermal phenomena both in literature and by an inquiry with students, the planning of the teaching intervention module, the preparation of teaching materials and the monitoring of learning processes with qualitative research methods. Computer on-line sensors for the measurement of four temperature in time contemporary plotted as senses extension play the role to stimulate the conceptual reduction between action and the formal description of the temperature in an in inquiry learning conceptual path implemented in in primary school. In a parallel class the teaching intervention path were implemented with the same activities using a dilatation thermometer, We pay attention on the role of graphs in the task of representing thermal phenomena as well as formal elements used in students descriptions of phenomena. We focus on the way in which students structure the complexity of thermal processes and construct. The thermodynamic approach to thermal phenomena is aimed at the reconstruction of ways for conceptual understanding foundation, identifying learning difficulties and reasoning evolution to set up of a rational for an educational path with the preparation of teaching materials and tutorials for the classroom work and the related monitoring. We analyzed the role of Problem Solving [8] and representation with TIC for overcoming conceptual nodes and developing formal thinking. The phases of the intervention module are the following:

1	Exploration 4 images for the identification of criteria that allow to classify the thermal conditions of objects and substances.
2	Experiment 1: measurement of the temperature of objects or substances on the desk.
3	Experiment 2: the temperature of the hand and the table
4	Experiment 3: exploration of the thermal sensation of objects and substances on the desk.
5	Open Problem Solving 1: design experiments to identify the variables that influence the thermal sensation.
6	Open Problem Solving 2 - experimental exploration - the variables that influence the thermal sensation
7	Experiment 4: thermal interaction between equal masses of water
8	Experiment.5: thermal interaction between different water masses
9	Open Problem Solving 3: from the graph T(t) to the Fourier thermal equilibrium law
10	Open Problem Solving 4: the role of mass in thermal interaction in the process of achieving equilibrium
11	Open Problem Solving 5: reinterpretation of the thermal interaction by wading to heating (calorimetry).
12	Problem Situations: qualitative and quantitative forecasts in different thermal interaction processes with 2 different perspectives (achievement of balance / heating)

Conclusions

The data analysis offers indications concerning the way in which the way children develop formal thinking. Operativity of children on associated with intellectual challenges allow students reflect to build knowledge. Inquiry Based Learning, as experimental explorations, empowers children to answer questions about thermal phenomena. The number of students that distinguishes the thermal sensation and temperature (from 13/30 to 28/30) increase after activity with respect to the test-in answers. Problem Solving allow students to take ownership of the problem, explain and interpreting the experimental and formal phenomena. Whit Problem Solving students recognize properties/quantities on which the thermal sensation depends. The Open Problem Solving are effective because pupils: interpret graphs of thermal interaction (28/30); apply interpretative strategies (11/30); analyze meta-cognitively the calculation procedures (5/16 experimental group); explicit strategies for the prediction of the temperature (14/30). Students construct the concept of temperature as state property, constant in all equilibrium situations; thermal sensation as a process descriptor; thermal interaction as a process (experimental group 14/16, control group 8/14); thermal balance (14/16 experimental group, 12/14 control group). The pupils increase the forecasting capacity (from 27% to 67% after OPS3) and the ability to justify the adopted resolution methods (50%). Students demonstrate their ability to interpret T(t) graphs in interaction processes (14/16 experimental group, 8/14 control group). The difference in the results of the experimental and control group highlights the role played by the *Termocrono* to develop formal though.

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