INTRODUCTION

I'm Maria Lucia Lo Cicero. I come from Palermo (Italy) and I'm a second year PhD student in "History and Mathematics Education, History and Physics Education, History and Chemistry Education" at University of Palermo.

In 2004 I get a degree in Mathematics. Two years later I finished the specialization school for teacher education (SISS) and this is the third year that I teach Mathematics and Physics in secondary school.

My research work is about Mathematics Education and, in particular, my doctoral thesis regards *The Acquisition of the Concept of Function and of its Representations.*

The basic idea of my research is that a possible of the approaches to introduce the concept of function could be the graphical one, using graph representation of real physics phenomena. This proposal draws from an historical-epistemological analysis of the concept of function, which in history developed within kinematics. Considering this analysis and taking into account the fact that history, «as a source of problems, from the teacher's point of view can become an instrument for planning and for the student an occasion to give meaning to mathematical concepts» (Spagnolo, 1998, p.76), I propose introducing the concept of function through a physical approach and graphical representation.

Till now my experimental researches concerned the reading and comprehension of graphs and forming inferences on the base of experimental data. These skills are part of the prerequisites necessary for the introduction of the concept of function passing through the graphical representation; I will deal with this concept more thoroughly in the future. The research questions that stemmed from the experimental work conducted up to now are the following:

RESEARCH QUESTIONS

Under the hypothesis that *the motion sensor is a good instrument to learn how to read graphs of a function*, I posed to myself the following research question:

Using the motion sensor to learn to read graphs of motion, will the student acquire ability and knowledge relative to the reading, comprehension and conjectures about graphs of any function?

THEORETICAL FRAMEWORK

The motion sensor is one of the MBL tools (Microcomputer Based Laboratory), introduced into physics teaching in the 90's to improve the students' learning and comprehension of physics concepts (Thornton & Sokoloff, 1990).

The advantages of the use of the MBL tools are multiple as they allow to visualize in tables and graphs the experimental results in real time and to analyze such data. This facilitates the comprehension of abstract representations as the data are revealed and represented in real time and the students can make observations on the physical phenomenon and can interpret, discuss and analyse the data as they see fit (Tinker 1996, Thornton 1997).

In particular, the possibility for the students to visualise and analyse the graphs of the bodies in movement or of objects physically perceptible at a sensory level, finds strong support in the cognitive theories *of the Embodiment of mind,* for which «the detailed nature of our bodies, of our brains, and of our daily functioning in the world structures human concepts and reasoning», and from *Metaphorical Thought*, according to which «for the most part, human being conceptualize abstract concepts in concrete terms, utilising ideas and models of reasoning founded on a sensor-motor system» (Lakoff & Núñez, 2005, p.27). Moreover, «the functions on the Cartesian plane are often conceptualized in terms of motion on a route» (Lakoff & Núñez, 2005, p.70) and the motion sensor induces this type of conceptualisation so that the student sees the graph constructed under his own eyes as "motion of a point that leaves a wake". This process facilitates the acquisition of the ability to read graphs of a function and the learning of such a concept so that «revealing the cognitive structure of mathematics, renders it decisively more accessible and understandable» (Lakoff & Núñez, 2005, p.30).

Moreover, the literature regarding the use of the sensor motion in mathematics education is a point of reference for my research. The most meaningful works have been:

- Arzarello F., Robutti O., *Approaching functions thought motion experiments,* Educational Studies in Mathematics, vol 57-3, (2004)
- Robutti, O., *Hearing gestures in modelling activities with the use of technology*, in F. Olivero & R. Sutherland (eds.), Proceedings of the 7th International Conference on Technology in Mathematics Teaching, Uiversity of Bristol, 252-261, (2005).
- Ferrara F., Savioli K., *Graphing motion to understand Math with children*, Proceedings of CIEAM 59 Congress, Dobogoko, Hungary, July 23-29, 2007

EXPERIMENTAL WORK AND RESEARCH METHOD

The experimentation consisted of the carrying out of laboratorial lessons[1], where the students compared the readings and the predictions of the graphs realised with the motion sensor and the software *Logger Lite*[2], It was led at different school levels, here listed in chronological order:

1. May 2007, 5th class of Primary School (10 years), *School: "G. Rodari" Via Fiduccia, Villabate, (PA), Italy;*
2. December 2007, 4th class of Classical Lycée (17 years), *School: Liceo Ginnasio di Stato (F. Scaduto), "*F" couse, *Bagheria (PA), Italy*.
3. April-May 2008, 3rd class of Middle School (13 years), School: "M. Buonarroti", Palermo, Italy
4. April-May 2008, 2nd class of Commercial Technical Institute (15 years), School: "Jacopo del Duca", Cefalù (PA), Italy
5. April-May 2008, 4th class of Classical Lycée (17 years), *School: Liceo Ginnasio di Stato (F. Scaduto), "*I" couse, *Bagheria (PA), Italy*.
6. April-May 2008, 4th class of Primary School (9 years), *School: "F. P. Perez", Palermo, Italy.*

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[1] Lessons was conducted by myself, except the last one, that was effectuated by a forming Primary School teacher, then having projected it together.
[2] In the research we used instruments and *Data Logger* from the Venier Software & Technologies. In the same way we could have used instruments and software from other equally valid companies.

I decided to perform the research activity on students of different grades to compare the obtained results, which we thought to be different according to their age and their courses of study.

The research methodology adopted is *Theory of Didactic Situations* by Brousseau (Brousseau, 1997). The laboratorial lessons started and finished with test, with the aim of evaluating the a-priori and a-posteriori state of the students. The lessons were conducted with a constructivist, positing question-stimulus to the students so as to solicit observations and discussions between pairs and with the teacher, allowing for the active construction of knowledge (Kilpatrick, 1987).

The phases of the didactical activity for both the classes were the following:

1. Discovery of how the motion sensor works, by the observation of graphs and tables representing a student's motion, and reflections on the variable studied by the sensor
2. Prediction and reading of the graphs of rectilinear student's motion of three types:
    a. Leaving motion from the sensor
    b. Approach motion to the sensor
    c. Still body with respect to the sensor
3. Prediction and reading of the graphs of various rectilinear student's motion, with leaving and approach with respect to the sensor.

During phase **2** the students observed and calculated space and time of departure and arrival, the length of space and the time spent. In phase **3** these values were observed and calculated for every tract of leaving, approach or stilling of the curve of motion. Also the maximum and minimum distance reached with respect to sensor was read. The students noted that the slope of every tract of the curve depended on the corresponding velocity of the student. Then the students were asked to make a relationship between spatial intervals and temporal intervals about tracts of a curve and to make comparisons.

Moreover the Middle and Secondary school students calculated the mean velocities and compared the slopes of sections of the curve with the velocity-time graphs.

For the Secondary school students there was a phase **4**, in which the students observed graphs of rectilinear uniform motions and uniformly accelerated motions of a train on tracks, developing the activity described above.

EXPERIMENTAL RESULTS AND CONCLUSIONS

As it is indicated by *Theory of Didactic Situations*, I made an a-priori analysis of students' behaviour in working out the test. The quantitative analysis of the tests was effectuated with the *Statistical Implicative* software *Chic* (Gras, 1979, 2000). In particular, the *supplementary variables* method (Spagnolo, 2005) was utilized.

Besides, the quantitative analysis was compared with a qualitative analysis of the laboratory lessons.

In this paper, for reasons of space, I omitted a detailed analysis of the tests and the experimental results. Summarily, they show that the laboratory activities conducted the students to total or partial acquisition reading skills and understanding of graph of functions. So it can be affirmed that the research question admits an affirmative answer: *the motion sensor can be useful for learning to read function graphs*.

Moreover, we noticed that the prediction process is important to acquire the skill of *forming inferences on the base of experimental data.*

FUTURE RESEARCH

My research schedule is to investigate the teaching/learning processes regarding function conceptualisation. Referring to Duval's *Theory of Semiotic Representation Registers* my purpose is to outline a didactic way to lead the students to the concept of function through treatment and conversion of its representations.

Moreover referring to Brousseau's *Theory of Didactic Situations* my future experimentation will include activities carried out in an a-didactical situation.

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