An Attempt for Teaching Meteorological Instruments to the Students of Agriculture by Using Self-Constructions

S. Spanos and X. Vatsios

Abstract The paper is a concise description of an attempt to teach laboratory meteorology in the school of agriculture at the University of Thessaly by using self-made meteorological instruments. After a thorough description of the operational principles and an exhibition of model constructions, students were asked to repeat the construction using ordinary materials and simple tools. A calibration procedure and sample measurements were also required in order to complete their project. Increased enthusiasm and interest from the students was especially encouraging for the future repetition of the attempt.

1 Introduction

Teaching of elementary meteorology in the Greek Universities incorporates a laboratory part (Hofstein and Lunetta 1982) in which students are familiarized with basic instruments and measurement procedures. Many of these instruments are still the traditional mechanical instruments that were used decades or centuries ago. This seems to be controversial with instrument evolution which has turned the old infrastructure to electronic devices. In modern instrumentation of meteorological stations the shrinking of the electronic sensors and the integration with data loggers produced small devices in which measurements are automated. This evolution has led to cheaper, more reliable and easy to maintain meteorological stations. On the other hand, this evolution has obscured the physical principles on which measurements are based. For a student with elementary knowledge of physics these devices are "black boxes" which receive and store data. It is therefore

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of great pedagogical value for students to become familiarized with traditional instruments and the measurement procedures. The problem has been realized by the majority of university schools which incorporate in their curricula the teaching of traditional instruments (Flocas 1998; Karapiperis 1966).

These instruments, which keep the names of their inventors, guide the students to discover the physical principles and laws on which measurements are based. Moreover, the historical value (Seroglou and Koumaras 2008) of these instruments introduces the student to the evolution of ideas in physics. Furthermore, the traditional instruments are still operational in many stations as a reference and for the continuity of the of time series. The construction simplicity of the traditional instruments offers the obvious advantage of an easy reproduction (Bohren 2001) with ordinary materials and simple tools. Based on this fact a series of instrument substitutes have been produced and tested in the Laboratory Education Centre (EKFE) of Magnesia. The reconstruction of these instruments was proposed to the students of agriculture in the University of Thessaly as a part of their course in elementary meteorology. The introduced procedure and a first evaluation of the results is presented in this paper. A short description of the motivation on which this attempt is based follows. In the third paragraph a brief description of the self-constructions is presented. In the fourth paragraph the grading of student's constructions is described and finally conclusions are drawn.

2 Motivation of the Attempt

Although the school of agriculture in the University of Thessaly owns a number of automatic meteorological stations, it does not operate a traditional meteorological station. As a result, students of meteorology were asked for their practical training to access the data from automatic stations in order to extract information and draw conclusions. This process was not popular among the students. On the other hand many students have shown a profound lack of understanding about the physical principles on which measurements were based. In the final tests many students for example believed that when a thermometer is exposed to the sunshine it measures the air temperature. For other students it was hard to realize that water volume per unit of collecting surface provides the rain depth.

A detailed study on the preconceptions that ordinary life supplies the students of atmospheric physics is not available in literature. However, the problem exists and cannot be addressed through lectures and demonstrations (Roth et al. 1997). In order to confront a well-established preoccupancy, only approaches based on new experiences can help. It has been proved that constructing an instrument from scratch and calibrating it in order to become operational is a very strong experience (Michaelides and Tsigris 2004). Such an experience has the power to demolish preoccupancy and restructure the previously gained experiences as a new formation. This is how knowledge is built according to constructivism.

Ordinary meteorological instruments were described during the lectures and each description was also accompanied by an exhibition of a constructed substitute. A calibration procedure followed the exhibition and at the end of the lectures, students were asked to select one of the proposed instruments for self-construction. When a prototype instrument was lacking, instead of the calibration procedure, students were asked to produce a series of measurements (Tsigris and Michaelides 2002) that can be easily reproduced by the teacher. Finally, the delivered self-constructions were graded on the basis of the accuracy of measurements and secondarily on robustness of the construction, aesthetics and innovation (Michaelides and Tsigris 2004).

3 Description of Self-Constructions

The first construction is a reproduction of an Arago-Davy actinometer by using twin thermometers (Fig. 1). One of these thermometers, which measure in the range between $-10°C$ and $110°C$ and can easily be obtained in the market, was modified by blackening the Hg tank with the flame of a candle (left one in Fig. 1). When the combination is exposed to the sun there is always a difference in the readings which

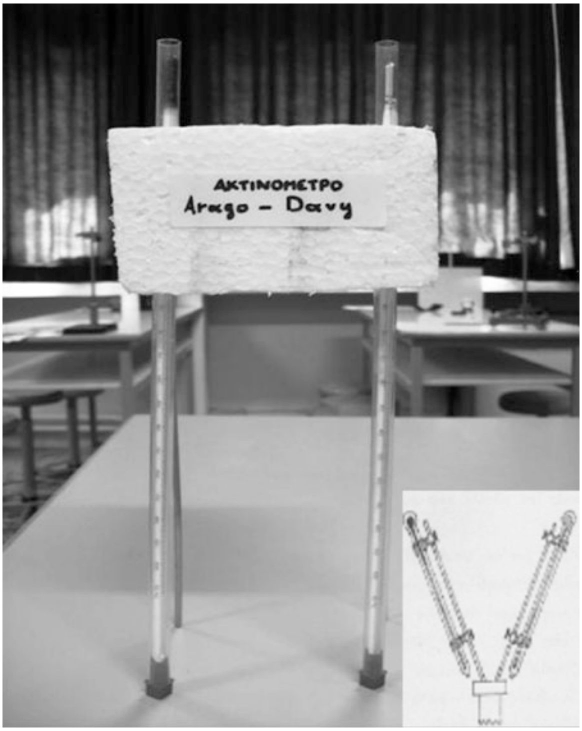

Fig. 1 A reproduction of an Arago-Davy actinometer (Model instrument at *lower right*)

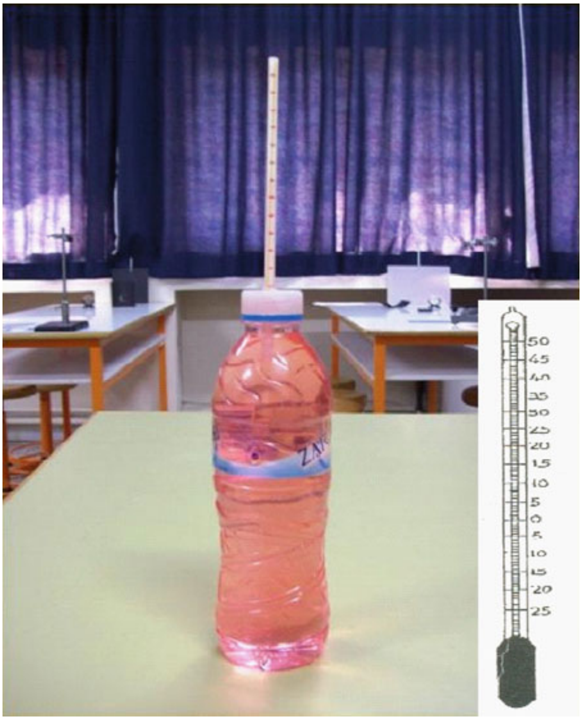

Fig. 2 The reproduction of a water thermometer (Model instrument at *lower right*)

is proportional to the intensity of the solar radiation. During the night or when the combination is in the shade the readings are equal and the difference is zero.

The second construction is a water thermometer (Fig. 2) which is based on thermal expansion of a colored water mass inside a straw. The construction is calibrated with the help of an ordinary alcohol thermometer and its accuracy depends on variations of the atmospheric pressure. When atmospheric pressure remains constant, it is relatively accurate. A refrigerator and a boiler are used for the calibration of the instrument.

The third construction is a reproduction of a simple rain gage (Fig. 3) by using a plastic water bottle. The upper part of the bottle is cut off and adapted to the rest of the bottle with its neck upside down. Calibration is performed by adding measurable water volumes and measuring the corresponding water depth. The surface of the collecting area is also calculated in the process.

The forth construction is an evaporation meter of “wild” type (Fig. 4) which is a self-construction based on an electronic weighting device with a water tank on it. The day by day difference in weight readings provides an estimation of evaporation capacity of the atmospheric environment. To calculate the evaporation depth, mass difference is transformed to volume difference with the help of water density and the result is divided by the evaporating surface.

Fig. 3 The reproduction of a rain gage (Model instrument at *lower right*)

The fifth self-construction is an anemometer of “Daloz” type (Fig. 5). It consists of a wooden mast, which is able to revolve around a vertical axis, with a semi-circle goniometer on the top of it and full-circle goniometer at the bottom. A small Styrofoam piece with a spindle shape is hanged from the centre of the semi-circle goniometer through a thin strand. The angle between the vertical axis and the strand depends on wind speed. The direction on the full-circle goniometer is the wind direction.

4 Results

For the majority of the students it was the first time that they tried to construct something which is above all functional. Therefore, they expressed their enthusiasm and satisfaction. Although the grading of the construction contributed only a 20% to the final grading, their participation reached the 90%. The feeling that they are contributing to a new, innovating means of teaching was probably a strong motivation. In contrast with our initial expectations female students were more enthusiastic than the male ones. The students delivered their self-constructions along with a report containing the calibration curve and/or sample measurements.

Fig. 4 The reproduction of an evaporation meter (Model instrument at *lower right*)

There were several constructions with functional problems and bad calibration. For example most of the constructed anemometers suffered from friction problems in the revolving vertical mast and lubrication was required. Other students who constructed the water thermometers had to cope with the non linear response of water expansion to temperature variation. All these problems were discussed at the end of the semester where everybody had the opportunity to see and examine the constructions of the others.

5 Conclusions

1. We conclude that the attempt showed several encouraging elements of learning motivation and stimulated the interest of the students on the subject.
2. In order to investigate the learning outcome, a better formalization of the entire procedure has to be established.
3. As a final step the design and carry out of an evaluation experiment is required to investigate the knowledge transformation that the students incorporated. A random separation of the students in two groups, from which the first attends only lectures and exhibitions and the second delivers the calibrated self-constructions, is a fine proposal in the design of such experimentation. In this case the evaluation will be based on groups performance differences.

Fig. 5 The reproduction of a "Daloz" anemometer (Model instrument at *lower left*)

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