Getting to Know the Thermodynamic Variables Through Scientific Inquiry

Paola Utreras[1], Yazmina Olmos[2]

Abstract

This work shows how the process of learning physics is enriched through authentic scientific inquiry practices, enabling a significant learning of sciences that is well beyond that of simple definitions. We suggest studying and designing strategies that promote a deeper understanding of the nature of the thermodynamic variables and how they relate to each other through the analysis of atmospheric data from a weather station located just a few meters away from the classroom. The proposed activities include the development of linear variable time series analysis, as well as frequency and period analysis. With these results, the students generate conclusions that enable them to understand the experiential nature of these variables. Finally, the students publish their results using scientific writing standards. We observed that, introducing subjects that are both interesting and close the students' realities and that affect them in their daily lives, it allows for a greater understanding of the issues. This deeper learning is reflected in an increased motivation and a higher rate of passing grades within the course.

Introduction

How to motivate students to understand the nature of science has been an arduous task for educators at various levels of education. Already in countries like USA have been carried out educational reforms leading to prioritize scientific inquiry as a method of teaching and learning science, because it induces a significant learning besides constituting a direct application of the scientific method as well as the critical thinking [5],[6].

This approach to learning science suggests the use of scientific inquiry as a strategy for generating more curious students not only knowledge but a series of stimulus and guide a process of discovery [7].

In the lecture Fluids and Thermodynamics for engineering students, historically the average passing rate has been 30%, with particularly difficulties related to the content “thermodynamic variables”. Besides, this chapter did not include practical activities or active methodologies to develop skills of students, the activities were limited to expository lectures, where the specific contents of the course, generated a passive role in students. Another major problem was the lack of motivation to this subject by students who saw thermodynamics as an abstract issue, far from their reality and did not affect their daily life.

Method

Our work is based on the idea that science education should reflect how scientific knowledge is constructed, that is, through experience [4]. To make genuine and pedagogical scientific activities must transform these activities and make them accessible to the students according to the educational level they are [3]. There are several ways to achieve authenticity in the scientific research with educational purposes. For example:

- Using real-world problems to which scientists face [2].
- Troubleshoot life of students [1].
- Connect students and scientists to share data for analysis, promoting discussion between them and facilitating direct communication.

Once presented the problem to study, knowledge building is divided into 4 stages:

- Plan and conduct research work
- Take conclusions
- Check theories
- Communicate results

1 Universidad Austral de Chile, Chile
2 Universidad Austral de Chile, Chile

Activity development

Students work in groups during the semester on a research topic, where the teacher has the role of facilitator guiding the student learning as well as sharing data and information.
The activity was held at the beginning of the unit of thermodynamic, which corresponds to the unit more students fail.
Working groups were formed with 4 members, using computers provided by the teacher and the internet connection to download the data from the Weather Station Miraflores. The work was done during the lecture time in a period of one week, after this term students should submit a report based on the following learning outcomes.

- Time series graphics .
- Interpretation of possible periods.
- linear fit of the graphs and interpretation of it.
- The thermodynamic relationship between the chosen variables.

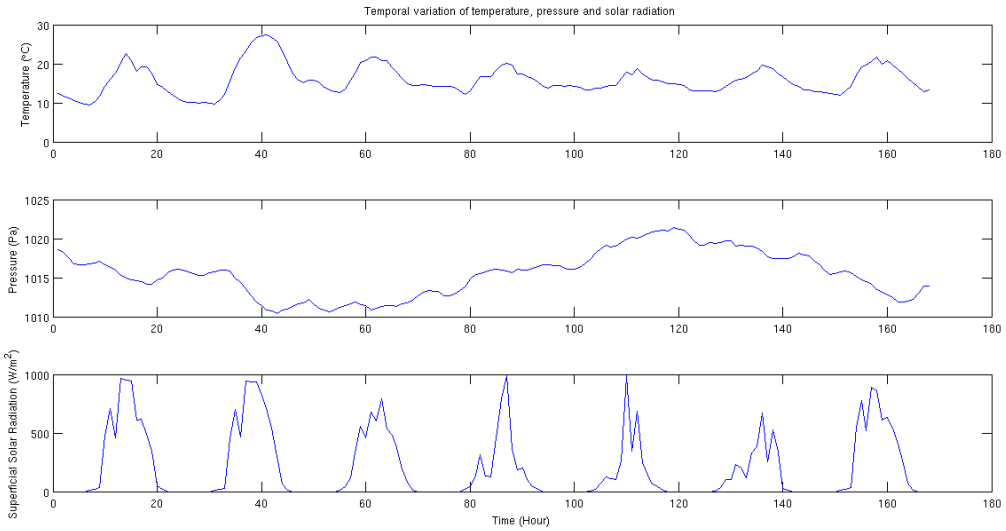

Figure 1: Graphic of the temporal variation of temperature, pressure and surface solar radiation measured by the weather station Miraflores, located in the Miraflores campus of the Universidad Austral de Chile.

The teacher in the classroom acts as facilitator and guide during the working sessions, supporting the work of the teams and guiding the conclusions.
In the last session they written report, this report is presented in the format of a standard scientific paper, which helps students to organize the work, synthesize is drawn develop coherent ideas and conclusions, important aspects in the training of engineering students and usually forgotten in the curricula.
The weather station used is housed in the Miraflores campus of the Universidad Austral de Chile, meters from the classrooms, and in a highly trafficked area. This station is the only open and public mechanism that exists in the city for current and historical atmospheric data, so it is a tool widely used by local scientists, helping in understanding and forecasting of atmospheric phenomena. This feature makes the activity performed by students even more authentic, since it corresponds to the work done by scientists in reality and not a dull and pointless task.

Results

To assess meaningful learning, the concepts studied under the process of scientific inquiry were evaluated, but in a different context, in a traditional evaluation. The result was positive in 70% of the responses.
After the activity a survey was applied to 40 students in the room, in which they expressed their approval to this activity, through the questions shown in Table 1 :
Table 1: Survey of students.

	Yes	Relatively	None
Does this activity help to your training as an engineer?	80%	20%	0%
Does this activity help to understanding the nature of the thermodynamic variables?	70%	20%	10%
Did you feel drawn to do this activity with your workgroup?	80%	15%	5%
Do you feel satisfied with the work done by the member of your team?	75%	20%	5%

Among the comments was identified in student dissatisfaction with the percentage assigned (weight), which was less than 50% of traditional evaluations , students gave great importance to this work and proposed that the final grade will be considered as relevant as other assessments

Conclusions

Unlike traditional laboratory experiences that are normally used to promote inquiry and teamwork, problems of genuine scientific inquiry given to students the experience of developing the knowledge in a real context. This produces great motivation because they realize that their knowledge and skills allow them to develop real and useful scientific activities, which gives them the responsibility to learn and achieve understanding of the phenomena.

In this activity students were able to generate time series where they could observe the diurnal and seasonal periodic variations of the variables of temperature and solar radiation and relate variations in humidity and pressure, also they noted the gap between variables closely related and attributing nature of cause and effect and significance of this phenomenon.

This activity applied at the beginning of the unit of thermodynamic variations was observed in the following indicators:

Significant learning
Approval level
Motivation for the course

Note that this subject is taught in the 3rd semester of engineering careers, which will change soon and will be located in the 4th semester, parallel to the subject of numerical methods. Modifications to that activity are proposed to include Fourier analysis and linear regression, topics covered in the above mentioned course.

Acknowledgments

We would like to thank the Department of Quality Assurance and Curriculum Innovations, Dacic of the Austral University of Chile who financed the development of this project, as well as the Faculty of Engineering at the same university who financed the weather station Miraflores.

Also and especially we want to thank our colleague Juan Carlos Osorio who received valuable help especially in the early stages of this work.

References

[1] Blumenfeld, P. C. Soloway E., Marx R. W., Krajcik, J. s., Guzdial M and Palincsar A., “Motivating Project based learning: sustaining the doing, supporting the learning”, Educational Psychologist, Lawrence Erlbaum Associates, Inc, 1991, 26 (¾), 369-398

[2] Edelson, D. C., Gordin, D.N. And Pea R. D.,”Addressing the challenges of inquiry-based learning through technology and curriculum design”, Journal of the Learning Science,1999, 8 (¾),391-450.

[3] Hee-Sun Lee & Nancy Butler, “Making authentic science accesible to student”, International Journal of Science Education, 2003, 25:8, 923-948
[4] Lave, J. And Wenger, E., “Situated learning: Legitimate Peripheral Participation”, Cambridge, MA: Cambridge University Press,1991.
[5] NCR (National Research Council):”National Science Education Standards”, Washington DC: National Academy Press,1996.
[6] NCR (National Research Council), “Inquiry and the Nartional Science Education Standards”, Washington DC: National Academy Press, 2000.
[7] Schwab, J. J., “The teaching of science as enquiry, The Teaching of Science”, Cambridge, MA: Harvard University Press, 1962, 3-103.