Using a Simulation to Explore a Kinetic Model of Gas: Teachers' Practices

Françoise Chauvet
Laboratoire de Didactique des Sciences Physiques,
Université Denis Diderot-Paris 7
fchauvet@club-internet.fr

Abstract

This presentation reports on a study of teachers' practices when implementing a computer-based simulation about thermoelastic properties of gases at the first level of secondary school (grade 10). A simulation tool of kinetic theory of gases has been proposed with resources for guiding teachers in pedagogical actions in actual classroom. The main didactic goal is to explore the relations between microscopic and macroscopic variables of the model. Interviews and class observations have led us to a detailed analysis of interactions between students, simulation and scenario proposed by teachers. Benefits and difficulties of teaching strategies have been pointed out. The mass of particles, a microscopic variable often neglected by teachers, turns out to be a key factor in students' construction of kinetic pressure and kinetic temperature concepts. The results suggest some possible improvements on the first version of the on line resources for teachers' collaborative work.

Introduction

This research was supported by the Institute of Teacher Training in the North of France and has been carried out for two years. The study deals with the appropriation by teachers of a teaching learning environment based on a computer simulation about kinetic model of gas. It aims at a better knowledge of teachers' practices in order to optimise the interface between science education research and teacher training.

1 Context

The context is that of a consensus between curriculum authors of a new syllabus on "the air around us" which was implemented [1] at secondary level (grade 10) with fifteen-sixteen year-old students and previous results of science education research about teaching of kinetic particle models.

As a matter of fact, a major point emphasises on activities of modelling, a basic activity in learning physics. We assume, with many researchers that modelling could be favoured by the use of simulation.

Many researches have been conducted on sequences on the particle model of matter. Our starting point, as in the new syllabus, is a particular sequence designed and validated by Chomat *et al.*, in 1990 [2] and later by M. Méheut [3], with students at grade 8.

Moreover, we have adopted the same problematic as in an European research (STTIS). In this study, transformations that teachers introduce when implementing innovative tools and sequences was a central point. In order to help teachers to implement a targeted computer simulation in a teaching sequence, our research questions are the following : To what extent do teachers transform our specific intentions ? What content of guidelines are useful for teacher training ? How to improve resources on line to favour the evolution of pedagogical practices, in a constructivist perspective ?

2 Design of the study

The method we have used is that of an empirical study. We have carried out an *a priori* study in several dimensions : analysing the specific content to be taught, the students' cognitive characteristics and the main teachers' tendencies when implementing new sequences in usual constraints. A first version of guidelines for teachers has been proposed in an in service training session and has been put on line.

We consider that teachers are "active mediators" between researchers' propositions and students. With the resources, teachers have built their own sequence on the properties of gases including the use of a simulation. They have implemented the sequence in theirs classrooms. The obtained data are scenarios, classroom observations (audio-recorded) and teachers' interview, most often conducted after a first lab-work session (N = 8). Recorded dialogues and/or written answers on worksheets allow to know students' reactions (N = 150). More specifically, we have pointed out some "critical points of practice" in actual teachers' strategies [4].

3 Specific teaching goals

Our proposal is quite different from the teaching goal of the previous sequence [3]. Because of institutional constraints, the learning process is not based on some complete activities of modelling: from the real world to model and theory/ and back, by using specific questioning and simulation. In our case the model is provided and it isn't even enriched, as in the Méheut sequence. The kinetic model of gas is the foundation of the calculating plane of the simulation: the motions of points are calculated by mechanical Newtonian laws and statistical laws coming from the Maxwell Boltzmann theory. With the visual plane, students have to imagine the effects of numerous particles in motion and to give meaning to the concepts of pressure and temperature. Our investigation focuses on a model exploration taking into account the two planes of the simulation.

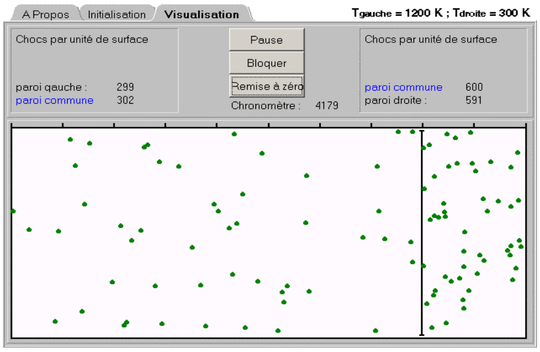

Figure 1. Screen copy.

Pressure is defined as the mean effect of numerous collisions of particles on a wall in contact with. No value of pressure is written on the screen. Pressure is seen as the product of two factors. One is the **frequency** per surface unit and is dependent on particle density and mean squared speed. Only these numbers are shown. The second one is a change of momentum when a particle hits the wall. This dynamic factor, depending on **mass and mean speed** of particles, has to be imagined by students. In previous research, pupils have called this factor **"force"** of hits. At this level, only a first approach of the first Newtonian law is available, without momentum and energy concepts. A moving wall in the middle of a box allows one to compare the pressures by the way of an analogy with the effects of hits from the two sides of this wall.

What we expect from a teacher' s guidance is to help students to take into account the "force" of hits in addition to the frequency in order to analyse what is pressure, to bring into play mass and mean speed when analysing temperature and thermal motion and to establish macroscopic relationships (law of ideal gases) from microscopic variables.

A particular emphasis is put on learning cycles involving prediction, experiment and debate. Questions are asked to provide opportunity for students to express their own concepts and confront the possible attached inconsistencies or the contradictions between these ideas and what they observe in a given situation on the screen.

4 Results

The "force" of hits could be introduced from two simulated situations. When different temperatures are selected in the two boxes, it is easy for students to relate speed and temperature. Asked to predict the motion of the central wall, all variables being the same (except T), students justify a correct answer by taking into account only the frequency of hits. Asked to explain why the wall is balanced, all students focus on the image and associate frequency of hits and "squeezing up" of particles. It doesn't work to introduce "force" and frequency in pressure. With two types of particles in the two boxes, (different masses, all other variables being the same), all students make a wrong prediction with the same reasoning based on frequency. But when they observe the central wall in balance, more than 50% of students reason in terms of compensation of "force" and frequency and bring into play mass and speed in the "force" of hits.

These results are to rely to previous teachers' ideas [5].

Conclusions

With this detailed analysis of students reactions, you have pointed out some possible keys for an evolution of teachers' practices. We have shown that an approach of a complex model can be complete and coherent with mass and speed of particles, even at elementary level. Introducing the mass first gives a better chaining to motivate students in reasoning on simulated situations. With an appropriate guiding, reasoning on several variables and using microscopic level to understand the relationships at macroscopic level are feasible. These results give a feedback to improve the on line resources for teachers and teacher trainers.

References

[1] Bulletin Officiel de l'Éducation nationale, Physique-Chimie, Classe de seconde, *B.O.E.N.*, n° 6 H.S. du 12 août 1999.

[2] CHOMAT, A., LARCHER, C. and MÉHEUT, M. *Modèle particulaire et démarches de modélisation*, 1990, LIREST-INRP, Paris.

[3] MÉHEUT, M. Designing a learning sequence about a pre-quantitative kinetic model of gases: the parts played by questions and by a computer-simulation. *Int. J. Science Educ.,* 1997, vol. 19, no 6, p. 647-660.

[4] VIENNOT, L. Physics Education Research : Inseparable Contents and Methods, the part played by critical details. In *Research on Mathematics and Science Education*. M. Ahtee, O. Björkvist, E. Pekkonen, V. Vatanen (Eds), 2001, University of Jyväskylä, Finlande, p. 89-100.

[5] ROZIER, S. and VIENNOT, L. Students' reasoning in thermodynamics, *Int. J. Science Educ.*, 1991, vol. 13, no 2, p. 159-170.

on line : http://www.epi.asso.fr; http://www.udppc.asso.fr.