PS5-D-Symp

Teaching about Energy in Secondary Schools: The case of two innovations and teachers' transformations of them

Fani Stylianidou and Jon Ogborn
Institute of Education, University of Sussex, United Kingdom
European project: Science Teacher Training in an Information Society(STTIS)

Abstract. It is our starting point that teachers' interpretation of a proposed teaching sequence may result in transformations of the original didactic intentions. This paper discusses two different kinds of curriculum innovations and their transformations by the teachers. One is the change from'transforming' to 'transferring' energy which first appeared in the recommendations concerning the teaching of energy of the 1989 Science National Curriculum for England and Wales. The other is the smaller scale innovation introduced by the curriculum materials developed by the 'Energy and Change' project. This project aimed to provide novel ways of teaching about the nature and direction of changes and energy introducing ideas related to the Second Law of Thermodynamics. For each of these two curriculum innovations we first identified the types of actions that ensue from the didactic intentions of the innovations and then we looked for their existence, absence or transformation through teacher case studies.

The problem. The predominant question which the STTIS research addresses is about the nature of difficulties arising when teachers are asked to adopt an innovative teaching strategy (STTIS 1998). By a 'teaching strategy', we mean a complex scenario containing actions and tools to present a specific content with the aim of helping students to build their knowledge system as far as that content (and its correlation with other contents) is concerned. Our starting point is that teachers' interpretation of a proposed teaching sequence may result in transformations of the original didactic intentions. We expect these transformations to relate to teachers' conceptual difficulties, to their epistemological views, and to their previous practice. We furthermore suspect that they may have important conceptual consequences for pupils' learning.

In this framework the UK team chose to look at two kinds of curriculum innovations, both broadly concerned with the teaching about energy. One is the national-scale innovation defined in the text of the first National Curriculum for England and Wales (DES 1989) about the teaching of energy; in this for the first time the concept of energy *transfer* as one to be learnt and experienced by pupils at the secondary level appears to replace this of energy *transformation* used by previous syllabi and many textbooks. Implicit in the recommendations of that first National Curriculum and of every version since is that energy should be thought of as 'staying the same kind of thing' while it goes / flows / is passed from place / object to place / object. Moreover, it should not be associated with its sources, but with the way ittravels. So, there are not different forms of energy, but there are different kinds of transfer - energy is carried in different ways, e.g. energy is transferred by work, heat (thermal energy transfer), electricity, and so on.

The other innovation we chose to look at is the smaller scale innovation introduced by the curriculum materials developed by the 'Energy and Change' project (Boohan and Ogborn 1996, Boohan 1996). This project aimed to provide novel ways of

teaching about the nature and direction of changes and energy, in particular introducing ideas related to the Second Law of Thermodynamics in a way accessible to pupils aged 11 upwards. To accomplish this, the project developed an abstract picture language through which the scientific story is told.

We saw these two kinds of innovations as complementary in many ways. The first is more explicitly concerned with content knowledge and is intended to be applied by all teachers without exception at national level. It is expressed in the form of general recommendations of what pupils should be taught, but does not suggest either a strict sequencing of concepts, or teaching strategies and pupils' activities. The second innovation should be seen as working at the local level; it describes an approach which is relevant to the teaching of asignificant number of topics, and provides explicit materials to be used by the teachers either in the classroom or for their professional development.

Design and procedure. For each of these two curriculum innovations the first goal was to locate connections between precise didactic intentions and specific types of actions by the teacher. Only after having identified these types of actions that ensue from the didactic intentions of the innovations would we be able to look for them in the classroom and acknowledge their existence, absence or transformation.

In the case of the innovation introduced by the National Curriculum for Science, an officially documented innovation, we thought it would be interesting to first investigate how the written recommendations concerning the teaching of energy were understood by beginning science teachers. Five training teachers were interviewed on their understanding of these recommendations. Twenty seven beginning teachers in total (these five among them) had previously attended a training session on the teaching of'Energy' and had been given a questionnaire to complete which aimed at eliciting their ideas about energy. Another five teachers were observed introducing the topic 'energy' to their classes and were interviewed afterwards about it. Observation records were kept, and in some cases pupils' work was collected.

In the case of the 'Energy and Change' curriculum innovation data came from two sources. An evaluation of the learning outcomes of the new teaching approach earlier conducted and reported elsewhere (e.g.Stylianidou and Boohan 1999) provided us with detailed observational notes about how the project's activities were used by two teachers over a period of eight months and with interview transcripts on what they thought about them.

In addition to these available data, data were collected from two other schools. In the first school, a teacher who had made spontaneous use of the innovative project materials and had diffused the ideas to other teachers in the school, was observed using the project materials, and was subsequently interviewed. This teacher had attempted to integrate the innovative approach suggested by the materials for the teaching of energy with more conventional teaching approaches. In the second school we attended an In-Service Training session in which the 'Energy and Change' approach and curriculum materials were presented to 13 teachers from the locality. An evaluation questionnaire was given out to them at the end of the session. One teacher from this group, was subsequently observed using the approach and interviewed by us. The schemes of work he used and provided us with show how the school has incorporated the innovative approach.

Data analysis and findings. The predominant idea orientating the research, as mentioned before, is that of *transformation* of didactic intentions by teachers. This means that the analysis is not focused on the "difficulties" teachers had with the curriculum innovations as such, but that we refer our observations to precise didactic intentions.

Concerning the National Curriculum innovation, our findings seem to indicate that the didactic intentions of the innovators are not fulfilled in today's teaching of energy. Our case studies of teachers suggest that although the term 'energy transfer' either as a noun or as a process has been adopted in the teaching of energy, its conceptual implications have not.. In other words whereas teachers have stopped using the term 'energy transformation', they see no problems in talking about energy being *transferred* from one *form* to *another*. This linguistic amalgamation of fundamentally different concepts and ideas is something that we also saw happening in the use of the 'Energy and Change' project's materials. Often the teachers adopted the suggested new ways of talking about energy and change, but not the meanings the new terms were meant to convey. In other words they accommodated the new nomenclature to their existing schemas; their underlying conceptions did not alter, only the terms they used to express them. Interestingly, this accommodation of the 'new' in the 'old' did not seem to be subconscious. The teachers identified differences between the two and gave reasons for using one in preference to the other. Additional findings along the same lines will be reported in the symposium.

General interest. The results of this piece of research hold interest for different reasons. First, because they partly concern a curriculum innovation enforced at a national scale. Any findings about the outcome of such an innovation are de facto of general interest..

Second, because the innovation in contention concerns the teaching of energy. The innovation was the product of extended and profound discussions in the academic and professional journals about the teaching of energy at the time (for example, Duit 1981, Schmid 1982, Warren 1982, Marx 1983, Driver and Millar 1986, Ellse 1988, Ross 1988, Solomon 1992); ten years after, the issues the innovation aimed to tackle remain as pertinent as ever.

Seen from another perspective, the results of this research offer usinsights in the process of the adoption of an innovation by tracing the incorporation of the 'Energy and Change' approach in teaching practices over a longer term.

Finally, seen in the context of the STTIS project, different kinds of data will constitute an opportunity to look for transversal aspects in our results, in order to point to some particular risks of transformation, whatever the topic, in the process of 'transmission' of innovations to (that is, through) teachers.

References.

Boohan, R. (1996). *'Energy and Change: Support materials'.* London: Institute of Education, Universityof London.

Boohan, R., and Ogborn, J. (1996). *Energy andchange. A set of three booklets.* Hatfield, England: Association forScience Education.

DES (1989) *Science in the National Curriculum*. London:HMSO

Driver, R., & Millar, R. (Eds). (1986). *Energymatters.* Leeds, UK: Centre for Science and Mathematics Education,University of Leeds.

Duit, R. (1981). Understanding energy as a conserved quantity.*European Journal of Science Education*, *3*(3),291-301.
Ellse, M. (1988). Transferring not transforming energy. *School Science Review*, *69* (248), 427-437.
Marx, G. (1983). *Entropy in the school.* Budapest:Roland Eˆtvˆs Physical Society.
Ross, K. A. (1988). Matter scatter and energy anarchy: the second lawof thermodynamics is simply common experience. *School ScienceReview*, *69*(248), 438-445.
Schmid, G. B. (1982). Energy and its carriers. *PhysicsEducation*, *17*(5), 212-218.
Solomon, J. (1992). *Getting to know about energy in schooland society*. London: The Falmer Press.
STTIS (1998). *Outline and Justification of Research Methodology: Work Packages WP1, WP2 and WP3*. STTIS Report.
Stylianidou, F and Boohan, R. (1999). 'Understanding WhyThings Happen: Case-Studies of Pupils Using an Abstract Picture Language toRepresent the Nature of Changes', *Research in ScienceEducation*, January 1999.
Warren, J. (1982). The nature of energy. *European Journal ofScience Education*, *4*(3), 295-297.