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New Perspectives for Learning - Briefing Paper 33

Understanding innovation in science teaching

Context of the Research

Innovations in science education are increasingly needed in order to foster greater scientific literacy. Results from science education research and the additional technological resources now available are contributing to a change of views with regard to the content, teaching/learning processes and methods and the role of teachers in science classes. Challenging new ways of teaching and learning are becoming available, but can only be implemented when teachers feel faithful to adopting them.

This project has focused on understanding the conditions that may enable curricular innovations to be transformed into successful implementations by science teachers. At secondary school level the project studied the implementation of informatic tools (for modelling, simulation and for real-time experiments); the implementation and use of specific images; and the implementation of innovative teaching sequences.

Within five countries (France, Italy, Norway, Spain, and the United Kingdom) the project observed experienced science teachers in real classroom situations. The teachers had volunteered, and were well motivated to adopting the curricular innovations. The observation of their classes could give relevant clues to the process of introducing innovation in real science classes.

Key Conclusions

The following general conclusions were reached: -

1. The introduction and embedding of didactic innovations into the school system for natural and normal usage is a complex process.

2. The innovations need to be flexible and robust, in order to ensure that the intentions of a designed innovation are shared by teachers, who have to proactively implement them.

3. Didactic innovations go through a “metabolic process”, that may be long, before they are fully “naturalised” i.e. thought and used as natural and appropriate strategies/tools for teaching/learning.

4. Internalising innovative approaches entails broad acceptance of their rationale and also means becoming capable of implementing them in different contexts and situations and interpreting them in resonance with their didactic intentions and potentialities.

5. Although, initially, an innovation needs to utilise specific content within a particular classroom context, the transformations done during its take-up can transverse to other contexts.

Specific conclusions relating to the use of informatic tools: -

6. Very few teachers have a lot of experience in using computers and many teachers have very little experience.

7. There is still a lot of uncertainly about the role of computer as an integral part of education.

8. In all the countries studied there are policies to develop computing in schools, but there are substantial differences in the actual provision of computers.

9. Generic software seems to prevail with word processing packages used the most, followed by spreadsheets.

10. Simulations are strongly used by a few teachers, however their use is not generalised yet.

11. Modelling tools are rarely used despite some very strong arguments in favour of their importance.

Specific conclusions relating to the use of images: -

12. As information society is creating a culture in which images acquire a higher profile as a way of communication, the use of images in science teaching is increasing.

13. Images should be presented as a coherent whole of different elements aiming at conveying a message.

14. Images are not trivially understandable. It is important to know which are the features of the images that might lead the students to difficulties in interpreting them.

15. Students tend to make narrative readings of the images, i.e. to interpret them as if they had a story-like structure giving excessive relevance to elements (as arrows) or compositional structures (as left to right arrangement) that can convey such kind of message.

16. The teachers' awareness of the students' difficulties reading images is not always very high. The interpretation of the difficulties expressed by their students should be emphasised.

17. When facing documents (images and text) that do not include all the information students need to interpret them, students often resort to interpreting mechanisms that can be related with lack of scientific background and/or insufficient knowledge of the visual language. That is, misreadings are observed when necessary information is missing from the document.

Key Recommendations

The following general recommendations were made: -

1. Teachers need positive assistance in coping with the transfer of innovations into actual class-work. To favour the take-up of innovations, appropriate teacher training is a crucial element, even if this alone cannot guarantee successful adoption by teachers of the innovation.

2. In order to acquire the know-how needed for the successful adoption of innovations, teachers need to be supported in becoming well aware of why the innovations are proposed. There should be emphasis on problems deriving from traditional teaching with examples of both students' learning difficulties and inefficient teaching strategies.

3. The training should address explicitly and extensively why the "old" approaches need to be avoided, modified, integrated with the "new".

4. As critical details of an innovative approach may deeply affect its impact, training should explicitly explain, show and illustrate, through real examples, that without appropriate detailed actions the innovative effects are easily reduced or nullified.

5. However, teachers' choices and actions depend on various factors, which include the disciplinary knowledge, convictions about teaching and learning processes, viewpoint about the role and relevance of lab-work, interests and objectives, image of science, social and communication capabilities.

6. Training should focus on helping the teachers become aware of and grasp a holistic view of innovation including topics, concepts, and approaches and not fragment into small-unrelated pieces. There should be emphasis on establishing links between the scientific contents that constitute a didactical unit, as well between the proposed activities, questions, specific episodes, etc.

7. Special focus is needed on increasing teachers' awareness about careful planning of the cognitive dimensions of class activities as well as of their practical aspects

8. Training should extensively explain and show the need to be extremely careful with all types of language used. Care is needed in drawing, reading and interpreting graphs, schemas and diagrams. It is necessary to be able to express scientific terms in everyday language, as well, to correctly use the scientific language in the scientific domain. To cross both domains has been detected difficult for teachers as well as for students. Therefore, an analysis of the understanding of new scientific concepts and words should be carried out in order to verify their correct usage.

9. There should be analysis of existing teaching materials (texts, images, activities, worksheets) in order to avoid needless misunderstanding or misleading of the concepts.

10. Special attention should be paid to encourage students to interact verbally with peers about the tasks and activities proposed, in order to improve understanding and learning.

Specific recommendations were made relating to the use of images:

11. Teachers should be trained about the grammar of visual language so that their drawings, schemes, graphs and diagrams convey the ideas and concepts that they desire.

12. Students and teachers should have specific training in the use of real-time graphs produced in experiments based on computer driven sensors. The optimisation of image's readability and the interpretation of the unique features of real-time graphs, including artefacts, should be particularly addressed.

13. Authors and designers of images should collaborate with curriculum (didactic) experts to optimise the suitability of images and concepts according the level of students' understanding

Specific recommendations were made relating to the use of informatic tools:

14. Training should consider that the use of IT in science is still 'fragile' and 'patchy', even this situation is changing rapidly.

15. Attention should be focused on the new opportunities created by the use of IT in science courses. The IT "real-time experiments" saves time of capturing data in labwork, and allows to spend more time for students' interactions, for the analysis of different variables and for the rapid repetition of experiments.

16. Claims that IT helps deepen understanding need to be backed up with specific examples of classroom activities and an analysis of the benefits that are felt to be associated with them.

17. Training should aim at creating clusters of teachers in each school in order to diffuse expertise among fellow teachers and potentially greatly increase the take-up of innovations based on IT.

Further Information

The full title of the project is “Science Teacher Training in an Information Society” with the final report completed on 30 April 2001.

Full report, Abstract, Summary Partner details Website

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