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Crossing the Borders: chemical education research and classroom practice.

Onno de Jong, Utrecht University, The Netherlands

1. Crises in current chemistry education

In many European countries, chemistry education faces a number of important recurrent difficulties. At the secondary school level, chemistry has a negative image with many students. They consider chemistry as a rather dirty discipline and they experience difficulties in understanding key concepts and rules. Well-known students' complaints can be formulated as 'I know this chemistry formula by heart, but I do not understand its meaning'. Many teachers complain that repeated explanation and demonstration are not very effective and frustrate the students. Besides, students' interest in chemistry as one of the chosen final examination subjects has decreased to a rather low level. At university level, the number of first-year chemistry students is also decreasing. Students complain that laboratory courses involve many boring 'cookbook' problems instead of challenging tasks to explore new chemistry areas. However, lecturers complain that many students are not able to connect lecture courses with laboratory courses and, for that reason, cannot apply (theoretical) knowledge of chemistry in the context of practical work.

Another category of problems concerns the chemistry curriculum. Well-known complaints concern the overload of topics, the vague course structure and a lack of modern topics. Besides, the connection between the chemistry curriculum at secondary level and at tertiary level is rather weak.

Taking on the current crisis requires, among other measures, the use of research (De Jong, et al., 1999a). Unfortunately, many researchers and teachers point out a gap between chemical education research and the implementation of the research results in classroom teaching.

2. The gap between research and teaching

Chemical education researchers and chemistry teachers experience feelings of dissatisfaction. Their complaints about a gap between research and teaching can be formulated as: much chemical education research does not really reach the teachers and, if it does, research outcomes do seem to be either not very useful or difficult to translate into feasible teaching/learning activities for classroom practice. There are several reasons for these complaints. I will mention three of the main ones.

First of all, there is the problem that Chemical education researchers have to survive, which means that they have to publish in high-ranked journals read by only a few teachers. Of course, researchers are free to publish in journals for chemistry teachers, and some of them do. However, that does not pay off in terms of scientific output. Chemistry teachers also have to survive, which means that they are too busy with their lessons and cannot find time for reading research articles. Even if they have time for reading, they need extra time for translating and integrating the content into their classroom practice, and this is a skill they may not have developed during their period of teacher training.

Another reason for the gap between teachers and education researchers might be the differences in expectations of these groups. Researchers might be inclined to believe that teachers are able to transform the reported research outcomes into useful ideas for classroom teaching. Teachers might be inclined to think that research provides them with solutions for all teaching difficulties. Unfortunately, both expectations are too high and not very realistic.

Finally, the gap may result from the choice of the research paradigm that is used. In my opinion, the gap between 'theory' and 'practice' will not be bridged by research that is based only on educational-psychological models, because these models are too general. For this reason, it is possible to develop several diverging chemistry courses from one and the same cognitive science theory. Conversely it is also

possible to base the same chemistry course on several different cognitive science theories. For that reason, it is important for chemical education research to take account of the content of chemistry courses. Such studies will have a rather domain-specific character (De Jong, et al., 1999b).

3. The line of domain-specific research

During the last decade, there has been increased interest in the studies of teaching and learning of specific chemistry topics, such as acid-base reactions or volumetric analyis. This domain-specific research is strongly stimulated by the current paradigm of constructivism. According to this perspective on the acquisition of knowledge (see e.g. Bodner, 1986), learning is a dynamic and social process in which learners actively construct meaning from their actual experiences in connection with their prior understandings and the social setting. Knowledge and learning are considered to be dependent on the situation: cognition is in part a product of the activity, context, and culture in which it is developed and used. A major implication for teaching is the idea that chemistry teachers should have an insight into students' (pre)conceptions of chemistry topics and should facilitate learning by creating conditions enabling conceptual change. Many domain-specific studies were focused on students' conceptions of chemistry concepts and rules (documented by Pfundt and Duit, 1991). These studies often involve qualitative methods for collecting and analysing research data. Frequently used instruments are interviews and so-called think-aloud protocols. This kind of protocol can be produced by inviting students to say what they think as they perform a certain task (introspection). Students, after finishing the task, can also be asked to tell what they were thinking during the task (retrospection). In both cases, students' statements can be audio-taped and transcribed. Domain-specific studies are often small-scale because of the time-consuming methods of analysis.

In my opinion, domain-specific research is a very important tool for improving chemistry education. However, its value depends on the nature of the research instruments. Interviews and think-aloud protocols can be used before or after classroom instructions, but they are not very fruitful for investigating the teaching and learning of chemistry in the usual context: the environment of the classroom and laboratory. For research in the classroom, the so-called classroom protocols are more powerful. These protocols can be produced by audio-taping discussions of students and teachers in educational situations and transcribing the statements. The protocols can be a rich source of information, although their analysis is not always very easy. They can also be used to investigate teachers' conceptions and actions.

4. Establishing closer links between research and development

A promising new approach to domain-specific research in this area is called the 'developmental research' approach (Lijnse, 1995). In this approach, a small-scale curriculum development is linked to in-depth research on social, content, and context specific teaching/learning processes. The structure of the research activities can be described as repeated cycles (or a spiral) which includes the following characteristics.

- The starting point is an evaluation of current educational situations.
- Research questions are formulated in conjunction with reflection on chemistry and chemistry education.
- New teaching strategies and materials are developed and implemented.
- Teaching and learning processes are investigated during classroom and laboratory sessions. Important research instruments are audio/video-tapes for producing protocols of classroom/laboratory discussions.
- The results are used in a new cycle of inquiry.

The research output can also contribute to the development of well-structured didactical models, well-founded classroom practices and effective courses for chemistry teachers. Furthermore, if developmental research is carried out at secondary level as well as at university level, the results can also help to strengthen the connection between both chemistry curricula.

References

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