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RESEARCH AND TEACHING PRACTICE IN CHEMICAL EDUCATION: LIVING APART OR TOGETHER?

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Introduction

About 50 years ago, chemistry education reform has stimulated the rise of chemical education research. Unfortunately, the implementation of research findings in the teaching practice is problematic. Researchers and teachers complain about a gap. This paper addresses reasons for the persistence of the research-teaching gap, and promising actions for bridging this gap.

The rise of chemistry education research

In the middle of the Cold War era, in 1957, the former Soviet Union launched the first space satellite (the 'Sputnik"), and evoked a shock in the world. For chemistry education, the 'Sputnik' effect initiated the reform many national curricula, which have also been criticized before for being old-fashioned, overloaded, and mainly facts-oriented. As a consequence, in several countries, a large-scale chemistry curriculum reform was initiated. Leading new curricula for secondary schools were the USA projects of Chemical Education Materials Study (CHEM Study) and the Chemical Bond Approach (CBA), and the UK project of Nuffield Chemistry. These projects focused on understanding concepts instead of knowing a large number of facts, and for that reason, students get the opportunity to use special student books of tables. The new curricula also focused on stimulating the development of basic skills, and classrooms were adapted (or added) for conducting laboratory work. The 1960s reform initiated the interest in gathering evidence to establish effects of the new curricula on students' knowledge and performance. So, chemistry education research was born.

Research in chemistry education was a young branch on the tree of human knowledge, much younger than research in modern chemistry (see Figure 1). In the beginning, studies were mainly focused on students' learning outcomes and did not explore the interaction of instruction and learning. Many research data were obtained by using multiple-choice questions and other quantitative methods of collecting data. However, in the 1980s, the interest expanded more and more towards studies of students' ways of reasoning and learning processes, followed, in the 2000s, by a growing interest in teachers' practical knowledge and teaching processes. Many studies involve qualitative methods for collecting data, for example, by recording discussions in classrooms.

Chemistry education research has provided a lot of data for helping particular groups of professionals, especially people who are involved in curriculum development or assessment designs. But what about the hard core of professionals: the teachers in the classroom? It is well known that the relationship between chemistry education research and chemistry teaching practice is problematic, at the secondary school level as well as at the university level. For example, researchers point out the poor effects of their efforts, while chemistry teachers complain about the absence of relevance of the research for their teaching. So, there is a serious research-practice gap.

Figure 1. Birth of research in chemistry and chemistry education

<u>Chemistry research</u>

≈ 1750 Modern macro chemistry (e.g. Lavoisier, Proust)
≈ 1800 Modern macro chemistry (e.g. Dalton)

<u>Chemistry education research</u>

≈ 1900 School chemistry education (e.g. J. of Chem. Ed., since ≈ 1920)
≈ 1960 Chemistry education research (e.g. J. of Res. in Sci. T., since ≈1960, Int. J. of Sci. Ed., since ≈ 1980)
≈ 1990 Chemistry teacher education research

Examining the research-teaching gap
In this paper, I will address two key questions about the research-practice gap (see Figure 2). Before the reader continues to look further, I would like to invite him or her to wait a while and to try to answer both questions by himself or herself.

Figure 2. Key questions about the research-practice gap

1. What are the most important reasons for the gap between chemistry education research and teaching practice?

2. What are the most important ways for bridging the gap between chemistry education research and teaching practice?

In my keynote, presented at the 18th ICCE Conference in Istanbul (2004), I talked about what is written above. However, before I continued my lecture, I announced a short break and invited my audience to think about both questions (Figure 2) and to write down their personal answers on a form. After the keynote, I collected the forms and selected the ones that were filled in by people who had indicated to have experience with teaching chemistry (at schools or universities) or chemistry education (at teacher training colleges) and to be familiar with chemistry education research. For the analyses of the answers, I used 36 forms, of which 14 forms from Turkish people and 22 forms from people coming from 16 other countries.

Views on the persistence of the gap

The answers to the question about important reasons for the gap were classified into two main categories: (a) personal reasons, expressed from the teacher or researcher perspective, and (b) structural reasons, expressed from the common perspective. The results show that most of the statements regard 'teacher' reasons, followed by 'researcher' reasons, and 'structural' reasons. Regarding the personal reasons, most statements refer to a lack of knowledge or skills. Regarding the structural reasons, most statements refer to insufficient communication and collaboration between researchers and teachers. Exemplary statements are given in Figure 3. Although the ICCE survey is small-scaled, the results cover a wide range of reasons that support findings and views from elsewhere. [1-2]

Figure 3. Exemplary statements about causes of the gap

From the teacher perspective:
" Insufficient guidance for teachers how to use evidence in the literature, lack of pedagogic knowledge" (UK).

From the researcher perspective:
" The chemistry education researchers don't teach chemistry in the school. They don't know how theory that they inquiry works" (Turkey).

From the common perspective:
" A lack of long and continuous collaboration between teachers and researchers. Only occasional exposures are not enough" (Israel).

The reported reasons can be explained from several factors behind them. Here, I will address four main explanations.

(i) The *need to survive issue.* Teachers cannot find enough time to reading research articles because they are already too busy with their core business, which is, teaching in classrooms. Even if they have time for reading, they need extra time for translate and integrate the content into their teaching practice. Researchers also have to survive, which means that they have to publish in high-ranked journals read by only a few teachers. Of course, some of them publish in journals for teachers, but that does not provide rewards in terms of 'research' output.

(ii) The *mutual expectations issue*. Teachers might be inclined to think that research ought to provide them quickly with final solutions for their teaching difficulties. Researchers might be inclined to believe that teachers are able to understand their reports and to transform research outcomes into useful ideas for teaching. Unfortunately, from both sides, the expectations are too high and the views are not very realistic.

(iii) The *innovation strategy issue*. Over the past decade, chemistry education reform has often been introduced by using the RDD-model: research, development, and diffusion. According to this 'top-down' approach, research projects are launched at universities or other research institutes, and the results are used for developing new curricula and teaching/learning materials in separate institutes that also take care of further dissemination of the products. From this perspective, the teacher role only consists of executing the new programs. As a consequence, a sharp distinction between researches and teachers is created. Nowadays, the RDD-strategy is considered to be rather old-fashioned, but, in my opinion, a lot of current curriculum projects use this model to some extent. This does not contribute to bridge the researcher-teacher gap.

(iv) The *research paradigm issue*. Over the past several decades, the research programs for chemical education have been strongly influenced by 'content-free' theories of teaching and learning. The conclusions from this research tended to be very general. However, most chemistry teachers are faced with specific content-related difficulties in teaching and learning. This discrepancy also contributes to the persistency of the research-teaching gap.

Views on bridging the gap

The answers to the question about important ways of bridging the gap were also classified into two main categories: (a) personal actions, expressed from the teacher or researcher perspective, and (b) structural actions, expressed from the common perspective. The results show that most of the statements regard 'structural' reasons, followed by 'researcher' reasons, and 'teacher' reasons. Many recommended actions were the counterparts of the reported reasons for the persistence of the research-practice gap. Exemplary statements are given in Figure 4.

Figure 4. Exemplary statements about actions for bridging the gap

From the teacher perspective:

" There should be teacher education programs and in these programs teachers must use new methods or new approaches and be informed about new studies" (Turkey).

From the researcher perspective:

*" More practical suggestions from researchers that can realistically be implemented"(*Ireland).

From the common perspective:

"Seminars to join the cultures. The interest is there but seminars must be scheduled" (Sweden).

Living apart or together?

Most of the suggested actions refer to improving the communication and collaboration between researchers and teachers. These issues are elaborated by several authors elsewhere.[3]
Regarding the improvement of communication between researchers and teachers, I would like to point out the promising use of Internet. Although many research journals are published on-line, nearly all of them require money for access. This is a hindering factor for teachers, because many of them have a very limited school budget for subscriptions. Fortunately, some electronic journals were free of charge, for example, the 'Chemistry Education Research and Practice', published by the University of Ioannina, Greece, on the website address http://www.uoi.gr/cerp, and the 'University Chemistry Education', published by the Royal Society of Chemistry, UK, on the website address htpp://www.rsc.org/uchemed. In the beginning of the former sentence, I used the word 'were', not to indicate that the access to both websites is no longer free of charge, but to indicate that both journals and their websites addresses are changed from 1 January 2005. From that date, they merged with each other towards a new journal, published by the Royal Society of Chemistry, UK, under the title Chemistry Education Research and Practice' (CERP), on the website address htpp://www.rsc.org/cerp. This journal continues to be available free of charge.
A very useful and new electronic database of studies focusing on students' difficulties in understanding specific chemistry concepts and rules can be found on the website address: www.card.unp.ac.za. The term 'card' in this address is an acronym for 'Conceptual and Reasoning Difficulties'. Currently, the CARD website contains over 5000 references as well as extensive information on chemistry difficulties, and will be expanding to include other areas of science, mathematics and technology. Access to the South-African website is also free of charge.
Another new overview of research results, but not free of charge, is given by the electronic journal "Science Education review', on the website address htpp://www.scienceeducationreview.com. The Australian journal includes summaries of carefully selected studies and other articled from around the world, compiled for use in teaching and research practice.

Regarding the improvement of collaboration between researchers and teachers, I would like to address a classroom-based action research approach that is called: 'developmental research'.[4] The main purpose of research is to develop theories together with instructional materials that are useful in classroom practice because they have been developed in practice. The structure of this research involves repeated cycles (a spiral) of stages that can be described concisely as follows. First, specific problems in teaching and learning are analysed. Second, in conjunction with reflection on chemistry and chemistry education, research questions are formulated. Third, drafts of new teaching strategies and materials are developed, discussed with teachers, revised, and implemented. Fourth, teaching and learning processes are investigated during classroom and laboratory sessions. Finally, the results are used in a new cycle of research. Recently, for chemical education, Stolk, Bulte, De Jong, and Pilot (2005) have presented an example of a development research project.[5] Their study deals with a new issue in the Dutch chemistry curriculum, viz. the teaching of chemistry concepts in daily-life contexts, for example, teaching cross-linked ionic polymers in the context of diapers for babies and very old people.

In conclusion, at the personal level, there are several promising ways to bridge the research-practice gap. But it is also important to establish communities of researchers, designers, teacher educators and teachers for working together on specific chemistry education projects, to bring in and exchange specific knowledge, and to built up new knowledge. For instance, the community can help teachers to articulate research questions that are relevant, open for answering under realistic conditions of time and money. To make the community fruitful and effective, it is important to create an atmosphere of equivalence and commitment, for instance regarding crucial decisions as the scope of an inquiry project. It is also important to take care of a clear stream of communication between the participants, for instance about agreements regarding tasks. In this way, these ‘communities of knowledge’ can also contribute to bring chemistry education research and practice more together.

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