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EXTERNAL VIEWS TO THE IMPLEMENTATION OF THE CONTENT PEDAGOGY RESEARCH PROGRAM OF THE HUNGARIAN ACADEMY OF SCIENCES

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ABSTRACT

In 2017, the Hungarian Academy of Sciences invited me to work as an external evaluator or a "critical friend" to five science education research projects, financed by the Content Pedagogy Research Program. The aim of the Content Pedagogy Research Program is to improve teaching and learning in Hungarian secondary schools through well-established research projects. The topics of the research projects have been in the areas of biology, chemistry, geography, and physics education at lower and upper secondary levels. I include geography as a science subject in this context, although geography also concerns social and political sciences and cultural studies.

Keywords: content pedagogy, science education research, design based research

As a critical friend, I have made three annual evaluations based on research groups' self-evaluation reports and statistical data available related to publications and other research outcomes. I have also made a site visit, interviewed all research groups and their sub-groups, and visited schools with which they have been collaborating. In my evaluations, I have assessed the research intensity and the impact of the research groups on school science according to the aims and implemented activities. Moreover, I have evaluated the international collaboration and its impact on teacher education. In this short reflective paper, I will analyse the activities and outcomes of the research group in general and describe some examples based on my previous evaluations of the annual activities.

THE RELEVANCE OF THE TOPICS OF THE RESEARCH PROJECTS

The steps towards renewal of science education that the research groups of the Content Pedagogy Research Program have taken are important in the modernization of science education in Hungary. The selected topics are innovative, relevant and important. Good examples of the topics are those related to the teaching and learning of modern physics, environmental physics, electromagnetic waves and optics, astronomy, medical microbiology, reasoning skills like probabilistic thinking and geography of micro- and mesoregions. This type of orientation to the teaching of new areas of science in lower and upper secondary education has happened in some other countries, like in Israel and the United States. Another view in the selection of the topics has been the aim to connect scientific ideas or topics and scientific practices. Scientific practices are those that scientists engage in, like asking questions, reasoning, planning and carrying out investigations, modelling and communicating. This connection between ideas and practices in science is important, because there are no science topics without practices and no practices without science topics!

While reading the reports of the research groups, I began to wonder, how do we know what is an important topic in science that we should teach at school? The reports have not given me a general answer as to why certain topics have been elected in the research groups. I have found one possible answer from the U.S. Next Generation Science Standards, which emphasises teaching and learning of disciplinary core ideas. Core ideas are important across science and engineering domains; they can be explanatory (used for explaining phenomena), generative (used for investigating and solving problems) and relevant (personal, local, global contexts). In my opinion, it is important to argue the importance of the topic in a research group (Krajcik et al., 2014).

Until now, teaching of science in classrooms all over the world has typically focused on topics that were researched a decade or two ago. New and relevant topics in physics and chemistry in particular are practically absent from the curricula and classrooms. Students learn basic Newtonian mechanics and thermodynamics without knowing anything about artificial intelligence, climate change, loss of biodiversity or other pressing challenges of science. Therefore, we might need more radical steps in the renewal of science education than the research groups has done until now. However, the orientation is excellent in the research projects even now. On the other hand, these large-scale challenges are not easy to introduce to students, because multidisciplinary knowledge is needed in order to understand the challenge; such topics are complex and can increase anxiety among young people. Therefore, it is important to support the development of young peoples' self-efficacy regarding their ability to learn and understand those challenges. Scientific knowledge is a central, but not the only, means of understanding the world. It is, therefore, important to place phenomena at the centre of science teaching, not scientific principles specific to one science subject.

PEDAGOGICAL APPROACHES DESIGNED IN THE RESEARCH PROJECTS

The research projects have developed innovative pedagogical approaches. Good examples are fostering scientific reasoning in school science, medical microbiology lab activities, problem-oriented teaching methods and inquiry-based chemistry teaching. One group has been developing out of school learning pedagogy. Another interesting example is the development of domestic and international practices related to the preparation for international competitions. As a part of development of pedagogy, the use of digital tools, like micro-computer labs and coding and robotics, have been developed in many projects. This type of use of digital tools supports the use of knowledge practices scientists use in a laboratory.

In my first evaluations, I recommended that the researchers make more clear connections with the previous research related to the development of the pedagogy. For example, I wrote that it is important to know how the pedagogy used in the laboratory could support student collaboration and engagement in active learning, and how the laboratory material and practices contextualise learning. In the case of textbook projects, I encouraged researchers to write in more detail how the new material and teaching according to this material engages students in learning. In the second- and third-year reports, the researchers have made these connections between research and development more clear.

However, better links with research and development could be made even now. For example, in order to acquire scientific knowledge and use this knowledge in various situations, research has emphasised the importance of students' active engagement in scientific practices. For example, in the classroom, scientific practices involve students asking questions and defining problems, planning and carrying out investigations, analysing and interpreting data, and developing explanations and designing solutions. Another outcome of science learning research is that students need to actively construct their understandings by working with and using ideas in real-world contexts (Krajcik–Shin, 2015). Consequently, a deep understanding and explicit presentation of how knowledge and knowledge practices are connected, as well as how students' active role in knowledge building are implemented in the research projects, makes these projects stronger.

There are novel and good examples of the designed worksheets, curriculum and learning material and pedagogical approaches being made available for teachers. One research group has designed a database of exercises and lesson plans and an online portal for searching those exercises and lesson plans. In this design, there has been a good collaboration among physics, chemistry and biology teachers in all phases. There are further opportunities to continuously update the system.

LOCAL AND INTERNATIONAL COLLABORATION

The aim in all projects has been to help science teachers in primary and secondary schools to develop interactive and student-centred knowledge acquisition and learning strategies. Therefore, collaboration with science teachers has been essential in all projects and also according to call for proposals. Based on my reading and discussion with teachers during the site visit, it become clear that researchers have been active in planning various teaching materials including textbooks, new types of worksheets, teaching modules and pedagogical approaches. The researchers have supported teachers in implementing and reflecting on teaching units. This type of collaboration supports teachers' professional development on new topics and pedagogy.

The researchers' and teachers' productive collaboration could be called a research–practice partnership (RPP), which has been suggested as a way to bridge the gap between pedagogical research and practice, and, consequently, as a way to support teachers' professional learning (Henrick et al., 2017). Specifically, RPPs are a long-term collaboration between practitioners and researchers that are organised for investigating problems of practice and for developing solutions for improving school practice and even school districts (Coburn–Penuel, 2016, 48.). I think that the research groups have already benefitted greatly from their RPP; however, the RPP could be more productive if researchers were to become familiar with new orientations inside RPP and implement these orientations in their own RPP.

The work through this Content Pedagogy Research Program that has been done with schools is, in general, important for higher education. The developed teaching modules and materials help upper secondary students to gain a realistic picture of science studies at the university level. This picture could make science careers attractive for young people. I am sure there will be more high quality and motivated students in science studies at Hungarian universities in the future.

All projects have been very active in various national-level collaborations. The researchers have networked with similar researchers, research groups and institutions in other Hungarian universities and developed pedagogical innovations. These innovations have also been disseminated through these collaborations.

All groups have had strong collaboration in teachers' pre- and in-service education. All projects have organised or participated in several local seminars, conferences and in-service training. Therefore, the projects have had—and will continue to have—an impact on the modernization of the science teachers' pre- and in-service training.

The topics of each research group are internationally interesting. Many researchers from various groups have visited foreign universities and there have been several visitors abroad in various research groups. The group members have participated in several international meetings and conferences. About one hundred local or international conference papers have been published already. However, there has been variation among the research groups in the publishing of articles in peer reviewed journals; for example, one research group has published about ten journal papers every year, and one has published a couple of papers in domestic journals. One group was active in organising an international conference in Budapest, and the sub-groups of the project were active in preparing presentations for the conference. While preparing the presentations, each sub-group presented the progress of the group and others gave feedback on the presentation. This type of support from colleagues has been useful and hopefully continues during the publication preparation process.

Consequently, the collaboration and networking of the research groups and researchers have been strong and versatile at the local, national and global level. This collaboration has supported the researchers in their research activities and also supported the dissemination of research outcomes.

COMBINING DESIGNING AND RESEARCHING

The needs and constraints related to the planned design work have been evaluated in most of the projects through, for example, the analysis of international textbooks or via surveys sent to teachers asking them to evaluate the applicability of the already existing learning materials or current pedagogical approaches. In one project, medical microbiology lab activities were recognised as a key area in the development of high school biology education, and several good arguments were given as to why the area is important. In addition to clarifying needs, literature reviews in the domains of the design work has been done in all groups.

There are also several good examples of research related to the testing of the designed materials or pedagogical approaches. Data-collection and analysis of data related to the implementation of the design outcome have typically been done well. For example, the research design related to the implementation of inquiry-based chemistry education through quasi-experimental design with a pre- and post-test approach is an example of good quality research. Moreover, there was a longitudinal view in this design. The sample was big enough for generalization and suitable for good quality journal articles. Another good example of high quality research has been the research activities related to the database of test items and learning materials. The use of the database has been tested in classroom situations, and there has been collaboration with science teachers and teacher educators in the testing. In this project, there are several high quality research outcomes, like journal papers and conference presentations.

Consequently, there have been good examples of combining of researching and designing. However, some groups could benefit from more systematic approaches in their research. The design and research could be better connected if the research group followed some traditional models of research and design. I can easily recognise that several projects have already followed a design-based research (DBR) approach, which connects educational research and praxis (Juuti–Lavonen, 2006). It is a general and pragmatic framework for design, development, implementation and evaluation of curriculum materials, courses and learning activities and it uses a pragmatic framework. DBR emphasises three aspects: (a) the design process is essentially iterative, starting from the recognition of the need to change praxis, (b) it generates a widely usable artefact, like a learning activity, a learning environment or pedagogical approaches and (c) it provides educational knowledge for more intelligible praxis (Bell et al., 2004). DBR comprises a combination of theory development, the prescriptions of successful design processes, and the prescriptions of successful design solutions.

FINAL REMARKS

The Content Pedagogy Research Program has had two types of aims. On one hand, it seeks to develop the teaching of science subjects in Hungarian schools. On the other hand, it aims to increase the quality of content pedagogy research in Hungarian universities. Based on the reports and site visit experiences, the first aim is achieved or will be achieved soon. All projects have been successful in the design, implementation and testing of new materials and teaching modules. Moreover, several books, e-books, web pages, laboratory sheets and pedagogical guidebooks for teachers have been published in Hungarian and are available for science teachers. Some of the materials have been or will be translated into English and, consequently, are available for broad international use.

Projects have made progress in pedagogical research orientation, although there is variation in this orientation. In the most positive cases, the research outcomes have been reported at not only national symposiums but also high quality international research symposiums, like ESERA (*European Science Education Research Association*) and EARLI (*European Association for Research on Learning and Instruction*). There is also variation between the groups in the publications in international peer reviewed journals.

In my opinion, Content Pedagogy Research Program as an activity of the Hungarian Academy of Sciences has potential in the renewal of Hungarian science education; indeed, it has already made a positive impact. As a member of the

Finnish Academy of Science and Letters, I hope to apply this model to our work in Finland. I would like to congratulate the Hungarian Academy of Sciences for implementing the Content Pedagogy Research Program.

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