An "Evidence-Based" Professional Development Program for Physics Teachers Focusing on Knowledge Integration

Hana Berger, PhD Thesis, 2009

Abstract

This dissertation is concerned with the design and study of an evidence-based approach to the professional development of high-school physics teachers responding to the need to develop effective continuing professional development programs (CPD) in domains that require genuine changes in teachers' views, knowledge, and practice.

This approach was developed within the context of a CPD program for teachers, focusing on promoting knowledge integration (KI) in physics lessons by using innovative learner-centered activities --knowledge integration routines-- (KIRs). These KIRs guide the students to explicitly link between components of their physics knowledge. For example, the "Interpretation of a Formula" KIR guides the students to make connections between a formula and its physical meaning. Each KIR is carried out through a common five-phase structure: individual work, group work, class work, homework, and individual reflection.

The aim of the program was to change the teachers' knowledge and views in this domain and to shift their practice towards a learner-centered pedagogy. The program used an "evidence-based approach" in which teachers implemented the KI activities, systematically collected "records of practice" about their teaching and their students' learning, discussed these records with their peers, and summarized the process and outcomes in evidence-reports. In addition, the program employed a "blended-learning approach" in which teachers were encouraged to interact via a website, in between the face-to-face meetings, by participating in a set of special activities designed to ensure continuity of learning during the program.

The goals of the thesis were to design an evidence-based model for the CPD program, to implement it with teachers, and to study its influence on teachers' knowledge, views, and practice, as well as its impact on students' learning.

The program was developed in three consecutive versions: a pilot, first, and second versions. Based on the pilot version (that was not part of this study), we developed the first version of the program in which we studied difficulties in employing the evidence-based and blended-learning approaches. According to our findings, we modified the strategies for enacting these approaches in the second version of the program. The influence of the program on the teachers and students was studied during the enactment of the second version of the program.

The research sample consisted of 21 physics teachers and 324 students. The data originated from several sources including transcriptions of face-to-face meetings and online postings, a research journal, interviews with teachers and students, teachers' evidence-reports, and students' filled out worksheets. The data were analyzed by using "mixed methods research".

The model implemented in the second version of the program was characterized by four main design principles: 1. The KI and evidence aspects are acquired simultaneously in an integrated manner. 2. The guidance of the teachers follows the principles of cognitive apprenticeship both in the evidence and the KI aspects. 3. The teachers experience the innovative activities as learners. 4. The program promotes continuity of teachers' learning through a structured "blended learning" approach.

The results of our study show that this version of the program achieved its goals; throughout the program the teachers progressed in their knowledge, views, and practice concerning the knowledge integration, and in the evidence and learner-centered aspects. The results also indicated that students improved their knowledge of physics and knowledge integration skills that were developed throughout the program.

More specifically, analysis of the teachers' discourse during the second version revealed that the program led to significant changes in teachers' knowledge about their students' knowledge and in teachers' views about the following: 1. the advantages of the KIRs' innovative teaching tool, 2. the “evidence” as a useful resource for evaluating the contribution of the KIRs to students' learning, and more generally, as a powerful tool for investigating students' learning, and for improving practice, and 3. several "learner-centered" pedagogical aspects: the importance and legitimacy of learning from peers, the need to listen carefully to students' ideas and reflections, and the need to investigate students' knowledge using a variety of methods, and to plan the teaching accordingly.

Analysis of the teachers' discourse also reveals that the particular evidence-based approach that was used in the program triggered two interrelated patterns of reasoning: "contrasting facts with expectations" and "generalizations". These patterns, which are based on comparing and contrasting, contributed to changes in teachers' knowledge and views.

The findings also suggest that there was continuity in the teachers' learning between the face-to-face and online environments: 1. The teachers discussed in both environments the same ideas about KI, evidence, and the learner-centered issues. 2. The teachers used the same reasoning patterns in both environments. The results also indicate that the discussion of ideas in the two environments led to extension of the teachers' ideas.

The teachers reported that through the implementation of the KIRs, they identified deficiencies in students' knowledge many of which were new to them. The teachers also reported that students improved their knowledge while advancing through the KIR phases both in the physical content and in using physics to explain phenomena and formulae.

In their interpretations, the teachers pointed to their current teaching as a possible reason for the deficiencies in their students' knowledge. In addition, they indicated that the improvement in their students' knowledge possibly resulted from the structure and the specific tasks of the KIRs. The teachers reported that their findings stimulated them to make changes in their practice in response to students' learning difficulties and to embed the KIRs into their practice.

Our analysis of the students' worksheets verified the teachers' findings about their students' initial state of knowledge and the improvement of this knowledge as a result of advancing through the KIR phases. When we extended the sample and examined worksheets of additional classes, we found similar findings. We also found that the students were aware of the improvement in their knowledge and attributed this improvement to their working with the KIRs.

All teachers reported that they used the KIRs to some extent. Moreover, there were teachers who also used the various phases characterizing the KIRs in learning activities other than the KIRs. To date, some of the teachers continue to use the KIRs, more than two years after the program officially ended.

Two major recommendations emerge from this study:

1. We recommend that KIRs be routinely incorporated into physics teaching. The results show that the KIRs contribute to teachers' practice and to students' learning and support the teachers in becoming more learner-centered in their teaching.
2. We recommend incorporating an evidence-based approach in long-term programs aimed at bringing about a significant change in the teachers' practice. In order to engage the teachers with the evidence endeavor, it is recommended to introduce them an innovative teaching tool that is considered by them important and to evoke their curiosity to find out empirically about the influence of the tool on their students' learning. It is also recommended to engage the teachers in ongoing interactions about their experience in implementing the innovative tools in their classes through an online platform by which special, simple online tools are enacted.

The present study has several limitations that suggest directions for further study, some of which can be based on the present set of data, but others require additional study. These directions include a detailed study of individual teachers' professional development, studies of ways to up-scale the evidence-based approach and use it effectively in less intensive courses, an extensive study of how students study with the improved versions of the KIRs that resulted from this study, and further investigation into how the new computerized tools can be utilized in professional development courses.