Collaborative Diagnosis of Scientific and Pedagogical Conceptions: An Instructional Model for Teaching Optics To Pre-service Science Teachers

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Abstract:

Instructional models for pre-service teachers are usually split between content courses and pedagogical courses and the learners are expected to develop the pedagogical content knowledge (PCK) on their own during their practical experience in teaching. This study presents a model for the incorporation of metacognitive strategies in a pre-service content course and investigates how the use of these strategies, contributes to the learning of content and pedagogy.

In this way, it was possible to make the best of the time period, in which the pre-service teachers are still students and assist them in becoming aware of the way in which they study themselves and the teaching methods which they experience. The assumption was that if they become aware of the way in which they study a scientific discipline, they will be able to adopt such a way in the future and adjust it to their own students

The study reported in this work was carried out in the context of a pre-service optical geometry course in an academic college of education. During the study the strategy "Collaborative Diagnosis of Conceptions" (CDC) was developed and explored. The CDC strategy was developed for learning the subject matter and for promoting meta-cognitive awareness about thinking, learning and teaching In addition, reflective assignments were combined into the course, which were aimed for developing metacognitive awareness, both in the field of optics (Content Knowledge), and in the field of optics teaching (Pedagogic Content Knowledge) and teaching in general (Pedagogic Knowledge). Metacognitive strategies are often used in the pedagogical courses, but not in the content courses.

The CDC process includes the comparison between different solutions, reaching an agreed solution or an explained disagreement, identification of scientific and non-scientific answers and analysis of these answers through the identification of the concepts that have led to these answers (for example, 'identification facets). In the context of teacher training, the process also includes suggestions for pedagogic treatment, meaning, what the teacher should do once the answer has been diagnosed.

During the course the pre-service teachers were exposed to student work and to the answers provided by students to the assignments which they (the pre-service teachers) receive in the course. Studies have shown that the scientific conceptions held by pre-service teachers are very similar to those held by students (Galili & Hazan, 2000). Therefore, as they learn to diagnose themselves and their classmates, they actually learn how to diagnose conceptualizations and perceptions of students in general.

The study was conducted using the Design Based Research approach. During the study a primary model of the course and assignments was applied in the year 1984-1985, the outcome and the processes were investigated, various processes and problems, which were given a solution during the application of this approach, were identified and characterized and were also dynamically investigated. The outcome of this work is, on one hand, an improved and consolidated model of the course and assignments, and detailed information on process and outcome on the other hand.

The study accompanied eight groups of teaching apprentices (n=159) who took the course "Optics – Light and Colour", from 1984-1988. The study contained three major parts :

1.) Design Based Research, which followed the design of the course and the teaching strategy and documented them.

2.) A study that investigated, in each development cycle, the effect of the course on conceptualizations and perceptions of optics students their pedagogic conceptions.
3.) A study which focused on the strategy of Collaborative Diagnosis of Conceptions and examined the process that occurred among the pre-service teachers while performing CDC assignments.

The study combines different tools: documentation of classes during the course (including recording of full lectures and collecting all the papers submitted during the course); questionnaires /exams before and at the end of the course; interviews with pre-service teachers; documentation of their reflective activity during and after class.

The results of study indicate that after the course, the pre-service teachers succeeded in:

1) Tasks which testify to quality comprehension of geometric optics, which is not usually achieved in traditional courses, such as tasks examining the understanding of the eye's role in the vision process (82% STD=14.5%).

2) Transfer tasks which examined solutions to issues in optics that had not been studied, such as tasks dealing with lenses (78.8% STD=26.4%).
3) 3.)'Diagnosis tasks' relating to 'facets' in optics (90.2% STD=16.8%).
4) Quantitative tasks (70.3% STD+15%). In most groups the success rate in quantitative tasks was lower than that achieved in qualitative and diagnostic tasks.

From the results of the study it is evident that no significant difference was found in the achievements in optics between group A, which had studied a CDC incorporated course, without reflection on pedagogy (89.0% STD=7.2%) and group B, which had taken the same course with the addition of reflection on pedagogy (81.9% STD=13.7%). However, a significant difference was found in the ability of the pre-service teachers to characterize the teaching methods with which they had studied: A (32% STD=15%), B (75% STD=20%). These results indicate that understanding the scientific contents does not necessarily lead to understanding the way in which these contents are taught, and guided intervention is required in order to encourage thinking about these aspects.

The study found that encouraging metacognitive thinking by the students was a major ingredient in their success in the course and their ability to understand the teaching strategies and methods incorporated in the course.

The teacher's role in activating the strategy of CDC was found to be significant and constituted an important ingredient in the success of the pre-service teachers. Too little scaffolding led to lack of success in performing the assignments; while on the other hand, too detailed guidance did not contribute to the students' development of metacognitive abilities.

There have been differences in the extent of the adjustment of the various teaching methods in the course to the various pre-service teachers. In some cases they failed to comprehend the method and some even expressed objection to this method and declared their preference of traditional teaching. It was noted that some of the students changed their approach to the teaching method during the course, but as a whole, the process of such a change is slow and can certainly not be implemented after a single semester's intervention. These differences did not result from gaps in the pre-sevice teachers` academic level, but were rather connected with their epistemological perception regarding the roles of the teacher and the students in class. This perception is the result of years of experience in educational systems as students and the consolidation of self identity in these matters.

Major Recommendations

a.) The results of the study indicate the potential of using the content courses in science for the promotion of the pre-service teachers' PCK. It is therefore recommended to utilize the courses to fulfill this goal, and not to leave this connection only to didactics courses.
b.) Adding reflective tasks at the end of a science class does not use up a lot of class time, but does significantly improve the ability to connect content knowledge with pedagogic content knowledge. It is therefore recommended to combine reflective activities that encourage metacognitive thinking of both the scientific content learned in the course and the pedagogy used in its teaching.

Possible follow-up studies

a) Study of the implementation of a geometric optics course in other colleges by other teaching-teachers.
b) Follow the pre-service teachers once they have already become teachers and examine whether they implement the principles they have learned in the course.
c) Design and investigation of other content courses in science using a similar approach.
d) Design and investigation of courses for teaching-teachers encouraging an approach that allows the combination between content and pedagogy.