

# A Metacognitive Strategy for Training Preservice Teachers: Collaborative Diagnosis of Conceptual Understanding in Science

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**Abstract:** Instructional models for pre-service teachers usually are 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. Metacognitive strategies are often used in the pedagogical courses, but not in the content courses. This study investigated how the use of metacognitive strategies, in a pre-service content course, contributes to the learning of content and pedagogy.

## Introduction

Instructional models for pre-service teachers usually are split between content courses and pedagogical courses and the learners are expected to develop the pedagogical content knowledge (PCK) (Shulman 1987,1990) on their own during their practical experience in teaching. Ball (2000) claimed that organization of teachers' learning tends to fragment practice and leave to individual teachers the challenge of integrating subject matter knowledge and pedagogy in the contexts of their work, assuming that the integration required for teaching is simple and happens naturally in the course of experience. In fact, this integration does not occur easily, and often does not happen at all. Yet, being able to do this is fundamental to the core tasks of teaching, and is critical to the ability to teach all students well. Sabar (1994) added that special frameworks must be constructed to help the students do this integration. McDermott (1998) claimed that most teachers tend to teach as they have been taught, thus, teachers should be given the opportunity to learn the content to be taught by them in the manner that they are expected to teach it. The study reported in this poster aimed to test this supposition and find what scaffolding is needed to realize it. The study was carried out in the context of a pre-service optic course. The course employed a meta-cognitive instructional strategy aimed at developing the pre-service students' deep understanding of content and at the same time develop their pedagogical content knowledge about ways to interact in the future with their students using similar instructional strategy.

## The research

In this research we designed a course on optical geometry for pre-service science teachers. The course integrated a metacognitive instructional strategy -- *Collaborative Diagnosis of scientific and pedagogical conceptions (CDC)* -- for learning the subject matter and for reflecting on their own learning and thinking. The course is designed with the perspective of Knowledge Integration (KI) (Linn & Eylon, 2006) trying to help the learners connect the pieces of knowledge they have, linking the new knowledge in optics to the old one they possess, and linking pedagogical knowledge to pedagogical content knowledge (PCK). DiSessa (1988) argues that scientific knowledge held by students is fragile and fragmented; we think that connecting the scientific knowledge is not enough for becoming a good teacher, and that the connection should be also to pedagogical knowledge. The goal of the research was to find out the contribution of the strategy to the learners':

- conceptual understanding
- ability to recognize the elements of the strategy
- understanding how these elements help the students in their learning,
- understanding how the strategy can help their future students.

The study also examined whether it was necessary to scaffold the development of students' pedagogical content knowledge.

The study consisted of two parts that differed in the amount of meta-cognitive scaffolding of the pedagogical aspects of learning. The first part of the study was carried out with a group of 20 pre-service teachers from a multicultural background (Moslems, Jews, Christians). They carried out regularly collaborative diagnosis of conceptions (CDC). The CDC strategy supports meta-cognition on the learning of content, by exposing the learners to different conceptions, and giving them an opportunity to discuss and reconsider their ideas. The strategy consists of five stages:

*Stage 1* - Creating an artifact – An individual activity aimed to elicit learners' conceptions.

*Stage 2* - Compare and contrast - The learners are asked to find the differences between their individual artifacts.

*Stage 3* - Creating a mutual artifact - The learners are asked to reach a consensus and to create the group artifact.

*Stage 4* - The source of different conceptions - The learners are asked to analyze the conceptions underlying the different artifacts.

*Stage 5* - What to do next - The learners are asked to choose a pedagogical strategy for helping the student from the previous stages.

These stages are followed by Class discussion aimed to expose all the pre-service teachers to the conclusions of the groups, and to build a common knowledge-base on both subject matter and pedagogical aspects.

The collaborative work is facilitated by a computer-based environment allowing students to test their ideas and compare them to their classroom friend's ideas. Class discussion is added helping to expose the learners to the conclusions from the work of the different groups, and to build a common knowledge-base.

All participants were administered pre/post content tests, attitude questionnaires and a posttest examining their understanding of the instructional strategy as well as their ability to use it. Three subgroups were followed closely throughout the course and their class discussions were recorded.

## Results

We found that the learners advanced significantly in their understanding of the optical concepts but could not characterize the instructional strategy or understand why it worked and how it can be used with students. We found different styles of interaction during the collaborative stage of the CDC. One style of interaction was driven by the wish to find the correct answer, and not to understand why the answer is correct or what led to the correct answer. Another style of interaction was driven by the wish to understand how the other group member thinks, or to explain to the group member one's own way of thinking. In these discussions we found a deeper understanding of the physical concepts and how the correct answer is connected to those concepts.

In the second part of the study, carried out with a group of 100 pre-service science teachers, we revised the strategy by adding interventions that supported metacognition on the pedagogy as well. For example, one of the strategies involved habitual reporting and discussion of learning that occurred in the conceptual and the pedagogical areas. The learners were asked to answer two questions in the end of each lesson. What have you learned about optics during the lesson? What have you learned about teaching optics? We found similar results in the learning of content as in the first part of the study, but there was a significant improvement in the learners' understanding of the instructional strategy and the pedagogical approaches that were used in the course.

These findings demonstrate the potential benefits of using metacognitive interventions in a content course, for the integrated acquisition of content and pedagogical content knowledge by pre-service teachers.

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