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Improving the professional competence of mathematics teachers[1]

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This article analyses and describes improvements in the professional competence of mathematics teachers in the final year of primary education in Chile. To this effect, a teaching strategy was designed that considered two didactic facets: classroom interaction, focussing on teacher activity; and transferral or application in the classroom of the subjects developed in schools participating in the study. Course subject matter was modified by introducing a didactic analysis based on mathematical skills and the solution of types of problems, thus promoting access, in a contextualised manner, to concepts conceived within the education reform and proposed in the study units. In addition, the skills of mathematics teachers were evaluated using a model which considers both general and specialised abilities, competence contextual frameworks and qualitative dimensions related to the conception of quality. The context frameworks, in turn, include elements that are not only mathematical, but also didactic, transversal and evolutionary, used by the teacher in classroom activities. The way in which these elements of the teaching strategy design are interconnected and are represented, provides the opportunity whereby the mathematics teacher can demonstrate his/her competence during the course of educational activities.

***Key words**: competence; learning process; mathematics; primary education.*

Introduction

The relationship between mathematics and social reality is growing and is considered imperative to an adequate formation of the student as a person and to the process of humanising the discipline, accompanied by a modern mathematics education that makes knowledge accessible. The current transformation of mathematics and pedagogy is considered to be a cultural phenomenon that plays an important role in the dynamics of progress and the corresponding changes that are necessary in the field of didactics. If we consider mathematical thinking and associate it with aspects of the society in which we live, different points of view emerge: those that consider mathematics as an objective, absolute body of knowledge, and pedagogic practice as a static instrument; and those that acknowledge that mathematical knowledge and educative practice are fallible and open to continuous revision. These concepts associate mathematics with the entire spectrum of social practice.

Problem solving and social reality

A similar relationship exists between the discipline of mathematics and events of everyday life, and many learning experiences of students in mathematics are set in the context of problem situations that arise in the classroom. In this sense, problem solving as

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a basic ability, and relating this capacity to different contexts, should be a high priority in the school education system, thus preparing students to deal with unfamiliar tasks and to identify some sort of adequate response (Díaz; Poblete, 2002). Experimental studies on mathematics didactics have shown that creating significant contexts is not only a stimulus to the learning process, but also provides the means for creating strategies (Rogoff and Lavas et al, en Bazzini, 2001). In short, the social environment in which the students are inserted provides an appropriate context for "doing maths".

Generally speaking, at present the curriculum is structured around three central elements:subject matter, abilities to be developed and contexts (PISA, NCTM, Freudhental). This way of structuring a curriculum means it can be organized according to an explicit, clear logic and facilitates the comparison of curricula from different countries and cultural backgrounds (Goñi, 2003).

Education reform in America

Education Reforms currently underway in America focus on improving the pedagogic quality of education in general. In the school teaching context, this has been complemented by various efforts to identify how best to create the conditions necessary to enhance educational institutions in such a way as to ensure that progress takes the form of viable, effective and lasting transformations that enrich and reform pedagogic practice. Similarly, systems to evaluate the quality of education have also been developed.

Over the past few years, various countries in America have participated in the evaluations carried out by the Third International Mathematics and Science Study TIMSS and the Programme for International Student Assessment PISA, and the results in mathematics have placed them consistently among the countries with lowest performance rates. In the specific case of Chile, continuous evaluations on as national scale of learning processes in mathematics at primary school level, have been characterized by low achievement levels; these results do not reflect either a qualitative improvement in the performance of the teaching staff who are faced with a reformed curriculum, or an effective transferral of the didactic activities to their pupils.

We believe that the success of Education Reforms from an endogenous perspective of the process, that is teacher–pupil interaction, depends, to a great extent, on the development of teacher capacity in the classroom to ensure adequate planning, development and achievement of goals outlined in both fundamental and transversal objectives. Thus, teachers, their disposition to change and the nature of the professional skills they possess, are a key element.

On this basis, we developed a didactic strategy that was put into practice in a study on improving the professional competence of mathematics teachers from almost all the schools of one region in Chile. We designed this strategy based on a model of professional competence (Poblete; Díaz, 2003) and on a classification of types of problems and types of mathematical skills (Díaz; Poblete; 2004). The study was carried out from both a quantitative and qualitative perspective. In this article we present the qualitative development of this didactic experience.

Competence context frameworks, General and Specialised Skills and Quality

We defined the competence of the mathematics teacher as the description of skills acquired effectively and efficiently when carrying out a teaching activity, related to quality in terms of performing an educative, formative task and doing it well. This means that these skills necessarily integrate understanding and knowledge in the field of mathematics teaching with the disposition to do the task well.

For the effects of our study, we proposed a method for evaluating mathematics teachers that considered general and specialised skills, competence context frameworks and qualitative dimensions relating to the conception of quality (Poblete; Díaz, 2003).

❖ Among some of the general skills, we highlight:

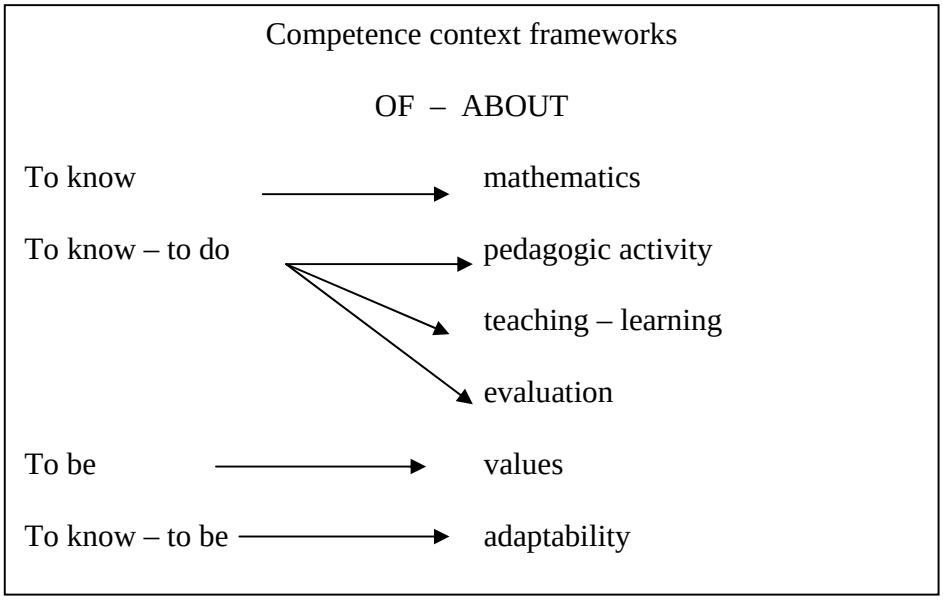
The ability to innovate, investigate and create during the teaching-learning of mathematics; the ability to apply knowledge relating to the discipline; the capacity to create a favourable atmosphere for learning mathematics; the capacity to adapt, to update and procure projection as a mathematics teacher.

❖ With regard to the specialised skills of the mathematics teacher, we include:

The ability to plan didactic activities in mathematics; the capacity to meet the new methodological and technological demands of the curriculum; the capacity to apply different teaching strategies; the capacity to understand, identify and apply teaching theories in mathematics; the capacity to facilitate mathematics learning through problem-solving, research and using active methods; the capacity to follow, develop and explain mathematical reasoning; the capacity to explain mathematical ideas; the capacity to connect different development areas in mathematics and their relationship with other disciplines; the capacity to use contemporary methods of evaluation.

In the same way, competence has been associated with teacher competence context frameworks that include elements used by the teacher that are not only mathematical, but also didactic, transversal and evolutionary in content (see Figure 1).

Figure 1: Professional Competence Model



The frameworks in turn possess dimensions related to the quality of professional performance that are associated with dimensions of relevance, efficiency, effectiveness, efficaciousness, processes and resources. The connection between the context frameworks, types of skills, both general and specialised and quality, together with related dimensions and the ways in which these elements are connected and represented, provide the opportunity whereby the teacher can demonstrate levels of competence while engaged in educational activities.

Problems Types and Areas of Mathematical Competence

The study considered the didactic treatment of mathematical subject matter and learning evaluation in both teachers and students, on the basis of types of problems and types of mathematical competence. Types of problem solving are classified according to their characteristics as: routine and non-routine, and according to their context, as real, realistic, fantastical and purely mathematical (Díaz; Poblete, 1994,) in the areas of algebra and geometry, in line with the subject matter proposed in the Education Reform. As regards types of competence, we focus on i) knowledge and development of mathematical procedures, ii) solving of routine problems and iii) formulation and solution of non-routine problems (Poblete; Díaz, 2003).

Development

This study of direct observation was carried out over an 8 month period during 2004 and was based on the design of a didactic strategy that would intervene in the entire range of mathematics subjects proposed in the official curriculum. The work of 37 teachers was observed at primary eight level, corresponding to the last year of primary schooling, in 28 urban state municipal schools in the tenth "Lake Region" of Chile.

The didactic strategy considered two facets: the first corresponded to didactic interaction in the classroom and centred on teacher activity while working with tangible, didactic material, designed specifically for this study. This material covered previously defined mathematical subjects, using exercises, situations and problem types, as well as types of mathematical skills. These skills differed from the conventional focus which prioritises the expositive class, in spite of the fact that the very nature of mathematic science includes the problem concept, traditionally, teaching has been limited to the solving of mathematical exercises.

The second facet corresponds to teacher transferral or application of the didactic activities developed in this study, in the classroom. This activity was complemented with support sessions in the schools where these teachers worked. The sessions were offered once a week by external mathematics teachers with secondary school pedagogic formation and a master´s degree in mathematics. The aim was, on the one hand, to ensure effective teaching support and establish a closer relationship with the classroom teachers and, on the other, to follow up transferral of these didactic activities to the pupils in the schools.

Teachers were taught according to the constructivist perspective of learning, with the aid of specially designed, pertinent teaching material and continuous evaluation, including a feedback process, in order to ensure the effective didactic transposition of the subject matter to students in the schools. The sessions with the teachers were held systematically – one day a week for four hours. Teacher initiative was encouraged through the stimulation of group discussion and the opportunity for active interaction.

As time progressed, effective links of professional confidence were established between teachers, which facilitated the levelling of knowledge and mutual reinforcement. Nevertheless, it was only from the third week onwards that transferral in the classroom began as expected. The didactic process was constantly oriented towards transferral to the pupils, even using films and videos to provide motivation and to facilitate the task. The different didactic activities undertaken by teachers during the teacher course, that included permanent evaluation of material learned, were reproduced in their schools with their own pupils.

Data collection was fluid and open, and based on interaction with teachers and class observation. Notes were taken of the conversations and questions that arose during analyses of the mathematics subject matter and the materials used. In addition, the different phases of the teaching and learning process were filmed. Individual interviews were held and free response opinion questionnaires were also used in order to gain insight into the significance that teachers and pupils attributed to their activities and to the whole process of didactic intervening. The purpose of using combined data collecting procedures was to ensure information gathered was valid in both communicative and activity terms, and would permit an accurate analysis of the study. Protocols were developed throughout the process, based on the collection and literal transcription of data obtained during class observation, individual interviews and opinion questionnaires.

Conclusions

The questionnaire on professional competence given to teachers at the beginning and end of the study, verifies an improvement in their professional skills with respect to their capacity to ensure that pedagogy is made didactic, and knowing how to make teaching synonymous with learning. Using a variety of problem and competence types resulted in the acquisition of different types of knowledge, strategies and capacities that were verified through the contextualisation of knowledge learned.

The achievement levels reached by teachers and pupils in the mathematics pre-test and post-test, the external supervision throughout the entire study and the questionnaire evaluating professional skills at beginning and end of the study, all reflect a qualitative improvement in the professional competence of the mathematics teachers and an effective and successful transferral of the didactic activities to their pupils.

It should be noted that the totality of the schools that participated in the study took part in the annual evaluation of the "Sistema de Medición de la Calidad de la Educación en Chile", SIMCE 2004 (National Education Quality Evaluation System) (Ministry of Education, 2005), and obtained a significant improvement in the mathematics results, according to the strict parameters used by the Ministry of Education examining board.

These results contributed to an improvement in the mathematics results both at the regional and national levels ("El Llanquihue" newspaper, 2005).

Based on the results obtained, we can confirm that the professional skills of mathematics need intervening to improve their levels of competence and that these abilities can be acquired in the context of reformed education systems. Discussion need only focus on clearly identifying the skills that the teacher must possess in order to adapt to the reformist processes of mathematics teaching, and adopt the correct method by which to

project the continuity of the process, without losing sight of the objective to ensure the integral formation of the pupil.

Discussion

On the one hand, mathematics teaching must include problem solving as one of its central elements, in accordance with the proposals of education reform in America. To achieve this, a knowledge of certain algorithms and methods is not sufficient; problem situations must be developed from different perspectives and formulated in different contexts, in order to harmonize the two components involved: the heuristic component and the specific subject matter of mathematical thinking. On the other hand, teaching must be a continuous process of interaction between the reality of the education system and a knowledge of the reality in which teacher is intervening. Pedagogic and scientific knowledge must be incorporated into pedagogic practice and closely linked to the didactics of mathematics, so that the teacher can fulfil his/her role as educator, using the skills associated with a competent professional, capable of consolidating the learning process in pupils in the context of education reform.

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