The Evaluation of the Professor of Mathematics and Quality of Education

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Introduction

Improving the quality of education is a big and complex challenge that involves much decision-making, for several factors have to be considered. Decisions on how to improve the quality of education must be based on the assessment of existing procedures and should include the elaboration and application of relevant assessment instruments and processes for the specific contexts to be assessed.

Evaluation as assessment and as research activity is an important component of the educational process, because it facilitates and regulates the changes produced in the process. Such changes are usually introduced by the teacher, who performs a mediating role in the learning by developing varied teaching actions in order to reconstruct, re-adapt and re-contextualise mathematical knowledge in the classroom. The question that arises is, "How does the teacher re-construct, re-adapt, and re-contextualise the mathematical knowledge in the classroom?" In other words, what kind of competences does s/he possess to practice his/her teaching? "It appears that even if the competence reflects a cognitive and attitudinal trait of the person, its characteristics will vary depending on the professional field involved, the kind of knowledge or skill involved. Thus, we can talk about and engineer's professional competence, a physicist's professional competence, a primary or secondary school student's competence" (Godino, 2000).

The issue of professional competences is closely linked to educational advances and development, and from this perspective the value given to the teacher's competence is an asset necessary in the reformulation of the teacher's training and, more particularly, of the teacher's performance. Some research about the teacher's classroom performance has been conducted (Rico, 1990; Ball, 1988; Llinares and Sanchez, 1990). Other studies focus on the different teaching approaches given to the teaching of mathematics: student-centred, content-based related to comprehension, content-based focused on routine actions or classroom-based (Kuhs and Ball, 1986).

Llinares (1988) describes certain features in the learning and changing processes that the mathematics teacher goes through, trying to balance the difficulties between theory and practice. From a "professional perspective", there is knowledge that originates from professional performanceand from the knowledge that supports and justifies decisions and actions in the work context of mathematics teaching. However, the teacher's training and the teacher's performance are two different issues. Several research studies relate these two issues. Eisenhart et al. (1993) identify the teacher trainees' difficulties in teaching in actual practice and analyse the way in which they contextualise the content learned at the university. Other researchers describe difficulty variables found in the students while attempting to introduce problem solving, among these are the meaning of the concepts involved, the regulation of their beliefs and the distinction between problem and exercise.

Thus, researchers talk about subordinate competences in problem solving or about a hierarchy of competences regarding contents (cultural and practical aspects plus those connected with the training), mathematical methods (modelling principles used), didactic procedures (strategies developed), and psychological procedures (level

of conscious operation) (Cazzaro, Noel, Pourbaix and Tilleuil, 2001). Blanco (1991) states that faced with difficulties in their perceptions and interpretations of information, students give more emphasis to algorithmic than to conceptual processes. This suggests a difference between the "professional knowledge" of the teacher of mathematics and the analysis of the epistemological nature of such knowledge. Professional knowledge, according to Bromme and Tillema (1996), is knowledge oriented towards professional activity. Such knowledge involves not only specific training in data and problem solving methods, but also information necessary to define and understand the problems faced by the professional.

The emergence of Reforms in the last decade has made the teacher a main concern for trainers and researchers in Mathematics Education, making the issue of the competences needed by such teacher to adapt to and face those reform processes increasingly popular in international congresses. The current Chilean Reform is aimed at improving teaching quality in education as a whole. In the context of school teaching, the reform has made considerable effort to implement educational practices in a way that can secure the development of feasible, long lasting transformations that enrich and renew teaching practices. This led us to develop an experimental assessment proposal of the competences of the mathematics teacher in Chile. The focus of the assessment was the setting of criteria that consider the aims of the Reform, its contents and conceptions, the teaching methods and assessment procedures employed by the teacher of mathematics.

Competences, Frameworks and Quality

For the purpose of this research, the competences of the mathematics teacher are defined as the skills effectively and efficiently acquired when teaching mathematics. Competences must necessarily be associated to quality, since the aim is to teach but to teach well. The assessment proposed here includes specific and general competences, competence context frameworks, and qualitative dimensions (Poblete, Diaz, 2001).

We define general competences as:

- Ability to innovate, enquire and create during the mathematics teaching and learning process.
- Capacity to encourage a favourable atmosphere for the process of mathematics learning
- Capacity to face socio-cultural diversity during the process of mathematics teaching
- Team work capacity in the professional work of the teacher
- Capacity to self-criticise their role as a trainer and as teacher of mathematics
- Skill to apply mathematics knowledge
- Capacity to adapt, update and project as a teacher of mathematics
- Capacity to foster and encourage ethical development in the student

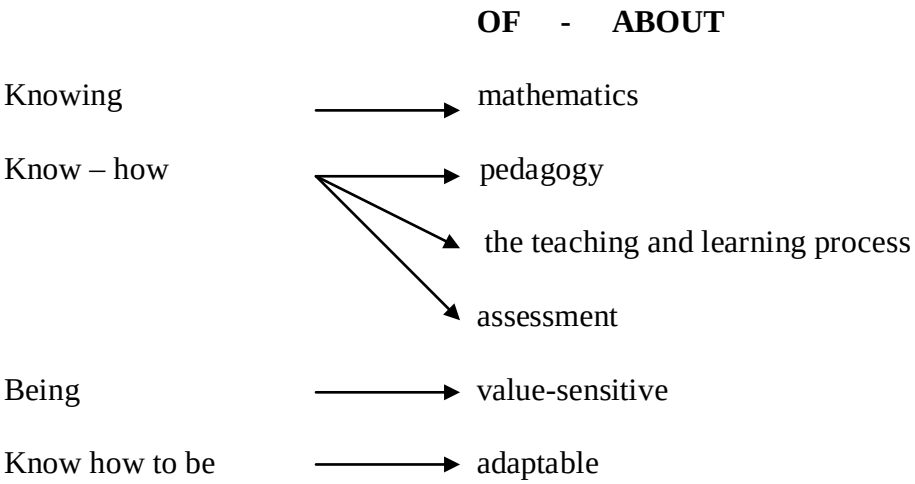
Regarding specialised competences, we see these as:

- Skill to plan didactic activities in mathematics
- Capacity to face curriculum, methodological and technological demands
- Skill in using varied teaching strategies
- Capacity to understand, identify and apply mathematics learning theories

- Skill to encourage learning through problem solving in mathematics by means of research and active methods
- Skill to follow, develop and describe mathematics reasoning
- Skill to describe mathematical ideas
- Skill to relate mathematical development areas to other disciplines
- Skill to use updated assessment procedures
- Capacity to design development projects or projects that contribute to improving the teaching of mathematics at local, regional or national level

We have related these competences to context frameworks of the mathematics teacher regarding knowledge of and about mathematics content; didactic know-how of and about teaching, of and about the teaching and learning process, and of and about assessment. We have also related these to the capacity of knowing about and being transversal in terms of values, and about knowing how to be evolutionary regarding adaptability (Poblete, Diaz, 2001).

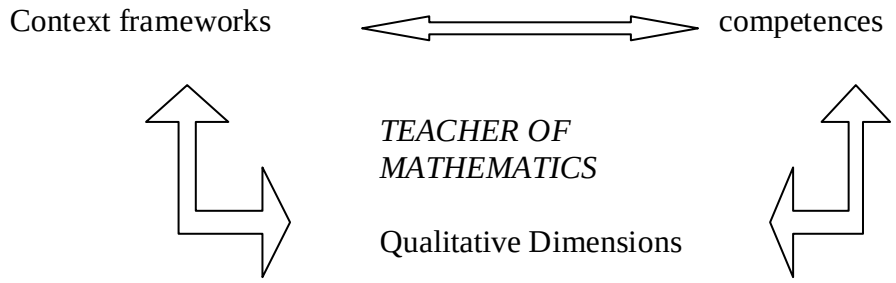
Competence context frameworks



The intersection of frameworks and the way they connect and represent each other allow the teacher of mathematics to perform educational actions in which s/he can demonstrate that competence. What is interesting in this interaction is that the actions performed by the teacher consider a quality conception (a conception of a subjective nature depending on how we define and accept quality). Thus, we have outlined specific features typical of the mathematics teacher that relate this quality conception to varied dimensions, among them:

Relevance: the educational aims that the teacher of mathematics wants to achieve
Efficiency: the optimisation in the use of educational resources that the teacher of mathematics makes to help the learners
Effectivity: concordance between the mathematics teacher's plans and the achievements obtained in the context in which s/he teaches.
Efficacy: congruence between the educational results achieved by the teacher of mathematics and the selection, distribution and organisation of resources.
Processes: relationship between the performance of the mathematics teacher and the results achieved.

Resources: integration of resources-human, material and information resources-that the teacher of mathematics has available for his/her educational work (adapted from Espinoza, et al., 1994). The graph below shows the existing relationship among all these aspects:



The connection among the context frameworks, the general and specific competences and their dimensions allow us to assess the competences of the mathematics teacher, a topic of utmost importance in the present political and educational agendas.

Methods

This study was conducted using qualitative and quantitative research methods. The qualitative method included the selection of mathematics teachers who teach 7th and 8th grades in rural and urban primary schools in the Tenth Region of the Lakes, in southern Chile. Data were compiled by means of non-participatory observations of a 90-minute weekly class for four weeks in all the provinces of the Tenth Region. Additionally, twelve interviews with students and eight interviews with teachers were conducted at the end of each session and later transcribed to protocols in order to complement the information gathered.

The population for the qualitative study included 349 State Primary Schools at levels in which the reform is being applied at present. A random sample of 70 schools, 26 from urban areas and 44 from rural areas, was taken. Altogether this included 2882 students, 84 teachers of mathematics and 82 teacher peers or administrative staff.

Once the criteria for competences and dimensions were clearly defined, self-assessment questionnaires for the teachers, peer assessment questionnaires, and student assessment questionnaires were devised and later used experimentally with representative samples. Prior to this first experimental procedure, the content of the questionnaires was validated by means of experts' opinions, sharing a degree of concordance among them that was equal to or higher than 80%. Reliability checks of the assessment instruments for the preliminary application as well as the final application of the assessment instruments were conducted using Alpha Cronbach with an average score of 0.92 for the three instruments used in the preliminary application, and 0.87 for the instruments in the final application. Therefore, internal consistency was found to be highly reliable.

The data obtained allowed a comparative analysis of inter groups and intra groups by province, so that it was possible to identify the differences among them based on ANOVA simple analysis, and make a comparison of average scores. These

were later interpreted based on the design of professional competences of the mathematics teacher previously described.

Results of the qualitative research

The data obtained from the transcriptions were classified looking for some convergence points; that is, in order to obtain a body of information from the students' and the teachers' interviews that would allow a systematic analysis that could lead to the categorisation of similarities in order to secure internal homogeneity; or to the categorisation of differences related to external heterogeneity. Our intention was to establish coherent organizational criteria for the information gathered so as to interpret it based on the competence frameworks, general and specific skills and quality dimensions.

Similarities

The similarities found between students and teachers considering the analysis design employed show that:

- Individuals acknowledge the use of a course book in class. This relates the teacher's performance to the context framework of didactic know-how and the competence of facing curriculum demands by means of resources.
- Students and teachers describe the level of knowledge in mathematics as average. This assertion is an example of the teacher's competence for self-criticising his/her teaching role within the context framework of know-how to teach and assess educational action and the results obtained.
- Teachers and students do not relate the teaching of mathematics to the moral or social values outlined in the Reform, which shows they have scarce knowledge and understanding about integrating transversal values. Considering the aims of the current Reform, this situation constrains the teacher's competence to encourage the ethical development in the students_ an issue related to the framework of being transversal in terms of values.
- Students believe that they are taught mathematics using everyday life situations. However, teachers express that they do not fully understand what contextualising the teaching of mathematics implies. Still when asked to provide examples, the teachers are able to propose some suitable situations. From this, we may infer that they are capable of adapting to the context and can update their teaching, integrating aspects of that context to their performance.

Differences

- Students state that they have been taught problem solving tasks, and the teachers acknowledge that they sometimes use problem-solving tasks in their teaching. However, it is not clear whether the teachers have competence for efficiently communicating the mathematical problems or ideas.
- Differences were found in terms of content mastery, meaning and genesis of mathematical content. Students believe that their teachers have mastery of mathematical knowledge, yet the teachers cannot signal the genesis of such content nor the mathematical meaning involved in it. There are also differences about the clarity with which mathematical content is taught -

students express that this is clearly done- and the argumentation about the establishment of relationships among mathematical concepts given by the teachers.

The differences encountered show that the teachers lack mastery of the context framework of knowing about mathematical content, and have scarce competence in the skill of communicating mathematical ideas.

- Students are not clear about being taught based on the Reform directives. Meanwhile, teachers state that they do plan their teaching based on the Reform. Another difference is that the students believe that they are being taught by varied teaching methods, while the teachers recognise little variation in their teaching methods. Nevertheless, when asked to describe the way in which they teach mathematical content, the teachers somewhat approach the directives suggested by the Educational Reform. It is worth noting that the students state that they have no access to software related to the teaching of mathematics.

  The differences described here relate to the teacher's competence to face new technological and methodological demands by using varied teaching and technological strategies. This assertion reflects the difficulty that teachers face to achieve the educational goals demanded by the curriculum.

- Students state that they do not do self or peer assessment in mathematics courses, while the teachers declare to use all assessment procedures suggested by the Educational Reform. However, they do not know about assessing learning by means of qualitative paradigms.

  These difficulties relate to the context framework of didactics and assessment know-how, and indicate scarce competence to use modern assessment procedures, incorporating them into their teaching performance.

Results of the Quantitative Methodology

The data obtained from the teacher's self-assessment, the students' assessment, and the assessment of peers and administrative staff comprised a body of data which allowed a comparative analysis of inter groups and intra groups by province, so that it was possible to identify the differences among them based on ANOVA simple analysis, and make a comparison of the average scores. This information was later interpreted in terms of the competence context frameworks, in terms of general and specific skills, and in terms of the quality dimensions that constitute the elements in our study of the professional competences of the teacher of mathematics. Based on that, we can say that:

The average answers obtained by means of the questionnaires to peers or administrative staff are not statistically significant. In the simple ANOVA analysis for the context frameworks, competences and dimensions obtained from the answers given by teachers, students and administrative staff in the four provinces, shows that the students' average is significantly lower than that of the teachers, peer teachers and administrative staff. The differences here relate to questions about the presentation of activities that contribute to the development of the skill in problem solving, to the use of audiovisual teaching aids, to the kinds of relations that the teachers make of

mathematics with other disciplines, to the encouragement of positive attitudes and values, to the opportunities students have to devise mathematical problems, and to the teacher's use of current cultural events to teach mathematics.

The teachers' average score is significantly lower to that of the students and peer teachers or administrative staff in questions related to the understanding of a mathematical problem, questions about the genesis of mathematical content presented in the questionnaire, and questions about the relationships between the mathematical concepts and their emergence. These questions are directly related to the frameworks of knowing about mathematical content, didactic know-how of the teaching and learning process and having the capacity to evolve. They also relate to the general competence of having the capacity to adapt, update and project as a teacher of mathematics; and to the specific competences of having the skill to encourage the learning of mathematics by means of problem solving

Significant average differences exist among teachers and students, in those questions about taking part in projects that might enable them to help students improve their mathematics learning, questions about taking part in courses, seminars, workshops or other kind of activities that can support their work and questions about assessment skills as expressed by the Educational Reform; the teachers' average was higher than the students'.

Significant differences were found in the peer teachers' assessment, but these only relate to the students. Peer teachers have a higher average in questions about the priority use of mathematical exercises or problems, and questions about the teacher's perception of satisfaction regarding the degree of achievement obtained compared with the number of students taught.

Discussion

This proposal of an assessment model of the professional competences of the mathematics teacher that features general and specific competences, dimensions regarding the teacher's beliefs about the quality of their work, and competence context frameworks has allowed us to assess the professional competences of the teacher of mathematics. This was done through the assessment of the teachers made by their peers, by administrative staff, and by the students.

Concerning the qualitative study, the similarities and differences found account for an adequate competence of the teacher of mathematics to face new curricular demands through the use of resources. They also show that the teachers possess self-critical capacity about their teachers' role, and that they can adapt and update their teaching incorporating context facilities.

On the other hand, the teacher of mathematics appears not to have clear competence to encourage the development of values and ethics in the students, which relates to the incorporation of transversal aims in the teaching of mathematics. S/he appears not to have competence to develop the skill of communicating the mathematical idea of a problem efficiently. Besides this, the teacher has no full command of the context framework of knowing about mathematical content and lacks competence regarding the skill of following, developing and exposing mathematical reasoning efficiently. The mathematics teacher also has limited competence to face new technological and methodological demands, and scarce competence to use varied and updated assessment procedures integrating them as a means to their teaching performance. These competences are associated with the context framework of didactic and assessment know-how.

The main differences found in the quantitative study highlight the teacher's lack of competence to communicate mathematical ideas efficiently, to develop and expose mathematical reasoning and to use varied means to aid their teaching. These differences relate to the context framework of knowing about mathematical content, and also to the context framework of didactic know-how in the teaching and learning process.

The highest average scores obtained from the teachers' own perceptions, their students', and their peers relate to the context framework of being transversal in terms of values and indicate that the teacher has competence to foster a favourable atmosphere to learn mathematics, to encourage the development of values in the students, to self-criticise their role as a teacher and to face new curricular demands based on the educational goals. In this way, the teachers relate their teaching to the achievement of results and optimise the resources at hand.

The results obtained by both research methods employed regarding the competences of the teacher of mathematics in his interaction with the students during the teaching and learning process indicate that the teacher of mathematics needs to be able to face unknown situations, to create and reconstruct mathematical knowledge, to recontextualise such knowledge in the classroom, to use teaching methods that encourage autonomous learning in the students and to assess such work considering the students' educational needs.

A view that defines the competences of the mathematics teacher as the skills effectively and efficiently acquired while teaching mathematics, integrating and developing knowledge and content with the aim of educating must necessarily relate these to quality dimensions in terms of teaching but teaching well. We acknowledge that other types of general skills inter relate with these, among them decision-making, the capacity to learn how to handle information, skills in interpersonal relationships, flexibility and openness to change, and others. All of these vary in each individual teacher. Nonetheless, the professional competences currently acquired by the mathematics teachers do not totally enable them to face the current Educational Reform process.

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