Learning about the effectiveness of teacher education: A Chilean study

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The article reviews some of the problems faced by teacher education in general and in Chile specifically, and on this basis, presents the results of a study focused on the effects of six teacher education programmes on future primary level teachers' learning of mathematics and mathematics pedagogy. The study describes the programmes and presents the results of a questionnaire and content knowledge test administered to future teachers in their first, third and final year of studies. The article considers as possible explanations for unsatisfactory effects of teacher preparation on future teacher learning, the relatively poor entry levels of student teachers and the generalist structure of the programmes. Differences among programmes between time allocation to mathematics and mathematics pedagogy learning did not appear to have an effect. Specific courses, however, did appear to make a difference among institutions.

Keywords: Teacher education, mathematics and mathematics pedagogy content knowledge, curriculum, teaching-learning strategies, programme effectiveness

Introduction

In many countries over the last twenty years different policies have been directed towards improving teacher preparation and performance(Rego & Namo de Mello, 2004; Kruss, 2008). Some policies have targeted the connection between teacher education and teaching in schools, as in the case of the "professional

development schools" in the USA (The Holmes Group, 1995), the preparation of reflective and critical educational practitioners exemplified in the BEd teacher preparation programme in Namibia (Zeichner & Dahlström, 1999), the creation in Uruguay of new types of institutions to widen the coverage and focus of teacher preparation (Vaillant & Wettstein, 1999), and the upgrading of teacher education to university status in South Africa (Kruss, 2008). Despite these efforts, there continues to be dissatisfaction with the achievements of teacher education, not so much because they have been proven to be ineffective, but because of the belief in a direct causal relationship between teacher preparation and unsatisfactory learner results as measured by national and international assessments.

In Chile the unregulated growth of teacher education programmes in private universities and the mushrooming of distance programmes of doubtful quality have raised concerns about the quality and effectiveness of these programmes. The reaction of the government has been to press for the closure of distance programmes and to set a content-knowledge examination for future teachers in their last year of study. Recognising these conflicting views about teacher education and the lack of recent evidence about how teacher education programmes are performing in Chile, we decided to examine six programmes in the context of the IEA TEDS-M[1] (International Association for the Evaluation of Educational Achievement Teacher Education Development study –Mathematics) in which Chile participates. This paper is centred on examining the effect of teacher education programmes by capturing the extent to which these programmes improve the knowledge base of future teachers as they progress to completion. To this end the paper presents the results of research conducted in the six sites, focusing on the preparation of basic or primary school teachers (grades 1 to 8). It describes the programmes and measures differences in knowledge of both mathematics content and mathematics pedagogy among three future teacher groups in the first, third and final years of teacher education. We selected these years as they indicate the entry conditions for future teachers, what they gain when teaching methodology courses are offered in the third year of study, as well as the status of the future teachers prior to graduation.

Teacher education in Chile

Universities and a few tertiary-level professional institutes prepare teachers for all the levels of the education system: pre-school, basic (grade1 to 8) and secondary (grade 9 to 12). During the period of the military government (1973-1990) these programmes suffered severe institutional changes, staff dismissals, and a gradual lowering of numbers and qualifications of applicants, which affected their quality. In the mid 1990s, recognising this situation, the government funded improvement projects for 17 universities through the Programme for the Strengthening of Initial Teacher Education (Fortalecimiento de la Formación Inicial Docente: FFID). The FFID initiative resulted in changes to the curricula of all participating institutions, improvements in teacher educator capacity, and increased opportunities for practicum and field experiences as part of the programme (Avalos, 2005). Entry numbers and their qualifications increased, assisted by scholarships for applicants with good secondary and university entrance examination results. This greater demand for teacher preparation admissions, however, produced what is now regarded as a problem: an increase in the number of new teacher education programmes in private universities. There is currently an influx of new suppliers and teacher education students, a consequent lowering of entry qualifications and, in addition, uncertainty about the process of improving teacher education quality. As a result stakeholders are questioning the quality of teacher education.

The preparation of teachers for the basic school level has unique problems due to its "generalist" structure and the pressures of having to prepare teachers to be competent in all nine subjects of the basic school curriculum over a four year period have undoubtedly affected the quality of teacher education.

Conceptual framework and literature review

The study upon which this paper is based centres on the "opportunity to learn to teach" offered by the teacher education programmes under perusal and its effect on the knowledge base of future teachers. The concept is borrowed from the international IEA TEDS-M study (Tatto, Schwille, Senk, Ingvarson, Peck & Rowley 2008) referred to earlier. The "opportunity to learn" is provided by the teacher education

curriculum, how its subjects are taught, the early field experiences and the quality of the practicum offered towards the end of the programme. In assessing the effects of teacher education we take "opportunity to learn" to be influenced by two kinds of factors: (a) entry characteristics of future teachers such as their socio-economic and educational background, including beliefs about education and teaching, and (b) by the organisational and institutional characteristics of the preparation programme (in turn marked by the policy context), together with the capacity of teacher educators and their beliefs about teaching and learning (Tatto *et al.*, 2008). While in the study underlying this paper, we consider the effectiveness of a teacher education programme in terms of how the "opportunity to learn" contributes to the quality of content and pedagogic knowledge and to changes in beliefs about teaching, for the purposes of this paper we focus only on the effects of "opportunity to learn" mathematics and mathematics pedagogic content knowledge. Mathematics knowledge is understood to refer primarily to what is needed to teach the school curriculum from 1st to 8th grade. Mathematics pedagogic content knowledge is understood in the sense described by Shulman (1987) and further developed regarding its importance by Brodie (2004). Figure 1 below illustrates the conceptual framework that underlies the study and this article:

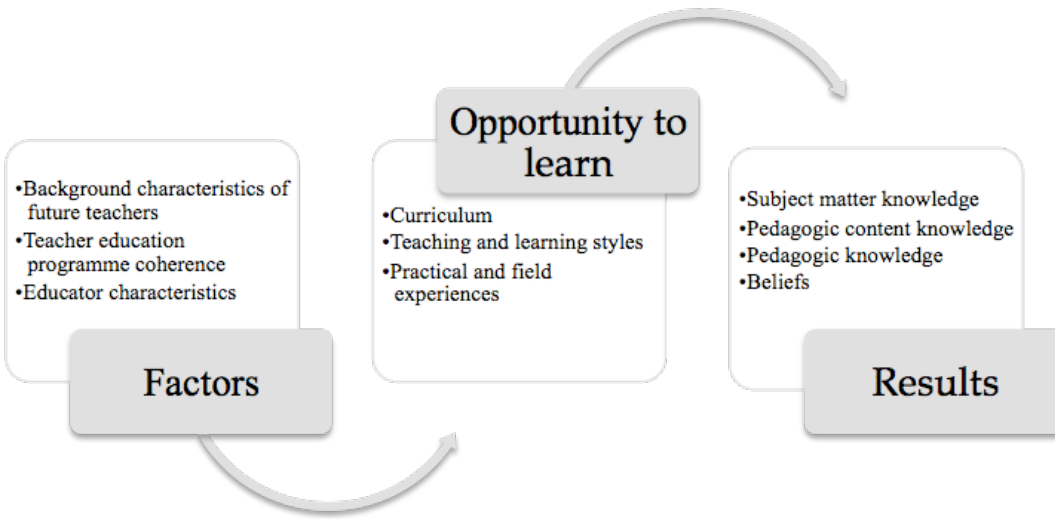

Figure 1: Conceptual framework

The effectiveness of teacher education has been the subject of many studies in different contexts, including South Africa (Sibaya & Sibaya, 2008) although the difficulty of isolating and capturing its effects or of agreeing on the key issues to be examined (graduate numbers, retention in the field, learner results), has resulted in research with "mixed and contradictory" findings (Ingersoll, 2007). This is further confounded when there is a diversity of suppliers such as in Chile. or when teacher education is limited through "alternative paths" as sanctioned in countries like the United States of America and England (Humphrey & Wechsler, 2007; Zeichner & Conklin, 2005).

Interesting approaches are, however, used to consider the impact of teacher education reported in the literature. In separate studies and under the assumption that teacher preparation affects the quality of teaching and therefore also influences learning results, Ingersoll (2007) and Wang, Coleman, Coley & Phelps (2003) examined teacher education structures and programmes in countries with above average and

below average scores in international assessments. The key finding of these studies was that differences in the duration of studies and type of teacher education institution (college or university) were not key factors in explaining the differences. According to Ingersoll (2007) and Wang, *et al.* (2003) rigour in the selection of teacher education candidates is the deciding factor, which in turn is linked to adequate salary and working conditions for teachers, as in the case of countries with good learning results, e.g. Singapore, Hong Kong, China and Korea.

As far as methodology is concerned, case studies of teacher education programmes considered to be effective, such as those reviewed by Zeichner & Conklin (2005), offer promising insights. One of the studies reviewed by these authors concludes that effective programmes embody: (a) a clear set of ideas and values about schooling and teaching; (b) a distinctive identity shared by all staff; (c) greater collegiality among teacher educators as a result of shared identities; (d) clear, explicit and reasonable programme goals; (e) rigour and academic challenge; (f) appropriate balance between general and pedagogical knowledge; and (g) an integrated or interdisciplinary approach to the curriculum, as well as strong integration between campus-based and school-based learning activities (Zimpher in Zeichner & Conklin, 2005, p. 696).

Changes over time, as future teachers move through their teacher education programme could be focused upon as another way of looking at the effectiveness of teacher education programmes. Thus, Swars, Smith, Smith & Hart's (2008) in the USA observed changes in future teachers' mathematical knowledge in the expected direction over two academic years and were able to trace these changes to activities within the preparatory programme, such as mathematics methodology courses and field practice experiences. Akyeampong & Lewin (2002) also studied changes in beliefs and attitudes among future teachers in Ghana at the beginning of their preparation, the end of their studies, and two years into teaching in schools. Despite evidence of changes that did not necessarily occur in the expected direction (possibly due to the research methodology employed or through misinterpretation by respondents) the authors suggest that this kind of research serves to orient and monitor the role of preparation processes in teacher education.

As far as the Chilean situation is concerned, it would appear that while the effects of teacher education are a central policy concern, the processes by which teacher education effects are produced, and how they interact with policy and structural conditions, are not well known or give rise to a series of questions that should be tackled by research. The research reported in this article is a first step in this direction.

Method

This research comprises case studies of six teacher education programmes in three geographical regions of Chile, which prepare generalist teachers for the basic school. Although the original study on which this paper is based had a broad set of objectives we focus in this article on changes in future teachers' knowledge of mathematics and mathematics pedagogy, possible links between these two dimensions and the "opportunity to learn" offered by these programmes. We do this, by a cross-sectional examination of the knowledge base of future teachers in their first, third and final year of study. The original study as a whole was oriented by the following questions: (1) To what extent is there an effect of initial teacher education on future teachers' knowledge of mathematics and mathematics pedagogy as they progress through their studies, and do programmes differ in this respect? (2) How is the curricular "opportunity to learn" offered by the programmes studied related to the learning of mathematics and mathematics pedagogy observed in the knowledge of future teachers?

The study was designed as a descriptive-exploratory set of case studies to identify trends and possible explanations for results, rather than an attempt to establish causality. To this end it uses a complementary methods approach (Green, Camilli & Elmore 2006), which combines descriptive statistical analysis and focus group qualitative analysis. The significance of differences in mathematics and mathematics pedagogy by group and programme were calculated using t-tests.

Our main source of evidence was provided by a comprehensive questionnaire administered to the three groups of future teachers who agreed to participate through signing a letter of informed consent; a review of the curricula in each programme; data from a questionnaire completed by educators in the

institutions, also agreed in a letter of informed consent; and focus group discussions with educators and students based on study results. All instruments, except the focus group protocol, are the same, or slightly adapted instruments used in the IEA TEDS-M study for the primary level, all of which were piloted and validated for the international study, among others by Chile. The focus group protocol included open-ended questions centred on three areas: (a) general views on their teacher education programme and their own intention to be teachers; (b) specific views on their opportunity to learn mathematics and mathematics pedagogy; (c) beliefs about mathematics and mathematics teaching. The future teachers' and educators' questionnaires shared the same type of questions and included information on personal and education background, opportunities to learn offered by the curriculum, and the teaching-learning strategies used by educators, as well as ratings of their beliefs about the teaching of mathematics. The future teacher questionnaire in turn included a section on mathematics and mathematics pedagogy knowledge with fixed-response and open-ended items, which were identical to the international test for the primary level. The responses to these items were corrected in line with international scoring criteria. Coders of open-ended questions were appropriately trained, and the coding agreement was verified by the double coding of a percentage of questionnaires. To facilitate the analysis a number of scale items on the "opportunity to learn" gathered the information in indexes consistent with the underlying conceptual basis according to which they were formulated and factor analysed for the international study.

The programmes and future teachers studied

The six teacher preparation programmes were taught at 5 public universities that differ in location, size and length of programmes. Two of the programmes (**La Serena** and **Ovalle**) are separate campuses of one university in the north of the country. The third is located in the capital city of **Santiago**. The rest are in the city of **Concepción**, which is the third largest in the country, the city of **Temuco**, in one of the poorest regions of Chile, and the city of **Punta Arenas**, in the extreme south. We refer to them in this paper by their location. All programmes have a duration of eight semesters, except the one offered at Temuco, which covers nine semesters and the one at Santiago, which runs over ten semesters.

Total enrolment (2008) ranged from a low of 129 in Punta Arenas to a high of 612 students in Santiago. Around 90% of the future teachers were female, although the proportion in Temuco was lower (70%). Most had attended public/municipal schools with parents who mostly had only secondary or basic education. Their university entrance examination scores were lower than those required for other degree courses such as medicine or engineering, but were higher than those required by equivalent private universities.

Becoming a basic education teacher can take between eight to ten semesters depending on the institution. Besides generalist preparation, two of the programmes include options to specialise in grade 5 to 8subject teaching (mathematics, science, language and social studies).

Main findings

Curriculum and opportunity to learn factors

The curricula in all the programmes studied cover four main areas, general education, professional or pedagogic preparation and school curriculum subjects, including special teaching methods, as well as field experiences and a final year practicum. The proportion of time allocated to each area differs somewhat per programme as seen in Table 1 below, with greater differences observed in the Punta Arenas programme, probably due to its inclusion of field experiences in the "professional" area rather than in the "practicum" area as in the other programmes.

Table 1: Percentage of time (credit hours) allocated to the main areas of the curriculum by university

Content areas	Serena-Ovalle	Santiago	Concepción	Temuco	Punta Arenas
General Ed.	9 %	2 %	7 %	3 %	2 %
Professional	22 %	27 %	37 %	29 %	47 %
School curriculum	43 %	50 %	30 %	39 %	42 %
Practicum	25 %	20 %	26 %	29 %	9 %
Total credit hours	**254**	**255**	**164**	**360**	**274**

Source: Curriculum maps of each institution available in their web sites

Mathematics content and mathematics pedagogy

In relation to school curriculum subjects, all programmes devote more time to language skills and mathematics than they do to the other nine subject areas, with mathematics taking 14% to 20% of the total time. The programmes differ in the way they distribute time for mathematics content knowledge and mathematics pedagogy. Three of the programmes use slightly more time to focus on mathematics content knowledge over mathematics pedagogy, while the other two differ in opposite directions. Thus the **Serena** and **Ovalle** programmes take more time to teach mathematics content than mathematics pedagogy, while the reverse is true of the **Punta Arenas** programme.

In relation to **mathematics content**, over 90% of all those surveyed (educators, future teachers and programme heads) agreed that their curriculum covered number topics, such as whole numbers, fractions, integer and real numbers. Also, 90% of final year students agreed their curriculum had covered geometry and measurement topics, such as one or two-dimensional coordinate geometry, analytic geometry, congruence and similarity, constructions with straight edge and compass, measurement units, computations and properties of length. Data and probability topics such as data representation, probability and statistics were covered to a lesser extent, as only half of the future teachers in all groups (slightly higher in the final year) had seen these topics in the curricula. Of all the groups only 10% had covered some topics in algebra.

Regarding **mathematics pedagogy content**, third and final year future teachers agreed that topics related to the teaching of mathematics and the preparation of lesson plans had greater coverage in their programmes. Exposure to **mathematics teaching** was measured through frequency ratings of having experienced activities that helped future teachers plan lessons, teach according to constructivist approaches, distinguish between procedures and concepts, prepare teaching materials, use assessment, focus on individual differences and teach cross-curricular themes. As seen in Table 2 below, future teachers at best rated the frequency of their exposure to these competences as "occasional" rather than "frequent", lowest among the first year and highest among the final year, but generally not significantly different from the third year group. Also, all groups were clearly more negative about experiencing how to handle learner differences, such as learning and emotional or behavioural problems.

Table 2: Acquiring learning competences (mean frequency ratings*)

Competences	First year		Third year		Final year		N
	Mn	SD	Mn	SD	Mn	SD	
Lesson planning **	2.4	0.8	2.8	0.6	2.9	0.6	486
Teaching for understanding***	2.4	0.8	3.0	0.7	3.2	0.6	551
Constructivist teaching**	2.0	0.8	2.9	0.7	3.0	0.7	506
Distinguish procedures and concepts**	2.1	0.9	3.0	0.8	3.1	0.8	559
Prepare teaching materials**	2.6	1.1	3.0	0.9	3.0	0.8	562
Use assessment for learning**	2.0	0.8	2.4	0.8	2.7	0.8	539
Cross-curricular teaching***	2.1	0.9	2.9	0.7	3.0	0.7	510
Focusing on individual differences**	2.1	0.7	2.7	0.6	2.4	0.7	270

* 1= Never; 2= Rarely; 3= Occasionally; 4= Frequently

** Significance at 1% level between first and third/final years

*** Significance at 1% level between first, third and final year

Source: Future Teacher Questionnaire

Field experiences and practicum

Final year students (90%) were more positive in their ratings of practical learning experiences, compared to just over half of first and third year future teachers. They were also significantly more positive about the opportunity to "observe models", "analyse pupil work", "apply methods learned", "try out research results" and "innovate in methods and practices", than their fellow students in first and third year. On the quality of the final year practicum supervision, future teachers views oscillated between being "somewhat in agreement" and "in agreement" with supervisors contributing to "improve my teaching methods", or valuing "the ideas and approaches I offered on the basis of what I had learned at the university".

Future teachers' content knowledge of mathematics and mathematics pedagogy

All future teachers in their first, third and final year of studies were tested for their knowledge of numbers, algebra, geometry and data topics, using the same test. They were also tested on knowledge of the mathematics school curriculum, planning for teaching and learning and on interactive teaching in the classroom, such as explaining concepts and procedures, generating fruitful questions, or diagnosing typical learner responses and misconceptions. All items were classified according to difficulty level as "novice", "intermediate" or "advanced", and looked for evidence of knowledge, application and reasoning. While the same content was covered for all three groups of future teachers, the number of items was lower for the first and third year ones. The test for final year students was applied in exactly the same conditions as in the international TEDS-M study.

Results showed that between 62% and 67% of future teachers in all years were able to handle novice level items correctly. A smaller proportion in all years responded correctly to intermediate level items, although there was an increase from first (33%) to final year (38%). As for advanced level items, a higher proportion of first year students responded correctly (37%) compared to the third (33%) and final year groups (35%).

From the perspective of the **content area covered,** data items had the highest overall rate of correct responses, increasing significantly from first to final year (51% to 59%) and also the lowest rate of "non responses" (15% to 17%). Numbers was next, with correct responses increasing slightly but significantly

from first to final year (41% to 45%). Algebra and geometry items were responded to in a similar pattern, with increases from first to final year, but only the differences in responses regarding geometry were significant.

Finally, we looked at responses from the standpoint of whether they were **mathematics or mathematics pedagogy** focused questions (around 27% of the items referred to mathematics pedagogy). Around half of students from all years responded correctly to mathematics questions, but only slightly over 30% responded correctly or partially correctly to questions requiring them to think about mathematics teaching situations, with final year students being somewhat better compared to those in third year (35% versus 32% of correct responses). See Figure 2 below.

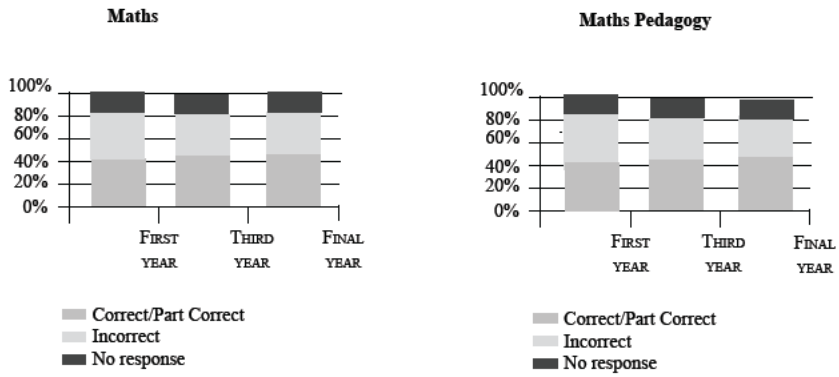

Figure 2: Mathematics and Mathematics Pedagogy Knowledge (Distribution of responses)

Source: Future Teacher Questionnaire

Discussion

The cases selected belong to strong institutions with long experience in teacher education and were all part of the FFID improvement programme between 1998 and 2002. They differ somewhat in terms of their students' background, but not substantially. All programmes prioritise the learning of school mathematics, either as a small number of separate subjects, or embedded in the mathematics pedagogy course, including primarily numbers, geometry and probability contents. The amount of time dedicated to these subjects, however, varies in terms of length (semesters of study). Also, the proportion of mathematics content varies in terms of number of courses and time allocated.

As far as future teacher learning is concerned, irrespective of the study programme, just over half of the final year students were able to respond correctly to mathematics topics; around 40% could handle the geometry and algebra topics examined; but only 32% of final year students were able to respond to mathematics pedagogy items. The results suggest that these future teachers may find it difficult to teach mathematics topics to a wide diversity of learners in all the grades for which they are being prepared.

Given that most of the topics tested, except for algebra, were included in the declared teacher education curricula of these institutions, we have to conclude to an extent, that from the curriculum perspective their teacher education programmes did offer the "opportunity to learn", but with insufficient coverage, when compared to the criteria of the international study exemplified in the nature of the test items. This insufficiency can be attributed to the "generalist" character of basic school teacher preparation and to the limited knowledge base on entry into teacher education programmes. Not only does this system place pressure on the time available to prepare teachers sufficiently to teach the entire offering of basic school curriculum subjects, but it does not take into account that future teachers may not feel equally comfortable, in terms of their inclination and prior school knowledge, to teach all subjects. In addition, these are not the best graduates from secondary school, nor will they be in the short term. To bridge the gap between what future mathematics teachers inherit from their own school experience and what they

should know, all but one of the institutions in this study offer upgrading courses in mathematics content, generally in their first year of study. Yet, as some future teachers told us during focus group meetings, these courses tended to be "boring" restatements of school knowledge, disconnected from their perceived teaching needs. In a number of cases, we learned that the course that really made a difference to future teachers' conceptual understanding of mathematics was the methodology course, usually offered in their fifth and sixth semester of studies, but too limited in time to deal adequately with their mathematics knowledge needs.

Besides the uncertain impact of generalist preparation to improve conceptual knowledge of mathematics, there were differences among programmes as to when future teachers showed a better level of knowledge. Thus, as Figure 3 shows, only two programmes show improved mathematics content knowledge in the final year compared to the first year (Punta Arenas & La Serena). Two programmes show a reverse situation with better results in first than in the final year. To complicate matters further, third year future teachers in the **Santiago** and **Concepción** programmes have better results than those in the other years. With the exception of Concepción, none of the differences are statistically significant on the basis of the Sidak t-test used. Results in mathematics pedagogy also reveal programme differences, with two programmes showing improvements in the final year compared to the first, and two others show better results among the third year group. The last two programmes reverse the situation with students in final year performing below those in first year.

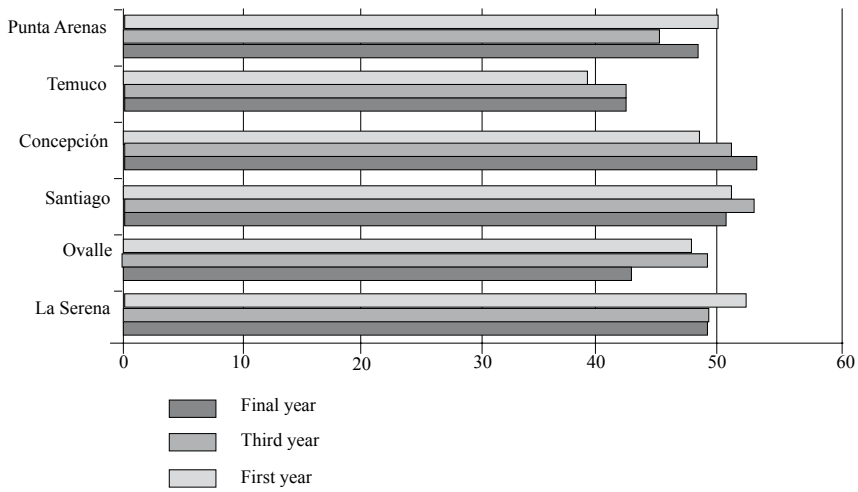

Figure 3: Percentage of mathematics correct responses by teacher education programme

Source: Future Teacher Questionnaire

These differences have possible explanations related to the characteristics of each programme. For example, the better results in mathematics knowledge of first year students in two programmes may be due to there being a first year course to upgrade and strengthen mathematics secondary school knowledge. The better results in mathematics pedagogy of third year future teachers in **Santiago** and **Concepción,** shown in the Figure 3, may be related to the quality of the teaching methods course they attended that year, as we learned from focus group discussions. On the other hand, differences in time allocation to mathematics content knowledge and mathematics pedagogy between the institutions are not consistently related to the knowledge exhibited by future teachers. For example, compared to other programmes **Santiago** has the highest number of hours allocated to mathematic knowledge and pedagogy, but its future teachers were less able to respond correctly to these items than those in the **Concepción** programme, which allocates less time to mathematics content knowledge. These results illustrate that time-allocations do not necessarily

coincide with expected learning results, and confirm the suggestions of Ingersoll, (2007), Wang et al. (2003) and Zeichner and Conklin (2005), that we must look at both the quality of those who are recruited into teacher education programmes and at the overall coherence of the programmes. Regarding quality of intake, as indicated earlier, we know that these programmes (particularly in the case of Temuco and Punta Arenas) recruit students at lower entry levels compared to those of other professions. On the other hand, coherence expressed as sequence of courses, content, topics and linkages among them, according to students, decreases as they become more aware of the totality of the programme, that is, coherence is rated as decreasing from the first, through the third, to the final year of studies.

All in all, in relation to our initial questions we have found some effect on the mathematics and mathematics pedagogy learning of teacher education programmes, but these effects differ in terms of programmes and the opportunity to learn provided by the offering. The opportunity to learn effects are further decreased by the generalist structure of the programmes and the weak school knowledge base of future teachers when they begin their studies.

Conclusion

In what way does this study help to understand and encourage reflection about research and policy for countries similar to Chile? First, the study offers further evidence for developing conditions that may help to attract good secondary school leavers into the profession. With little time available and often limited capacity of teacher educators to build on unsatisfactory prior knowledge it is important to recruit the best possible candidates, which in turn requires making the teaching profession an attractive one, especially in terms of working conditions.

Second, institutions and educators need to review their programmes periodically to check for coherence. They need to operate good assessment systems that follow and monitor a student's development throughout the programme, check for problems encountered in learning (subject and pedagogical contents), and provide compensatory learning opportunities when needed. Case study research can serve to illuminate both positive and problematic aspects in the programmes as a whole.

Finally, as indicated by Zeichner and Conklin's (2005) review of the effectiveness of teacher education, teacher educators need to follow new teachers into schools and study how they deal with different demands and contexts. This means that although accountability policies such as accreditation and certification provide valuable safety nets, they are not of themselves able and should not be expected to act as sole levers for improvement.

Notes

[1]We refer to the Teacher Education and Development Study in Mathematics (TEDS-M) conducted by the International Association for the Evaluation of Educational Achievement (IEA) of which final results will be published at the end of 2010. The study is one of the first to look broadly at the teacher education processes in different country contexts (17 countries) and to examine its effect on mathematics content and pedagogic knowledge as well as beliefs about teaching.

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Acknowledgment

The authors wish to thank the National Fund for Science and Technology in Chile (FONDECYT 1070176) for funding of the research underlying this article.