THE IMPACT OF A SOCIO-CONSTRUCTIVIST APPROACH ON PROSPECTIVE PRIMARY TEACHERS' ATTITUDES ABOUT TEACHING AND LEARNING IN GENERAL AND MATHEMATICS IN PARTICULAR

El impacto de un programa de enfoque socioconstructivista en las actitudes de futuros profesores de primaria sobre el aprendizaje y la enseñanza en general y sobre las matemáticas en particular

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Abstract: Cognitive Acceleration programs have been successful in promoting reasoning skills in school students and in changing the pedagogy of the in-service teachers applying them. The novelty of this study is that it implemented, for the first time, that socio-constructivist approach with prospective teachers. The results suggest that the cognitive acceleration course promoted positive changes in their attitudes about teaching and learning in general and mathematics in particular.

Keywords: prospective teachers, mathematics anxiety, cognitive acceleration, attitudinal change

Resumen: Los programas de Aceleración Cognitiva (AC) han logrado promover exitosamente el desarrollo de habilidades de razonamiento en estudiantes escolares y, al mismo tiempo, han cambiado las prácticas pedagógicas de los profesores en ejercicio que han implementado dichos programas en sus aulas. El aporte de este estudio es que utilizó por primera vez este enfoque socio-constructivista de enseñanza con futuros profesores durante su proceso de formación inicial docente. Los resultados encontrados sugieren que el programa de aceleración cognitiva impulsó cambios positivos en las actitudes de los participantes sobre el aprendizaje y la enseñanza en general y sobre las matemáticas en particular.

Palabras clave: futuros profesores, ansiedad sobre las matemáticas, aceleración cognitiva, cambio actitudinal

INTRODUCTION

Mathematics anxiety and a profound dislike of maths is a common phenomenon among prospective primary teachers (Quinn 1997, Tooke and Lindstrom 1998, Zettle and Raines 2000, Vinson 2001, Sloan, Daane, and Giesen 2002, Uusimaki and Nason 2004, Uusimaki and Kidman 2004, Bursal and Paznokas 2006, Gresham 2008, 2007). Scholars (Levine 1996, Martinez and Martinez 1996, Raymond 1997, Hart 2002, Uusimaki and Nason 2004) have associated it with prospective teachers' previous teaching-learning experiences. Teachers with negative attitudes and beliefs regarding mathematics might transmit similar feelings about the subject to their students (Sovchik 1996, Zettle and Raines 2000, Vinson 2001, Sloan, Daane, and Giesen 2002, Uusimaki and Nason 2004, Gresham 2007). In addition, negative attitudes towards mathematics have been related to poor performance in mathematics (Post 1992, Gresham 2007): this might create a vicious circle that would reinforce such previous, negative attitudes.

Some educators (Tobias and Weissbrod 1980, Furner and Berman 2004, Uusimaki and Nason 2004, Gresham 2007) have related the development of mathematics anxiety in students to traditional teaching techniques that are frequently used in mathematics classrooms. By contrast, a number of non-traditional or infrequent teaching and learning methods have been documented as not only playing a crucial role in diminishing students' negative attitudes and beliefs regarding mathematics, but also in promoting positive feelings and beliefs towards it, such as problem-based learning (Gresham 2007), collaborative group work (Beswick 2006), relating mathematical experiences to the student's real-world environment (Gresham 2008), reflection (Hart 2002), simulations, discoveries and challenges (Seymour 1996, Vinson 2001, Gresham 2007), among others.

For teachers implementing these teaching strategies in order to benefit their students' learning, it is necessary to review their beliefs and conceptions about teaching and learning. Beliefs are the basis of teachers' practice (Hart 2002, Pajares 1992). Consequently, in order to change and affect teachers' practice, it is first necessary to deal with their beliefs.

The problem is that most teachers' beliefs are already formed when they enter teacher preparation programmes, because beliefs are usually developed through previous experience. Therefore, Hart (2002) proposed that, in order to have a real impact on teachers' practices and to develop the necessary constructivist views that new educational trends demand, teacher preparation courses should include teaching and learning experiences that put these principles into practice. Hart (2002) also claims that teacher education should not deal with the content of the discipline separately, and by using traditional teaching methods. Otherwise, prospective teachers will not be able to inform their future practice based on their own experiences as learners; thus, the likelihood of changing their beliefs is dramatically decreased.

THE ROLE COGNITIVE ACCELERATION (CA) PROGRAMMES HAVE PLAYED IN PROMOTING POSITIVE CONCEPTIONS AND ATTITUDES ABOUT TEACHING AND LEARNING

The main purpose of every CA programme is to accelerate students' cognitive development and the acquisition of formal reasoning skills (Shayer and Adhami 2007). In doing so, every CA programme implements a professional development (PD) training that promotes teachers' reflection, not only about their teaching and learning assumptions, but also about how those views shape their teaching models inside the classroom.

Teachers' being aware of their pedagogical conceptions is the first essential step towards the pedagogy required to promote students' thinking (Adey 2005, Adey 2006, Shayer and Adhami 2007). In fact, according to Mcguinness (1999), part of the difficulty in training teachers to teach thinking skills can be explained by the fact that teachers' previous knowledge is often called into question when they are trying to adopt and promote a more constructivist learning environment in their classrooms: this is an indispensable condition for many thinking skills initiatives.

Several studies have explored the impact of Cognitive Acceleration PD programmes on teachers' pedagogy (Adey 2006, Endler and Bond 2008, Hodgen 2011, Hodgen, Johnson, and Adhami 2004, McGregor and Gunter 2001). Even though school variables like the ethos promoted by principals and other authorities are mediators of the effect of the PD programme on teachers, it was possible to observe changes in teachers' practice even in lessons that were not part of the CA programme. In this sense, teachers started to (i) ask students to discuss and share their reasoning with others; (ii) give students the opportunity to engage in higher thinking processes like prediction; (iii) challenge students' ideas by introducing conflicting or unanticipated information; (iv) ask students to verbalize their own thinking; (v) arrange groups of students with a pedagogical and dialogical intention; (vi) ask more challenging, open-ended and unstructured questions (McGregor and Gunter 2001). It is interesting to note that all these changes are remarkable, especially considering that at the beginning of the course less than 10% of the participating teachers thought that the CA programme would change their teaching yet, at the end, all of the teachers reported changes.

According to McGregor and Gunter (2001), it is possible to think that those changes are not the mere acquisition of teaching strategies but the result of changes in teachers' assumptions and views about the nature of teaching and learning. In this sense, their follow-up study has shown that after participating in the CA professional development programme teachers started to define learning as a process of constructing and verbalizing reasoning processes and concepts rather than memorizing contents.

The case study conducted by Hodgen and Askew (2007) found that the PD programme of the Cognitive Acceleration in Mathematics Education (CAME) approach promoted teachers' attitudinal changes in relation to mathematics. For example Ursula, one of the participating primary teachers, shifted from…a position of silence, or disconnection with mathematics, to a position of author/ity, a belief in her own active role in the construction of mathematical knowledge (Hodgen and Askew 2007: 471).

RESEARCH QUESTIONS

This study explored how prospective primary teachers in Chile responded to an undergraduate course that adapted the professional development programme from the Cognitive Acceleration in Mathematics Education (CAME) approach in the context of learning mathematics, with the purpose of exploring if at the end of the programme prospective teachers experimented changes in relation to their views and attitudes about teaching and learning in general, and mathematics in particular.

In this sense, this study attempted to answer the following research questions:

1. Do prospective teachers change their conceptions about teaching and learning in general and mathematics in particular after participating in a CAME course?
2. Do prospective teachers change their attitudes about teaching mathematics after participating in a CAME course?

METHODS

Selecting and recruiting the participants

I decided to work with prospective teachers who were in their fourth or fifth (last) year of their Bachelor of Education programmes, because they have had some internship experience in order to reflect on the approach in relation to their experience as future teachers, and not only as students.

The specific sampling method I used was an intentional cluster sampling (Hesse-Biber 2010), whereby the smallest eligible unit was Education Departments and not individual students. Three Schools of Education participated in this research. For confidentiality reasons, they will be indicated as follows: (i) UA, (ii) UB and (iii), UC. I decided to include only three universities for reasons of feasibility. As I had to deliver all the CAME lessons and analyse all the data collected from them, three was a large enough number to ensure variability within my sample, while still being small enough to be manageable within the resources and time frame of a rather small study.

For recruiting individual students, I sent an email to the secretaries of the Departments of Education and they forwarded the invitation to the potential participants. As a response to that invitation, a group of students from each university registered for the course (see Table 1). However, only a group of them actually participated fully (see Table 2), which means that they attended at least 80% of the CAME sessions.

Table 1. Students registered for the course

	UA	UB	UC	TOTAL
Nº students in the 1st session	24	11	10	45

Table 2. Participating students per University

	UA	UB	UC	TOTAL
N° students attended to 80% of the sessions	14	8	4	26

Research procedures

16 CAME activities were selected given that the course was going to be applied during a 16-week university term. For selecting the activities, I took three criteria into consideration:

1) The appropriateness of the activities for the group of students with which I was going to work.
2) The coverage of the six different strands that are included in CAME lessons.
3) The inclusion of activities of differing difficulty based on the Piagetian levels described by each activity.

Table 3 shows the name of the activities selected, the main strand of focus (black circle), the secondary strands of focus (white circle) and the range of Piagetian levels covered by each.

The next phase consisted of adapting the activities to the appropriate context. Each CAME session lasted between 50 and 60 minutes and I followed the same structure during each session. At the beginning of each activity, I presented the students with the problem that we were going to solve during the session. They worked in order to try to find a solution in pairs or in groups of three, depending on the number of students who attended the session. As discussion and reflection are key components of every cognitive acceleration activity, I usually asked them to work with someone who did not think the same way as they did.

When most of the groups had found a solution, we held a class discussion in order to share ideas and to analyse if there was a solution that seemed better than the others and in which contexts the other solutions could be more useful. At the end of the session, the students had to think about future applications of the skills the activities attempted to develop.

Table 3. The CAME activities selected, their strands and Piagetian levels

Lesson	Number system and properties	Multiplicative Relations	Functions	Algebra models	Shape and Space	Data Handling	Range of Piagetian Levels 2B 2B* 3A 3B 4 5 6 7/8
Furniture design	○				○	●	5 - 6
Sam and the newspaper						●	5 - 6
Which offer shall I take?		○	●	○			4.5 - 6
Chocolate box		○	●	○			5 - 7
Circle functions		○			●		4.5 - 6.5
Three dice		○				●	5.5 - 6.5
Prediction and correlation						●	5.5 - 6.5
Accuracy and errors	●	○					5 - 6
Heads and tails I and II						●	5 - 6
Expressions and equations	○			●			5 - 6
Comparing correlations		○				●	5.5 - 6.5
Rates of changes		○	●	○			5 - 6
Data relations	○					●	5.5 - 6.5
Chunking in algebra			○	●			5 - 6
Accelerating the acceleration			○	●			5 - 7
How do I handle the data? I and II		○	○			●	5.5 - 6.5

Fuente: *Adhami et al., 1998*

Collecting the data

The only information I found concerning the application of a CA programme in a relatively similar context to the Chilean one is the case of Colombia (Uribe and Solarte 2007, Uribe 2009), which applied CASE in three secondary schools. However, as I said before, the novelty of this particular study not only resides in the fact that it was applied for the first time in Chile, but mainly that it was used with prospective teachers instead of in-service teachers. Based on the lack of previous evidence from similar contexts and/or teachers, this research not only carried out a pilot study in adition to the main study, but also was intended to be exploratory (Burns and Grove 1987, Brink 1989). The following data collection methods were used:

Prospective teachers' learning journals

Education professionals (Black, Sileo, and Prater 2000, Langer 2002, Varner and Peck 2003, Thorpe 2004, Creme 2005, Sutton, Townend, and Wright 2007) have considered learning journals to be a valuable learning tool that promotes reflective and metacognitive skills.

As the most important research objective was to explore prospective teachers' perceptions of the CAME programme in relation to teaching and learning, and because the CAME course in general is oriented towards developing thinking skills, I considered that writing learning journals would be a powerful learning and research tool. On one hand, it could help prospective teachers to reflect on their own learning processes and, on the other hand, it could allow me to be part of that learning process since they probably would not share all their thoughts with me if they did not write them down. For these reasons, after every other session, I asked prospective teachers to write down their reflections about the learning process they were experiencing during the course.

My role as a teacher researcher: CAME sessions' field notes

Teachers conducting research on their own classrooms is a frequent research tool (Baumann 2001, Loughran 1996, Nolen 2007, Peeke 1984). One of the benefits teacher research provides is that they are already 'insiders' in the research contexts, so teachers do not have to start by constructing relationships with the participants before the research is being conducted. When referring specifically to the advantages of the dual role of teacher and researcher in the context of teacher training, Loughran (1996) claims that the researcher has the unique and valuable opportunity to observe the evolution of teachers' change during the process, which was actually the purpose of this particular study.

Despite the benefits and practicalities of this kind of research technique, in the case of this research one evident challenge was the position of power that was inevitably connected to my role of teacher-researcher. As this asymmetrical relationship cannot be denied or eliminated, a good way of dealing with it was to follow certain ethical procedures (Marshall and Batten 2004) that allowed me to ensure that their participation in the research project was voluntary and informed.

The role I played during CAME sessions and the field notes I wrote evolved during the data collection stage. As Kawulich states:

> It is important in the early stages of the research process for the researcher to make accurate observation field notes without imposing preconceived categories from the researcher's theoretical perspective, but allow them to emerge from the community under study (2005: 8).

Therefore, during the first CAME sessions, I wrote field notes that were more general and descriptive; while later I became more analytical and hypothetical.

However, from the beginning, I used the type of observation field notes that Angrosino and DePerez (2000) call 'selective', which consists of deciding the topics, activities or aspects of the situation on which the researcher will focus.

Finally, in order to ensure the rigour of my field notes, I always wrote them within 24 hours of the session and I always came back to them before the next session to make comments and to highlight certain issues that I wanted to stress or to be particularly focused on during the next session. As a result, the process of writing my field notes was essentially an iterative and analytical process.

Interviews

Interviewing is one of the most frequently used methods of data collection in education (Dilley 2004, Baker and Johnson 1998). The purpose was to explore my participants' perceptions and processes of change in-depth and from their own points of view. The interviews were semi-structured.

I interviewed four prospective teachers from UA University, four from UB University and only three volunteered from UC University. Of these 11 interviewees, only one gave up the CAME course before it finished (for medical reasons), so I did not have an opportunity to conduct a follow-up interview with her. In total, I conducted 21 interviews: 11 pre-course interviews and 10 follow-up interviews.

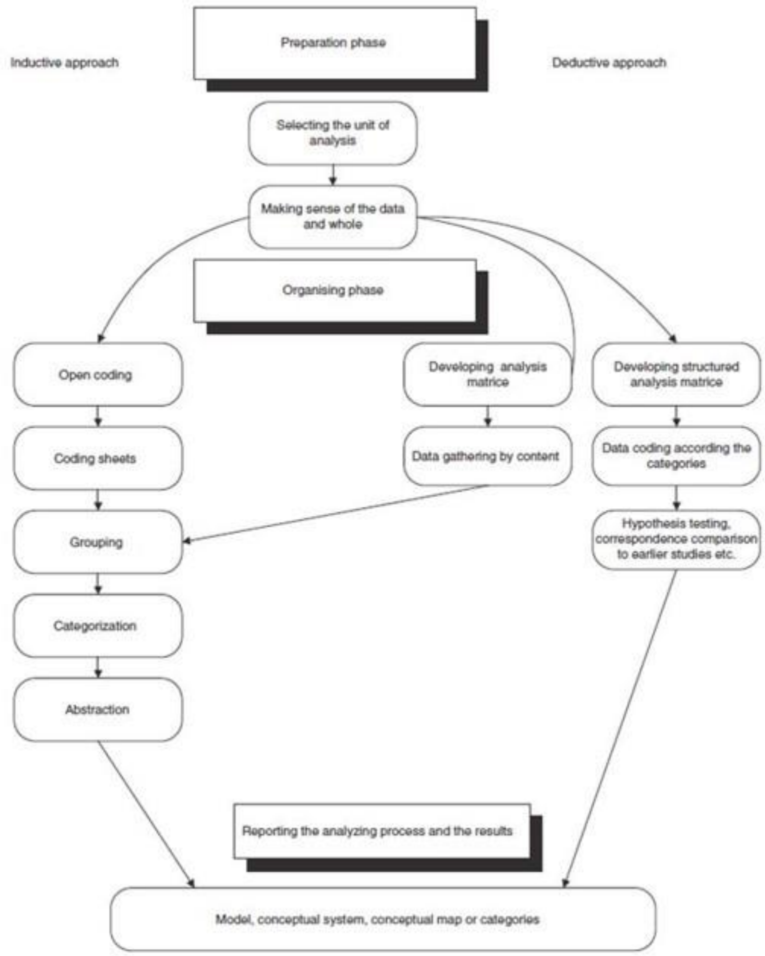
Data analysis

All the written material, which included interview transcripts, field notes and learning journals, was analysed using Hsieh and Shannon's (2005) content analysis. They claim that this is useful when the researcher wants to explore or describe a phenomenon that has a relatively limited theoretical and literature background, as is the case in this research.

Initially, a list of codes was derived from the literature review and the research questions as a way of guiding the initial immersion in the text. However, that code list was considered to be preliminary, given that it was theoretically driven and the questions addressed by this research were novel; therefore, I could not completely rely on previous evidence. For this reason, the codes from the initial list were treated in the same way as the codes that emerged during the coding process. In other words, they were continuously revised and adapted in the light of new evidence.

The data analysis followed the conventional content analysis process described in Figure 1. I first read all the transcripts in order to have a complete picture in mind. I then read every word in detail, with the purpose of creating the first emerging codes and linking some text passages to the existing (theoretical) ones, by using qualitative data analysis software (ATLAS.ti, version 5.2). The next step was to re-read everything but, this time, highlighting my impressions and reflections, as well as taking note of thoughts and aspects that were relevant to the initial analysis. Subsequently, based on these initial thoughts, the first labels for the codes emerged and they began to be structured into a preliminary coding list.

Figure 1. Preparation, organisation and the resulting phases in the content analysis process



Fuente: *Elo & Kyngäs, 2008*

As a result, I started to find relationships between the codes, which meant that they were organised into broader categories, or group codes. Each code, subcategory and category was then defined and exemplified. It is important to mention that, as stated previously, this was a continuous cycle in which I continuously revised and refined the codes until they formed a coherent and trustworthy representation of the raw data. Appendix A presents a summary of the final code list.

Validity

Based on the recognition that we can only access reality as observers and interpreters and the fact that researchers are part of the reality they are trying to explore, validity is understood as the extent to which the account is grounded in the perspectives of the community under study (Kirk and Miller 1986, Lincoln 1995). In relation to this, Maxwell (1992) claimed that validity is always relative, because it cannot be separated from the perspectives of those involved in the research process. This does not mean that every account is equally valid, but it implies that some accounts are more valid given different perspectives.

Using triangulation or different methods/data to approach the same phenomenon serves the purpose of strengthening the research results and, consequently, their validity. Given the complexity of social reality, it is commonly agreed that it could be better understood by using multiple approaches and various types of data, in order to have a complete picture of the phenomenon under study. For this reason, three different types of qualitative methods were used (interviews, learning journals and field notes) for answering the research questions.

One example of the way in which I used different kinds of information to triangulate my data is the following: Before starting to code an interview, I read the complete transcript and wrote a summary that covered the main ideas revealed during the interview with the purpose of not losing the meaning of the interview as a whole through the coding process. The second step was to code the interview and the learning journal of the same person several times, until I had the impression that the emergent code structure was coherent with the original data. Having done that, I then compared the interview summary, the code structure and my field notes on that person in order to explore if the conclusions reached by each method independently were coherent. In the event that they were not coherent, I returned to the original data in order to make the necessary adjustments and to ensure that the conclusions were a fair representation of the original data.

Reliability

Within the context of qualitative research, the term reliability is usually understood as being related to credibility, transferability and trustworthiness (Phillips 1987, Hsieh and Shannon 2005). In other words, it generally means that the conclusions drawn from the data are truly supported or grounded in them.

When referring to securing validity in a research process that uses content analysis, Kohlbacher (2006) claimed that one of the most important challenges is related to the trustworthiness of the coding. The terms inter-coder and intra-coder reliability are central to this issue. Inter-coder reliability is defined as the level of agreement between two different coders when coding the same text extract, and is usually expressed as a proportion between 0 and 1, with 0 being null agreement and 1 being perfect agreement. In turn, intra-coder reliability assesses the stability of the coding of one coder (Kohlbacher 2006).

In order to strengthen the reliability of my results, 15% of the data was doubled-coded. This involved two complementary, yet different, processes. On one hand, two different people coded the same text independently and we then compared, discussed and agreed on a final version of our coding. This process was intended to reduce the bias that might be involved in the coding process of only one coder. I found an 87% correspondence between the two coders, which might lead me to suggest that the coding list had an acceptable level of definition and clarity when guiding the coding process. On the other hand, 30% of the data that was not coded by two different people was coded twice in order to explore the concurrence level of my own coding of the same text on two different occasions. As a result, I found a 92% concurrence between my first and second coding, which is an acceptable level of agreement given the characteristics of the process.

Ethical procedures

This study (REP (EM)/10/11-44) followed the King's College London guidelines for good practice in academic research and received full ethical approval from the Education and Management Research Ethics Panel.

It was very important for my students to understand the difference between participating in the course and participating in the research project. Even when some of them were not interested in taking part in the research, they were still allowed to take the course. In order to explain this, I gave them an information sheet during the first session that stated that this course was part of a research project and that voluntary participation in it involved the following:

1) Writing learning journals every other session of the course

2) Possibly being invited to participate in an interview that would last no more than 60 minutes at the beginning and at the end of the course

I explained to the prospective teachers that their participation in the research was purely voluntary. In the information sheet, I also explained that they were free to choose not to write the learning journals. In addition, they had the right to leave the course or the research project at any time and to withdraw all of their information from the study before November 2013, when the data analysis stage was scheduled to begin. Apart from accepting the terms stated in the information sheet, they had to sign a consent form as a way of formalising their agreement to participate in the project. Both documents clearly expressed that they had the right to withdraw their participation before November 2013 without experiencing any consequences.

Some students who were contacted and invited to participate did not agree to take part in the study. I did not report any individual's attendance with the university tutors. For the interviews, I contacted potential participants and gave them an information sheet that stated the purpose of the research, the nature of their participation and a consent form in which they could agree to being interviewed. Both documents clearly expressed that they had the right to withdraw their participation at any time without experiencing any consequences. The information sheet also gave them basic information regarding the length of the interview, the purpose thereof and that it would be audio recorded and transcribed verbatim for data analysis purposes. It also stated that the audio recording would be destroyed after the completion of the analysis.

RESULTS

Prospective primary teachers change in relation to their conceptions about teaching and learning in general and mathematics in particular

The most frequent view about learning found among the participants, is that students should play an active role in their learning processes by discovering and/or constructing their own learning (6/11, f=10). These kinds of statements are coherent with what constructivist theories claim about the process of learning, which might suggest that prospective teachers held constructivist views about teaching and learning. Accordingly, prospective teachers claimed that students' learning takes place when they are actively involved in and engaging with their own learning processes (see appendix B.1.)

The views about teaching that the interviewees shared at the beginning of the course did not have frequencies as high as the ones related to learning, but they did reflect similar views about teaching and learning. Firstly, they stated that teachers should try to identify their students' learning needs and strengths in order to be able to improve their learning experience (4/11) (see appendix B.2.).

Prospective teachers identified the role that teachers should play in their students' learning as that of a mediator (2/11). They did not go into detail in the sense of explaining what they understood by mediation, but they did refer to this point explicitly by using that term (see appendix B.3.).

Even though they claimed that students should play an active role in their learning processes by discovering and/or constructing their own learning and that teachers should mediate the learning process of their students, what they said about ways in which teachers can support learners did not seem to be directly linked to what they said about learning. It is possible that the mediator role is a better fit with the socio-constructivist approach. However, the kinds of examples they gave did not sound much like problem-solving/discovery-type learning. This could suggest that their ideas are not yet fully formed; thus, even though they know what is expected of them and what they would like to do inside the classroom, they might not yet have experienced how this is achieved in a classroom situation.

These contradictions were present in the discourse of various prospective teachers and will be further explored in the next paragraphs. My own impression as a researcher is that, although they have heard and learned some socio-constructivist theories about teaching and learning, they have not seen them in practice during their experiences at school or as undergraduate students. Therefore, even though they are able to talk in a constructivist or socio-constructivist manner and to understand the advantages of that approach for teaching and learning, they do not have a coherent mental image of how a teacher actually puts these principles into practice or of good examples of this kind of practice.

Finally, two prospective teachers also claimed that one of the most important things in the teaching process are teachers' expectations about students' learning (2/11). In other words, if teachers do not believe in their students' capabilities and do not have high expectations of their ability to learn, this might prevent students from learning (see appendix B.4.).

As I said before, even though these prospective teachers' views about teaching and learning sounded congruent with the latest educational theories, most of the interviewees (6/11, f=7) made comments that led me to infer that they held contradictory theories in this regard (see appendix B.5.). Most of the interviewees (6/11) reflected simultaneous and contradictory views about teaching. This phenomenon might be related to two different factors:

1) the limited professional practice (or internships) that prospective teachers have had so far during their initial teacher training, meaning that their discourse about constructivism could be mainly theoretically grounded

2) the lack of constructivist teaching models, both at school and at university, that could have given them the chance to observe constructivist principles in practice.

These hypotheses are, to some extent, supported by the comments participants made when the CAME course was finished. Firstly, they started to strongly criticize how mathematics is usually taught in Chilean schools (9/11, f=46), in the sense that processes and mistakes receive less emphasis than do the results themselves; thus, learning and understanding the reasoning behind mathematics does not receive attention. Interviewees also mentioned that teachers frequently do not allow the development of different processes to get to the same result, but demand that students follow exactly the same algorithm that was shown during the class. The other criticism they mentioned is that mathematics is usually taught in a mechanical/theoretical way that does not promote thinking, understanding, abilities, application and/or transference (see appendix B.6.).

Only 13 of the 46 quotations that criticize the way in which mathematics is currently taught were mentioned during the pre-course interviews, which means that the other 33 arose after the course was over. This is one of the reasons that I think that it was a new experience for them to see socio-constructivist principles put into practice. After participating in the course, they may have had the opportunity to contrast their own beliefs about teaching mathematics and what they had experienced regarding teaching and learning mathematics with what they experienced during the CAME course. While this process may have caused them to say more about their beliefs regarding teaching and learning mathematics, the issues raised indicate that they formed a new or adapted version of how mathematics might and could be taught.

In fact, even though prospective teachers' experiences during the CAME course could have been similar to what they had heard about how mathematics should be taught, at the end of the course most of them (9/11, f=29) reported that it was very different from what they had seen regarding teaching and learning mathematics. Specifically, they claimed that the methodology we used during the course was new for them and was very different from what they were used to in other math courses at university or at school, and that it was also a novelty for them to talk about the relevance of developing thinking skills in their students (see appendix B.7. and B.8.).

The findings that were presented in this subsection show how prospective teachers claim they changed their views regarding teaching and learning in general and about mathematics in particular after participating in the CAME course. In this context, it is plausible to think that they moved to a more constructivist stance and expressed fewer contradictory views about teaching and learning. This is it not only because they experienced the constructivist principles put into practice as students, but also because they were consciously aware of them and talked about this explicitly at the end of the course (7/11, f=15) (see appendix B.9.).

Prospective primary teachers change in relation to their attitudes about teaching mathematics

During the interviews, most prospective teachers (9/11, f=22) described their bad experiences with mathematics either at school or at university, which, in many of the cases, were linked to the teachers that they had during their trajectories as mathematics students/learners. In this context, the difference between the number of quotations related to bad experiences when learning mathematics (f=22) versus the quotations connected to good experiences (f=6) is very interesting (see appendix B.10. and B.11.).

The predominance of bad over good experiences related to learning mathematics might be associated with prospective teachers' lack of confidence regarding teaching mathematics. During the pre-course interviews, seven of the eleven participants mentioned in various ways that they did not feel sufficiently prepared to teach mathematics (7/11, f=23) (see appendix B.12. and B.13.), which may be related to the absence of solid and positive models of good mathematics teaching. The difference between the number of quotations related to being confident (f=9) and not confident (f=23) regarding teaching mathematics is very similar to the difference between good and bad experiences with learning math mentioned in the previous paragraph.

Prospective teachers' comments about how confident they felt about teaching in general were not as frequent as their comments about teaching mathematics in particular. However, in the case of their confidence to teach, the situation was more balanced because almost half of the teachers reported not feeling confident about teaching in general (6/11, f=7) (see appendix B.14.), while five out of eleven declared they felt confident about it (5/11, f=6) (see appendix B.15.).

In the context of the lack of confidence, especially regarding teaching mathematics, it is relevant to remark that most of the prospective teachers (7/11, f=20) commented that the CAME course had a positive impact on their confidence about their ability to teach mathematics (see appendix B.16.) and to share their reasoning with their peers (see appendix B.17.).

This finding, in conjunction with the fact that prospective teachers began to be more aware of their thinking processes after the course, and were also able to talk about them, could have a positive impact on the kind of activities they promote, the amount of discussion and the culture of thinking they emphasize inside the classroom. In a similar manner, prospective teachers' confidence in their mathematical capabilities improved (see appendix B.18.).

The other attitudinal change that was observed in prospective teachers was that most of them (9/11, f=22) claimed that they had fun during CAME lessons (see appendix B.19.), that the activities were motivating (see appendix B.20.) and that they could use these types of activities to motivate their students in the future (see appendix B.21.).

It is worth noting that, given the prospective teachers' unfortunate histories of learning mathematics, I considered this motivation to be an attitudinal change, because most of them were not initially motivated with a mathematics course.

DISCUSSION

Finding that teachers tend to teach in a similar way to which they were taught is a problematic conclusion, particularly when considered in conjunction with the fact that most prospective teachers who participated in this study had negative prior experiences of mathematics, either at school or at university. In many of these cases, the unpleasant memories were associated with the teachers they had had during their trajectories as mathematics students/learners. The number of times that prospective teachers recalled negative experiences with mathematics in contrast to the number of times they mentioned good memories was startling. However, engaging prospective teachers in thinking skills activities over several months during their training course seems to have changed their views about teaching and learning in general and with respect to teaching mathematics in particular. These findings are consistent with previous literature, which revealed that many teachers tend to teach in the same way in which they were taught as students, either at school or at university (Ball 1988, Borko and Mayfield 1995, Hill 2000, Bruce 2004, Henderson and Rodrigues 2008).

As can be seen, the findings of this study are consistent with previous literature and research on this topic, which showed how primary teachers experience anxiety and negative attitudes towards mathematics (Burgess and Mayes 2008, Ernest 1989, Henderson and Rodrigues 2008, Hodgen and Askew 2007, Murphy 2006, Smith 1996). In addition, previous research evidence makes perfect sense in light of the results of this study, which point out that one of the aspects of the CAME course valued by prospective teachers, and which was explicitly reported at the end of the course, was the fact that they learned by actively participating in CAME lessons, by handling real life mathematical problems and by following a methodology that was consistent with a constructivist view of teaching and learning. These claims are not surprising when taking into consideration the fact that all cognitive acceleration programmes are theoretically and practically driven by constructivist principles. However, as this was never made explicit to the participants in this course, it is interesting to note that not only did they recognise this aspect, they also commented on its value.

In other words, it can be hypothesised that the approach to teaching and learning encapsulated in the CAME course could be related to the observed changes in views regarding teaching and learning in the prospective primary teachers. The CAME methodology complies with many of the research-reported features about classroom arrangements that promote positive attitudes towards mathematics (Beswick 2006, Gresham 2007, Hart 2002, Vinson 2001), in that it presents challenging, real-life problems to students that they have to solve in small groups and about which they must reflect in terms of their progress, as well as ways in which the processes could be improved and transferred to other situations or contexts.

In fact, it was only at the end of the CAME course that prospective teachers began to criticise the way in which mathematics is usually taught. Taking part in the intervention changed the ways in which prospective teachers viewed and valued the teaching approach to mathematics. One of the most frequent criticisms that participating teachers made of conventional mathematics instruction was the fact that teachers tended to overemphasise the result at the expense of the process. In this sense, they reported that teachers did not usually allow different ways of getting to the same answer, and that mathematics is usually taught in a mechanical/theoretical way that does not value thinking, understanding, application or transference. Participating teachers also thought that this aspect of their previous mathematics instruction experience was related to their negative concept of and attitude towards mathematics. This description is consistent with the traditional practices of teaching mathematics that previous research has associated with the development of negative attitudes in this regard (Tobias and Weissbrod 1980, Furner and Berman 2004, Uusimaki and Kidman 2004, Gresham 2007).

All the claims prospective teachers made regarding the CAME course support the idea that it changed their beliefs regarding effective mathematics teaching and learning by experiencing this for themselves. Based on these findings, it is possible to suggest that their participation in the CAME course gave them the opportunity to contrast what they had previously been told about teaching mathematics, what they had seen of teaching and learning mathematics in practice and what they experienced during the

CAME course. As a result, they reached the conclusion that teaching and learning mathematics could be much more meaningful and interesting than they had previously experienced during their trajectories as mathematics learners at school or at university.

In this sense, even though prospective teachers may have been introduced to constructivist approaches to mathematics teaching during their studies, most of the participants explicitly reported that, at the end of the CAME course, the methodology was very different from that which they had previously experienced with regard to teaching and learning mathematics in practice. Specifically, they claimed that the methodology used during the course was new to them and was very different from what they were used to in other mathematics courses at university or at school. The recognition that CAME methodology was not only innovative but was also attractive for prospective teachers might have influenced the development of attitudes and views towards teaching and learning mathematics that were more constructivist and more beneficial for students' learning. This could be considered to be a powerful outcome of the course.

In this context, the socio-cultural experience of the CAME intervention for the participants of this intervention group allowed them to experience and to conceptualise the process of teaching and learning of mathematics quite differently, because what CAME tries to do is to present challenging problems to the students that they have to solve in a collaborative way with their classmates. In this sense, the exchange of different points of view and discussion among students is key to accomplishing the objectives of every CAME lesson. In relation to group work, Blatchford et al. (2003) claimed that, in the future classroom, students working together will be key to the process of learning from and with each other, because we live in a society in which enormous amounts of information are broadly and instantaneously available; thus, the most appropriate learning scenario is one in which groups of students make sense of this information together. For this reason, teachers need to promote their students' collaborative practice in order for them to understand, make sense of and make use of that information in a meaningful way. This requires a more socio-constructivist approach in the classroom than that which the prospective teachers would have encountered in either their school or their university experiences. Blatchford's (2003) research team also pointed out that another benefit of learners working collaboratively is that their achievement improves considerably, in comparison to when they are working on an individual basis.

All the evidence presented and discussed so far has significant implications for the development of effective initial training programmes for prospective teachers, since it suggests that the methodologies used during teacher preparation courses may have as strong an impact on teachers' future practice as the actual content and teaching/learning theories covered in such courses. With regard to this point, Adler et al. (2005) stated that most mathematics teachers have not yet developed the necessary skills and knowledge that the teaching practice will demand of them and, more importantly, have not yet learned them in ways that would be useful for teaching their future students efficiently. For this reason, it is imperative not only to talk about the principles behind the new educational trends during teacher preparation courses, but to incorporate them into the methods used during these courses in order to give prospective teachers the opportunity to experience, as learners, that which they are supposed to impart as teachers.

Similarly, Remillard (2000) states that many teacher training instances are not effective because the design and implementation of such initiatives have not considered that the core ideas they are trying to install are meaningless to many teachers, because they are forced to put into practice teaching methods that they have not seen in practice as students. Also, Schifter and Fosnot (1993) claim that many teachers see changes in educational programmes as interesting teaching models, but do not know how to apply them to their own teaching experience because they are very different from what they are used to in terms of mathematics instruction.

For this reason, Brown et al. (1999) state that, to some extent, teachers need to unlearn what they bring to their mathematics education courses in order to be able to break the vicious cycle of reproducing their experiences as students and to develop new teaching practices that are consistent with current educational reforms. Bruce (2004) takes this claim one step further by arguing that not only are prospective teachers' methodologies mainly the result of their previous school experience, but so are their mathematical ideas and understanding. Here, Bruce (2004) claims that the concepts of mathematics, the teaching of mathematics and mathematics learning are closely interlinked.

These conclusions and the evidence from this and other studies presented in this research should alert teacher educators to the factors that might have an important role in expanding teachers' future practice. While this does not mean that such practices are not changeable, it does imply that initial teacher training instances are compelled to take this evidence into account at the time of designing and implementing courses in order to provide prospective teachers with adequate experience to develop the abilities, capabilities and knowledge required to promote their students' learning potential in the classroom.

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APPENDIXES

Appendix A: Final Code List Summary

CATEGORY	SUB-CATEGORY	CODE NUMBER	CODE NAME	CODE DESCRIPTION
CAME	EXPERIENCE	1	CE_CONFIDENCE	More confident about teaching maths
		2	CE_MATHSKILLS	They realised they have maths skills
		3	CE_METACOGNITION	They are more aware of their own learning/thinking processes
		4	CE_MOTIVATION	The course was motivating
		5	CE_THINKINGSKILLS	They had to use their own reasoning skills to solve the problems
	IMPROVEMENTS	6	CI_APPLY	They did not put what they had learned into practice
		7	CI_STUDENTS	It would have been better to have more classmates participating
		8	CI_TIME	The course or the sessions were too short
	METHODOLOGY	9	CM_CONSTRUCTIVIST	The course methodology was constructivist
		10	CM_DIVERSITY	The course emphasised a flexible approach to the problem
		11	CM_NOVELTY	The methodology we used during the course was new to them
		12	CM_SHARING	Having to share was useful in terms of learning from their peers
MATH	LEARNING	13	ML_ABILITY	Being able to learn maths is related to a general ability
		14	ML_CONCRETE	Learning maths should be concrete
	TEACHING	15	MT_BASIC	Teaching primary maths is basic, simple or 'easy'
		16	MT_COMPLEX	Teaching maths is complex
		17	MT_CONF	They feel confident about teaching maths
		18	MT_INTEGRATED	Maths should be taught as an integrated subject

		19	MT_MECHANIC	The process/mistakes should be emphasised more
		20	MT_NOCONF	They do not feel confident about teaching maths
		21	MT_USEFUL	Teachers should help students to realise that maths is useful
	EXPERIENCE	22	ME_BAD	They have had previous, bad experiences with mathematics
		23	ME_GOOD	They have had previous, good experiences with Mathematics
LEARNING	VIEW	24	LV_ACTIVE	Students should play an active role in their learning processes
		25	LV_CONCRETE	They refer to learning as being concrete
		26	LV_EMOTIONS	A key to learning is promoting positive emotions in students
TEACHING	FEELINGS	27	TF_CONF	They feel confident about teaching in general
		28	TF_NOCONF	They do not feel confident about teaching in general
	VIEW	29	TV_CHALLENGE	Teachers should challenge students and should make them think
		30	TV_CONTRADICTION	There are contradictions regarding their teaching views
		31	TV_EXPECT	Teachers should have high expectations of their students
		32	TV_MECHANIC	Teachers usually teach in a mechanical way
		33	TV_MEDIATOR	Teachers should be mediators of their students' learning
		34	TV_STUDNEED	Teachers should identify their students' needs
THINKING	VIEW	35	THV_APPLIED	Thinking is being able to apply prior knowledge to new areas
		36	THV_COMPLICATED	They say that is difficult to define thinking
		37	THV_KNOWLEDGE	Thinking is related to the amount of knowledge a person has
		38	THV_MIND	They view thinking as being the same as mind/intelligence
	TEACHING	39	THT_CONF	They feel confident about promoting thinking skills

		40	THT_LACK	Teachers/schools do not encourage students to think
		41	THT_NOCONF	They do not feel confident about promoting thinking skills
		42	THT_RELEVANT	Teaching thinking is crucial for meaningful learning

Appendix B: Quotations that exemplify the results described

B.1.

...discovery means that...you always have to look at ways in which children can infer their own learning and make discoveries...I don't know...to discover the meaning of words, learning has to be active for children, they are constantly looking for ways to solve things... (Emily, Interview, December).

B.2.

Well, I think that teachers always have to be attentive to their students, to see and to identify the students who have special learning needs, and to provide extra support for them… (Emily, Learning Journal, September).

B.3.

As a teacher, you have to be the mediator of your students' learning. You have to be there to pose them a problem, to teach them the alphabet, to teach them how to add, to go along with them during their processes, but they are the ones who have to discover the final result (Emma, Learning Journal, September).

B.4.

Based on my internships, I've learned that the most important thing is what teachers expect from their students. Some teachers have told me, "Don't waste your time with him, he's not able to do it". In contrast, if the teacher is hopeful about a student, that student will be able to move on (Molly, Learning Journal, October).

B.5.

(…) it's been said that pedagogy has to be constructivist, as do teaching and learning, but there also have to be a degree of behaviorism, because the teacher must provide a foundation for the content…In the end I feel that the teacher has to ask for silence in the classroom in order to be able to create a space for delivering the content and, from then on, the students could construct their own knowledge (Olivia, Interview, December).

B.6.

Many times, what they teach us in mathematics is a list of contents and some formulas, which is presented as being the only way you can solve certain problems...for example, what you most frequently see promoted in the [mathematics] classroom is to try to solve a problem by using a formula or an algorithm (...) but what about the analysis, what about the evaluation of different methods? That's not often promoted in the classroom, the most common approach is to try to apply a formula, and that's it (Zoe, Learning Journal, November).

B.7.

…they [the Department of Education] did not tell us what this course was going to be like but, when you presented the first session and the activity, I found it novel and different. (...) it was something we weren't used to. From the first activity, we realized that this class was going in a different direction, that it wasn't similar to the other [courses], that we were going to learn something meaningful, that we're going to benefit from this workshop, from this knowledge and from these group experiences. So, in the end, we came for those reasons (Zoe, Interview, December 2012).

B.8.

In the classroom, teachers usually tell students what to do and how to do it, with instructions, with everything…I mean…it's very…very structured, and they don't usually let students express themselves, they are not encouraged to think at all, they have everything done for them…I really think that this course has been completely different from all the other courses I've attended because, in mathematics, you are usually exposed to content, but not to content that is related to such concrete things (…) there were two occasions when our math teacher at university gave us a problem and we had to find a solution for it, but none of the problems were meaningful, we just had to apply some formulas to solve them (Jessica, Interview, September).

B.9.

I think that the teacher's role is also important. This University has a plan and a mission to develop constructivist teachers, but I haven't seen this in every course…but this course makes a contribution to the constructivist training that the University is looking for in order to create constructivist teachers…you presented us with a model, because teaching math is very complicated, I personally think so…I think that you broke the mould of the close-minded math teacher who only cares about the result and not about the procedure (…) Yes, I think you're a model for us, a model that we can follow when we teach (Olivia, Learning Journal, October).

B.10.

I think that I have hated maths since I was a child. I had bad experiences with my math teachers. They always…I always found it difficult, and teachers never took me into consideration, they didn't explain things to me well. So, because they didn't explain things to me, I felt silly…I didn't like it and I simply blocked math out and didn't want to learn…I was in second grade and the teacher gave me an E, even though I really put in a lot of effort. All my classmates got an A or a B. I remember that the teacher suggested that I was a bit stupid when it came to math. That was when I put math on my blacklist and I have failed math ever since. I think these are the kinds of bad experiences children have during their childhood (Jessica, Learning Journal, November).

B.11.

I fought…from first to twelve grades with my math teacher. I couldn't understand what maths was for. I thought that calculators could do all the work, which reflected my views about maths. Why do I have to do it if the calculator can get to the result? Do you know what I mean?…and when you told us in the first class that the workshop was going to be related to mathematics, I was immediately discouraged. I said, 'Ah! How boring!' So my expectations about the course were negative (Sarah, Interview, August).

B.12.

My weakness is mathematics…I'm becoming reconciled to this, because I always was bad at math. At school, I failed math every year when I was in secondary school...but I do feel that it's important because, as a primary teacher, you have to teach every subject and if I don't know how to explain mathematics, even though it'll be my responsibility. If I'm not explaining it well, I'll be responsible if the student doesn't learn (Olivia, Learning Journal, August).

B.13.

Lucy reported that she felt '…nervous, a bit anxious (…) because I'm not good at maths' (Lucy, Learning Journal, September).

B.14.

I feel…a bit scared, because you realize that you don't know everything and maybe you don't know anything. So I feel afraid of facing students who might catch me out (Sophia, Learning Journal, August).

B.15.

[I feel] fine, because one of my strengths is my creativity; so, if I see that my methodology is not working, I can change it easily. Therefore, I feel that I'll be able to teach them (Jessica, Learning Journal, December).

B.16.

I have good grades in mathematics…I can't say that my achievement is poor, because I've obtained good grades in my math courses and in my didactic courses, but I didn't feel confident about teaching math because I felt I only knew concepts, only theoretical things, just the formulas…so I didn't know an adequate methodology to teach math. I felt that I was going to teach in the same way in which I was taught: only concepts, formulas and nothing else. I didn't feel prepared, but after this workshop…we hadn't had anything similar to this course, and it helped me to realize how we can develop our abilities to work with our students, to know how can we promote their skills to the maximum. That's why I say that the methodology we used in this course can be used in our classrooms and I think that this is the best method to follow (Zoe, Learning Journal, November).

B.17.

The truth is that I don't feel completely confident about mathematics, but in comparison with how I felt before the course, I do feel more confident now…In fact, before the course I would never have gone to the blackboard to explain what I did because I was very insecure.

I was afraid of doing it incorrectly, but not anymore...Now, I'm even motivated to look for strategies to teach my students, because I know this will help them, and it is also fun (Jessica, Learning Journal, November).

B.18.

I feel that I learned a lot. Before the course, I wasn't able to stand up in front of my classmates to explain something. At the beginning I was ashamed, but during the course I discovered that I do have the tools to get to a result...so I didn't care anymore if what I was doing was right or wrong, because what I was explaining could help my classmates to understand other ways of solving the problem…because, at the end, we always shared our procedures and compared them…yes, sharing and comparing was important (Olivia, Learning Journal, December).

B.19.

…apart from that, the most fun classes use activities that promote discussion inside the class, like 'hey! I think this' and, at the end, everyone has to support what they did…All that makes you keep thinking…'hey! I can do this, I can do that'. It keeps you awake all the time... (Emma, Learning Journal, October).

B.20.

The activities weren't like regular activities, they were much more… innovative and they also encouraged us to look for a solution, to think hard, and they also promoted our interest in getting to a result (…) In addition, as we were always working with everyday problems, this worked as a hook, it motivated you (Emily, Interview, August).

B.21.

For example, playing bingo and things like that are very useful strategies for teaching certain things to children, apart from being fun for them…that learning will last longer than if you just teach them theoretically, because the learning is concrete. Also, if they are having fun, they'll be paying much more attention (Jessica, Learning Journal, December).