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A COLLABORATION MODEL FOR THE TRAINING OF IN-SERVICE SECONDARY MATHEMATICS TEACHERS

Andrés Pinzón
Universidad de los Andes
aa.pinzon364@uniandes.edu.co

Pedro Gómez
Universidad de los Andes
argeifontes@gmail.com

In this document, we describe a collaboration model used in a training program for in-service teachers of secondary mathematics. We briefly describe the curricular design of the program and focus on the methodological aspects that promote interdependent learning. We found that the program contributes to the learning of in-service teachers in relation to their planning practices in, for example, the use of curricular documents and their prediction of student errors.

Mathematics teachers do not work or learn alone. Teaching and learning are social practices and collaborative enterprises (Secada & Adajian, 1997). For these reasons, research in teacher training has been concerned with teacher professional development programs that are based on sociocultural views of learning (Lerman, 2001; Llinares, 1998). In particular, Wenger's social theory of learning (1998) and his notions of community of practice and interdependent learning provide a conceptual framework for the investigation of the learning processes that take place when teachers work together. However, although education promotes the learning of teachers and informs what teachers learn in social terms, very little is known about how these contexts allow learning (Graven & Aurbaugh, 2003). In addition, there has been little research that examines the specific interactions and dynamics that occur in these contexts. Hence, "one analytic task, therefore, is to show how teachers, in and through their interactions with one another and with the material environment, convey and construct particular representations of practice" (Little, 2002). As Krainer (2003) has stated, there is much to be asked in relation to the role of social learning in teacher training: "To what extent can an approach like 'community of practice' be applied to learning at schools and universities? What can we learn from 'learning enterprises'? What implication for research in teacher education has an approach that builds on 'community of practice'? (p. 96).

The work that we present in this document relates to the theme of "Contexts, forms and results of collaboration between teachers of mathematics" which is a focus of the ICMI Study Conference 2020. It aims to contribute to the reflection on interdependent learning processes in the context of secondary mathematics teacher training programs. We address the following research question: What effect does the program have on teacher planning practices? We firstly present a postgraduate in-service training program for secondary mathematics teachers that is conceptually based on the social theory of learning. Next, we describe the curricular design of the program and focus on the methodological aspects that promote interdependent learning. Finally, we reflect on the contribution of the program in the learning of in-service teachers in relation to their planning practices.

Training program

The Master's Degree in Mathematics Education at the Universidad de los Andes (Colombia) is designed to deepen the pedagogical content knowledge of in-service secondary mathematics teachers. Its purpose is to contribute to those teachers' ability to design and implement learning

opportunities that lead to the improvement of the mathematics performance of students. The program provides opportunities for teachers to develop competence in the analysis of topics taught in school mathematics, to predict students' learning processes of those topics and use that information to design and develop curriculum (Gómez, 2018).

The structure of the training program is based on the model of didactic analysis, as a conceptualization of the activities that the teacher performs in order to plan, carry out and evaluate their mathematics lessons (Gómez, 2002, 2007). The didactic analysis is configured around a cycle that comprises four stages of analysis: subject matter, cognitive, instructional and performance. Each stage of analysis brings into play pedagogical concepts on the basis of which in-service teachers can: (a) identify and organize the multiple meanings of a specific mathematical topic (subject matter analysis); (b) select the relevant meanings for instruction and predict the performance of schoolchildren when tackling tasks (cognitive analysis); (c) select the tasks that can contribute to the achievement of the learning objectives (instruction analysis); and (d) evaluate their lesson planning with the purpose of producing information that is relevant for subsequent cycles (performance analysis).

In summary, the program provides teachers with the opportunity to deepen their mathematical and pedagogical knowledge for planning, implementing and evaluating their mathematics lessons.

Organization of academic activities

The program is delivered in blended mode and consists of eight consecutive modules that span over four semesters. The students are organized in groups of three or four people. Each group works on a topic of school mathematics. Each group analyses the topic it has chosen, produces a curricular design, implements it in the classroom, evaluates the implementation and then revises the design. Each group is accompanied throughout the two years of the program by a mentor. The role of the mentor is to comment on the work of the group and to guide the group in each of its activities. The groups also receive the ongoing support of the coordinator who is in charge of the management of the program.

At the end of the first five modules, each group produces a design of a series of lessons on its topic. The last three modules focus on the implementation of that series of lessons in one of the group member's schools. The group collects and analyses the information that emerges from the implementation and produces a report that includes the final version of their curricular design (see Figure 1).

Each module lasts for nine weeks and is composed of four activities of two weeks duration that share the same methodological structure. For example, in the second activity of the module on cognitive analysis the groups are asked to predict the difficulties and errors that students may make when they engage in the group's chosen topic .

The responsibilities of groups and teachers are the same in every activity (see Figure 1). Groups submit a draft of their work at the end of the first week, after having solved their doubts, if needed, with the professor. This meeting takes place on Skype. Four days later they receive their mentors' revision of the draft. At the end of the second week, groups can meet on Skype with the coordinator in order to resolve any doubts concerning their presentation. The next day, the groups, the professor

and the coordinator meet at the university for a four hour session. In the first part of this session, each group has nine-minutes to present its work. After the presentation, the in-service teachers can make comments and ask questions about each group's presentation. In the third part of the session, each group reacts to those comments and questions. The session ends when the professor and the coordinator summarize the main issues of the discussion and comment on the presentations. Four days later, each student submits his comments and criticisms to the work of a group assigned to him.

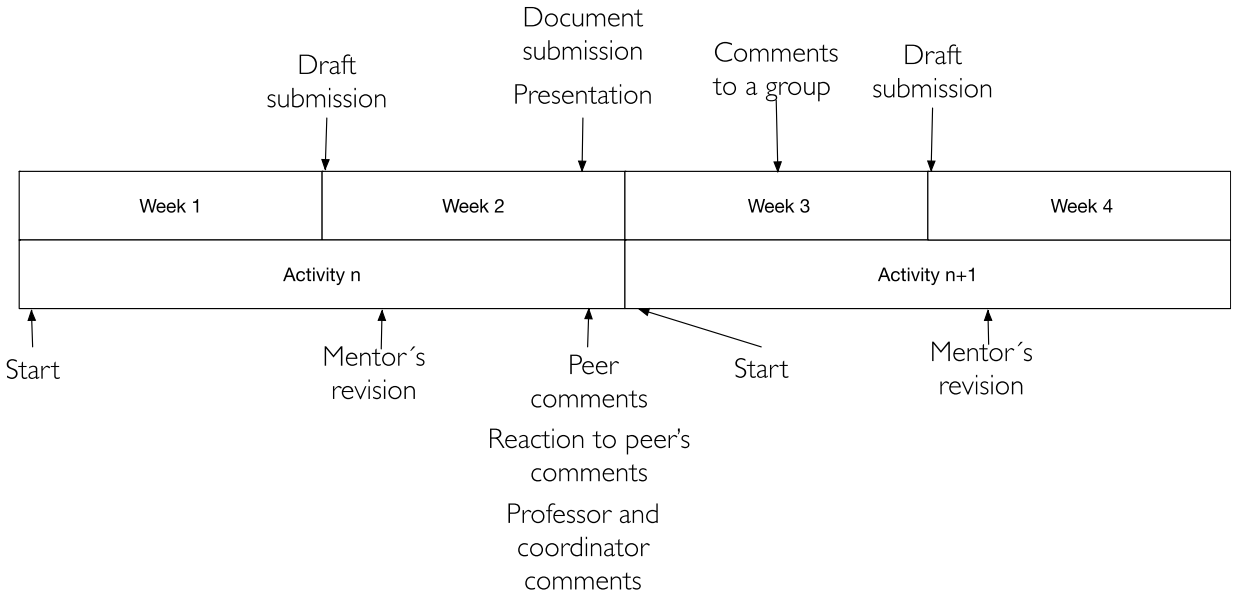

Figure 1. Methodological structure of an activity

Interdependent learning in the program

In this program, the in-service teachers learn by working in a virtual or face-to-face manner, interacting with the professor and mentors and each other to compare and discuss their work with that of other groups. Therefore, the learning of the in-service teachers is fostered through group work and group interaction, meetings with the professor, interaction with their mentor, other students and other groups, and through autonomous work.

Team work. The in-service teachers work in groups throughout the program. The members of each group work collaboratively to prepare the draft and the final document with the results of each activity. The collaboration among the members of a group is stimulated by the fact that they have to submit a draft, a presentation and a final document with their work by specific dates and times. This collaborative work implies inquiring about the requirements of the activity in relation to their school mathematics topic. They have to compare their points of view and reach agreement on the presentation of the result of their work. Through these processes, a collaborative environment is fostered in which each member of the group learns and contributes to the learning of their colleagues. The coordinator of the program contributes to the functioning of the group and promotes interdependent learning among the members.

Meetings with the professors. During the first week of each module, the in-service teachers attend a classroom session in which the professor introduces the curricular design of the module and

presents the activities that the groups must carry out. During the following weeks, groups meet with the professor every fortnight in order to allay concerns that may arise during the completion of the draft document. They also interact with the professor during the face-to-face session.

Interacction with colleagues. In addition to promoting interdependent learning among members of a group, the program encourages interaction among students through the constructive comments and criticisms that each student makes to the final work of another group. Each group receives the comments of at least three colleagues from other groups and can react to these individual comments in the following face-to-face session.

Another interaction with colleagues arises from the discussions that are generated as a result of the presentations of each activity. Once the groups finalize their presentations, their colleagues make comments and critique their work. Each group reacts immediately to resolve the concerns that may arise at that time or that have been identified in the individual comments.

Interaction with the mentor. Each group has a mentor who comments on the work of the group. The mentor makes comments to the draft document and the group can react to those comments by making adjustments for their final document and presentation. Subsequently, when the results of each activity are presented in the final document, the mentor comments again on the work of the group. The professor takes the mentor's comments into account in the assessment of the group's work.

Autonomous work. Each in-service teacher is involved in individual work. This includes reading the module notes, watching videos of the professor, and engaging in his own inquiries in order to comment on the final document of another group. Each teacher, while contributing to the work of his group, has to reach agreements with his peers on the outcomes of the submitted group's work. In this way, each in-service teacher builds his own identity within the group.

Coordinator counseling. Every Friday, prior to the face-to-face session, the groups have the option to meet with the coordinator to resolve concerns relating to their presentation. The coordinator closes the face-to-face session with an evaluation of each group's team-work.

In short, the in-service teachers learn by putting pedagogical concepts into practice. They do this by analysing a specific mathematical topic, for which they produce, implement and assess a series of lessons. They work in groups and have to reach agreements in order to present the results of their work to their colleagues. They also have to contribute individually to the work of the group and to react systematically and periodically to the mentor's comments on the drafts and final versions of their work. They also have to observe the work of other groups on different mathematical topics, and comment on and critique the work of other groups. In Figure 2, we summarize the different products and interactions that take place in the training program that favour interdependent learning.

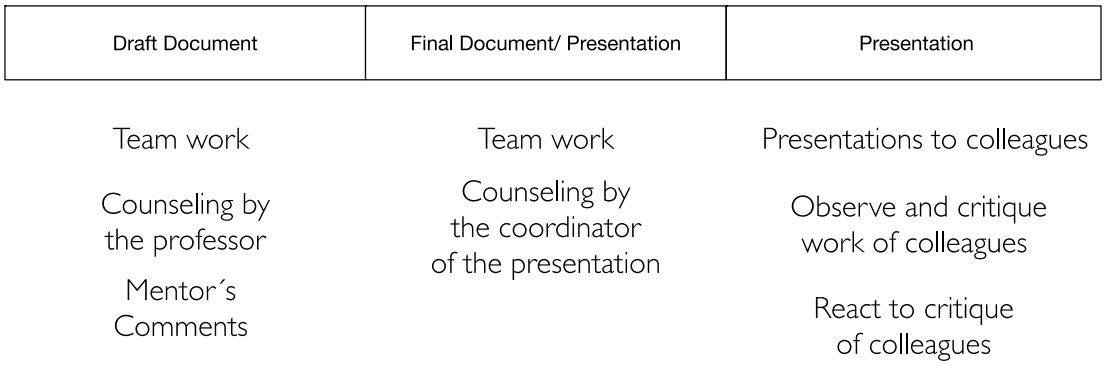

Figure 2: Interdependent learning in the training program

Inquiry into the learning of the in-service teachers

Below, we present preliminary results of the pilot study of the learning of a group of in-service teachers who participated in the program.

Sample and information gathering

The sample for this study corresponds to a group of 23 in-service teachers of the Master's Degree in Mathematics Education of the Universidad de los Andes, of whom 12 were women. The majority (90%) taught in public schools, 75% had undergraduate teacher training and the majority (89%) had more than 5 years of teaching experience. We identified the curricular planning practices of these teachers through a survey that each teacher answered twice: when entering the program and on completion of the program. Although the program is designed based on the idea of community of practice, the questionnaire is based on the learning expectations of the program in relation to the teachers' planning practices. The survey asks in-service teachers to describe one of their most recent lessons. In so doing, the survey focuses on facts relating to the in-service teacher's current practice, not about the his opinions about ideal curricular practices.

The survey is organized into three sections: planning, implementation and evaluation. The questions include open ended and multiple-choice questions. In this paper, we focus on the planning questions. These were organized into five categories: use of curricular documents, conceptual dimension, cognitive dimension, formative dimension and social dimension. The cognitive dimension, in turn, was divided into expectations, errors and forecasts. The formative dimension was divided into the selection of tasks, student performances, teacher performance and sequence of tasks.

For each question, we formulated codes to allow us to classify the answers of the teachers. In some cases, we also formulated categories for groups of codes. The in-service teachers' responses were coded by text segments. Therefore, an answer to a question could be coded with more than one code. For example, a teacher claimed, "It is common for students to confuse the properties of addition with the properties of multiplication. So, I propose activities to differentiate them in each

case". This teacher has anticipated a specific difficulty and, at the same time, he has proposed a way to address it. Each question's codes were weighted according to the expected response of an "ideal" teacher. An "ideal" teacher is one who had successfully satisfied the program's learning expectations.

We verified the normality of the data through the Shapiro-Wilk test with a confidence level of 95%, P value= 0,997. Finally, given that the sample is composed of the same subjects who completed the entry and exit survey, we used the t-Student test for paired data to compare the responses of the teachers and establish whether there are statistically significant differences.

Results in planning practices

For each category, we calculated the value of the t-statistic, the P value of a tail, and the rejection or not of the hypothesis on equality of means (α= 0.05). If the hypothesis of equality of the means was rejected, the effect size (Cohen's d) was calculated. There are three categories in which we found statistically significant differences. In the use of curricular documents (basic competency standards, guidelines and institutional syllabus), we found a positive difference (P= 0.025) and a medium effect (d= 0.55). This is the case of teachers who, before starting the training program, did not use the curricular documents or used them only to select content. Once the program has concluded, these teachers use those documents to address more curricular issues (e.g., learning objectives or assessment).

Another positive difference (P= 0.03), and with a little more effect than in the previous category (d= 0.61), concerns the student error forecast category. This is evidenced in the fact that the teachers at the end of the program take into account, in greater proportion, the possible errors the students may make when solving the tasks.

In the third category, related to the prediction of student performance (strategies not foreseen in the solution of tasks), the difference is negative (P= 0.03). This implies an opportunity for improvement of the program. For the other categories considered in the planning, we did not find statistically significant differences.

Regarding the dimensions of the curriculum, the cognitive dimension shows a statistically significant difference (P= 0.04) and a positive median effect (d= 0.52). Finally, when assessing the whole section of planning practices, we found that there is a statistically significant difference (P= 0.02) and a positive median effect (d= 0.57). Therefore, the training program seems to have a positive effect on the planning practices of its graduates.

Discussion

In this study, we have described the design, objectives and methodological framework of an in-service teacher training program that promotes interdependent learning. In this program, teachers are expected to develop a sufficiently in-depth pedagogical content knowledge of a subject that enables them to support the decisions they make in their lesson planning (Gómez, 2018). We showed that the in-service teachers work in groups on a single topic throughout the program and that group-work systematically promotes the processes of negotiating meaning between the members of a group. The comments of the mentor and critique of their colleagues (both written and oral) encourage these processes of meaning negotiation to generate doubts, raise differences of

opinion and require a solution to the problems that are posed by the mentor and their colleagues. By solving these problems and reaching agreements, each group builds a shared repertoire of concepts, procedures and techniques that materialize their learning. Additionally, individuals build their own identity (and develop their knowledge) by contributing to the group's work, and by commenting and critiquing the work of a group different from their own (Pinzón, Gómez, & Acebedo, 2015).

The methodology used to measure the learning of the teachers participating in the training program was the comparison of the characteristics of their planning practices, before and after passing through the program, by means of a questionnaire. The use of this questionnaire allowed us to formulate and verify hypotheses about the extent to which they put into play what they learned in their classrooms.

Although the results for this sample of teachers does not seem to account for the total achievement of the program's goals, this pilot study provides us with relevant information on opportunities for improvement, in the short and medium term. Interactions between and within groups can be affected by factors such as pre-program training (graduates and non-graduates) and classroom experience (more or less than five years). Likewise, this kind of study can be complemented with other studies that use class observations.

The results of the study show us that participation in the training program contributes to the improvement of teacher planning practices. This is evidenced primarily in the use of curricular documents and in the prediction of errors that students may make when solving tasks. These results may be useful for those who are interested in the evaluation of mathematics teacher training programs whose focus is on classroom practices.

Our findings align with other studies that show that teachers plan more from intuition than from academic learning (Miller et al., 2014) and that they are more concerned about the tasks to be assigned to students than what they aim to achieve (Akyuz et al., 2013; Strangis, Pringle, & Knopf, 2006).

Unlike other teacher training programs, this program does not teach theory, nor does it aim for teachers to become researchers. Teachers collaborate in groups by addressing problems related to their practice and, in this way, construct meanings about concepts and curricular techniques that, when used in practice, can contribute to the learning of their students.

We have described a mathematics teachers' training program that promotes teachers' collaboration in order to contribute to their learning. We have shown that teachers improve their planning practices. How this type of collaboration enhance teachers' learning and contribute to teachers' practice is still an open question.

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