The study presented here is a part of ongoing research, in which ‘situated knowledge’ and ‘cognitive apprenticeship’ form the framework that allows us to deal with the knowledge and the learning process of pre-service elementary school teachers in our mathematics methods courses. On the basis of a learning levels previously identified, our aims are to validate these levels and to examine the relationship between individual levels of the students of a group and the group level. Our results confirm the possibilities offered by the levels of learning for assessing the process of learning to teach, considering either the individual or the group, and suggest different ways of establishing the relationship between individual levels and group level.

BACKGROUND OF THE STUDY

Pre-service teacher development is a process during which knowledge and modes of reasoning similar to those of the expert should be acquired. Among the features that characterise this process, the following may be cited:

- It occurs through active participation in a context defined by ‘authentic activities’ (understood as ordinary cultural practices (Brown et al., 1989)).
- Learning is based on participation in different ‘authentic activities’, with the help of the teacher educator.
- The individual activity acquires full meaning from prior knowledge and beliefs.
- Participation in such ‘authentic activities’ can increase or modify the understanding of the contents involved in those activities.

This conception of situated learning causes several ideas related to the generation of the teacher’s knowledge to emerge. Among these ideas, the integral nature of this knowledge, its continual development resulting from its use in new tasks, and the unending teacher training understood as continuous learning going beyond the initial education program, may be pointed out. The learning process of the future teacher may be seen as a “specific” reproductive cycle (Lave & Wenger, 1991) in which knowledge is integrated into the activity.

For us, these ideas are summarised in so-called ‘learning itineraries’ (García, 2000). In the itineraries, we start of a situation/task that approaches the professional tasks of the mathematics teacher. We provide to the students with conceptual tools that allow them to solve the task. These tools are understood as those concepts and theoretical constructs that have been generated from research in mathematics teacher education leading to understanding and handling situations in which mathematics is taught and learned (Llinares, 2000). They can be provided through videos, articles in mathematics education literature, or information provided for teacher educators. Through the learning itineraries, students are encouraged to think of themselves as
teachers, and share their comments and opinions with the group. From the theoretical referents, learning has been understood as ‘the simultaneous setting in motion of the different tools, interaction and communication of the information coming from them leading to reasonable decisions’. In this sense, we consider two dimensions in the social learning developed through the interactions in the groups: the learning of the group considered jointly and the learning of an individual considered as a member of the group.

The study presented here is a part of ongoing research, which aims at determining how student teachers use conceptual tools provided in the learning itineraries. In a previous work, an attempt was made to see how the use was made by different groups of the students (Garcia et al, 2003). The characteristics identified for each group - considering the group as an analysis unit - allowed four levels to be devised:

<table>
<thead>
<tr>
<th>Use of the conceptual tools by the groups</th>
<th>LEVELS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual tools not identified</td>
<td>1</td>
</tr>
<tr>
<td>Tools identified, but not related to decisions</td>
<td>2</td>
</tr>
<tr>
<td>Conceptual tools provided are identified and applied (used)</td>
<td>3</td>
</tr>
<tr>
<td>Conceptual tools are identified, applied and integrated in a more general framework</td>
<td>4</td>
</tr>
</tbody>
</table>

This paper describes our progress in characterisation of the process of learning to teach by focusing on the individual students in groups. Specifically, we attempt to

- validate the characterisation of these learning levels, both for the groups and for individual students
- examine the relationship between the individual levels of the students in the same group and the group level.

We understand validation as the possibility to categorise learning through those levels regardless of whether it is considered the learning of a group or an individual.

**METHODOLOGY**

The data analysed for this paper were generated by student teachers in our mathematics methods courses through an itinerary that we had designed. The course lasted 60 hours. The itinerary described here was followed in that course, and took approximately ten hours to complete. The task, which is the starting point of the itinerary, was for the student teachers to interpret their pupils' production. The mathematical content involved in the task was related to school primary geometry and, in particular, plane figures. The task took the form of a case, in which we tried to show a common situation in a teacher’s professional practice. In this situation, student teachers had to make a decision on how they would choose to collect information about pupils’ prior ideas and knowledge, posing some questions for the
student teachers about the procedure (questionnaire, interview, informal talk, etc), the type of information they would consider relevant, and how they would assess their pupils’ answers.

When the task design was complete, we searched for conceptual tools that should be available to the student teachers for them to be able to perform this task. The conceptual tools given to the students came from information that had been provided them about Van Hiele levels (Jaime y Gutiérrez, 1990), plane figures (Hemmerling, 1971; García y Bertran, 1989; Clemens et al, 1989), and spatial reasoning, and difficulties and mistakes in learning geometry (Dickson et al 1991). We also gave them some orientation on the subject in the Spanish curriculum at the grade-level in question.

When the itinerary had been designed, the task and the above mentioned materials were given to several groups of students. Below, we describe the sources used for gathering the information that we utilised to collect the data.

Participants
The study included 84 primary school student teachers enrolled in two mathematics methods courses with similar characteristics. Following the students’ criteria, they were divided into 16 small groups. The groups were made up of 4 to 6 students.

Data collection procedures
Data collected includes:

- Group reports, containing the answers to the questions about the task, including the reasoning that had led them to their final decision.
- Tapes and transcripts of audio-recorded group discussions as the itinerary was being carried out
- Individual student teacher reports, including reflections on how they had contributed to the group in carrying out the task. These reports were collected three times, before, during and after group work.
- Each student teacher was interviewed individually for about 30 minutes. One of the interviews took place at the beginning of the session to collect information about their previous ideas and background concerning the task. Another was toward the end of the itinerary, focusing on the agreement/disagreement between individual positions and final group decisions.

Data analysis
The data was analysed in the following steps: 1) The group reports were analysed by the following inductive process. Units of analysis were identified and classified taking into account the elements considered basic to the task-solving process, the presence of the tools provided in these elements, and any relationships established (or not) between tools. We were then able to identify group levels. 2) Researchers
analysed group discussion recordings in detailed, coding the transcripts on the basis of the use each individual student made of the conceptual tools in those discussions.

3) Individual reports and interviews were analysed looking for evidence of student development during the itinerary and in the justification of decisions made - from prior ideas to the identification of theoretical constructs as tools in developing a professional task.

RESULTS

Validation of the learning levels

Concerning validation of the learning levels previously identified, from the analysis of the group reports, we were able to identify different group levels according to their use of the conceptual tools. Five groups were included on the first level. These groups of students were clearly situated at a personal stage, with attitudes based on previous experience. They did not identify the conceptual tools as useful in carrying out the task, as illustrated in the comments quoted below, when one of the groups on this level tried to justify how they had classified the pupils’ answers to the questions on the questionnaire they had designed:

“Question 3 [in our questionnaire] was meant to find out the children’s ability to identify which of the shapes shown they thought were polygons. Their answers lead us to affirm that most of the students know the criterion differentiating a shape as a polygon, since 27 students answered correctly and 2 were wrong…” (G6T).

They thus went along, evaluating student responses to each of the questions on the questionnaire they had designed to collect information on their students’ understanding and previous ideas, based exclusively on the number of right and wrong answers in identifying plane figures.

On a second level, students were able to identify some conceptual tools, but they did not relate that presence/absence to anything. Five groups were found to be on this level. The following response is representative of one of these groups, in which the student teachers based their evaluation on the curricular orientation and information about plane figures provided in the itinerary to find a ‘progression’ in the pupils’ understanding:

“To establish the various steps in which we have classified the answers to the questionnaire, we represented them on a progression hypothesis. Each step is a degree of difference in knowledge, whereby the student progresses from the simplest to the most complicated:

- No knowledge of plane figures
- The student conceives of a polygon as a closed plane figure
- The concept of a polygon acquired by the student is “plane figure, closed ad delimited by a straight line”
- The student knows how to group polygons by the number of sides they have
- The student recognizes the names of the polygons by the number of sides” (G2T).
There were four groups on the third level. On this level, the groups tried to make a general classification that included all the questions. They somehow went from the level of each answer to the pupil’s level. The following is representative of the student teachers’ explanations:

“We formed groups to establish the general criteria:

- Do not know and do not answer
- Recognize the basic shapes
- Know the plane figures and their characteristics
- Are able to recognize the plane figures and point out their characteristics in any context”

…This classification enables us to make an initial assessment of the students’ previous ideas and then use them as the starting point for the study of Geometry …” (G2M).

Finally, there were only two groups on the highest level, in which the conceptual tools were identified and used, incorporating the relationships among them in a more general framework, as we can see in the following comments:

“The easiest way to see the results (of the questionnaire we designed) would be to make a table in which the van Hiele levels can be compared with the answers given by the children and see their situation. When we had said when we designed our questionnaire, the questions that we had included were related with the Levels 1, 2 and 3.

After checking the results, we find that the children answered Questions 1 and 4, which refer to Level 1, Visual Recognition, correctly, so it can be seen that they have arrived at this level.

On Questions 2 and 5, they seem to have rather a lot of difficulty in beginning to reason or analyse (Level 2). They are aware of the elements which comprise the figure, but are not able to relate them to each other.

Very few were able to solve Question 3, so we can see that Level 3, informal deduction, has not yet been arrived at.

In view of the questionnaires, we believe that the pupils are on Van Hiele’s Level 2, and this is where we have to start to work” (G4M).

These results allowed us to validate our previous identification of levels. In addition, we were able to show the difficulty of establishing relationships among different conceptual tools, that is, the difficulty that implies their use in solving a task in pre-service elementary school teacher education programs. Program configuration through professional tasks allows student teachers to translate concepts, ideas and ways of reasoning into the process of solving those tasks. This implies the use of knowledge other than propositional knowledge that is traditionally appraised in some teacher education programs.

We think that one of the objectives for future research in mathematics teacher education should be the search for relevant professional tasks that can be incorporated into mathematics teacher education programs and that foster the use of
conceptual tools. The constructs of ‘purpose’ and ‘utility’, developed by Ainley et al. (2002) as a framework for task design by mathematics teachers might be considered in a mathematical teacher educator context. We agree with these authors in the sense that “Designing tasks that are purposeful for learners ensures that the activity will be rich and motivating” (Ainley et al, 2002, p.21).

The relationships between the individual levels of students in the same group and the group level

Analysis of the individual reports and interviews enabled us to identify individual student levels in the same group. From the overall analysis of the research instruments, we were able to examine the characteristics of the individual/group level relationships. The following table focuses on one group at each of the levels found showing some of the different relationships that we identified.

<table>
<thead>
<tr>
<th>Group Level</th>
<th>Group</th>
<th>Group characteristics</th>
<th>Individual/Group level relationship characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>G6T</td>
<td>There were 6 students in this group. All the students were on Level 1.</td>
<td>Group and student levels are the same. The students did not identify the conceptual tools, and based their assessments on previous experience. Nobody posed ‘dilemmas’ in the group discussions.</td>
</tr>
<tr>
<td>2</td>
<td>G2T</td>
<td>This group had 4 students. Two of them were on Level 2 and two on Level 1.</td>
<td>The two students on the highest level influenced the group’s decisions with respect to the use of conceptual tools. Nevertheless, group interaction did not cause Level 1 students to improve their level.</td>
</tr>
<tr>
<td>3</td>
<td>G2M</td>
<td>This group was made up of 5 students. All the students were on Level 2.</td>
<td>The individual students identified tools as belonging to different domains (learning, content, teaching, etc). These tools were ‘joined’ in the group interactions, increasing the group’s Level from the individual Level of the students.</td>
</tr>
<tr>
<td>4</td>
<td>G4M</td>
<td>There were 5 students in this group. Two of them were on Level 3, with some characteristics of Level 4, another two students were on Level 2 and the last one was on Level 2, with some Level 3 characteristics.</td>
<td>The generation of dilemmas in group discussions created an opportunity for constructive dialogue and helped to increase the group’s level.</td>
</tr>
</tbody>
</table>
CONCLUSIONS AND LIMITATIONS

One of the goals of this study was to examine the potential of using learning levels, identified on the basis of the use of conceptual tools, for characterising the process of learning to teach. The study results point out how useful learning levels are for assessing that process, whether the individual or the group is evaluated.

We have identified different ways of establishing the relationships between the levels of the individual students in a same group and the level of that group. Two groups in which all the members were on the same level were identified. In Group G6T, the group level is the same as the level of the students in it. We might represent the relationship in this group in the following way: L1 U L1 U L1 U L1 = L1. In the other group (G2M), the members of the group have identified different conceptual tools that are ‘joined’ in the group discussions, establishing a relationship that could be represented as: L2 + L2 + L2 + L2 + L2 = L3.

Two groups in which the students were on different levels were also identified. In both cases, the group was situated on the highest level. Nevertheless, the relationships found are different. Two students who are on Level 2, and who lead group decisions influence the relationships in Group G2T. The relationships in Group G4M are strongly determined by the dilemmas that some of the students posed – particularly the students in transition between levels. By trying to answer those dilemmas, the group was situated at Level 4.

The different relationships identified have led us to pose a need to delve further into the suitability of level/itinerary. The itinerary we have designed might not be adequate for Level 1 students. So we asked ourselves the following questions: Should we try to find itineraries that are useful for all the groups, regardless of the level of the students in the group? Should we diversify the itineraries according to learning levels? We hope that this paper takes a step toward bringing these questions to light.

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References


Sánchez, García & Escudero


