Computer-Supported Collaborative Learning

Designing for Change in Networked Learning Environments

Proceedings of the International Conference on Computer Support for Collaborative Learning 2003

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Kluwer Academic Publishers

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COLLABORATIVE MODELLING OF RATIONAL NUMBERS

Abstract. In teaching mathematics, it is often assumed that new ideas about numbers will smoothly follow from prior ones. Therefore, teaching strategies aim at the enrichment of students' prior knowledge about numbers. However, learning difficulties in the area suggest that, in certain cases, reorganisation of prior knowledge is required. Following the conceptual change paradigm we describe a CSCL environment designed to develop a deeper understanding of the structure of the set of rational numbers.

1. INTRODUCTION

The history of mathematics, as well as empirical research on learning in mathematics, suggest that the conceptual shift from the discrete "natural" numbers to the "dense" rational or real numbers is a very demanding one. In terms of the theory of conceptual change that Vosniadou (2002) proposes, it is assumed that the idea of discreteness is a fundamental presupposition. When students are later exposed to the concept of rational numbers they try to incorporate the new information to their prior knowledge of natural numbers. In this process the presupposition of discreteness can constrain students' understanding of the structure of the set of rational numbers leading them to "synthetic models" that differ from expert understanding. Therefore, students' progress in comprehending the structure of the set of rational numbers presupposes the reorganisation or students' prior knowledge in ways that make possible an understanding of the notion of "density", which is a principal property that differentiates rational from natural numbers. In terms of the theory proposed by Vosniadou, this conceptual shift is characterised as radical conceptual change. In a recent empirical study, Vamvakoussi and Vosniadou (2002) investigated ninth grade students' ideas about the structure of the set of rational numbers and found that, as expected by the theory above, students displayed a strong tendency to limit their representation of the set of rational numbers to subsets of rational numbers that preserve the property of discreteness, for instance decimals with the same number of decimal digits (i.e. 2.1, 2.2, 2.3 etc.), or fractions with the same denominator (i.e. 1/4, 2/4, 3/4, 4/4). Moreover they found that the presupposition of discreteness constrains students' understanding of an external representation of real numbers, namely the "number line".

In later progress in the didactic approaches for conceptual change Vosniadou (Vosniadou & Kollias, in press) proposes the construction of models as a means for synthesizing the various guidelines that research has shown to be conductive towards conceptual change (Vosniadou, 2002). Models are artefacts that can concretise students' construction of explanations, offer means for smooth variations

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of explanations (through changing the detailed characteristics of the model) and make students' thinking visible and amenable to critical appraising from other students. However organizing the classroom towards this end can provide a powerful challenge for teachers. The fear of loss of control of the classroom is indeed an important reason that prevents teachers, at least in Greece (Vosniadou & Kollias 2001), from trying pedagogical innovations in their classroom.

CSCL environments can structure the communication patterns in the classroom so that students can collaborate more efficiently (Kollias, Vlassa, Mamalougos, & Vosniadou, 2000 & Kollias, Vlassa, & Vosniadou, 2001), express their opinions in more thoughtful ways and discuss thoughtfully about them. Relative to our present goals we expect that the construction of a CSCL environment will give students the opportunity:

- to express their ideas about the structure of the set of rational numbers
- to externalise their visual representation of the structure of rational numbers
- to see their fellow students' ideas about the structure of the set of rational numbers and realise that these can be quite different, though defendable, than their own
- to argue with fellow students relative to the structure of the set of natural numbers

Prior pilot research by one of the authors (Vamvakoussi, 2001) has shown that students are quite motivated to discuss in a face-to-face setting with an adult about the nature of numbers and explain their opinions.

We expect therefore that students will be motivated to make their understanding of numbers visible through the construction of models and to discuss about their constructions with fellow students when given the opportunity through appropriate CSCL software. Our further hypothesis is that students will progress in their understanding of the nature of rational numbers and the property of "density". We also intend to use the archive of the old opinions expressed through the software to make the progress of the classroom on the nature of numbers an issue of discussion. We believe that this intervention will be an efficient means for deeper understanding of the nature of mathematics construction by the students.

2. METHODOLOGY

2.1 The school setting

The intervention is going to take place in the 9th grade of the 2nd High School of Koridalos in the subject-matter of mathematics. This is a public school in an area with low-middle income. The mathematics teacher and the computer science teacher are both experienced and pedagogically informed. The students are familiar with computers although they have no experience with collaborative learning or with CSCL. The intervention will take place in the school's computer room and the students will be working in groups of three, with one PC and one account in the software SYNERGEIA for each group.

2.2 The software: SYNERGEIA

Students use SYNERGEIA, a special CSCL software, that has been developed and tested through the European project ITCOLE (http://www.euro-cscl.org/site/itcole). SYNERGEIA is a data base having both synchronous and asynchronous tools. Students can upload and share files and participate in thread-based discussions. It is mandatory that students categorize their comments in the discussions according to a scheme aiming towards developing metacognitive awareness. More detailed description of the software, its progeny and variants can be found in http://www.euro-cscl.org/site/itcole/public_deliverables.html.

2.3 Design

By the time the intervention takes place, the participating students will have covered everything they are supposed to know about real numbers, including operations, ordering, turning a decimal into a fraction and vice versa. They will have also used the number line extensively, both as a way to represent real numbers and as a tool, when solving equations.

After an initial introductory activity, to get students acquainted with the use of the software and some basic options it offers, students will be asked to imagine themselves as points on the line of numbers, each point corresponding to a given number. Students will first present their own ideas about numbers, both in written notes and by uploading the drawings they will construct. Then the students will discuss through SYNERGEIA the commonalities and differences of the different interpretations of rational numbers. Finally the students will work face-to-face in groups of six to construct posters that present their understanding of rational numbers. Finally, a different class of the same grade in a small mathematics-fair will comment upon their posters.

As it is explained in the following section, students will take pre and post tests, which will reveal the level of their understanding of the structure of rational numbers. Decisions on how to group students will be made by the researchers and the teachers, according to the results of the pretest and the social dynamics in the classroom. Prior research in a similar CSCL environment has shown that there exists a strong correlation between the quality of students' collaboration and the amount of cognitive and metacognitive comments they exchange as they collaborate (Kollias et al., 2001). It is thus important to group students in such ways as to enhance collaboration. It is also important to include in each group students at different levels of mathematical understanding.

After the completion of the intervention each student will have the chance to see his/her answers in the pre- and- post tests and will be asked to comment on them, in the environment of SYNERGEIA. The emphasis will be for the student to realize what –if any- has changed in his/her initial ideas about the structure of the set of rational numbers and reflect on that. We expect to also gather in this final step useful data about students' developing of a deeper understanding of the nature of mathematics learning.

2.3 Data collection

In order to follow up changes of students' ideas about the structure of the set of rational numbers, we will use a paper-and-pencil questionnaire developed for the purposes of the empirical study mentioned above (Vamvakoussi, 2001, Vamvakoussi & Vosniadou, 2002). The questionnaire will be used both as a pretest and a posttest of students' understanding.

Other sources of data include students' notes in SYNERGEIA, audio taping of student discussions in their groups and final interviews of the students referring to reflections from their experience of mathematics learning in this CSCL environment.

3. CURRENT STATE OF THE WORK

At this point we are starting the intervention and do not have data to report. It is expected that the intervention will be completed by the end of March 2003. The results of our analysis will be presented in the CSCL2003 meeting.

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