NAS04549 Growth of teacher knowledge: The promise of CSCL

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Abstract

To ensure that universities meet the needs of their learners more completely, teaching and learning strategies should be adopted to make educational provision more flexible. This study investigated how a lesson-planning task within the context of a computer-supported collaborative learning (CSCL) environment facilitated the growth of teacher knowledge, specifically the subject-matter knowledge and pedagogical content knowledge about the teaching of ratios and fractions. This study used a CSCL environment called *Knowledge Forum*® with a cohort of preservice teachers collaborating in a lesson planning task. The social interaction within the computer-mediated community in this study contributed to the growth of teacher knowledge by providing a new social context for learning that prompted students to articulate their ideas and make ideas visible for peer inspection. Through peer-to-peer interactions like asking questions, requesting clarification, revising interpretations, or elaborating ideas, the students learnt both the limits and utility of different models to explain mathematical notions. These on-line social interactions supported knowledge integration by helping to broaden students' initial repertoire of instructional representations and mathematical constructs, demonstrating personal utility for particular ideas, and encouraging students to refine their understanding of mathematics.

Key Words: Pre-service teacher education programs, Computer Supported Collaborative Learning, Lesson planning

A significant challenge of preservice teacher education is to enable participants with diverse academic backgrounds and experience to acquire the knowledge and pedagogical skills to teach in ways that may diverge widely from their own school experiences or that involve a subject area in which they did not excel. Another major challenge facing preservice teachers concerns the transformation of their disciplinary knowledge into a form of knowledge that is appropriate for students and specific to the task of teaching (Shulman, 1986).

This research explores computer-supported collaborative learning (CSCL), where computers are used to support collaborative learning by improving students' ability to analyse and synthesise data and to co-construct concepts and grow understanding. Research on collaborative learning environments suggests that in certain contexts, such electronic supports or scaffolds can increase the depth of student learning (Scardamalia & Bereiter, 1995). CSCL is described by Ward and Tiessen (1997) as an instructional approach that attempts to engage students in the intentional pursuit of their own learning goals and in social interactions aimed toward the development of understanding. This approach to learning is supported by a variety of educational theories and instructional practices including collaborative learning, active learning, intentional learning, distributed expertise, resource-based learning, constructivist theory, and project-based instruction (Ward & Tiessen, 1997). In CSCL, student collaboration plays a central role, resulting in students feeling a part of the learning community so that their contributions subscribe to the common knowledge pool (Hartley, 1999).

Design and Method

This study used a teaching experiment methodology (Steffe, 1983) but extended this methodology by having the preservice students also engage in a computer-mediated community of practice, where groups of participants were required to collaboratively design lesson plans for the teaching of fraction and ratio. The CSCL environment enabled the participants to interact

asynchronously with other participants within the study as they developed, evaluated and revised their lesson plans for the mathematics teaching session.

Participants

This study included 10 participants (all Caucasian females) and 2 expert mathematics educators. All the participants were volunteers from a cohort of preservice teachers (N=350) enrolled in a four-year Bachelor of Education degree course at Queensland University of Technology. The study commenced by holding a whole-group meeting to outline the goals of the research study. At this meeting, the participants were asked to form three small working groups. Two groups of three participants and one group of four participants were formed. These three self-selected groups were formed on the basis of friendships and the pragmatics of timetabling of the participants' classes.

Procedure

This research project used a CSCL software application called 'Knowledge Forum,' which evolved from an application known as 'Computer Supported Intentional Learning Environment' (CSILE). CSILE was originally developed in the late eighties and is a networked learning environment for fostering higher-level processes of inquiry in elementary education (Scardamalia, Bereiter, McLean, Swallow, & Woodruff, 1989).

This study proceeded in four phases;

1. Generation of initial group lesson plan.
2. Evaluation of group lesson plans.
3. Generation of final group lesson plan.
4. Analysis of lesson plans

Phase 1: Generation of initial group lesson plans

The first phase the activity was an iterative process where each group was asked to meet twice face-to-face and engage in the development of an initial lesson plan on ratio and fractions for a class of Grade 7 students. Each group was required to determine the timing and agenda of their meetings. At the conclusion of these meetings, each group was required to post its lesson plan onto Knowledge Forum. Once the lesson plan had been posted onto Knowledge Forum it could be viewed by the participants in other groups.

Phase 2: Evaluation and revision of lesson plans

In the second phase, the participants evaluated and provided constructive feedback to other groups about their lesson plans. According to the research literature on different models of community, apart from needing a rich discourse, another distinguishing feature of knowledge-building communities (e.g., Scardamalia & Bereiter, 1994) and communities of learners (e.g., Brown & Campione, 1994) is a focus on increasing the depth of understanding. Therefore, as well as simply being active in the reading and posting of comments, the participants were encouraged to engage in critiquing of the lesson plans. It was expected that the process of critiquing would increase their understanding and hence the community knowledge, providing a deeper level of understanding of teacher knowledge about the teaching and learning of ratio and fraction.

The constructive feedback about other groups' lesson plans was done via comments posted into the Knowledge Forum shared database. These comments provided the groups with external views about their lesson plan in particular and about the topic of teaching fraction and ratio in general, thus allowing new ideas to emerge from sources outside of the group that had constructed the lesson plan.

Phase 3: Generation of final group lesson plan

At this phase of the study the groups had to submit a final group lesson plan onto Knowledge Forum. The development of the final lesson plan was informed by the various comments made by the other community members (i.e., other participants, and the expert mathematics educators) during Phase 2 of the study.

Phase 4: Analysis of lesson plans

The analysis of group lesson plans focused primarily on the changes that occurred to types and sequences of instructional representation used to explain ratio and fraction concepts as participants progressed from developing their initial group lesson plan, through to their final group lesson plan. Once a lesson plan had been reviewed by the community, which could include the members of the group that constructed the lesson plan, the information was extracted from the lesson plan and was plotted into a concept map by the researchers.

The concept maps (see Figure 1.3 for example) firstly identified the mathematical notion and represented this with an oval, for example, part-to-part notion of ratio. Secondly, the types of instructional representation used to articulate the mathematical notions were plotted as triangles. The examples of the instructional representation were represented as rectangles and as each instructional representation was introduced a number was attributed to it. For example, a one meant that this was the first instructional representation used and a two for the second and so forth. Utilising ideas from Payne, Towsky, and Huinker (1990) about the sequencing of instructional representations, it was possible to determine changes in the participants' repertoire of knowledge about the teaching of ratios and fractions (as represented on the concept maps) as they progressed from their initial group lesson plan through to the development of their final group lesson plan.

Results

Two sets of results are presented:

1. Analysis of community participation in the lesson planning task.
2. Analysis of group lesson plans.

Analysis of community participation in the lesson planning task

Knowledge transforming discourse is central to knowledge building because it is the means through which knowledge is formed, criticised, and amended (Scardamalia, Bereiter, & Lamon, 1994). Therefore, it is important to have most participants actively engage in the knowledge-building activity of the community. In this study, there was evidence of high overall levels of participation in the Knowledge Forum environment by most participants in the study. Two forms of participation were observed: reading of comments and lesson plans posted in the Knowledge Forum shared database, and posting of notes or comments onto the Knowledge Forum shared database.

As each note or comment was posted, Knowledge Forum tracked the number of times it was read and by how many different people. On three occasions (Notes number 1, 27 and 45), a single posting was read over 60 times (Figure 1.1). This occurred after each of the three groups had posted their initial lesson plans on the Knowledge Forum shared database. This data provided evidence that the lesson-planning task stimulated participation in the community. The number of different people reading these postings also showed that a majority of the community reviewed these lesson plans. The community participants read each of the postings an average of 16.65 times (range 3-63). The average number of different people reading each posting was 8.52. After removing the three postings that attracted more than 60 comments from consideration, the average number of times the community participants read each of the postings was 14.4 and the

average number of different people reading each posting was 8.3. That is, on average the community participants read considerably more postings than the number they posted.

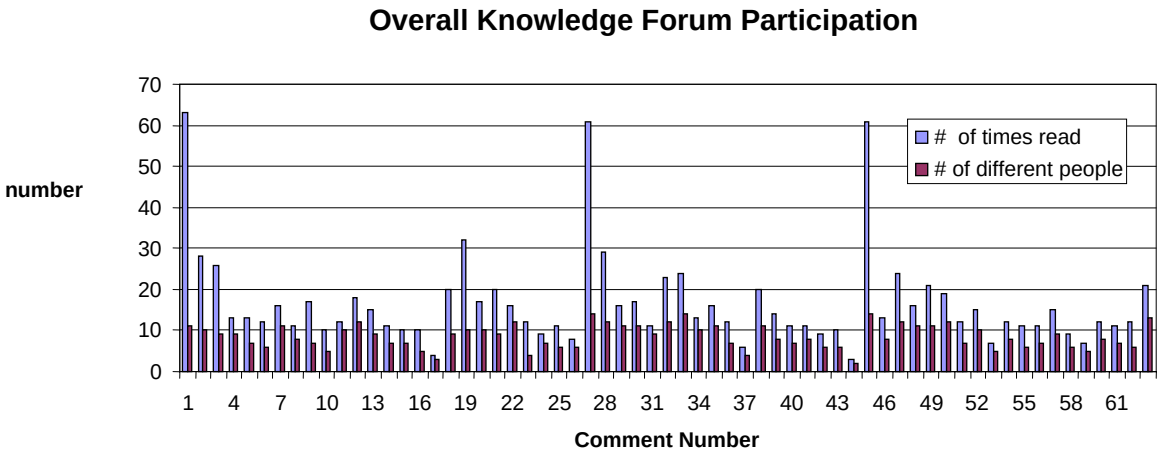

Figure 1.1 Number of comments read in Knowledge Forum

There were 62 notes/comments generated by 10 preservice teachers and 2 experts in the on-line community. Overall, 83% of the participants contributed by posting notes/comments in the Knowledge Forum environment (Figure 1.2) and over the course of the semester each participant posted an average of 4.2 notes/comments.

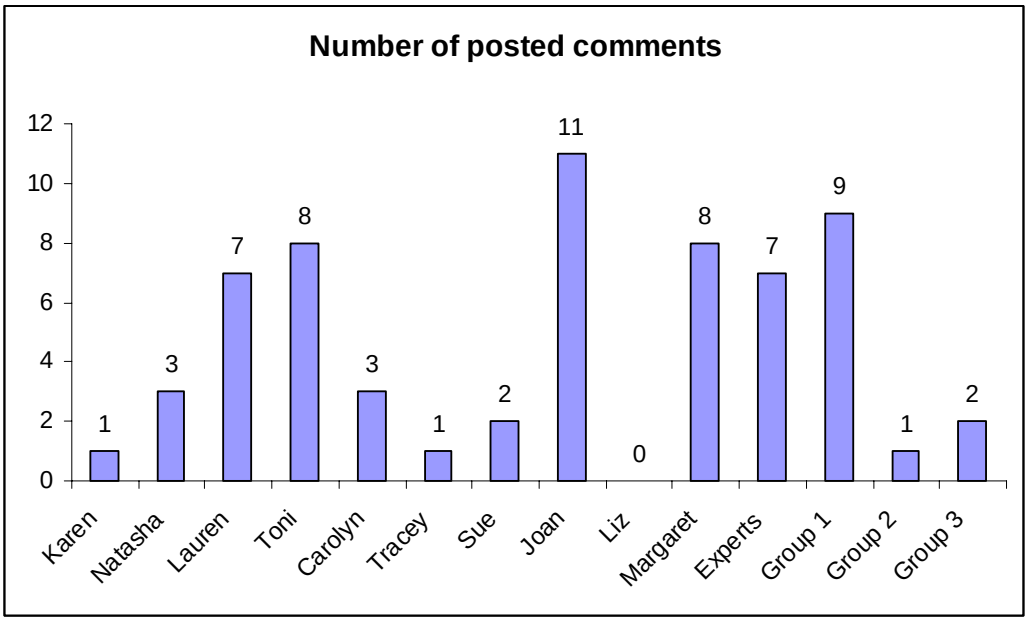

Figure 1.2 Number of individual entries contributed in the electronic conferences

As some comments were posted under the identity of the group, it was difficult to determine what individual contributions were made. However, Group 1 made a large number of comments and this may account for the generally lower number of individual postings made by members of that group.

Cumulatively, these findings indicate that the lesson-planning task appears to have been the catalyst for rich discourse in the Knowledge Forum environment.

Analysis of group lesson plans

The mathematical notions and instructional representations contained with each of the groups' lesson plans were plotted into concept maps and analysed. The groups had the following members:

Group 1: Liz, Natasha, Karen, and Tracey
Group 2: Toni, Carolyn, and Margaret
Group 3: Sue, Joan, and Lauren

In Group 1's initial lesson plan concept map (Figure 1.3), the repertoire of knowledge about the teaching of ratio and fraction had limitations in the selection and sequencing of instructional representations. This group attempted to develop the mathematical ideas by introducing ideas of part-to-part, then equivalence of ratio, proceeding to $2:3 = x:15$ and finally part-to-whole notions of fractions. These notions were not linked and the instructional representations were sequenced in a progression that may not sufficiently build on previous ideas and notions. The lesson plan used real objects, tables, concrete models and language to facilitate the learning of these mathematical notions. However, on only one occasion were these instructional representations linked. This linkage is shown on the concept map (Figure 1.3) and represents in the lesson plan, a link between the concrete model (counters) and language (normal written language). The research literature indicates the importance of developing mathematical ideas in a hierarchical sequence and of having linked and purposefully sequenced instructional representations (Payne et al.,

1990). This is not reflected in this Group's initial lesson plan. Therefore, it is highly probable that this lesson plan would cause some confusion in learners during the lesson.

By contrast, concept map analysis of Group 1's final lesson plan (Figure 1.4) indicated that fundamental mathematical concepts were introduced in a hierarchical sequence that would establish a sound understanding of ratios and fractions. The lesson plan started by using the idea of comparison to introduce the fundamental ratio idea of part-to-part. These mathematical notions were scaffolded with a wide variety of purposefully sequenced instructional representations that were linked in such a way as to reinforce understandings about the mathematical ideas. The instructional representations utilised include real objects, tables, and concrete models as well as language and symbols.

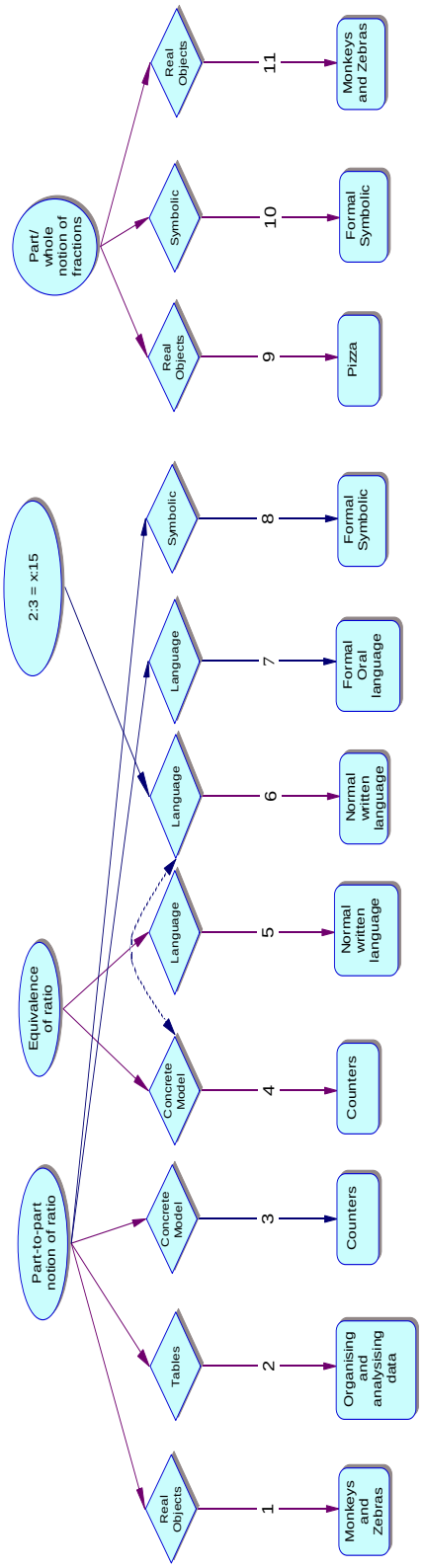

Figure 1.3 Concept map for Group 1's initial lesson plan

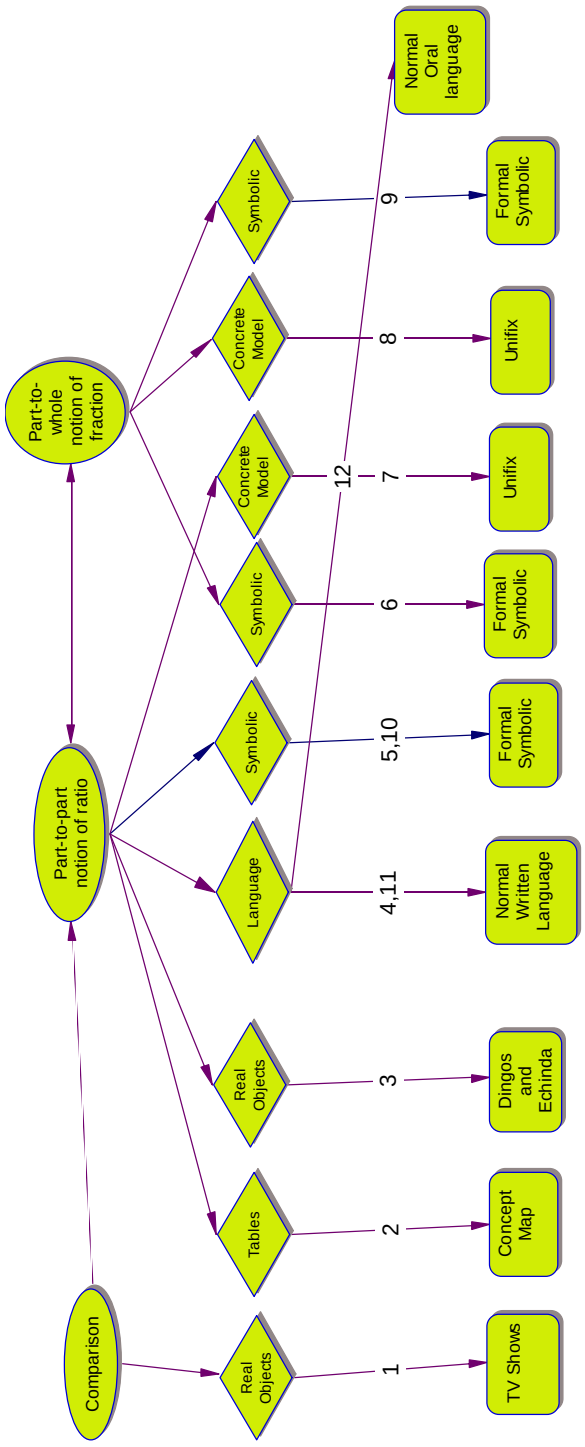

Figure 1.4 Concept map for Group 1's final lesson plan

Group 2's initial group lesson plan (Figure 1.5) addressed the two most fundamental notions of ratios and fractions, part-to-whole and part-to-part. However, these two mathematical notions were not conceptually linked. The concept map (Figure 1.5) shows that the two mathematical notions are treated separately and not linked by ideas nor instructional representations. Furthermore, the instructional representations used to support the mathematical notions (e.g., concrete models, language and real objects) were appropriate but failed to connect with a symbolic representation. A symbolic representation was described as by Payne et al. (1990) as a representation that is useful to connect the other types of instructional representations.

In the final lesson plan (Figure 1.6) the selection and sequencing of the instructional representations (concrete models, real objects, language and graphs) were more purposeful and integrated in nature than in the initial lesson plan. As illustrated in Figure 1.6, the final lesson plan proceeded from concrete models and real object representations to language representations and then to graph representations. In contrast with the group's initial lesson plan, there was much more integration and conceptual linkage between the different instructional representations used. For example, the language representations were overtly linked to the real object and graph representations. The graph representations were used as a means to organise and synthesise the knowledge generated from interactions with the real objects and language representations.

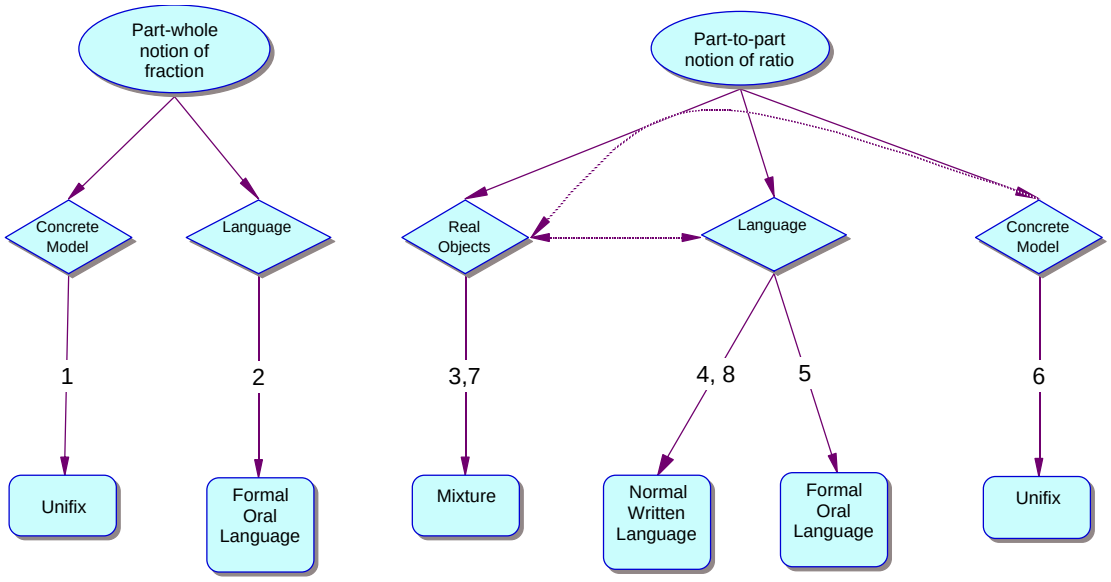

Figure 1.5 Concept map for Group 2's initial lesson plan

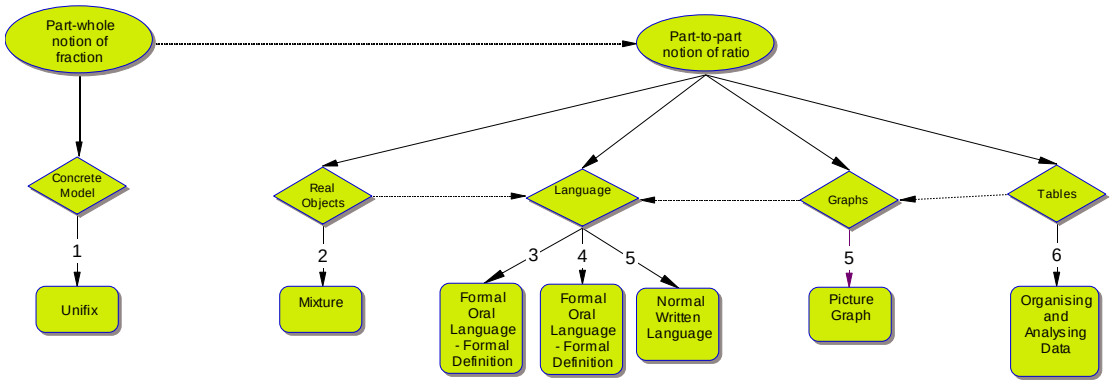

Figure 1.6 Concept map for Group 2's final lesson plan

In Group 3's initial lesson plan (Figure 1.7), the repertoire of knowledge about the teaching of ratio and fraction was limited in two respects:

1. Amount and sequence of mathematical content.
2. Selection and sequencing of instructional representations.

Group 3 attempted to introduce the following list of mathematical concepts in their initial lesson plan: comparison, part-to-part, whole-to-whole, part-to-whole notion of ratio, equivalence, and part-to-whole notion of fraction. These notions were introduced in a sequence that the review of the research literature indicates would make learning about ratio confusing for primary school students (Lesh, Post, & Behr, 1987). Furthermore, these mathematical concepts were not linked. Group 3 introduced a number of instructional representations to support each of the mathematical notions. Although these instructional representations were appropriate, they were not connected and failed to draw together the ideas generated from real objects, language, concrete models and symbolic representations of ratio.

Concept map analysis of Group 3's final lesson plan (Figure 1.8) revealed that significant advances had been made in their repertoire of knowledge about the teaching of ratios and fractions. These advances occurred both in their knowledge about the structuring of mathematical content and in the selection and sequencing of instructional representations.

In the final lesson plan (Figure 1.8), Group 3's focus was on the most fundamental notions underlying the concepts of ratios and fractions. Furthermore, there was a clear two-way conceptual linkage between these fundamental notions. Similarities and differences were clearly identified in the lesson plan. Thus unlike the initial group lesson plan, the structuring of the mathematical content in the final lesson plan indicated that Group 3 members were now cognisant

of the hierarchical and cumulative nature of the relationship between the different notions underlying the concepts of ratios and fractions.

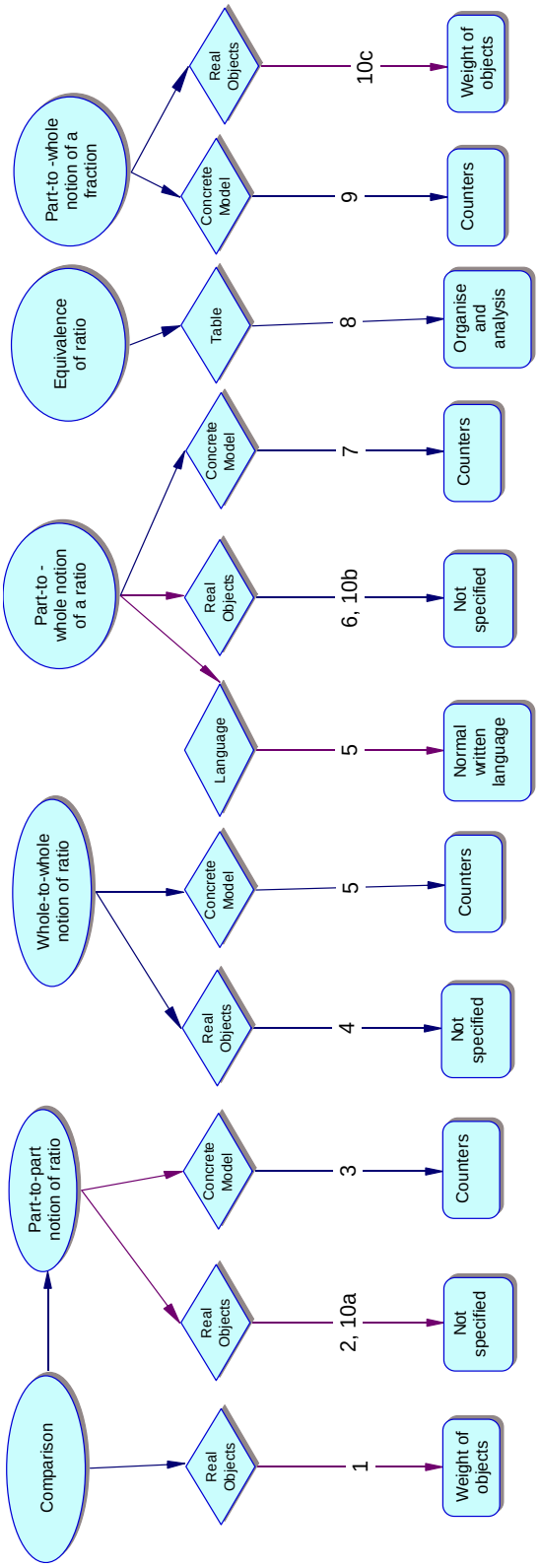

Figure 1.7 Concept map for Group 3's initial lesson plan

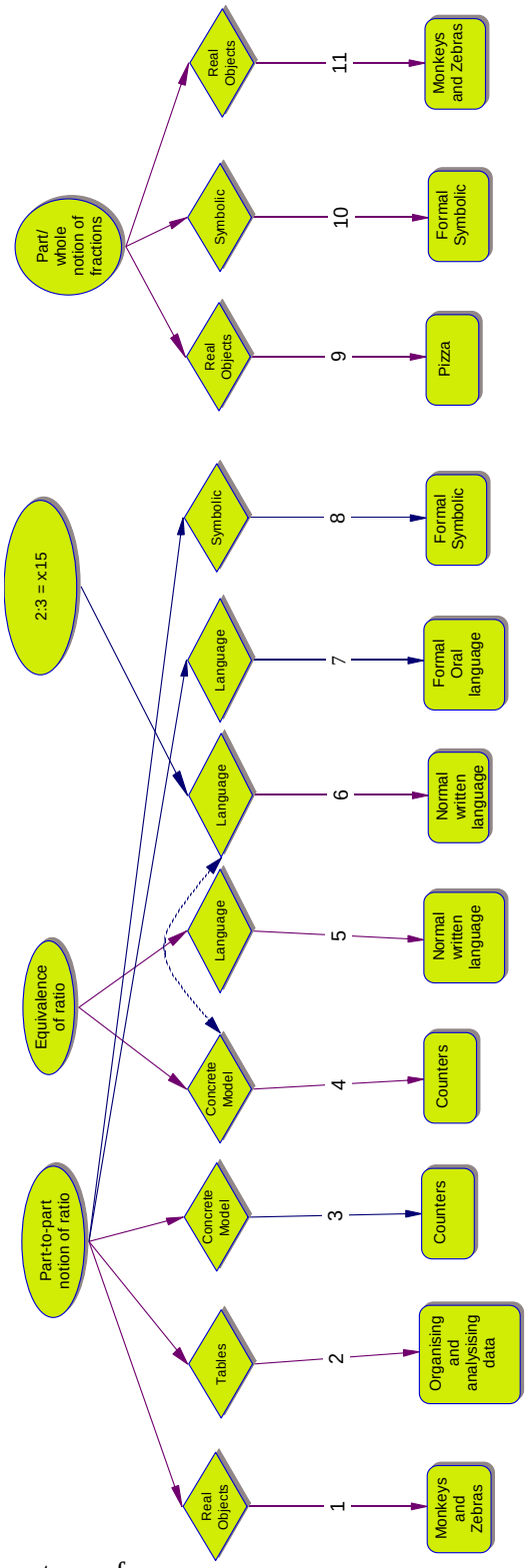

Figure 1.8 Concept map for Group 3's final lesson plan

Discussion

The findings from this study indicate that the lesson planning task appears to have been a catalyst for rich knowledge building discourse by the participants. This is reflected in the number of times they contributed to the on-line community and in the changes to their repertoires of knowledge about ratios and fractions. Concept map analysis of each of the groups' initial and final lesson plans clearly indicated that "new comprehension" (Shulman, 1998) about the teaching and learning of ratio and fraction had been developed by the groups. Undoubtedly, each group's collective understanding and repertoires of knowledge had grown. The social development of knowledge through the lesson-planing task was clearly evident.

Each final lesson plan showed significant change from the initial lesson plans in the type and use of instructional representations. In the majority of cases the final lesson plans used a number of types of instructional representations: real objects, concrete models and symbolic representations, to note a few. Most lesson plans used instructional representations to reinforce mathematical notions by repeating a number of the representations being used

Another marked contrast between the initial and final lesson plans was evident in the linkages that occurred between the various mathematical notions. In all the final lesson plans, the preservice teachers made conceptual linkages between the mathematical notions; in some cases these were two-way links.

Overall, this study provided many examples of how a community of knowledge builders can promote and share experiences, which in turn can advance the understanding of subject-matter

and pedagogical issues. Moreover, electronic discussion in Knowledge Forum broadened the repertoire of ideas that preservice teachers considered in lesson planning and helped to improve their ability to ask knowledge-advancing questions, as well as comment on lesson plans proposed by other participants. The preservice teachers realised that their peers could play a role in their own learning processes.

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