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ABSTRACT

Concept mapping, a technique of graphically representing concepts and their relationship, was used to assess changes in the structural knowledge of prospective teachers at three levels of a teacher education program. The concept "teacher planning" was mapped at the beginning and end of the semester by 49 students in introductory, intermediate, and advanced undergraduate courses in teacher education. Scores calculated included: (1) item scores; (2) level scores; (3) similarity to group and instructor scores; and (4) item stream similarity to instructor scores. Content analysis was compared with instructors' intentions for student concepts. Both qualitative and quantitative analysis indicated that student maps became more differentiated and organized, with evidence of development of a shared vocabulary between instructor and student. Concept maps provide an overview of student thinking on a concept. A sample concept map is attached. (SLD)

# Concept Mapping in Assessing

# Prospective Teachers' Concept Development

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The present work was conducted while at Syracuse University.

Concepts and their interrelationships shape our perceptions of the world. Yet concept development is notoriously difficult to access. This investigation used concept mapping, a technique of graphically representing concepts and their relationships along two dimensions, to assess changes in structural knowledge of prospective teachers at three levels of a teacher education program.

Scores were calculated for student-constructed pre and post maps, for the following: item scores (indicating differentration), level scores (indicating degree of hierarchical organization), and similarity to group, similarity to instructor and item stream similarity to instructor scores (indicating development of a shared technical vocabulary). Content analysis addressed questions of how content of the maps changed within and across courses, and these were compared with instructors' intentions for students' thinking.

Findings from both the quantitative and qualitative analysis indicated students' maps became more differentiated, organized, and evidenced the development of a shared technical vocabulary. The types of information concept maps can provide are illustrated in this paper.

Concepts and their interrelationships shape our perceptions of the world, and help determine our actions. As teacher educators, one of our goals is to build powerful conceptual structures related to the processes involved in teaching. Yet conceptual growth is notoriously difficult to assess. Concept mapping, a technique of graphically representing concepts and their hierarchical interrelationships along two dimensions, is a useful technique for examining changes in content and organization of individuals' conceptual structures. Figure 1 illustrates an example of a concept map constructed by a student in an introductory education course. Concept mapping requires students to structure concepts and their interrelationships from memory, and thus from their perspective rather than a framework imposed by the instructor or test-maker. Much of the recent research on teachers' thinking has examined implicit beliefs or theories, inferring them from ethnographic observations, or clinical interviews (Clark & Yinger, 1979). A more direct approach to exploring preteachers' concepts related to teaching is described here.

## Theoretical Background

Lewin (1951), Werner (1978), and Ausubel (1978) suggested that concept development involves increased differentiation among concepts and increased hierarchical organization and integration of concepts. Building on Ausubel's (1978) distinction between rote and meaningful learning, Novak (1977) defined rote learning as new information "arbitrarily stored in a cognitive structure or . . . associated with weakly differentiated concepts at low levels of abstractness and inclusiveness" (p. 113). Meaningful learning occurs when new information is subsumed into a large structure which relates it to other concepts. Concept mapping portrays a graphic representation of how a student is thinking about a particular area, providing a framework to which an instructor can link subsequent instruction.

To be useful in assessing structural changes in students' thinking, maps should have features which demonstrate these changes that theorists predict. One would also expect changes in the content on concept maps resulting from instruction. Within a course or program of study, convergence towards a group consensus, or towards an instructor's concept map, might be expected. Novak (1977) supports the use of concept mapping in assessing conceptual growth. He points out that standard achievement measures are inadequate in telling about "the specific conceptual hierarchies an individual possesses" (p. 114). Concept mapping has been widely recommended as a technique for assessing students' structural knowledge (e.g. Bogden, 1977; Moreira, 1979; Novak & Gowin, 1984), yet few studies have examined quantitative and qualitative differences in concept maps produced by individuals with varying degrees of educational experience, or before and after instruction. The remainder of this paper discusses a recent study on concept mapping and suggests how the procedure might be used in assessment, instruction, and program development.

## Study of Preteachers' Concept Maps of Teacher Planning

Concept mapping is a process by which individuals illustrate their respective understandings of a content area by letting their thoughts flow freely and then hierarchically organizing, in chart form, these free associations around the concept, and indicating interrelationships between ideas with connecting lines. Superordinate--subordinate relationships, interrelationships among subordinate concepts, as well as content diversity are graphically presented. The following quantitative scores were derived from pre and post concept maps of students in three consecutive courses in Syracuse University's teacher education program, for the concept teacher planning:

1. item score (indicating degree of differentiation), the number of discrete entries included on an individual's concept map. The item score in Figure 1 is 59.

2. item stream score, the number of distinct superordinate concepts attached to the central concept. The item stream score in Figure 1 is 5.

3. level score (indicating degree of hierarchical organization), the largest number of subordinate levels employed in a single item stream. The level score in Figure 1 is 6.

4. similarity to group score (indicating group consensus), the sum of the frequency of each entry in the total group of students at the same educational level, divided by the total number of items for that individual.

5. similarity to instructor score, the number of entries identical to entries on the instructor's map.

6. item stream similarity to instructor score, the number of item streams identical to item streams on the instructor's map.

Pre and post measures, consisting of concept maps constructed at the beginning and end of a semester course as part of the course requirement, were derived in each of the above areas for three groups of students and their instructors, at three levels of a teacher education program. Forty-nine students in either a) an introductory education course, called Study of Teaching, b) an intermediate course, Personalizing Teaching and Learning, or c) an advanced undergraduate course, Strategies of Teaching, participated in the study. Scores derived from maps of these students were compared across the three groups for a global concept (teacher planning) relating to all three courses, and within each group from the beginning to the end of the semester. Quantitative analysis of the maps addressed the question of whether scores followed the changes theorists predicted, e.g. increased differentiation, hierarchical organization, and similarity to instructor.

Content analysis of the maps addressed the issue of whether there were consistent differences in individuals at different levels of the program, and explored the nature of those differences. The question of whether there were changes in maps resulting from direct instruction in a particular content area was addressed. Each instructor was interviewed several times across the semester regarding their goals for students' thinking regarding teacher planning. They were asked to construct maps of how they would like students to think about the topic at the end of their course.

Content analysis dealt with questions such as, "What were the particular content concerns of students at the three levels of the program?"; "Were there structural differences in maps of students at different levels of the program?"; "How did the content of the maps relate to instructors intentions for student thinking?"; and, "How did content of students' maps compare with content concerns of experienced teachers regarding teacher planning?". The qualitative analysis provided information about how a student was thinking about a subject area, information which could then be used by an instructor to modify instruction. The remaining portion of this paper presents select findings from this study illustrating the types of information concept mapping can provide.

## Findings and Potential Uses of Concept Mapping

### Correlational data

Year in school and prior number of education courses were both significantly and negatively correlated with students' similarity to instructor scores on the pre maps, and significantly and positively correlated with students post test similarity to instructor stream scores, as indicated by Pearson Product Moment correlations ($p<.01$). That is, more advanced students

adopted the instructor's overall organizing concepts more so than less advanced students. Interviews with instructors of the courses indicated that this was at least partially consistent with their intentions. The instructor of the introductory course was primarily concerned with increasing students' repertoire of concepts related to teacher planning, whereas the instructor in the intermediate course was concerned with having students think about planing with a particular (Lewinian) framework. In the advanced course students were expected to apply the framework in actual planning for instruction.

This was one of the many examples of how the qualitative data enhanced the interpretability of the quantitative data. This trend was also observed in comparing two subgroups in the advanced course--those who had taken the two prerequisite courses vs. those who had not. A paired comparison t-test by subgroup indicated that item score gains from pre to post mapping were not significant for students who had had the prerequisite courses, but were highly significant for students who had not ($p < .0001$). On the other hand, pre to post similarity to instructor score gains were highly significant in the group who had had the prior course work ($p < .0004$). Students who had the prior coursework brought with them a larger repertoire of concepts related to teacher planning (they did have larger mean item scores on the pretests) and their learning involved focusing in on those concepts for which they received instruction, whereas students who had not had prior coursework were developing a broader repertoire of concepts related to teacher planning.

Pre to post differences in scores derived from concept maps

Overall, item scores and similarity to instructor scores increased significantly ($p < .01$) from pre to post mapping as indicated by a General Linear

Models Procedure. Similarity to instructor stream scores and similarity to group scores also generally increased from pre to post mapping. That is, students had increased concept differentiation, and increased shared vocabulary with each other, and the instructor, after instruction. The expected differences between groups at three levels of the program for these scores failed to occur, perhaps due to the small number of students taking the courses in the prescribed sequence. Between group differences in map content were observed. Content analysis of the maps indicated that more advanced students had clearer, more organized maps than beginning students.

Qualitative changes in maps from pre to post mapping

Qualitative changes in the maps from pre to post mapping came from several sources:

a) the researcher analyzed pre and post maps within each group in terms of changes in content, organizational structure, clarity of superordinate-subordinate transitions, and abstractness and inclusiveness of concepts.

b) instructors commented on changes they saw in the maps.

c) in the introductory course, students were given the opportunity to compare their pre and post maps in class and discuss changes they observed. These were recorded by the researcher.

d) in the advanced course, students wrote essays comparing their pre and post map and the researcher summarized common themes in these.

The following changes were common to a large number of maps, and were corroborated by the above data sources. As compared to pre maps, post maps were more developed in terms of number of items and clarity of overall organization, were organized around more abstract, inclusive terms, reflected more

course content, and focused more directly on the processes of planning and instruction. Many students noted dramatic changes in their thinking from pre to post mapping. Most students reacted very positively to having the opportunities to organize their thoughts via the mapping, and compare changes in their thinking. A few students were uncomfortable with mapping on the pre maps, indicating they weren't sure of "the right way" to do it. Most were more comfortable the second time arcund. The following comments from two students were typical:

> It was nice doing this assignment so that I am able to see the change in my thinking.

> I was shocked to see the differences between my first concept map and my current concept map. I could see how much I have learned this semester and how my perceptions of teaching had changed, for the better. There were many differences in my maps, which I found hard to believe. I was surprised to see such a dramatic change in my thinking. For instance, the way in which I categorized was much more sophisticated, indicating a higher level of thinking.

Concept mapping seems to have excellent potential as a tool for self-evaluation of learning gains.

Content analysis of concept maps

In order to compare item streams (superordinate concepts) and items listed on maps within and across groups, each student's item stream and item labels were listed and frequency counts within and across groups were tabulated for both pre and post maps. Generally, there was great diversity in the content and organization of the maps. Three categories common in all three groups are the streams--time, subject, and materials. The categories

materials and methods were common for all three groups' post maps. If one looks to the literature on teacher planning and effectiveness, one finds that these factors are critical both in the way experienced teachers think (Crocker, 1983) and in their effectiveness with students (McDonald, 1977). There were more commonalities in both item streams and items as the level of the course increased, and within each course from pre to post mapping sessions. That is, group consensus seemed to develop within each course and within the program as a whole.

These are but the most general of the findings from the content analysis. Such analysis seems highly useful in providing instructors within a course, information on which concepts were being assimilated as a result of instruction and how these concepts are being organized. Such analysis is also useful in program development, providing a profile of students' thinking in each course, which can then be compared to the intent of the program, and used to improve instruction.

## Summary

The partial findings of a study on concept mapping of students at three levels of a teacher education program were presented to illustrate the types of information and analyses that can be provided by concept maps. The technique seems congruent with an increased focus by researchers on teachers' thinking. Mapping focuses on how a student is thinking regarding a topic area, structured from his or her own perspective. Concept maps have some limitations in this respect, as one cannot determine the meaning held by a student for a particular term, or why a student sees two concepts as related. However, maps do provide an overview of how students are thinking about a particular topic. When more depth is desired, maps can serve as the focus for an interview with individual students.

Aside from their documented usefulness in planning for instruction (Stewart, VanKirk, and Rowell, 1979), in improving recall of text (Armbruster and Anderson, 1980), as a study strategy (Reigeluth, 1979), and in "learning to learn" (Novak & Gowin, 1984) maps are also useful in assessing changes in students' structural knowledge. Novak and Gowin (1984) say that the greatest significance of concept maps may be in the improvement of evaluation in education.

Measures derived from concept maps have construct validity in that they are derived from Ausubel's theory. However, many learning gains were not reflected in quantitative scores derived from the maps (e.g. increased clarity in organization), and the qualitative analysis of the maps was the richest source of information about content and organization of students' thinking. This information is useful in assessment of student's learning gains, in program development, and in students' self-evaluation. Mapping provides detailed information on the types of information students are acquiring and on how they are organizing the information. As with any methodology, there are inherent limitations in the concept mapping approach. Problems with using scores derived from concept maps as an assessment device include many of the same problems as any other free recall measure. For example, irrelevant items and repeated items may contribute to inflated item scores. Distortions of content or ambiguous responses are not reflected in scores. Several of the scores derived from the maps are not independent. If the central topic is too broad, it may elicit only a small percentage of the students' repertoire of technical vocabulary. Regarding the qualitative analysis of the maps, inferences, and judgements are made concerning the maps' clarity in organization, abstractness, and inclusiveness, which may not be replicable. There are

connections and hierarchies on student maps which don't make sense to an outside observer. The focus of the analysis shapes the results. For example, in this study, I looked at similarities in maps by analyzing most frequent item streams and items from pre to post mapping across the three groups. I did not look at changes in least frequent item streams and items, though this might have yielded some interesting results. Finally, the relationship between students' concept maps, their actual planning and interactive decision-making, and their effectiveness as teachers needs to be explored.

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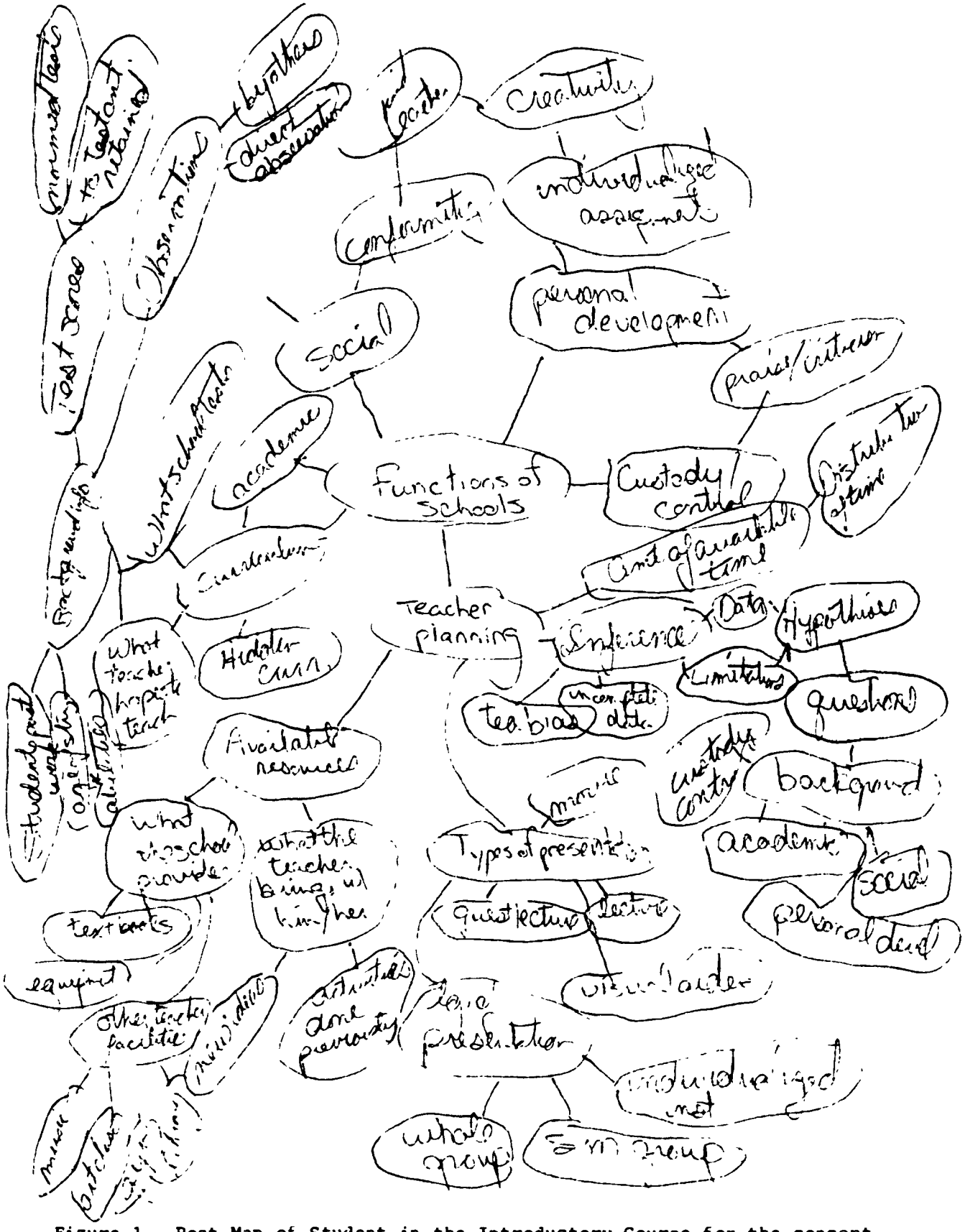


Figure 1 Post Map of Student in the Introductory Course for the concept, "teacher planning".