

## TRACING CONCEPTUAL CHANGE IN PRESERVICE TEACHERS

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**Abstract**—This article reports on a study examining changes in preservice teachers' conceptions of teacher planning associated with a year-long course on Curriculum, Instruction, and Assessment. Changes were measured by pre and post concept maps. Conceptions of planning on pre-maps differed significantly by certification level (elementary or secondary). Conceptions on post maps differed significantly by course instructor (three sections). Qualitative shifts in responses on pre and post maps are also noted. A new method is described for determining group patterns of response, and depicting them graphically. This method makes analysis of concept maps more practical for educators (less time consuming), and thus may contribute to further program evaluation studies.

### Background

#### *Concept Mapping*

Concept mapping is a procedure developed for tracing conceptual change that has been used in several studies of teacher education. Beyerbach (1988) examined changes in preservice teachers' conceptions and development of technical vocabulary by analyzing pre and post concept maps of students in three courses given at three different levels of one teacher preparation program. In another study (Morine-Dershimer, 1989), I analyzed pre and post concept maps on teacher planning and on subject matter content developed by secondary education majors in connection with a generic methods course, during which they planned and taught a series of four lessons on a topic of their choice in peer teaching sessions. Michelson (1988) compared the coherency of semantic trees produced by preservice teachers in early field experiences with those produced during student teaching. Roehler, Herrmann, and Reinken (1989) noted that semantic trees produced by novices contained fewer concepts and showed less coherence than those produced by experts.

Kagan (1990) has criticized studies that used concept maps to evaluate teacher cognition on

several counts, including: small numbers of subjects (4–15); emphasis on short-term changes; comparison of student maps with a "target" map, such as the course instructor's concept map; complex and time-consuming systems of analysis; and faulty assumptions that such maps reflect cognitive structure. All of these are valid criticisms. In an attempt to avoid these problems, the study reported here involved 65 preservice students, examined changes in their concept maps during a year-long course, and developed a fairly simple system for analysis of maps that did not involve comparison with a "target" map. The maps students produced were considered to be evidence of knowledge growth, rather than reflections of cognitive structure.

#### *Program Evaluation*

This study also addresses some issues in evaluation of teacher education programs. Amid the many calls for reform in education (e.g., The Holmes Group, 1986), there have been only a few voices calling for equal attention to that essential accompaniment to any effective reform: evaluation (e.g., Zeichner, 1989). A major problem with evaluation during a period of reform has to do with efficiency and economy. When teacher educators are involved

in designing and implementing new courses, they have little time or energy left for evaluating results. We need program and course evaluation procedures that require a minimal investment of time by students (for data collection) and by faculty (for data analysis), yet provide useful information about what students are or are not learning.

A prior study at the University of Virginia addressed this issue by comparing three different data collection measures to determine: which provided the most information about prospective teachers' conceptions of effective teaching; which most clearly provided information on conceptual change in these teachers; and which was most economical in terms of the amount of information provided in relation to the investment of time and energy for data collection and analysis. The three measurement tasks included: concept mapping (Saunders & Tankersley, 1990); a computer-assisted Kelly Repertory Grid exercise (Artiles & Trent, 1990); and critiquing a videotaped teaching episode (Mostert & Nuttycombe, 1990). Students in the second and fourth years of the University of Virginia's 5-year teacher preparation program were randomly assigned to one of the three tasks, and responses of 70 students were analyzed and compared. The task that provided the most information in the most economical way was the concept mapping task (Morine-Dershimer, 1990).

A major contribution of this prior study was the development of some simpler procedures for analysis of concept maps, as well as a method for use of these maps to examine group patterns of conceptual change, rather than focusing on individual patterns of response. A limitation of the prior study was that it used a cross-sectional design to examine conceptual change. The study reported here used the new analysis procedures, with some additional refinements, but employed a longitudinal design.

## Method

### *Objectives*

This study was designed to investigate possible changes in preservice teachers' concepts of teacher planning associated with a year-long

general methods course, which was accompanied by a practicum experience in a field setting. Questions addressed include:

1. What changes occur in preservice teachers' concepts of teacher planning, as measured by pre and post concept maps administered as part of a course on curriculum and instruction?

2. Are the pre or post differences in the concepts displayed by preservice teachers associated with: (a) certification level (elementary or secondary), or (b) course instructor (three section leaders)?

### *Subjects*

Participants in the study were 65 students in three sections of a course on Curriculum, Instruction, and Assessment taught in the fourth year of the University of Virginia's 5-year teacher preparation program. Eighteen elementary majors were students in one section of the course, and 47 secondary majors were students in two other sections of the course. (A number of elementary majors who were course participants in a fourth section could not be included in the study because their fall course instructor moved away, and students' pre maps were lost in the process.) Fifteen of the students were men, and 50 were women.

All instructors in the course followed the same general syllabus, and they met regularly during the year to plan instruction and share information on student responses. I served as the course coordinator, but did not teach a section. In the fall semester the course focused on lesson planning and use of alternative instructional models. Students planned and taught lessons using three different models, first in peer teaching settings, and later in their field placement settings. In the spring semester the course focused on unit planning and classroom assessment measures. Students planned and taught a 2-week unit in their field placement setting.

### *Data Collection*

On the first day of class in the fall students were asked to make a concept map depicting their view of the important components of teacher planning. All students received the same written directions, together with an example of a concept map on "leisure activities." On the

last day of class in the spring semester students were again asked to draw a concept map showing their view of the important aspects of teacher planning. The same written directions were provided as a reminder. When the post maps were completed, students were given their pre maps (held by the course instructors during the year), and were asked to compare the two maps. They wrote short descriptions of the changes they saw, noting what they considered to be the reasons for any changes in their thinking about teacher planning.

### Data Analysis

*Categories.* Based on elements identified in students' concept maps, a set of categories was developed to describe responses. These categories were then included as sub-categories within a set of major categories identified as part of the earlier study which compared three tasks for measuring conceptual change (Morine-Dersheimer, 1990). Table 1 presents the resultant category system, together with examples of responses within each category.

*Measures of centrality and specificity.* Each map was coded by assigning a category to each response. Measures of centrality and degree of specificity were then calculated for each category on every map. Centrality was determined by the level at which the category was first introduced on the map (i.e., proximity to the central concept). Degree of specificity was determined by the proportional frequency of items associated with the category (number of items in the category divided by the number of items on the map).

For example (see Figure 1), on a map developed by a student preparing to teach secondary English, a circle directly connected to the central concept of Teacher Planning was Content (Level 1). Emanating from the Content circle were several spokes labeled drama, poetry, novels, short stories, and writing (all Level 2). Stemming from the "writing" spoke were two additional references: creative writing and critical writing (Level 3). On this map the category of Content was introduced at Level 1, so the centrality measure for Content was 1. There were a total of 8 items relating to Con-

tent, and a total of 40 items on the whole map, so the specificity measure for Content was .20. On the same map, this student put "grading" as an offshoot of "critical writing." This was the only reference to the category of Evaluation, so the specificity measure was .025. The category was not introduced until Level 4, so the centrality measure was 4. (The higher the centrality measure, the less central the category.)

Because the emphasis was on determining group measures, it was essential to have a measure for each category for every student. A "weighted" measure of centrality was used for categories that were not included at all on a given map. For the map shown in Figure 1, there were no items referring to Teacher Beliefs, so the specificity measure for that category was .00. The map as a whole extended only to the fourth level. The weighted measure of centrality was counted as being two levels below the furthest level existing on the map (essentially, this meant "off the map"). In this instance the centrality measure for Teacher Beliefs was 6 (2 below 4). On a map that extended to 8 levels, a category that had no items noted on the map was assigned a centrality rating of 10.

*Comparisons.* Measures of centrality and degree of specificity were used to identify group means for purposes of comparing patterns of response for the various sets of students (e.g., elementary majors compared to secondary majors). Analysis of variance for repeated measures (SAS) was used with degree of specificity measure, to identify significant differences in patterns of reference to each of the 12 sub-categories. Discriminant function analysis (SPSS) was used with raw frequencies for specificity (number of items mentioned) to compare patterns of reference to the three major categories of Curriculum, Instruction, and Social Context.

The measures of categorical centrality and specificity were interpreted as evidence of students' knowledge about aspects of teacher planning, and their tendency to emphasize the importance of certain aspects, rather than as evidence of students' cognitive structure. Group means were used to develop grids providing graphic displays of patterns of emphasis. In addition, some qualitative differences in patterns of response were noted.

Table 1

*Categories and Sample Responses*

Categories	Sample responses
Curriculum	
Goals	Objectives for the year Problem-solving skills IEPs
Content	Reading Science Poetry Creative writing
Instructional Materials and Resources	Textbooks Library books Outside sources (people) Visual aids
Lesson and Unit Plans	Daily lesson plans Unit plans Long-term planning
Instruction	
Classroom Management	Rules for the classroom Reinforcement of behavior Rules for: lining up, bathroom, drinks, hallway
Instructional Process	Instructional methods Group work Cooperative learning
Time and Timing	Length of period Actual learning time Time for planning
Evaluation and Feedback	Tests Grades Pupil feedback Self-evaluation
Social context	
Student Characteristics and Background	Individual needs of students Physical limitations Emotional needs/self-concept Student interests Ability level
Teacher Beliefs or Principles	Integrate subjects Plan for the unexpected Variety of instruction
Professional Knowledge	Familiar with material Able to present material Knowledge of current professional research Competencies—National Teacher Examination (NTE)
Professional Relationships	Thinking about the profession as a whole Cooperation with teachers Consultation with other teachers Cooperation with principal

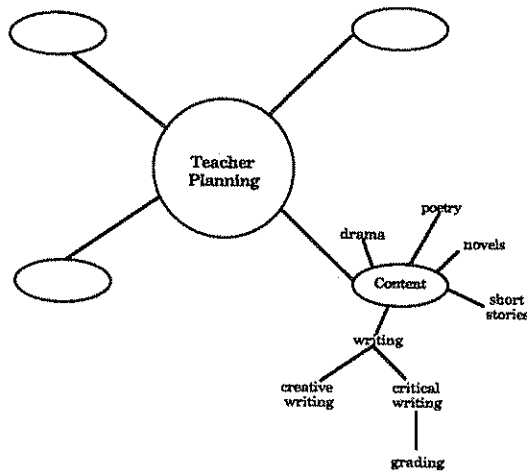


Figure 1. Map segment: Secondary English major.

## Results

### Major Categories

Discriminant function analysis indicated that elementary and secondary majors differed significantly in their patterns of reference to the three major categories on their pre maps (Wilks' Lambda = .867; chi-square = 8.61,  $df = 3$ ,  $p < .05$ ). Elementary majors mentioned Curriculum matters as important aspects of teacher planning more frequently than secondary majors. Secondary majors mentioned Social Context factors as important aspects of teacher planning more frequently than elementary majors. On post maps discriminant function analysis showed no significant differences between these two groups in frequency of reference to the three main categories (Wilks' Lambda = .965; chi-square = 2.22,  $df = 3$ , N.S.). Elementary and secondary majors met in different course sections, and had different instructors, but followed the same general course syllabus, so the final similarity in patterns of emphasis on these major categories suggests that this procedure was effective in conveying basic course concepts to both groups.

### Specificity of Sub-Category References

*Certification level.* ANOVA results showed that certification level of students contributed to significant differences in degree of specificity for several of the 12 sub-categories, as well as for the main categories. For sub-categories associated with Curriculum aspects of planning, elementary majors were more specific than secondary majors (listed more individual items) in their references to Content on both pre and post maps ( $F = 6.43$ ,  $df = 1$ ,  $p = .014$ ). For sub-categories associated with Instructional aspects of planning, elementary majors were more specific than secondary majors in their references to Instructional Process on both pre and post maps ( $F = 4.28$ ,  $df = 1$ ,  $p = .043$ ). Secondary majors tended to be more specific in their references to Evaluation on both pre and post maps, and this difference approached significance ( $F = 3.11$ ,  $df = 1$ ,  $p = .083$ ). There were no significant differences between elementary and secondary majors in specificity of reference to any of the sub-categories associated with Social Context aspects of planning.

*Time.* Time of mapping (pre or post) was also a factor contributing to significant differences in specificity of reference to several sub-categories. For Curriculum aspects of planning, students showed a decrease in specificity of reference to Content from pre to post maps ( $F = 5.82$ ,  $df = 1$ ,  $p = .01$ ), and an increase in specificity of reference to lesson plans and unit plans ( $F = 8.01$ ,  $df = 1$ ,  $p = .006$ ). For Instructional aspects of planning, students showed a decrease in specificity of reference to Time and Timing from pre to post maps ( $F = 6.43$ ,  $df = 1$ ,  $p = .014$ ), and a marked increase in specificity of reference to Evaluation ( $F = 18.74$ ,  $df = 1$ ,  $p = .0001$ ). For sub-categories associated with Social Context there were no significant differences in specificity from pre to post maps.

*Instructor.* Instructor as a factor also contributed to significant differences in specificity of reference to several subcategories. Students of Instructor C displayed patterns of emphasis different from students of Instructors A and B. They emphasized Content less on both pre and post maps ( $F = 6.31$ ,  $df = 2$ ,  $p = .019$ ). They showed a much greater increase pre to post in

reference to lesson plans ( $F = 3.91$ ,  $df = 2$ ,  $p = .025$ ). They tended to be higher in specificity of reference to Evaluation on post maps, and this difference approached significance ( $F = 3.03$ ,  $df = 2$ ,  $p = .056$ ).

#### *Patterns of Specificity and Centrality*

Because concept maps are graphic devices for displaying relationships among concepts and elements, an analysis confined to numbers clearly loses something in its translation of results. As far as I can determine, no prior studies have attempted to provide a graphic display of group patterns of response on concept maps. In this study, the group means for specificity and centrality were used to develop grids illustrating students' pre and post map emphases on the 12 sub-categories. Categories that were most central to the main topic of Teacher Planning appear on the left half of the grid, while categories that were least central appear on the right half of the grid. Categories that were mentioned with most specificity appear in the upper half of the grid, while categories mentioned with least specificity appear on the lower half of the grid. This division results in a grid of four quadrants, with the upper left quadrant containing the categories most heavily emphasized (both central and specific), and the lower right quadrant containing the categories least emphasized (neither central nor specific). These grids are used to compare the pre and post patterns of response for each of the three class sections.

Figures 2 and 3 present grids illustrating group patterns of emphasis on the pre and post maps for students of Instructor A. This was a class of elementary majors. On pre maps (Figure 2) the most emphasized categories were Content, Materials, and Instructional Process, with Goals, Management, and Time also located within the upper left quadrant, but falling close to the borderline. On post maps (Figure 3) the most emphasized categories were Students, Materials, Management, and Evaluation, with Goals and Instructional Process falling close to or on the borderline between the first and second quadrants. The major changes depicted on these two grids involve a strong increase in emphasis on Evaluation and on Student Characteristics and Background, and a

moderate increase in emphasis on Plans, combined with a decrease in emphasis on Instructional Process, Content, and Time and Timing.

Figures 4 and 5 present grids illustrating patterns of emphasis on pre and post maps for students of Instructor B. This was a class of secondary majors. On pre maps (Figure 4) the most emphasized category was Instructional Process, with Goals, Students, and Materials falling within the upper left quadrant, but located on the borderline. On post maps (Figure 5) the most heavily emphasized categories were Materials, Evaluation, Student Characteristics and Background, Instructional Process, and Goals. The major changes depicted on these two grids involve a strong increase in emphasis on Evaluation and Materials, together with a moderate increase in emphasis on Teacher Beliefs and Content.

Figures 6 and 7 present grids illustrating patterns of emphasis on pre and post maps for students of Instructor C. This was a second class of secondary majors. On pre maps (Figure 6) the most heavily emphasized categories were Instructional Process and Materials, with Evaluation also included within the upper left quadrant, but falling close to the borderline, and Management included just across the borderline. On post maps (Figure 7) the most emphasized categories were Evaluation, Instructional Process, Materials, Plans, and Management. The major changes depicted on these two grids involve a strong increase in emphasis on Evaluation and Plans, together with a moderate increase in emphasis on Goals. These grids demonstrate that group patterns of emphasis in each of the three sections changed from pre to post maps, but the only change common to all three was a strong increase in emphasis on Evaluation. Of particular interest is the fact that students of Instructors A and B appear to be quite similar in patterns of emphasis on their post maps, as both included Evaluation, Instructional Process, Materials, Students, and Goals in the first quadrant, while both relegated Professional Knowledge and Professional Relations to the fourth quadrant. They differed only in emphasis on Management (quadrant 1 for Section A, quadrant 2 for Section B) and on Teacher Beliefs (quadrant 2 for Section B, quadrant 4 for Section A). This similarity is interesting because Instructor A's students were

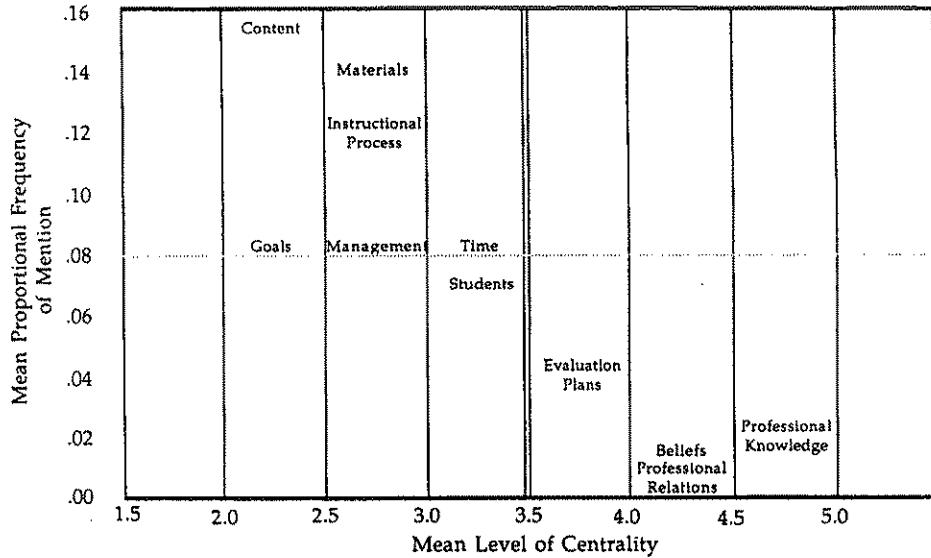


Figure 2. Instructor A's premaps: Group patterns of centrality and specificity ( $n = 18$ ).

elementary majors, while Instructor B's students were secondary majors.

Students of Instructor C, who were also secondary majors, might reasonably be expected to exhibit patterns of emphasis quite similar to those of Instructor B, but in fact the post map emphases of these students were clearly different from those of students in both

of the other sections. The major differences were that Goals was assigned to quadrant 2, and Students and Content were assigned to quadrant 4 by students of Instructor C, while students in sections A and B included Students and Goals in quadrant 1, and placed Content in quadrant 2. Possible explanations for this difference in course outcomes for students in section C are

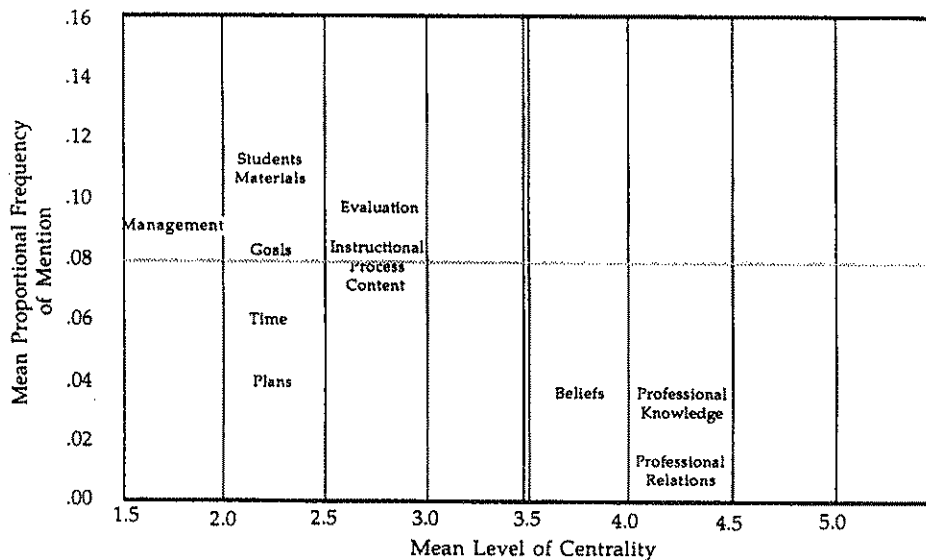


Figure 3. Instructor A's postmaps: Group patterns of centrality and specificity ( $n = 18$ ).

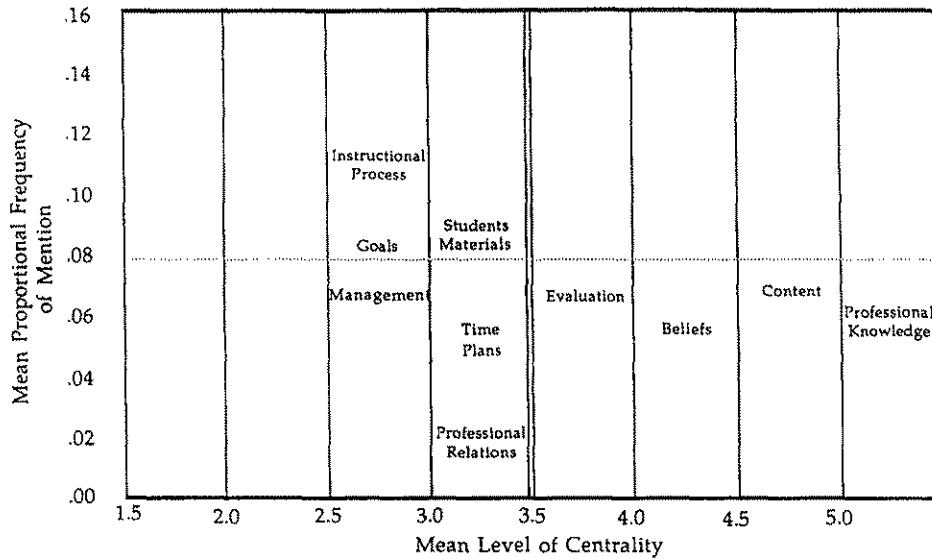


Figure 4. Instructor B's premaps: Group patterns of centrality and specificity ( $n = 25$ ).

explored in the Discussion segment of this paper.

#### *Quality of Responses*

Some qualitative shifts in student responses on pre and post concept maps were also noted. Three types of response were identified: Labels,

Explications, and Overly Detailed Listings. Labels included single-term statements like Plans or Goals, with no additional information provided. Explications included individual comments stated in phrases (e.g., "positive atmosphere in classroom") or clusters of related terms (e.g., "social skills, cognitive skills, and values" all noted as sub-categories under the

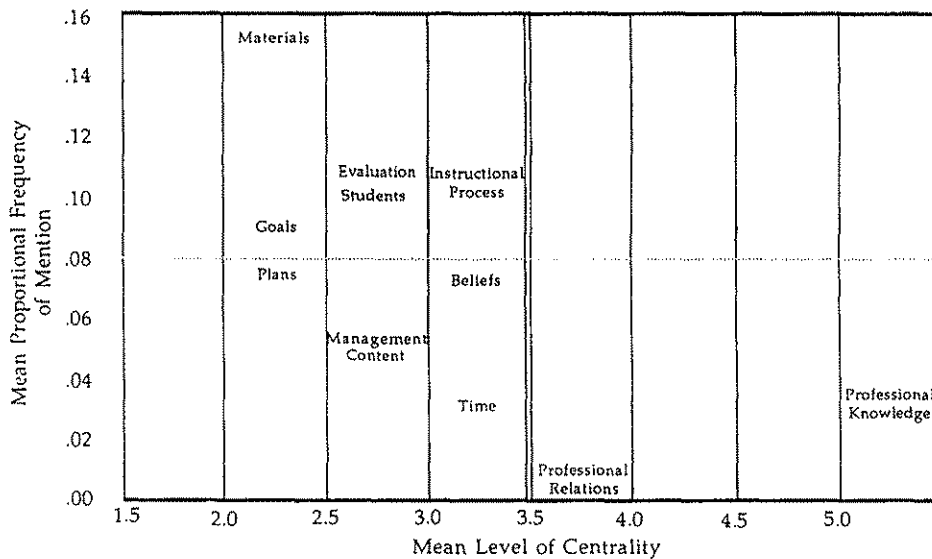


Figure 5. Instructor B's postmaps: Group patterns of centrality and specificity ( $n = 25$ ).



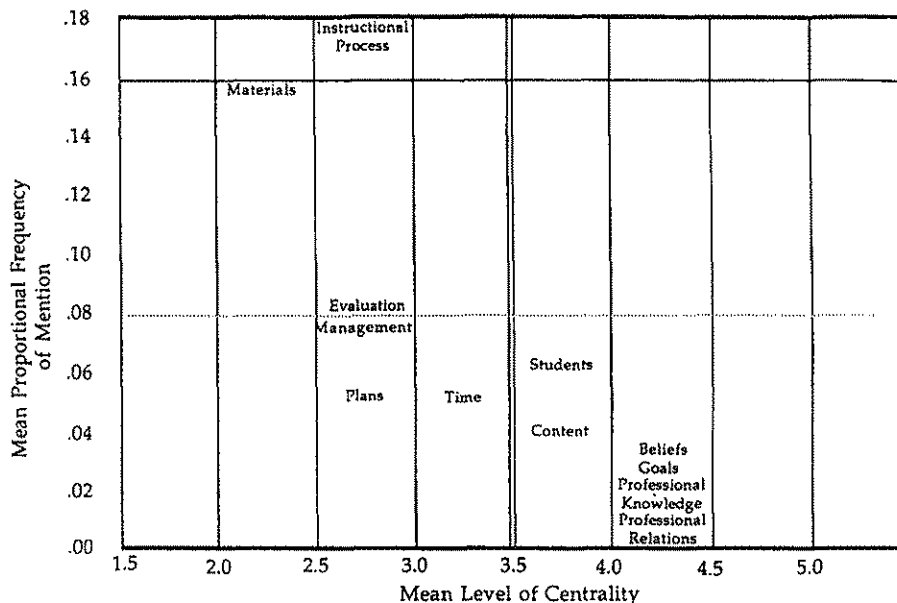


Figure 6. Instructor C's premaps: Group patterns of centrality and specificity ( $n = 22$ ).

heading of Goals). Overly Detailed Listings (ODs) included extended clusters of comments like the following which appeared under the heading of Materials: "tapes, videos, movies, markers, papers, pencils, flash cards, manipulatives."

Elementary majors had a tendency to OD in

their references to Content on their pre maps, listing the many subject areas to be planned for (e.g., "language, mathematics, spelling, reading, science, history, art, music, computers, and recess"). This tendency was less noticeable on post maps. Both elementary and secondary majors were prone to OD in

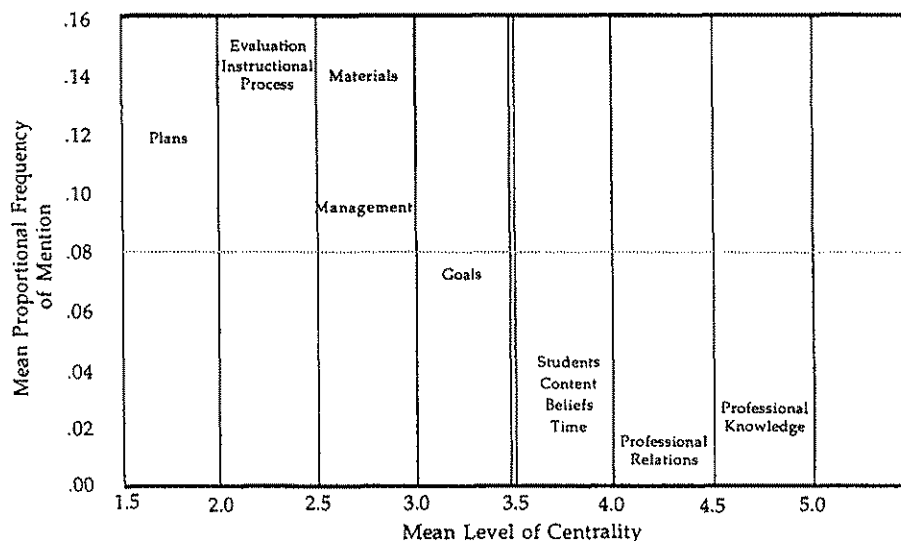


Figure 7. Instructor C's postmaps: Group patterns of centrality and specificity ( $n = 22$ ).

their references to Instructional Materials on both pre and post maps. The Materials list in the paragraph above was produced by an elementary major. A comparable one from a secondary major included: "teacher's green plan book, pencils, rulers, handouts, overhead projector."

The categories of Goals and Evaluation tended to be expressed as Labels on pre maps, but generally shifted to Explication on post maps. For example, a reference to "tests/quizzes" on a pre map changed on the post map to: "assessment methods — discussion, projects, tests, papers; assessment bases — improvement, effort, attainment of goals." Teacher Beliefs were infrequently mentioned on pre maps, but when comments on this category appeared on post maps they took the form of Explications (e.g., "active learning," "delegate the responsibility of learning to kids," "tie to preceding lessons," "get student input for planning").

Comments referring to the categories of Instructional Process and Student Characteristics tended to be presented in the form of Explications on both pre and post maps, but the content of the explication changed from pre to post. For example, under Instructional Processes on an elementary major's pre map a cluster included "games, group work, projects, busy work," while a comparable cluster on a secondary major's pre map included "lecture, discussion, guest speakers, field trips." Both elementary and secondary majors were more apt to include a cluster like the following on their post maps: "cooperative learning, direct instruction, concept attainment." Under Student Characteristics a typical pre map cluster noted "student achievement levels, what kids like, number of kids, age of kids." Post map clusters gave more attention to relationships between Student Characteristics and other aspects of planning (e.g., "how lesson fits into students' lives — will it cause student to think, will it interest student, what have students been studying").

#### Discussion

##### *Information for Specific Program Evaluation*

Several findings of this study are useful for evaluation of the particular course and program in which the concept maps were produced.

Results that can be interpreted as positive feedback in light of course goals include the pre to post increases in emphasis on Evaluation and Plans, as the course dealt specifically with instructional planning and assessment. Another positive result was the pre to post decrease in degree of specificity in references to Content, which derived mainly from the decreased tendency of elementary majors to provide overly detailed lists of subject areas. The decrease in emphasis on Time and Timing suggests that classroom experience helped to allay student fears about working within class schedules. Further, the increase in use of Explication, rather than Labels or Overly Detailed Listings, from pre to post maps was a positive result, reflecting increased knowledge and improved organization of knowledge held by students. Finally, the pre to post changes in content of Explications related to Student Characteristics and Instructional Process showed that students were aware of a broader set of options for instruction, and had a clearer sense of relationships among factors important in planning of instruction.

Results that signal areas where course instruction might be improved include the minimal changes noted from pre to post maps in the area of Social Context, particularly the sub-categories of Student Characteristics and Background, and Teacher Beliefs or Principles, for the course as designed emphasized these aspects of planning quite strongly. In both of these areas students of Instructors A and B showed an increase in specificity and centrality over time, while students of Instructor C showed little or no change. A combination of factors probably explains this result, including instructor differences in prior experience teaching the course, and prior involvement and interest in the research on teaching that contributed to course content. Providing details about these factors would endanger the anonymity of the participants in this study, but it was the case that (presumably as a result of these factors) Instructor C did not really teach the course as designed. That is, although the course syllabus was the same for all three sections of the course, actual instruction in the three sections did differ. The differences in concept maps produced by students in the three sections revealed differences in student outcomes attributable to this

fact, and underscored the importance of contributions made by specific instructors in this core course.

#### *Information for Methodology*

The significant results of this study, identifying certification level, instructor, and time of mapping as influential factors in students' concepts of teacher planning are important for future efforts to improve teacher education program evaluation. This study has demonstrated that it is possible to analyse concept maps using a simpler procedure, and that this procedure can lead to useful descriptions of group patterns of response. The fact that group patterns can be discerned and displayed in graphic forms is an added benefit of the analysis procedure used here. Most important, perhaps, is that the process used for data analysis is reasonably economical in terms of information provided for time expended. This is a critical factor for most teacher educators interested in program evaluation.

This research has also demonstrated that it is possible for studies using concept maps as a data collection device to avoid most of the characteristics of studies criticized by Kagan (1990). The simplified analysis system made it possible to include larger numbers of participants in the study, and did not require scoring in relation to a target map in order to identify desirable changes in student perceptions.

Because many of the recent reforms in teacher education programs involve an increased emphasis on the teacher as decision maker, studies that investigate the cognition of prospective teachers can make an important contribution to program evaluation efforts. Improvements in the methodology associated with studies of teacher cognition, particularly changes that make the techniques more practical for use by teacher educators, can serve to improve both the quantity and quality of program evaluation studies. This study is a step in that direction.

#### *Next Steps*

An important limitation of this study is that it provides no information as to whether the patterns of response on concept maps of teacher planning are in any way related to teaching practice. Kagan (1990) has criticized research

on teacher cognition as a field because so few studies have examined associations between performance on tasks designed to reveal patterns of thinking or decision making, and actual classroom instruction or student outcomes. She refers to this as a lack of evidence regarding the ecological validity of our measures of teachers' cognition.

In a follow-up study, with the assistance of several graduate students, I am addressing this issue. In the first half of this follow-up study, we identified three groups of secondary education students, based on post concept map differences in their patterns of emphasis on two categories of particular interest: Student Characteristics and Background; and Teacher Beliefs or Principles. We followed these prospective teachers into student teaching, and collected data on their interactive behavior and interactive decision making, as well as pupil responses to their lessons. In each of these areas there were clear group differences in observable patterns that were closely related to the group differences in emphasis on the concept maps (Morine-Dershimer, 1992). We hope to publish a report of these results in the near future. In the second half of the study, we plan to carry out a similar design with elementary education majors.

Preliminary results in this follow-up study do provide evidence for the ecological validity of the concept mapping measure used in the study reported here. Specifically, these results indicate that an increased emphasis on Student Characteristics/Background and Teacher Beliefs/Principles, as exhibited on pre to post concept maps of teacher planning, is associated with improvement in the instructional effectiveness of prospective teachers, as measured by pupil engagement in lessons that they teach. If the next phase of this study provides similar results, it will give added support for the usefulness of concept mapping as a tool for evaluation of teacher education courses and programs.

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