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AUTHOR Owens, John E.

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ABSTRACT

Repertory grid technique and extensive interviews were used to investigate the personal constructs of mathematics and mathematics teaching held by four preservice secondary mathematics teachers. Kelly's Personal Construct Theory and Perry's developmental scheme provided frameworks for analysis of the experiential, pedagogical, and mathematical perspectives through which the preservice teachers interpreted their undergraduate teacher preparation programs and anticipated their roles as teachers. Mathematical constructs tended to focus on simple algorithmic exercises guided by personal success with pre-college mathematics. Participants generally evidenced neither constructs with which to assimilate the implications of higher mathematics nor the anticipatory schema to deem such material relevant. Role constructs tended to focus on social, versus intellectual, qualities. (PK)

Preservice Secondary Mathematics Teachers' Constructs of Mathematics and Mathematics Teaching

John E. Owens

The University of Alabama

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Abstract

Repertory grid technique and extensive interviews were used to investigate the personal constructs of mathematics and mathematics teaching held by four preservice secondary mathematics teachers. Kelly's Personal Construct Theory and Perry's developmental scheme provided frameworks for analysis of the experiential, pedagogical, and mathematical perspectives through which the preservice teachers interpreted their undergraduate teacher preparation programs and anticipated their roles as teachers.

Mathematical constructs tended to focus on simple algorithmic exercises guided by personal success with pre-college mathematics. Participants generally evidenced neither constructs with which to assimilate the implications of higher mathematics nor the anticipatory schema to deem such material relevant. Role constructs tended to focus on social, versus intellectual, qualities. Responsibility for curricular substance was vested in others.

Preservice Secondary Mathematics Teachers' Constructs of Mathematics and Mathematics Teaching

When you've been a student for 16 years, it is not natural to be a teacher. (A student in an undergraduate methods course).

The teaching methods (Bush, 1982) and mathematical content (Freudenthal, 1973; Byers, 1983) experienced by preservice teachers during the student years influence their perceptions and practices as teachers of mathematics. These experiences alone, however, scarcely account for teaching practice--else all teachers undergoing a similar program would develop comparable skills and styles.

Prior school experiences form part of a larger set of events that are important factors in the preservice teacher's development. But the significance of an event is not measured solely in terms of its nature or frequency. Rather, the meaningfulness must be considered in relation to the individual's perception of the nature and importance of the event.

The importance of personal interpretations in the development of a student's knowledge and practice of mathematics has been discussed in several spheres. Confrey (1984) suggested that

> students are not simply passive recipients of mathematical knowledge; they transform it by actively interpreting, synthesizing and evaluating what they learn in light of what they already know, believe and expect. (p. 1).

Erlwanger (1975), Confrey and Lanier (1980), and Herscovics and Chalouh (1985) have found evidence of the consequence of students' mathematical frames or themes in directing student understanding of mathematics.

Similarly, the teacher's conception of teaching and of mathematics are relevant factors in determining classroom practice (Thompson, 1984; Cooney (1980); and others). The study reported here builds on each of these themes, applying the notion of frames to the preservice teacher as student.

In particular, using Kelly's (1955) personal construct theory and Perry's (1970) scheme as bases, the study investigated the nature and relative importance (to the individual) of constructs related to mathematics and mathematics teaching held by four preservice secondary mathematics teachers. It is through the lenses of such individuals that teacher preparation accomplishes, or fails to accomplish, its ends. And it is through an understanding of these lenses that meaningful teacher education must evolve.

Theoretical Perspective

Personal construct theory is based on the philosophical position of "constructive alternativism" (Kelly, 1955). Kelly states the basic tenet of this position as the assumption "that all of our present interpretations of the universe are subject to revision and replacement" (p. 15). On this foundation he builds his image of "man-the-scientist" --a view that man seeks to "predict and control the course of events with which he is involved" by constantly creating and testing hypotheses.

Kelly developed personal construct theory as a systematic manner of describing an individual's conceptual system in terms of an evolving network of dichotomous images (constructs) which guide the choices each person makes. For example (provided by Hudson, 1968), a person who perceives a career choice through a "discipline/self-expression" construct, with discipline perceived as "good," would tend to seek a field characterized (in the individual's mind) by "intellectual precision," shying away from one perceived as an "unruly sprawl."

Kelly argues that each person's construct system is uniquely composed of a finite number of bi-polar templets, which he termed constructs, that control the way in which events are perceived. This constantly evolving network is both modified by experience and determines how experiences are perceived by the individual.

Kelly states as his "fundamental postulate" that "A person's processes are psychologically channelized by the ways in which he anticipates events." Through a flexible and frequently modified network of pathways an individual seeks to predict, and thus anticipate, future events. However, it is not the pathways themselves, but the constructs that facilitate, or restrict, the choices of paths that constitute the individual's construct system.

The development of these pathways may be inhibited by "threat" (when a newly evolving construct is at odds with a more encompassing one), by a preoccupation with old material through which "old or familiar material tends to be fixed in place by old and childlike constructs" (p.168), and through lack of a laboratory that provides "a situation in which there is present, for the person to re-sort, a sufficient amount of stuff out of which new constructs can be formed" (p.169).

Kelly developed repertory grid technique for eliciting and investigating relationships between the various constructs that make up the individual's conceptual system. This technique, embodying a series of elicitation instruments and correlation matricies, attempts to describe the primary constructs through which an individual interprets events.

Primary emphasis in this study was placed on the constructs underlying the participants' views of mathematics and their role as mathematician, of the high school mathematics curriculum and their role in the formation and implementation of the curriculum, of learning mathematics and their role as learner, and of teaching mathematics and their role as teacher.

Perry's scheme is used as a complement to Personal Construct Theory, providing a more global framework for describing the participants' developing "worldview" as it relates to teaching and to mathematics. The scheme was designed to describe the intellectual and ethical development of undergraduate college students and is primarily concerned with the relationship of the individual with perceived authority.

Four major stages of growth are posited: Dualism (a dichotomus good/bad, right/wrong, we/others structuring), Multiplism (a plurality of answers is perceived but without internal structure), Relativism (multiple perspectives emerge, allowing for contextual analysis of events), and Commitment (acceptance of personal responsibility for choices in Relativism). Alternatives to growth (Escape, Temporization, and Retreat) are available to the individual at various stages.

Perry's scheme can be construed, in Kelly's terms, as describing the area of the construct system responsible for the individual's control over his/her own destiny--an area that encompasses the individual's perception of the role of "authority" versus "self" in assigning responsibility for intellectual development.

These conceptions share a view of intellectual development as the culmination of deliberate, interpretative acts of an individual. Taken together they present a dynamic view of an individual's interpretation of events, structured by a constantly evolving set of constructs and constrained by the individual's self-perceived responsibility for the "reflective judgment and informed action" (Cornbleth, 1986) that defines the professional teacher.

Design of the Study

The study was conducted over a nine-week period during the spring of 1986. Data were collected from each of the seven secondary mathematics education majors enrolled in a post-student-teaching seminar at the University of Georgia. Each completed a series of seven one-hour interviews and a written task in addition to elicitation and ranking instruments characteristic of repertory grid technique. From the six students who had jointly progressed through the mathematics education curriculum four students, representing a range of achievement on college coursework, were chosen for case studies:

> Case 1: Susan. Susan is a twenty-two year old white female, a life-long resident of a medium-size city in a western state who has attended the University for four years on an athletic scholarship. After a strong high school program, including Advanced Placement Calculus and English, she has maintained a 3.4 (out of 4) overall grade point average in all courses

with A's and B's in her mathematics courses. Susan originally intended to major in medicine, transferring to mathematics education to avoid a conflict between her athletic schedule and laboratory course requirements.

Case 2: Laura. Laura is a twenty-two year old white female. A native of a rural county near the University, she attended a local junior college for two years before enrolling in the secondary mathematics program. A straight-A student in high school (mathematics courses through Algebra III), she has maintained a 3.8 overall grade point average in college, earning A's and B's on all mathematics courses.

Case 3: Tim. Tim is a twenty-three year old white male from a small town in a predominantly rural portion of the state. After graduating with honors from high school (mathematics through Algebra III), he attended a nearby junior college before transferring to the University as a pre-pharmacy major. Tim's overall grade point average of 2.7 reflects a preponderance of C's in his mathematics courses.

Case 3: Ellen. Ellen is a twenty-six year old white female from a small town in a rural county near the University. She entered a joint-enrollment program at a local junior college during her senior year of high school (her school offered no mathematics beyond Algebra II) and remained after graduation to earn an associate degree in mathematics before entering the University to major in secondary mathematics. Ellen currently has a 3.2 overall grade point average with primarily B's in her mathematics courses.

Interviews

Interviews were of three types: open-ended discussions aimed at developing an understanding of the participants' conceptions of mathematics and its teaching, focused interviews for eliciting participants' reaction to scenarios of hypothetical secondary mathematics classroom situations dealing with student misconceptions, and problem-solving sessions designed to investigate the participants' understanding of major ideas in the secondary mathematics curriculum and the "socially effective symbols" (Kelly, 1955) with which they communicate these understandings.

In addition, interview data formed the primary basis for ascertaining the participants' development relative to Perry's scheme and served as a medium for exploration of meanings ascribed to grid items by the participants.

Repertory Grids

Repertory grids were administered in two stages utilizing construct elicitation and final grid instruments. Two sets of initial elicitation instruments, one eliciting role constructs and the other topic constructs, were completed by the participants prior to the first interview. Each set involved the presentation of triads of teaching roles or mathematical topics which the participants were instructed to group in the following manner: "Consider the three topics (roles) presented. Describe some way in which you view two of the topics (roles) as similar yet different from the third." For example, asked to group a favorite high school mathematics teacher, a favorite college mathematics instructor, and a disliked high school mathematics teacher the participant might group the two favorites by describing them as "encouraging" in contrast to the disliked instructor who was perceived as "intimidating".

Descriptors used by the participants to characterize the similarities and differences supplied a range of bi-polar constructs for the resulting final grids. Participants were asked to use these constructs to rank, along a Likert-type scale, a selection of roles (topics) representing teaching (mathematical) elements (Table 2, 3). Grids were analyzed using procedures suggested by Fransella and Bannister (1977). Correlation matricies (Table 2-5), relationship (variance) scores (Table 1), and cluster graphs (Table 6) were constructed for each participant's role and topic grid. Summary charts of relationship scores (Table 1) comparing participants across elements and topics were constructed for cross-case comparison.

<u>Relationship Scores and Cluster Graphs</u>

Relationship (variance) scores play a pivotal role in personal construct theory. These represent the explained variance from each of the constructs on the final grids and reflect the relative "intensity" with which constructs impact on the participants' interpretation of experience (Fransella and Bannister, 1977). A construct with a higher relationship score is thus posited to represent a more global influence, or control, on how the individual interprets events. Table 1 includes the relationship scores and ranking for the role and topic grids.

Cluster graphs can be used to graphically portray relationships between constructs for an individuals' system. These graphs depict certain trends or groupings within the participants construct systems and, by choosing similar coordinate systems, allow (with some caveats) for comparisons across individuals.

Coordinates represent the signed variance (x 100) between the constructs chosen for the axes and the remaining constructs. Choice of axes in Figures 1-4 represents the construct with the highest relationship score (y-axis) and the construct with the highest relationship score but not significantly related to the first axis (x-axis).

Note that while constructs in Personal Construct Theory are bipolar (e.g., "encouraging/intimidating"), only the "likeness" pole (e.g., "encouraging") of the construct is given here for brevity. Comments relating to a participant's positive or negative connotation of a construct refer to the stated pole. For example, if Laura is described as viewing "easy" in a positive sense, this refers to the connotation she attributes to the likeness end ("easy") of the construct "easy/difficult." Judgments of positive or negative connotations were based on interview data and correlations with other constructs.

Results

Results reflect a process of commingling grid and interview data. Although the grids provide only part of the data, they form a useful manner in which to group the findings for presentation. Thus the results are presented under headings reflecting the elements and constructs associated with the grids (i.e., topics by construct and by element; roles by construct and by element). Emphasis is placed here, for brevity, on the constructs to which the group as a whole ascribed the five highest and five lowest scores.

<u>Topic Grids - Constructs</u>

"Easy" and "creative" received the highest scores, followed by "easiest to teach," "advanced," and "most useful." "Creative" and "advanced" were generally viewed in a negative sense by all but Susan; the remaining constructs were viewed positively by all.

These ratings tend to reflect both the participants' mathematical ritage and their anticipated use of mathematics. All reported being rceived by family, teachers, and peers as "good" a mathematics--a connotation they enjoyed and a strong influence on their choice of career. The mathematics of their successes came "easy" and was characterized by an exactness, of "knowing you were right when you finished a problem."

Mathematics that did not "come easy" was quickly conquered through "hard work," often attributed to being "challenged" by a teacher. At the college level, however, mathematics became more difficult. "Advanced," which had previously represented success in trigonometry or Algebra II, and "creative," which was not a term necessarily thought of as relating to mathematics, took on new meaning and precipitated in each a "crisis" of self-confidence in mathematics.

Responses to this crisis of higher mathematics varied across the participants. Susan (Table 2) began to see, during her second abstract algebra course, this branch of mathematics as more "philosophy" than what she conceived of as mathematics. Accepting this, she progressed through her higher mathematics courses accepting, but not enjoying or attributing relevance to the content. Laura (Table 3) absolved herself of responsibility for the coursework, relying on her advisor's assurance that these were necessary and reassured by her grades that (in spite of not understanding the material) she was "doing well."

Tim's (Table 4) view of mathematics separated "advanced", which he admired but with which he experienced difficulty, from "abstract", which he disliked. Similarly, "creative" was removed from both "advanced" and "abstract," with Tim restricting his view of creativity to being able to develop slight modifications to "given" solutions to problems. Ellen

(Table 5) viewed "advanced" mathematics as "just something you do." "Creative" mathematics, at a elementary level, alleviated her boredom; at a higher level of mathematics, however, requirements for "creativity" became threatening, causing her to "cry every night" during her first upper-level course.

While "easy" mathematics represented the participants' mathematical history and reflected fears generated by higher mathematics, "easiest to teach" suggests the degree to which the participants' future roles are anticipated. The participants expressed confidence in "being able to do" the mathematics of the secondary curriculum--given adequate preparation time. There was a constant concern, however, with their ability to communicate their knowledge to the students.

Attempts to describe useful mathematics tended toward simple consumer usages (balancing checkbooks and buying groceries, for example) along with vague notions of "high tech" applications (e.g., "Engineers use it, don't they?") or attributions of "usefulness" to other areas of mathematics (e.g., "The quadratic formula is useful in 'doing parabolas'."). Simply put, arithmetic is invaluable for daily living; the purpose of algebra is preparation for calculus which may be useful for "designing computers." Applications requiring the algebra, geometry, and trigonometry of secondary mathematics were unknown.

This dual conception of mathematics as a "rite of passage" along the road to a degree and an inherent belief in its usefulness could not be reconciled by the participants. They had faith in the usefulness of mathematics at an elementary level, based on personal experience. At the level of high school algebra and above there was only the belief that mathematics was useful, based on a seeming cultural idiom that mathematics is inherently important and essential.

In essence, there were two distinct mathematics for the participants--the simple, useful mathematics of everyday life and the abstract, perhaps useful for others, self-fulfilling mathematics of the curriculum. Relating these conceptions to teaching tended to bring out a similar two-tiered approach--advanced concepts were reserved for "better (mathematically) kids" while lower achievers were to be presented the simple life-skills mathematics.

Susan's (Figure 1), Laura's (Figure 2), and Tim's (Figure 3) cluster graphs most graphically depict variations in the "usefulness" of mathematics. Laura's constructs related to "most useful" tend to be similarly related to "easy," Tim's to "best at," and Susan's to "varied." Laura's constructs reflect her criteria of success as measured by grades--the most useful mathematics to her is the mathematics she can perform the best.

Tim's relating of "best at" with "most useful" is indicative of his conception of practical "shop math" as both his forte and as necessary skill. Tim's background reflects more familiarity with mechanical equipment than the other participants--those with more analytical skills in his home town tend to become mechanics in mills.

Susan, conversely, sees the "most useful" mathematics as that which is "varied" (related to "advanced" and "abstract"). However, her main concern is not with the practicality of mathematics but with the ability to perform more advanced mathematics well as prerequisite to college requirements--where mathematics serves the role of allowing students to "achieve their potential" through "high tech" degrees.

Low Relationship Scores. Low relationship scores provide evidence of constructs that do not figure prominently in determining how the individuals interpret their experiences. This can be caused by a feeling that the construct is inherent to the topic (e.g., mathematics is intrinsically "exact"), a judgment of a false dichotomy, or a general sense that these are not constructs one places major importance upon when evaluating roles related to mathematics or its teaching.

The constructs receiving the lowest relationship scores were "invigorating", "conclusive", "organized", "exact", and "abstract". The relative unimportance of "invigorating" suggests a perception that mathematics is not intended to be exciting or enjoyed. During the interviews the participants often expressed "satisfaction" with mathematics, primarily in the context of "solving a problem others could not" but failed to attribute a sense of amazement at things mathematical.

This lack of "amazement" did not extend to teaching, where the participants eagerly related stories of student teaching episodes. This lack of motivation residing in the mathematics itself, except in a satisfaction role, is echoed in the perception of the role of teacher as motivator, responsible for the "liveliness" of the class through organization and personal involvement or energy--i.e., the "class" must be interesting but not necessarily the subject itself.

The low scores received by "conclusive", "organized", and "exact" (which each participant ascribed favorably to mathematics in the interviews) and perhaps "abstract" can be construed in terms of Perry's (1970) observation that criteria assumed to be inherent to the subject are given little concern.

Topic Grids - Elements

Solving equations was given, overall, the most favorable ratings by the participants. High ratings were attributed on constructs related to ease of learning, personal ability to perform, and enjoyment. Word problems, conversely, were rated low on constructs related to ease of learning or teaching and personal ability to perform, but high on constructs related to creativity and usefulness.

The high ratings on solving equations are indicative of the participants' curriculum-based view of mathematics and of their prior successes. Solving equations formed the bulk of their remembrances of secondary mathematics with the rapid manipulation of equations seen as primary to their success. It is these skills they anticipate teaching to their future charges.

Word problems, conversely, pose a threat to both the participants' self-image as mathematician and to their anticipated teaching endeavors. The threat from word problems seems, however, less than the threat of non-standard problem solving exercises. Word problems, although perceived as difficult, have the potential of being reduced to formulamatic solutions.

Proof drew the strongest and most negative reactions of the elements. It was rated low on constructs related to ease of learning, personal ability to perform, enjoyment, and usefulness, but high on constructs related to cognitive levels and conclusiveness.

The ratings on cognitive levels and conclusiveness are expressive of a tendency to view proof as something developed by "mathematicians." The participants felt no personal involvement in the constructing of proof, viewing their role as primarily that of replicating existing demonstrations with only minor "changes in the order of steps" allowed.

The negative reaction to proof seems to derive both from high school experiences in Geometry class (which was typically liked by the participants) and from college-level coursework. The college work tended to reinforce, rather than alleviate, the early conceptions of proof as irrelevant and difficult, adding a threatening element to the task.

Graphing equations, working with fractions, and probability and statistics received few extreme ratings compared to the elements described above. Graphing equations was generally considered enjoyable, while working with fractions was considered a rather simple, low level task. Probability and statistics was viewed as somewhat arbitrary, generally difficult and not liked, but also as a useful topic in the curriculum.

Role Grids - Constructs

"Respected", "inquisitive", "encouraging", "motivating", and "interesting" received the highest relationship scores on the role grid. These ratings are indicative of the participants' emphases on the social aspects of the teacher's role, as opposed to the cognitive side--intelligent, for example, rated no higher than fifth on any grid. Lower rated constructs that might be construed as cognitive in nature (e.g., abstract, complex, serious) were deemed by the participants as generally negative social criteria.

Only "respected" tended to harbor potential, in the participants' views, for subject matter competence--a "respected" teacher must "know her stuff." However, in spite of obvious gaps in the participants' own knowledge of secondary mathematics, each expressed confidence that when the time came they would be ready to "present the material."

During the problem solving sessions each participant reached at least one situation in which they were not able to communicate an understanding of some topic from the secondary curriculum. At this juncture they were asked to express how they would handle a situation in the classroom for which they were unable to provide answers. Responses ranged from Susan's half-joking "I would prepare well enough to see that coming and skip that in the lesson" to Tim's "I would tell them to think about it and we would talk about it tomorrow. Then I would go home and study."

When asked if any of their teachers had ever evidenced lack of knowledge of the content, all adamantly defended their teachers--even those they considered their worst teacher--as fully conversant in the subject. Tim, for instance, recalled several incidents of teachers telling his class to "go home and think about it." Yet he seemed assured that his teachers were actually "challenging" him rather than clothing--as he would--difficulty with the question at hand.

Laura (Table 3) rated "respected" first on her role grid. She appears to place significant importance on being "respected," satisfying (by performance) this desire by attempting to please those she deems in authority. Her constructs related to "respected" tended toward "effort" measures as opposed to (to her) threatening creative or intellectual ones. Laura's cluster graph (Figure 2) demonstrates the lack of identification of "respected" or "encouraging" qualities with such cognitive criteria as "intelligent" or "inquisitive."

Susan (Table 2) demonstrated a similar desire to be "respected", although her constructs included more active, demonstrative qualities (e.g., "inquisitive" and "authoritative"). Tim (Table 4) attributed the most respect of the participants to intellectual skills.

Ellen's view of "respected" seems dominated by a combination of a desire to be "respected" and her perception of other's attitudes. Thus she rated herself second (her highest self rating), but her best mathematics teacher fifth, and her worst teacher sixth--deferring any personal beliefs to her perceived sense of other's lack of respect for teachers. She expressed a belief, based on impressions gathered from "newspapers and others," that teachers were no longer "respected" individuals.

Marked differences existed in the participants' use of the constructs. For example, both Susan and Ellen attributed the highest relationship score to "inquisitive". Ellen related this construct positively to "personable" and "flexible" and negatively to "serious". Susan showed positive relationships to "intelligent", "interesting", "organized", "encouraging", "aggressive", "respected", "authoritative", "motivating", and "reliable". Ellen's constructs are more characteristic of a social orientation toward "inquisitive", where Susan shows an aggressive, more cognitive leaning.

Laura gave her lowest rankings to constructs generally highly rated by the others. On the role grid Laura's lowest relationship scores were on "intelligent" (which she rated lowest of the participants) and "inquisitive" (ranked in the top three by the others). Laura's status relative to Perry's scheme suggests she has placed judgment of her "worth" in the hands of others--in terms of satisfying their criteria. Under these conditions "intelligent" and "inquisitive" are constructs that can safely be relegated to unimportance; measures of these qualities are others', not her own, responsibility.

Other anomalies exist that can provide insight into individual conceptions. Ellen, for example rated "serious" second highest (the others rated this 11, 14, and 17) and related this construct negatively to "personable." Ellen expressed a constant concern for being "boring" as a teacher, a concern that may have been heightened by her experiences during student teaching.

Low Relationship Scores. Lowest rated constructs included "abstract," "people-oriented," "complex," "serious," and "conscientious." "Abstract" and "complex" tended to be viewed by the participants somewhat negatively, but there was a general sense that these were not necessarily criteria commonly used in evaluating people. The negative connotation may have been a result of the generally strong negative association (except for Susan) applied to the mathematical counterparts of these constructs.

The relatively low ratings of the remaining constructs tend to be the result of impressions that "people-centeredness," "seriousness," and "conscientiousness" are inherent to the roles of the teacher. Exceptions to this were evidenced by Tim, who rated "conscientiousness" high and expressed concern for his own effort--he rated himself high on this construct but described a need to "watch himself" for he had "slipped" in the past, resulting in poor grades in early mathematics courses; and by Ellen, who had a fear of being "a boring teacher" and rated "serious" high (in a negative sense).

<u>Role Grids - Elements</u>

The participants' self-ratings, with the exception of Ellen, were generally high for "people-centered" characteristics such as "motivating" and "respected." Susan, who viewed "abstract" mathematics in a positive light, also viewed "abstract" and "complex" as positive personal qualities. Laura viewed these qualities negatively, as she did their mathematical counterparts; Tim and Ellen viewed the role characteristics somewhat more negatively than the mathematical equivalents. Ellen's self-ratings demonstrated a particularly low self image; her closest identification was to a typical high school mathematics student.

Three of the participants credited one or more outstanding secondary mathematics teachers as a major factor in their career decision. These three tended to rank themselves and their "best mathematics teacher" closely across the constructs of the role grids.

Although Susan and Laura ranked their best teacher extremely high, Tim did not--suggesting "idealization" of a teacher is not a prerequisite for close identification with a former teacher. Ellen, whose grid evidenced a lack of identification with a previous teacher, similarly demonstrated a lack of identification with teaching during the interview sessions.

The participants typically viewed their best teacher as the most intelligent of the roles--above college professors. This suggests the view of intelligence held by the participants is not based entirely on subject-matter competence. This teacher was ranked high on "aggressive" (the worst teacher ranked low), a characteristic the participants, with the exception of Tim, did not apply to themselves--suggesting aggressiveness, although admired in a teacher, causes a conflict with the participants' self-image as student-centered, "friendly" teacher.

The participants' worst mathematics teacher was rated low on thirteen of the seventeen constructs, and high only on "serious" (which was generally viewed in a negative context). This may suggest a lack of critical differentiation--a tendency to view a teacher as "all good" or "all bad".

Peer rankings consisted of no low or high rankings. This lack of strong views regarding their fellow students was hypothesized to result from a lack of familiarity and interest, rather than a thorough evaluation of peers. Discussion concerning future roles in the classroom among peers seemed almost nonexistent as a topic of conversation outside the classroom. During the interviews, however, the participants seemed to relish the opportunity to discuss their fears and hopes as teachers.

This lack of a laboratory in which to explore their own and others' roles within the profession may be due to social pressures and inherent to the life of the undergraduate. If extrapolated to future teaching roles, however, it does not suggest a high level of professional involvement or examination of teaching practices.

A typical high school mathematics student did not fare well on the role grid. Low ratings were particularly present on cognitively-oriented skills ("intelligent", "organized", "complex") and on characteristics related to "respectability" ("respectable", "authoritative", "reliable"). This reflected a negative appraisal of high school students' interest and ambitions, seemingly contradicting the participants oft-expressed strong "student orientation".

A typical college mathematics professor rated high on cognitively-oriented characteristics (including "abstract" and "complex", which all but Susan viewed negatively) but low on more affectively-oriented criteria. The low ratings on "interesting", "personable", "flexible", and "people-oriented", each a characteristic generally high on the participants' self-rankings, suggests a distinct lack of identification with teachers of higher mathematics.

Central to this appraisal of college mathematics teachers was a lack of differentiation of the perceived role of the teacher at this level. As with the mathematical content, the participants tended to judge the professor's role through the same lens they judged the high school teacher--failing to allow for differences that may be inherent in the role.

Perry's Scheme

In his original study Perry found few undergraduate to have reached the stage of commitment; relativism was reached by more, but these stages together still formed a minority. Similarly, none of the participants in this study were judged to have reached "commitment."

Susan was judged to be in the position of "relativism competing"--a position in which she is caught between an evolving realization of inner authority (characterized by her critical analysis of roles and high relationship scores relative to the roles) and an older need for external structure (characterized by a reliance on set curriculum and a general sense of loose construing on the topic grid). She has yet to decide if she will teach upon graduation, suggesting a degree of temporization in which she may consolidate her efforts toward teaching or decide on some other goal.

Laura's reliance on external authority was the most extreme of the subjects. Her responses suggest a state of multiplism--she readily accepted varying explanations, alternative solutions, and different methods of teaching--but was unwilling to make any judgment as to the structure or hierarchies involved. To Laura, all judgments of those she perceived as authorities were valid; authorities whose role she saw as establishing criteria against which she could measure herself.

Perry's scheme posits a route for those who have perceived the complexity and uncertainty of a multiplistic world and are unable to assert personal judgment on events. Laura seems to have taken this route of escape, finding her identity in carrying out assignments of external authority through performance.

Tim's position seemed to be the lowest of the participants--bordering between Positions 2 (multiplicity pre-legitimate) and 3 (multiplicity subordinate). Tim's reliance on authority ("authoritative" was ranked first on his role grid), couched in "us versus them" terms and his rejection of abstract mathematics or of personal interpretation--characterized by a view of geometric proof as "given"--suggests he has not yet accepted a multiplistic world.

Ellen was judged to be in a position of "multiplicity correlate," from which the world may be viewed as a mixture of domains--some ruled by absolutes of right and wrong, others in which legitimate uncertainty is prevalent. In these areas of legitimate uncertainty, however, there is no hierarchy of values--in essence "Everyone has a right to her own opinion."

In particular, Ellen seems to have adopted a position of escape into dissociation, described by Perry in terms of a passive delegation of responsibility to fate. These positions are in keeping with Ellen's relatively low relationship scores (suggestive of loose construing) and her tendencies to low self-esteem and lack of perceived personal responsibility for her actions as teacher or for her curricular choices.

In reflecting on his original work Perry suggested that he had underestimated the tendency of undergraduates to, in face of incessant change and a flood of new ideas, select alternatives to growth. These alternatives are not necessarily permanent and may merely represent a "gathering of energy" (in Kelly's terms a loosening of constructs in preparation for regrouping at a higher level) as the undergraduate assimilates new structures.

These case studies suggest that alternatives may indeed be more prevalent than previously thought. The permanence of these effects can only be known through time. However, temporization, such as Susan exhibits, seems more normal and less serious to someone on the verge of a major life-change (graduation) than does the escape of Laura or the dissociation of Ellen.

Discussion

If preservice teachers are thought of as active processors of information, then the lenses through which they view experience play a central role in determining the decisions each individual will make as a teacher. Although these lenses are as unique as the individual whose construct system they form, certain constructs--based on the sharing of experiences and language common to students in high school and teacher preparation programs--seem prevalent among the preservice teachers on which this study is based.

The preservice teacher's view of mathematics appears based more on the individual's prior academic success with the subject than with an involvement with or interest in the nature of mathematics. "Mathematics," primarily computation and algorithms characterized by solving equations, has "come easy" to the individual. This construct of "easy mathematics," coupled with an anticipated use of mathematics as a secondary teacher gleaned primarily from student experiences, guides the individual's interpretation of mathematical experience. This view may result in avoidance, rejection, or alienation of the implications of higher mathematics.

Through this lens word problems may be seen as confusing or intimidating and proof as mere aberration (limited to one geometry course and higher, irrelevant mathematics) than central to the subject. Creativity is a two-edged sword--admired as a goal, but threatening as a task. Similarly, advanced mathematics causes mixed emotions; but whether it is viewed positively or negative, there seems little understanding of its purposes or applications.

The evidence presented here suggests a tendency for the construct systems of some preservice teachers, relative to the role of "teacher", to develop in a manner that identifies the individual with a previous "best mathematics teacher" from their high school experience. This teacher may or may not be idealized. Whether the individual's constructs that relate to teaching roles developed because of this "best teacher", existed before and found this teacher as a "kindred spirit", or developed in concert with successive role models (which I suspect is the most likely explanation) is not known.

Teachers, as well as the mathematics itself, tend to be viewed in terms of emotional constructs. Personal qualities such as motivation and respect outweighed and tended to influence the participants' judgments of teachers' intellectual standings. Secondary mathematics students are generally viewed as unenthusiastic toward mathematics and of relatively low intellectual capacity. Peers played little role in the preservice teachers' conception systems.

Conceptions of Mathematics

A three-tiered view of mathematics appeared to be operating in the participants' description of their knowledge. On one level is the knowledge necessary to explain a series of procedures or solve a given mathematical problem stated in a mathematics textbook. This level 1 knowledge was seen by the participants as relevant to teaching secondary mathematics.

The second level constitutes knowledge pertaining to word problems, applications, and problem solving. These are seen as necessary for mathematics to be "useful" but are approached with a degree of uncertainty. As teachers the participants seemed to perceive their role as reducing such exercises to the form of level 1 questions--primarily in terms of groupings of word problems with clearly prescribed algorithms to be practiced.

In the participants' experiences certainty has played a significant role in their contact with mathematics--the "certainty" of equation solving providing particular satisfaction. Providing this "certainty" for their students and maintaining it for themselves as teachers make mathematics "easy" and "easy to teach."

The third level concerns abstraction and proof. These ideas are seen as more appropriate for advanced mathematics than for secondary mathematics or secondary mathematics teachers and may be reduced to level 1 questions--"proof" becomes a series of prescribed steps in geometry and generalizations become algorithms or definitions. These ideas are described not as central to mathematics but as somewhat irrelevant to the participants' own conceptions and to their anticipated uses of mathematics in the classroom.

Manifestation of the participants' understanding of secondary school mathematics can be described along an "integrated/active versus dissociated/passive" continuum expressing the degree to which the individual feels mathematics is an integrated part of daily life and the level of personal responsibility each feels for the development of mathematical understanding.

The extremes of this continuum can be characterized by Susan and Ellen. Susan approached an unknown topic in mathematics as "I don't know this, but I know other things that relate to it and I can probably work through it." She appeared to be actively creating (or recreating) mathematics. Mathematics, albeit at a relatively low level, was recognized as a normal and important component of her daily existence.

Ellen's approach can be characterized as "I don't know and that's all right. I'll know it if I need to teach it later." The need to be able to clearly illustrate and explain mathematics other than giving precise instructions in specific teaching situations seemed somewhat irrelevant. Mathematics appeared to be a sometimes interesting sidelight, but not a part of her life.

The remaining participants demonstrated variations of positions along this continuum. Laura's reaction can be described by "I don't know this, but I should. I have been taught this somewhere." This is essentially a passive approach viewing mathematics as an accumulation of facts and strategies to be remembered. Mathematics is a part of her life only to the extent that she has invested a sense of self-worth in her ability to perform in this area she sees as "respected."

Tim seems to have accepted mathematics as more central to his everyday life than Laura. However, he differs from Susan in that his view of "useful" mathematics is not necessarily related to "school mathematics," but to a more practical conception of mathematics. This suggests that the integration of mathematics (for a mathematics teacher) must be qualified by the degree to which it can be associated by the individual with mathematics in the classroom. Tim's mathematics, as indicated by his constructs, may be more appropriate in a "shop math" course versus Susan's "academic track" approach.

Tim also exhibits a degree of passivity in his approach to mathematics in the area of assigning responsibility for the creation and nature of mathematics. While he wants to "do it himself," he sees mathematics as primarily an established body of facts from which he can choose tools with which to work. Creating those tools or questioning their efficacy is not his purview.

Higher Mathematics

Mathematics in the participants' high school curriculums and through college calculus was perceived as a generally linear progression --each course (with the exception of geometry) was viewed as preparation for the next, leading toward the calculus. After calculus, however, mathematics "turned in on itself." No longer was previous attainment or hard work sufficient for guaranteed success, nor were "certain" answers inevitable. No longer was this "mathematics" as they had known and at which they had been so successful.

Tim experienced difficulty with abstraction earlier than the others ("the deltas and epsilons of calculus") and tended to resist the implications of higher mathematics. Susan, Laura, and Ellen were confused and distressed by this new look at mathematics--precipitating in each a crises in her conception of mathematics and in her ability to continue earlier successes. Although each responded in a different manner, a common thread was the observation that the courses in higher mathematics had made them "like" mathematics a little less (including Susan who philosophically accepted this "different" mathematics).

The constructs related to mathematics tended to emphasize simplicity--"easy", "easy to teach", "advanced" (viewed negatively or strictly from a curriculum perspective), "most useful" (describing consumer applications), "creative" (in a negative, intimidating sense). Similarly the low intensity scores can be interpreted to describe the participants' conception of mathematics as inherently "organized", "exact", "conclusive", and un-"invigorating".

Armed with these constructs, the preservice teacher faces not courses designed to develop constructs more conducive to Thompson's (1982) "integrated, comprehensive, reflective" view of secondary school mathematics, but courses that change entirely the ground rules they have come to understand as defining mathematics.

Confronted with this "crises" and, except in Susan's case, without the relativistic structures with which to interpret mathematics in a broader sense--and with an anticipatory schema that sees little use for this content--alternatives to growth should not seem surprising. Tim's rejection of abstraction, Ellen's dissociation from decisions concerning content, and Laura's assignment of judgment to others are examples of these alternatives.

Constructs related to roles associated with mathematics teaching can be used to support this hypothesis. Role characteristics that play a central function in the participants' evaluative systems center on benevolent, emotional concerns. Constructs formed throughout the secondary school experience tend (with the possible exception of Ellen's case) to identify the participants closely with favorite teachers.

But the college mathematics professor is seen as very different from this role model. Without the structures with which to evaluate each model (professor, high school teacher) in its own context, the professor presents a model at conflict with the preservice teacher's anticipated role as teacher--further removing higher mathematics from a developmental role in the students' conceptions of the subject.

Going Home

Each of the participants in the study anticipates returning to the school system from which he/she graduated. (Although Susan has yet to decide whether or not she will teach, she expressed a preference to teach in her home, or a similar, system). Each expressed a feeling of comfort at returning to their previous school system. Only one, Tim, actively pursued a position in a system generally considered to be of different socio-economic status, or with different academic emphasis, from his/her home system. Tim's attempt was based on personal reasons unrelated to the teaching position or school system involved.

The participants also tended to take teaching positions for the coming year that reflected their conceptions of mathematics and teaching. Susan preferred a position teaching advanced mathematics; Laura will teach middle school mathematics--a position she sees as involving the teaching of basic (exact) skills; Tim will teach remedial mathematics in a preparation program for the state basic skills exam--a position he sees as demanding strong discipline and "practical" mathematics; Ellen will also teach middle school mathematics, although she expressed no preference other than finding a position close to her home.

This tendency to return home suggests the power of past experiences and role models in determining the participants' future. It may further suggest, if this trend is generally true, a degree of "inbreeding" among school systems. Similarly, the selection of a position (to the extent that it is the participant's choice) suggests the participants are controlled by--but not necessarily aware of--these constructs in their selection of teaching positions.

Implications for Teacher Education

When I walk into my doctor's office I expect him to have a broad and deep knowledge of common maladies and to be able to communicate effectively with me so that he may discover symptoms that may require further investigation. I do not expect him to know the intricacies of brain surgery or to be thoroughly conversant in molecular biology. Neither do I consider him less a doctor for these "shortcomings." In fact, if my doctor had spent his medical school days studying gene splicing or the subtleties of DNA to the exclusion of intensive work in diagnosing and treating common ailments, I would most likely seek out another doctor.

When I observe a teacher or a student teacher I similarly look for a broad and deep knowledge of the mathematics at hand and the ability to communicate effectively, recognizing student conceptions and their implications. I do not look for a topologist or a algebraisist, nor do I think the teacher less a "mathematician" for not having proven Godel's Theorem. But the fact is that the teacher likely has had little or no contact with the mathematical content of the secondary curriculum during the college years, except to the extent that basic operations of algebra are used in other courses. It is little wonder the teacher looks on the material of the secondary curriculum as inconsequential except as preparation for "real" mathematics, and on him/herself as anything but a mathematician.

The secondary curriculum is perceived by the preservice teacher as focusing on the mechanics of "equation solving" as the measure of mathematical competence--beyond arithmetic, mathematics serves little purpose other than preparation for still more mathematics. The college curriculum attempts to "enlighten" the teacher mathematically not by expanding his/her conceptions of secondary mathematics but by the wholesale introduction of new perspectives and ideas. The coursework appears to be based on Freudenthal's (1972) observation that

> Educational programmes and methods are influenced by a belief which is natural for every mathematician, that mathematical education is education to become a mathematician. (p. 73).

The preservice mathematics teacher neither has the constructs with which to interpret these experiences as relevant nor incentive to do so.

I do not question the assertion that set theory, analysis, or the notion of "function" can serve as powerful structures which permeate mathematics anymore than I question the centrality of DNA in human physiology. These structures, however, are not relevant to the preservice teacher. If they are to be, then the current mathematical preparation of teachers at the college level is in conflict with the preservice teachers conceptions of mathematics and mathematics teaching, and programs must be redesigned to take these conceptions into account.

However, an alternative exists if the aim of the secondary mathematics curriculum is genuinely taken to be the development of problem-solving skills and an appreciation of the power and presence of mathematics. Preservice teachers are guided by a belief that mathematics is inherently useful and that secondary mathematics can be an easy, intuitive subject. Building on these conceptions and strengths suggests a teacher preparation program that prides itself on the development of context within which the stuff of secondary mathematics can develop and becomes valuable in and of itself--not for some possible future.

To the extent that teachers see their role as primarily that of social director, "tending" the transmission of material over which they have no charge, "mathematics" and "education" must remain mutually exclusive sets. The teacher education program should provide a laboratory in which the preservice teacher can examine his/her own role and the roles of others--Brown (1982) uses the metaphor of "group therapy" to describe such a process. Within this program mathematics serves as a "central construct rather than as a control variable in the teaching of mathematics" (Shulman, 1985).

References

Brown, S. I. (1982). On humanistic alternatives in the practice of teacher education. Journal of Research and Development in Education, 4, 1-12.

Bush, W. S. (1982). Preservice secondary mathematics teacher's knowledge about teaching mathematics and decision-making processes during teacher training. Unpublished doctoral dissertation, University of Georgia.

Byers, B. (1983). Beyond structure: Some thoughts on the nature of mathematics. Proceedings of the Fifth Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.

Confrey, J. (1984). An examination of the conceptions of mathematics of young women in high school. Paper presented at the Annual Meeting of the American Educational Research Association.

Confrey, J., & Lanier, P. (1980). Students mathematical abilities: A focus for the improvement of general mathematics. School Science and Mathematics, 80, 549-556.

Cooney, T. J. (1984). The contribution of theory to mathematics teacher education. Paper presented at the Fifth International Congress on Mathematical Education.

Cooney, T. J. (1980). Research on teaching and teacher education. In R. J. Shumway (Ed.), Research in mathematics education. Reston, VA: National Council of Teachers of Mathematics.

Cornbleth, C. (1986). Ritual and rationality in teacher education reform. Educational Researcher, 15(4), 5-14.

Erlwanger, S. (1975). Case studies of children's conceptions of mathematics, part 1. The Journal of Children's Mathematical Behavior, 1, 157-283.

Fransella, F., & Bannister, D. (1977). A manual for repertory grid technique. New York: Academic Press.

Freudenthal, H. (1973). Mathematics as an educational task. Dordretch-Holland: Reidel.

Herscovics, N., & Chalouh, L. (1985). Conflicting frames of reference in the learning of algebra. Proceedings of the Seventh Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.

Hudson, L. (1968). Frames of mind. New York: Norton.

Kelly, G. A. (1955). The psychology of personal constructs. Volume 1: A theory of personality. New York: Norton.

Owens, J. E. (1987). A study of four preservice secondary mathematics teachers' constructs of mathematics and mathematics teaching. Unpublished doctoral dissertation, University of Georgia.

Perry, W. G. (1970). Forms of intellectual and ethical development in the college years: A scheme. New York: Holt, Rinehart and Winston.

Shulman, L. S. (1985). The study of knowledge in teaching. Paper presented at the Annual Meeting of the American Educational Research Association.

Thompson, A. G. (1984). The relationship of teachers' conceptions of mathematics and mathematics teaching to instructional practice. Educational Studies in Mathematics, 15(1), 105-127.

SUMMARY RANK ORDER GRID - TOPICS
RELATIONSHIP SCORES / RANK

	SUSAN	LAURA	TIM	ELLEN	TOTAL	
1 invigorating	203/15 100/15		549/5	277/12	1129/15	boring
2 easy	413/8	780/1	539/8	532/3	2264/1	difficult
3 abstract	475/5	450/13	398/11	294/9	1617/11	concrete
4 easiest to learn	292/11	670/3	507/9	469/6	1938/6	hardest to learn
5 essential	327/9	580/6	549/5	178/14	1634/10	unnecessary
6 varied	550/1	478/11	155/15	533/1	1716/9	routine
7 advanced	543/2	670/3	392/12	412/7	2017/4	basic
8 most useful	536/3	580/6	549/5	294/9	1959/5	least useful
9 best at	264/13	666/5	603/1	373/8	1906/7	worst at
10 organized	295/10	422/14	603/1	112/15	1432/13	disorganized
11 conclusive	241/14	552/9	261/13	255/13	1309/14	inconclusive
12 exact	273/12	552/9	184/14	504/5	1513/12	arbitrary
13 creative	448/6	678/2	493/10	533/1	2152/2	standard
14 most liked	478/4	473/12	601/3	292/11	1844/8	least liked
15 easiest to teach	416/7	571/8	601/3	532/3	2120/3	hardest to teach

SUMMARY RANK ORDER GRID - ROLES
RELATIONSHIP SCORES / RANK

	SUSAN	LAURA	TIM	ELLEN	TOTAL	
1 intelligent	684/11	430/16	569/5	417/6	2200/10	dumb
2 interesting	902/6	699/2	324/12	456/4	2381/5	dull
3 organized	819/9	583/8	542/10	410/7	2354/6	sloppy
4 serious	296/17	547/11	565/9	507/2	1915/14	fun-loving
5 personable	852/8	573/9	190/17	507/2	2122/11	cold
6 encouraging	970/1	699/2	530/11	391/8	2590/3	intimidating
7 inquisitive	970/1	430/16	692/3	513/1	2605/2	unconcerned
8 aggressive	902/6	515/13	722/2	194/15	2333/8	passive
9 conscientious	528/15	543/12	688/4	276/13	2035/13	lacksadasical
10 flexible	679/12	679/5	253/16	456/4	2067/12	rigid
11 abstract	652/13	564/10	306/13	142/16	1664/17	concrete
12 complex	652/13	487/14	293/14	383/9	1815/15	one-dimensional
13 respected	912/4	701/1	669/5	330/11	2611/1	discreditable
14 authoritative	819/9	487/14	723/1	323/12	2352/7	unreliable
15 motivating	970/1	694/4	667/7	223/14	2554/4	deadening
16 reliable	912/4	615/6	508/8	115/17	2250/9	unreliable
17 people-oriented	450/16	584/7	291/15	374/10	1699/16	content-oriented

TABLE #1

SUSAN'S RANK ORDER GRID - TOPICS

	DOING PROOF	GRAPH EQN.	WORD PROB	SOLVE EQN.	WORK FRAC	PROB STAT	
1 invigorating	5	1	3	2	4	6	boring
2 easy	3	4	5	1	2	6	difficult
3 abstract	3	1	2	5	6	4	concrete
4 easiest to learn	6	5	3	2	1	4	hardest to learn
5 essential	6	2	1	4	5	3	unnecessary
6 varied	3	2	1	5	6	4	routine
7 advanced	4	2	1	5	6	3	basic
8 most useful	3	4	1	5	6	2	least useful
9 best at	4	1	5	2	3	6	worst at
10 organized	1	5	2	6	3	4	disorganized
11 conclusive	1	6	2	3	4	5	inconclusive
12 exact	1	5	4	3	2	6	arbitrary
13 creative	2	3	1	4	6	5	standard
14 most liked	6	4	5	1	2	3	least liked
15 easiest to teach	6	2	5	3	1	4	hardest to teach

SUSAN'S RANK ORDER GRID - TOPICS
CORRELATION MATRIX - SIGNIFICANT @ P<.05

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
III								+++							1
	III						---								2
		III			+++	+++									3
			III												4
				III		+++									5
					III	+++						+++			6
						III	+++								7
							III								8
								III							9
									III						10
										III					11
											III				12
												III			13
													III		14
														III	15

SUSAN'S RANK ORDER GRID - ROLES

	MATH ED. MAJOR	MATH PROF	BEST MATH TEACH	ME	H.S. MATH STUD.	WORST MATH TEACH	
1 intelligent	4	2	1	3	6	5	dumb
2 interesting	5	4	1	2	3	6	dull
3 organized	4	2	1	3	5	6	sloppy
4 serious	1	4	3	5	6	2	fun-loving
5 personable	4	5	1	2	3	6	cold
6 encouraging	4	3	1	2	5	6	intimidating
7 inquisitive	4	3	1	2	5	6	unconcerned
8 aggressive	5	4	1	2	3	6	passive
9 conscientious	2	3	1	4	6	5	lacksadasical
10 flexible	5	4	3	1	2	6	rigid
11 abstract	4	5	3	1	2	6	concrete
12 complex	4	5	3	1	2	6	one-dimensional
13 respected	3	4	1	2	5	6	discreditable
14 authoritative	4	2	1	3	5	6	unreliable
15 motivating	4	3	1	2	5	6	deadening
16 reliable	3	4	1	2	5	6	unreliable
17 people-oriented	3	5	4	1	2	6	content-oriented

SUSAN'S RANK ORDER GRID - ROLES
CORRELATION MATRIX - SIGNIFICANT @ p<.05

2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
	+++			+++	+++		+++					+++	+++			1
III			+++	+++	+++	+++		+++					+++			2
	III			+++	+++						+++	+++	+++	+++		3
		III						---								4
			III			+++			+++	+++	+++			+++		5
				III	+++	+++					+++	+++	+++	+++		6
					III	+++					+++	+++	+++	+++		7
						III		+++					+++			8
							III									9
								III	+++	+++					+++	10
									III	+++					+++	11
										III					+++	12
											III	+++	+++	+++		13
												III	+++	+++		14
													III	+++		15
														III		16
															III	17

TABLE #2

LAURA'S RANK ORDER GRID - TOPICS

	DOING PROOF	GRAPH EQN.	WORD PROB	SOLVE EQN.	WORK FRAC	PROB STAT	
1 invigorating	6	3	1	2	5	4	boring
2 easy	6	3	5	2	1	4	difficult
3 abstract	1	2	4	3	6	5	concrete
4 easiest to learn	6	4	5	3	1	2	hardest to learn
5 essential	6	5	4	3	1	2	unnecessary
6 varied	3	4	1	6	5	2	routine
7 advanced	1	3	2	4	6	5	basic
8 most useful	6	5	4	3	1	2	least useful
9 best at	6	3	4	2	1	5	worst at
10 organized	4	2	6	1	3	5	disorganized
11 conclusive	6	2	4	1	3	5	inconclusive
12 exact	6	2	4	1	3	5	arbitrary
13 creative	2	4	1	5	6	3	standard
14 most liked	6	1	4	2	3	5	least liked
15 easiest to teach	6	3	5	4	1	2	hardest to teach

LAURA'S RANK ORDER GRID - TOPICS CORRELATION MATRIX - SIGNIFICANT @ P<.05

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
III															1
	III		+++			---		+++				---			2
		III	---	---		+++	---								3
			III	+++		---	+++							+++	4
				III		---	+++							+++	5
					III				---			+++			6
						III	---							---	7
							III							+++	8
								III		+++	+++	---			9
									III						10
										III	+++		+++		11
											III		+++		12
												III			13
													III		14
														III	15

LAURA'S RANK ORDER GRID - ROLES

	MATH ED. MAJOR	MATH PROF	BEST MATH TEACH	ME	H.S. MATH STUD.	WORST MATH TEACH	
1 intelligent	5	3	1	4	6	2	dumb
2 interesting	4	5	1	2	3	6	dull
3 organized	4	2	1	3	5	6	sloppy
4 serious	3	1	4	5	6	2	fun-loving
5 personable	4	6	1	2	3	5	cold
6 encouraging	4	5	1	2	3	6	intimidating
7 inquisitive	5	3	1	4	6	2	unconcerned
8 aggressive	3	2	1	4	6	5	passive
9 conscientious	4	3	2	1	6	5	lacksadasical
10 flexible	4	5	2	1	3	6	rigid
11 abstract	4	2	3	5	6	1	concrete
12 complex	5	2	3	4	6	1	one-dimensional
13 respected	4	3	1	2	5	6	discreditable
14 authoritative	4	1	2	3	6	5	unreliable
15 motivating	3	4	1	2	5	6	deadening
16 reliable	3	4	1	2	6	5	unreliable
17 people-oriented	4	5	3	2	1	6	content-oriented

LAURA'S RANK ORDER GRID - ROLES CORRELATION MATRIX - SIGNIFICANT @ p<.05

2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
					+++					+++						1
III			+++	+++				+++					+++			2
	III					+++					+++	+++	+++			3
		III							+++						---	4
			III	+++				+++								5
				III				+++					+++			6
					III					+++						7
						III						+++				8
							III				+++		+++	+++		9
								III							+++	10
									III	+++					---	11
										III					---	12
											III		+++	+++		13
												III				14
													III	+++		15
														III		16
															III	17

TABLE #3

TIM'S RANK ORDER GRID - TOPICS

	DOING PROOF	GRAPH EQN.	WORD PROB	SOLVE EQN.	WORK FRAC	PROB STAT	
1 invigorating	6	1	2	3	4	5	boring
2 easy	5	1	4	2	3	6	difficult
3 abstract	2	5	6	3	4	1	concrete
4 easiest to learn	6	3	5	2	1	4	hardest to learn
5 essential	6	1	2	3	4	5	unnecessary
6 varied	6	3	2	4	5	1	routine
7 advanced	1	2	3	5	6	4	basic
8 most useful	6	1	2	3	4	5	least useful
9 best at	6	3	4	1	2	5	worst at
10 organized	6	3	4	1	2	5	disorganized
11 conclusive	1	2	3	4	5	6	inconclusive
12 exact	1	2	5	3	4	6	arbitrary
13 creative	6	2	1	3	4	5	standard
14 most liked	6	3	4	2	1	5	least liked
15 easiest to teach	6	3	4	2	1	5	hardest to teach

TIM'S RANK ORDER GRID - TOPICS
CORRELATION MATRIX - SIGNIFICANT @ P<.05

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
III		—		+++			+++					+++			1
	III														2
		III		—			—					—			3
			III			—		+++	+++				+++	+++	4
				III			+++					+++			5
					III										6
						III				+++					7
							III					+++			8
								III	+++				+++	+++	9
									III				+++	+++	10
										III	+++				11
											III				12
												III			13
													III	+++	14
														III	15

TIM'S RANK ORDER GRID - ROLES

	MATH ED. MAJOR	MATH PROF	BEST MATH TEACH	ME	H.S. MATH STUD.	WORST MATH TEACH	
1 intelligent	4	1	2	3	6	5	dumb
2 interesting	4	5	3	2	1	6	dull
3 organized	3	2	4	1	5	6	sloppy
4 serious	3	1	4	2	5	6	fun-loving
5 personable	3	6	2	1	5	4	cold
6 encouraging	6	2	1	3	4	5	intimidating
7 inquisitive	5	1	2	3	4	6	unconcerned
8 aggressive	4	3	2	1	5	6	passive
9 conscientious	5	2	3	1	4	6	lacksadasical
10 flexible	2	5	4	3	6	1	rigid
11 abstract	3	1	5	4	6	2	concrete
12 complex	3	1	4	6	5	2	one-dimensional
13 respected	4	2	1	3	6	5	discreditable
14 authoritative	4	1	2	3	6	5	unreliable
15 motivating	5	3	1	2	4	6	deadening
16 reliable	4	3	2	1	6	5	unreliable
17 people-oriented	2	6	3	4	1	5	content-oriented

TIM'S RANK ORDER GRID - ROLES
CORRELATION MATRIX - SIGNIFICANT @ p<.05

2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
					+++						+++	+++				1
III									—	—						2
	III	+++				+++	+++									3
		III				+++						+++				4
			III													5
				III	+++						+++		+++			6
					III		+++				+++	+++	+++			7
						III	+++					+++		+++		8
							III						+++			9
								III								10
									III	+++					—	11
										III						12
											III	+++	+++			13
												III				14
													III			15
														III		16
															III	17

TABLE #4

ELLEN'S RANK ORDER GRID - TOPICS

	DOING PROOF	GRAPH EQN.	WORD PROB	SOLVE EQN.	WORK FRAC	PROB STAT	
1 invigorating	5	2	3	1	6	4	boring
2 easy	5	2	6	1	3	4	difficult
3 abstract	1	3	6	2	4	5	concrete
4 easiest to learn	5	1	6	2	3	4	hardest to learn
5 essential	6	4	2	3	1	5	unnecessary
6 varied	3	4	1	5	6	2	routine
7 advanced	2	4	3	5	6	1	basic
8 most useful	6	4	1	3	5	2	least useful
9 best at	5	2	3	1	4	6	worst at
10 organized	1	5	3	2	4	6	disorganized
11 conclusive	2	5	6	4	1	3	inconclusive
12 exact	5	3	6	2	1	4	arbitrary
13 creative	3	4	1	5	6	2	standard
14 most liked	4	2	3	1	6	5	least liked
15 easiest to teach	5	2	6	1	3	4	hardest to teach

ELLEN'S RANK ORDER GRID - TOPICS
CORRELATION MATRIX - SIGNIFICANT @ P<.05

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
III													+++		1
	III		+++								+++			+++	2
		III					—								3
			III											+++	4
				III											5
					III	+++					—	+++			6
						III						+++			7
							III								8
								III					+++		9
									III						10
										III					11
											III	—	+++		12
												III			13
													III		14
														III	15

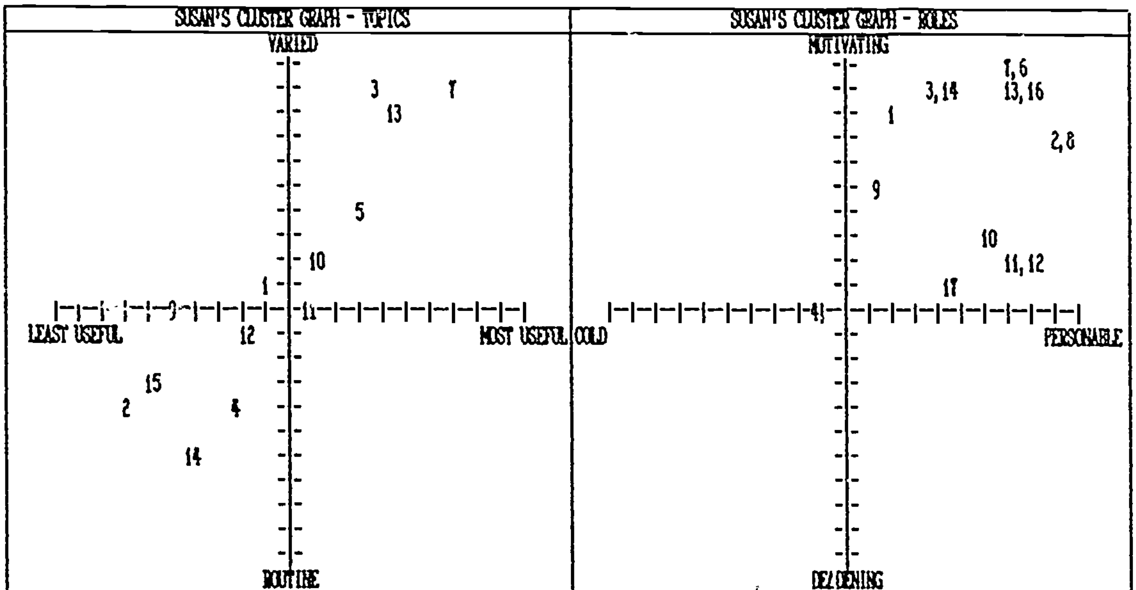
ELLEN'S RANK ORDER GRID - ROLES

	MATH ED. MAJOR	MATH PROF	BEST MATH TEACH	ME	H.S. MATH STUD.	WORST MATH TEACH	
1 intelligent	4	2	1	5	6	3	dumb
2 interesting	1	5	2	4	3	6	dull
3 organized	2	3	1	5	6	4	sloppy
4 serious	4	3	2	5	6	1	fun-loving
5 personable	3	5	4	2	1	6	cold
6 encouraging	2	5	1	3	4	6	intimidating
7 inquisitive	2	5	4	3	1	6	unconcerned
8 aggressive	2	1	4	3	5	6	passive
9 conscientious	1	5	2	6	3	4	lacksadasical
10 flexible	1	5	4	3	2	6	rigid
11 abstract	3	2	6	5	1	4	concrete
12 complex	1	2	3	5	6	4	one-dimensional
13 respected	4	1	5	2	3	6	discreditable
14 authoritative	1	2	3	6	5	4	unreliable
15 motivating	3	5	6	4	2	1	deadening
16 reliable	6	3	2	5	1	4	unreliable
17 people-oriented	4	5	1	3	2	6	content-oriented

ELLEN'S RANK ORDER GRID - ROLES
CORRELATION MATRIX - SIGNIFICANT @ p<.05

2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
	+++															1
III				+++				+++								2
	III									+++						3
		III	—		—			—								4
			III		+++			+++								5
				III												6
					III			+++								7
						III										8
							III									9
								III								10
									III							11
										III		+++				12
											III					13
												III				14
													III			15
														III		16
															III	17

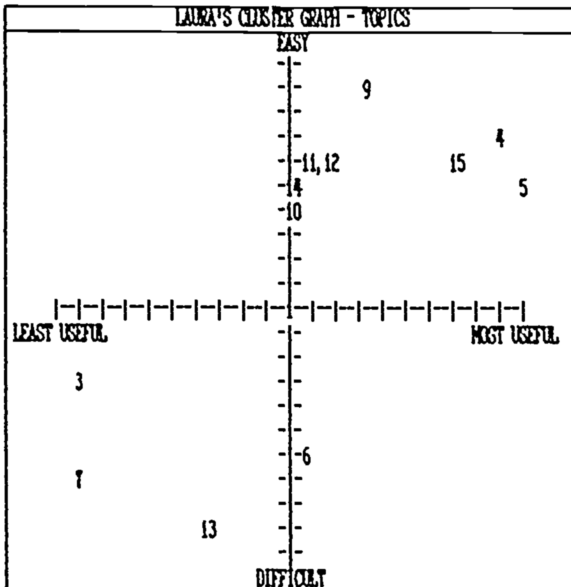
TABLE #5



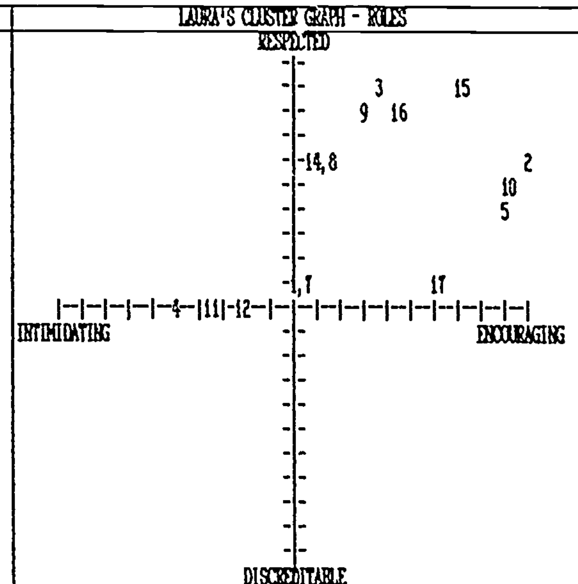
1-invigorating, 2-easy, 3-abstract, 4-easiest to learn, 5-essential, 6-varied, 7-advanced, 8-most useful, 9-best at, 10-organized, 11-conclusive, 12-exact, 13-creative, 14-most liked, 15-easiest to teach

1-intelligent, 2-interesting, 3-organized, 4-serious, 5-personable, 6-encouraging, 7-inquisitive, 8-aggressive, 9-conscientious, 10-flexible, 11-abstract, 12-complex, 13-respected, 14-authoritative, 15-motivating, 16-reliable, 17-people-oriented

FIGURE #1

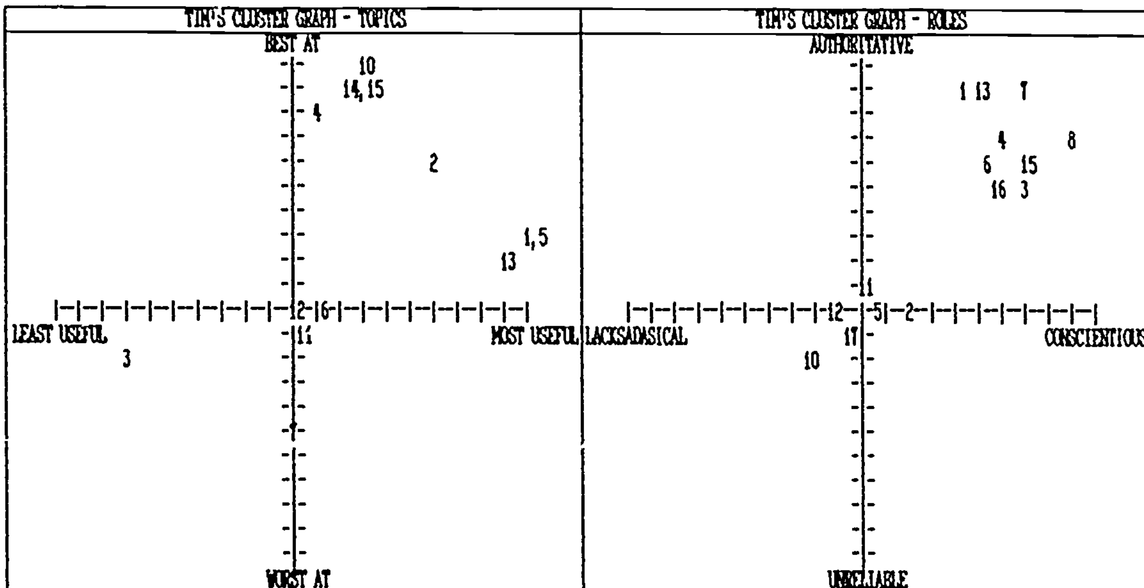


1-invigorating, 2-easy, 3-abstract, 4-easiest to learn, 5-essential, 6-varied, 7-advanced, 8-most useful, 9-best at, 10-organized, 11-conclusive, 12-exact, 13-creative, 14-most liked, 15-easiest to teach



1-intelligent, 2-interesting, 3-organized, 4-serious, 5-personable, 6-encouraging, 7-inquisitive, 8-aggressive, 9-conscientious, 10-flexible 11-abstract, 12-complex, 13-respected, 14-authoritative, 15-motivating, 16-reliable, 17-people-oriented,

FIGURE #2



1-invigorating, 2-easy, 3-abstract, 4-easiest to learn, 5-essential, 6-varied, 7-advanced, 8-most useful, 9-best at, 10-organized, 11-conclusive, 12-exact, 13-creative, 14-most liked, 15-easiest to teach	1-intelligent, 2-interesting, 3-organized, 4-serious, 5-personable, 6-encouraging, 7-inquisitive, 8-aggressive, 9-conscientious, 10-flexible 11-abstract, 12-complex, 13-respected, 14-authoritative, 15-motivating, 16-reliable, 17-people-oriented,

FIGURE #3

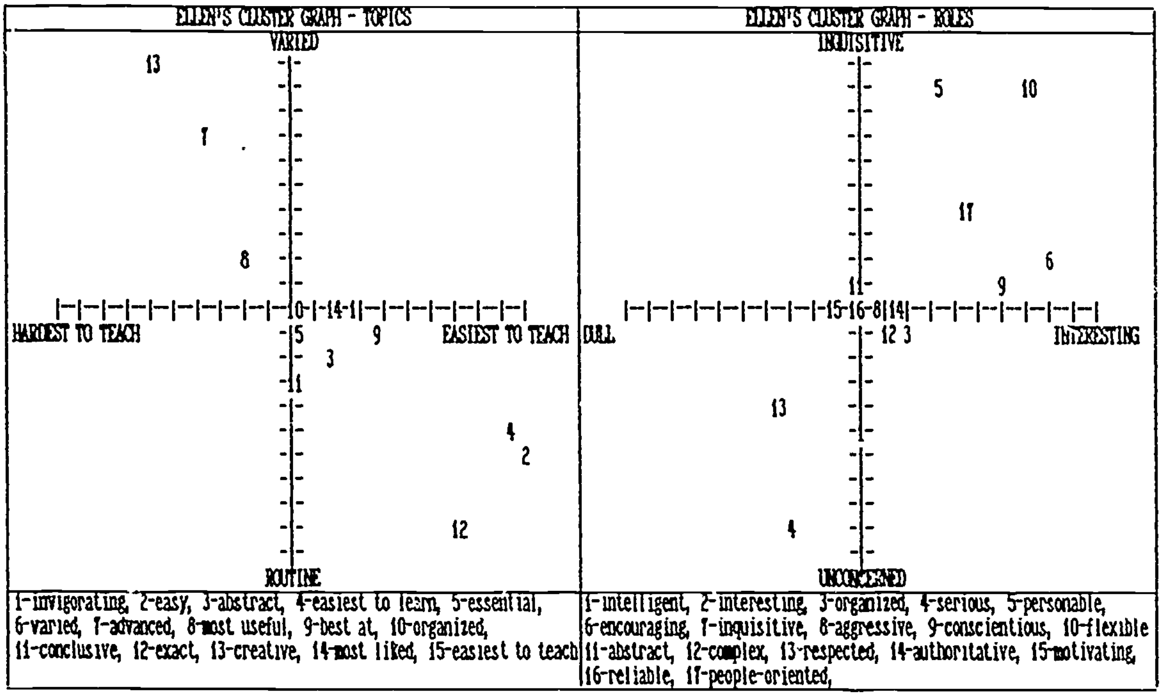

ELLEN'S CLUSTER GRAPH - TOPICS
VARIED
HARDEST TO TEACH
EASIEST TO TEACH
ROUTINE
1-invigorating, 2-easy, 3-abstract, 4-easiest to learn, 5-essential,
6-varied, 7-advanced, 8-most useful, 9-best at, 10-organized,
11-conclusive, 12-exact, 13-creative, 14-most liked, 15-easiest to teach
ELLEN'S CLUSTER GRAPH - ROLES
INQUISITIVE
DULL
INTERESTING
UNCONCERNED
1-intelligent, 2-interesting, 3-organized, 4-serious, 5-personable,
6-encouraging, 7-inquisitive, 8-aggressive, 9-conscientious, 10-flexible
11-abstract, 12-complex, 13-respected, 14-authoritative, 15-motivating,
16-reliable, 17-people-oriented,

FIGURE #4