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ABSTRACT

A longitudinal case study was conducted to explore changes in how beginning science teachers conceptualize science teaching. The current study explored the development of two of these teachers who were chosen because of their contrasting levels of expertise after their first semester of independent teaching. The research was designed to elicit the participants' personal beliefs about science teaching and science teachers. Three data collection methods, concept mapping, a repertory grid interview technique and stimulated recall interviews were used to allow triangulation. Data were collected as early as possible in the preservice year, at the end of that year and after one and three semesters of independent teaching. The initial stimulated recall interview for each participant occurred during the first continuous 3-week teaching experience. Findings raised questions about possible implications for selection, preservice education, and induction of science teachers to enhance the quality of the contribution of new members of the profession. Appendixes show the frequencies of comments in different categories in each stimulated recall interview, the focused forms of each repertory grid, and concept maps drawn at each stage. (Contains 26 references.) (LL)

HOW DO SCIENCE TEACHERS BECOME PROFESSIONALS?

Implications of Case Studies of Two Beginning Teachers.

A paper given at the Annual Conference of the A.T.E.A.

Brisbane, July 1994

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HOW DO NEW SCIENCE TEACHERS BECOME PROFESSIONALS?

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ABSTRACT

A longitudinal case study has been exploring the changes that occur in how beginning science teachers conceptualise science teaching. The study began at the commencement of their one-year pre-service Diploma in Education course and has followed them into their first year of teaching.

This paper explores the development of two of these teachers. These were chosen because of their contrasting levels of expertise after their first semester of independent teaching. The findings raise questions about possible implications for selection, pre-service education and induction of science teachers to enhance the quality of the contribution of such new members of the profession.

RATIONALE

Teacher educators are keenly aware that from the time of their first classroom experience some aspiring teachers appear reasonably competent, others slowly achieve a satisfactory level of expertise as teachers, and some, despite their apparent effort and desire to achieve do not make significant progress. Disparity in expertise continues into the early and later years of independent teaching, but "improvement" does not appear to be directly correlated with initial competence.

PREVIOUS STUDIES

Recent educational research has acknowledged the complexity of teaching, often using qualitative methods to investigate aspects of the task and role which do not lend themselves to direct measurement. Teacher thinking was an early field of investigation to use qualitative methods, either newly developed, or adapted from other fields of research. Clark (1986), and Clark and Peterson (1986) reviewed research developments in the area of teacher thinking for the preceding ten year period, documenting changes in the way the researchers had conceptualised the mental processes occurring during teaching, at the stages of planning, interactive teaching and post-lesson reflection. These studies generally investigated experienced teachers. Such studies had also explored interaction amongst such variables as planning and classroom interaction, student behaviour and teacher decisions.

Towards the end of that decade researchers explored interaction between teachers' implicit theories and beliefs and various aspects of their behaviour. Campbell (1985) identified nine categories of variables which influenced student teachers' behaviour and decisions. The category which seemed most influential in all phases of the teaching process was "Student teachers' ideas, beliefs and characteristics".

Findings of the studies included unexpected contrasts: some teachers behaved in ways consistent with stated theories, others held conflicting theories and seemed to act from different theories under different circumstances (e.g. Nespor, 1985; Elbaz, 1983).

Conflict and interaction between teacher theories and beliefs and administrative and curriculum decisions received some attention. These studies heightened awareness of the complexity of teaching and of interactions between personal beliefs and attitudes, learned techniques, knowledge, experience and the teaching context.

More recent studies have continued to explore such interaction and have often focused on beginning teachers, and/or those at the preservice stage, (e.g. Borko, Livingstone, Mc Caleb and Mauro, 1988; Busher, Clarke and Taggart,1988; Morine-Dershimer, 1989). Some have involved longitudinal case studies of individuals or small groups (e.g. Russell, 1988; Baird, Fensham, Gunstone and White, 1987; Hoz, Tomer and Tamir, 1990, Gudmunsdottir, 1991)

Another significant influence in research in science education has been the emerging emphasis on a constructivist understanding of the learning process. This study was based on the premise that aspiring science teachers have at least fifteen years' experience as students in science classrooms and bring with them knowledge, attitudes and beliefs about teaching as they commence their pre-service teacher education course (Feiman-Nemser & Buchmann, 1986). It was believed that these would influence their perceptions of the teachers and classrooms they observed and their interpretation of theories and methods discussed in the course of their study, and their implicit and explicit personal theories.

THIS STUDY

The study was designed to elicit the participants' personal beliefs about science teaching and science teachers at four stages and to trace changes in these. Three data collection methods were used to allow triangulation. The methods were concept mapping, a repertory grid interview technique and stimulated recall interviews.

DATA COLLECTION POINTS.

Data was to be collected at four stages: as early as possible in the pre-service year, at the end of that year and after one and three semesters of independent teaching. The initial stimulated recall interview for each participant occurred during their first continuous three-week teaching experience, in May of their pre-service year. The concept map and repertory grid were developed in January, during their first week of the course. At other stages the three sets of data were gathered within a shorter time span.

Initially eleven students were enrolled in the science methodology unit, and all agreed to participate. Six continued into the following year, having completed the course and obtained a full time teaching position immediately. Participants did not have access to data from earlier stages. The generalised pictures drawn from data collected at the first three stages for two contrasting participants will be reported in this paper. Appendix 1 shows the frequencies of comments in different categories in each stimulated recall interview, focused forms of each repertory grid and the concept maps drawn at each stage by these two participants.

DATA COLLECTION METHODS

Concept Maps

The concept mapping method used the central concept "Science Teaching", and required each participant to generate associated concepts and to arrange these on a large sheet of

paper, beneath the central concept, connecting concepts, using directional arrows and labelling linking lines. Concepts were categorised, and the complexity of the map was also considered in analysing the data (Novak & Gowin, 1984; Fensham, Garrard & West, 1982).

Repertory Grids

The repertory grid method was based on that used by Zuber-Skerritt, (1988). A pro-forma (Appendix 2) was used on which each participant was asked to identify, as elements, two "good" and two "poor" teachers of science. The pro-forma provided two other elements, labelled "Self as science teacher" and "Science teacher I want to become".

A triadic method was used to elicit constructs. The grid pro-forma indicated, on each line, three of the "teachers" for comparison. The participants were asked to choose, from the three, the pair who were "more alike as teachers of science". They then wrote a description of how these two resembled each other, as science teachers, on the left of the grid, and on the right a description of how the other teacher differed from the pair. This method elicited eight constructs, each with both "poles" described. The grid pro-forma provided a ninth construct: "Effective - Ineffective". Participants rated all "teachers" according to how much they resembled the left-hand description of each of the nine constructs.

The FOCUS algorithm of the RepGrid 2 computer program, a distance-based hierarchical cluster analysis technique, was used to sort the constructs and elements according to their similarity (Centre for Person-Computer Studies, 1990). This also produced "matching" scores for both elements and constructs. Categories were developed from the data to enable grouping, as was done with the concepts from the concept map. Frequencies of comments in categories were examined, together with the patterns of the focused grids and the element and construct matching scores.

Stimulated Recall

The stimulated recall interview required the researcher to videotape a lesson taught by the participant. As soon as possible after the lesson, always the same day, the researcher and participant together viewed this videotape and the participant was encouraged to comment on the lesson and tape at any time. Either participant or researcher could stop the videotape to allow this discussion. The interview was audiotaped and transcribed. The transcript was the basis for analysis of the content of the interview. Again categorisation of comments was used as a means of organising the data. The coding was based on that developed by Marland & Osborne (1990) with two additional categories introduced: "Evaluative Comments - Self" and "Evaluative Comments - Other" which were needed to cater for the large number of such comments. Two of the original categories: "Principles of Tactics" and "Models for Classroom Practice" were combined and the merged category renamed "Strategies", as this title more accurately described the comments made by these beginning teachers.

Triangulation

The three types of data collected at each stage were compared seeking common or contradictory themes or emphases (Matheson, 1988). The stimulated recall interviews at each data collection point were analysed first, as the participants' own words, discussing their own teaching, gave a richer picture of their perspectives. This was then compared

with the other two types of data collected at the same stage. The descriptions of beliefs for each participant at the different stages were then compared.

Preliminary analysis of the first three sets of data has indicated that participants did bring with them distinctive attitudes and beliefs about teaching. Some of these were firmly held, so were developed, elaborated and modified over time, rather than undergoing fundamental change.

IMPLICATIONS

A range of expertise was evident, even within the six original participants who successfully completed their pre-service course and obtained teaching positions immediately. Study of individuals' beliefs and attitudes and comparison with measures of the expertise and professionalism at the end of the pre-service year and after one semester of independent teaching may suggest implications for selection, pre-service education and induction of beginning science teachers.

RESULTS

PARTICIPANTS

Generalised results for two participants will be described in this paper. These have been chosen as representing contrasting levels of expertise. Self-chosen pseudonyms will be used. 'Basil' was enrolled in two senior subject areas within science, Biology and Chemistry, and received a rating, at the end of the pre-service year, of '5', the highest available, in both these Units. 'Philip' was awarded a rating of '3', the minimum rating needed to pass the subject. His area of specialisation was Physics. Comments from the Principals of the schools at which Basil and Philip were teaching in their initial year suggested that Basil was considered to be coping very well, while Philip was not and steps were being taken to try to assist him.

BASIL

Basil had attended a relatively small suburban school for boys where his academic achievement was above average, though not outstanding. He entered a Bachelor of Applied Science course, with most subjects chosen from the biological sciences area, and some from chemistry. He passed the course in minimum time, with relatively consistent grades. His final Grade Point Average (on a seven-point scale) was 4.5. After completing the degree at the end of 1990 Basil worked for one year as a sales assistant before entering the Diploma of Education Course.

During Semester 1 of his Diploma of Education course Basil was placed in a junior secondary boys' school and in Semester 2 in the adjacent senior co-educational school. After completing his pre-service course Basil obtained employment in a small inner-city boys' high school, with a large number of migrant and aboriginal students. He was teaching science to one group in each of Years 8, 9 and 10, Chemistry to a combined Year 11 and 12 group, and Religious Education to one class in Year 9.

THE BEGINNING OF THE PRE-SERVICE YEAR

Stimulated Recall Interview

Basil's first stimulated recall interview used the videotape of a lesson with a Year 9 science class. It was a revision lesson on the topic "Bonding". The interview took place immediately after the lesson.

Strategies used in the lesson included oral revision of types of chemical bonds and the use of diagrams both on the board and using the overhead projector. Students worked individually on problems. Correction of their work included taking oral responses and bringing students to the board to illustrate answers. If these were not correct the class was involved in correcting them. When students did not understand one type of problem the teacher explained it. He then set further examples for students to try.

Table 1 in Appendix 1 shows the distribution of Basil's comments in the categories. Evaluative comments were the most frequent, and dealt largely with lesson effectiveness, and students' progress. He used some self-evaluative comments, mostly relating to mannerisms apparent on the videotape.

Repertory Grid Interview

The construct descriptions in this first grid, shown in focused form in Table II of Appendix 1, emphasised clear, interesting communication to students in a way that is relevant to them. In this grid Basil's ratings for "Good Science Teacher 2" were identical with those for the "Science Teacher I Want to Become", indicating the importance of this person as a model. The constructs: "good knowledge and able to convey it" and "able to present topics in an interesting way" were rated identically with the provided construct whose positive pole was "effective". This suggested that these two construct were the most significant in his judging of teacher effectiveness.

Concept Map

Basil's concept map from the beginning of the pre-service year was really a "chain", with only one concept at each level and six concepts generated by him. The words written on the arrows did translate the links into genuine propositions. Some of these propositions resembled the constructs used in the repertory grid. The first four concepts on the map, with linking words, form the proposition: "Teacher uses communication to convey information to students". Both these ideas also appeared as constructs on the repertory grid. Figure 1 in Appendix 1 shows the map.

THE END OF THE PRE-SERVICE YEAR

Stimulated Recall Interview

The lesson which was videotaped for the stimulated recall interview was a Year 11 Biology lesson on protein synthesis and genetic engineering. There was much verbal interaction with students and use of board diagrams. Student involvement and interest were high and Basil seemed confident of the content and was able to incorporate student input. The categories of comments from the interview, which was conducted immediately after the lesson, are shown in Table III in Appendix 1.

As in the first interview the most common comments were evaluative ones, with the majority of these relating to aspects other than self. There were frequent mentions of students' understanding, attention and contributions to the lesson. The strategies mentioned during this interview referred several times to the relevance of content to students. "Knowledge of Students" and Strategies" comments were again linked and comments in other categories also emphasised student learning and involvement and relevance.

Repertory Grid Interview

Most of the constructs Basil used on his second repertory grid were related to the subject, and its presentation, together with teacher enthusiasm. The focused form of the grid is shown in Table IV of Appendix 1. "Interest" was stressed in most constructs. Again Basil's "Good Science Teacher 2" was closely linked to "The Science Teacher I Want to Become". Basil's rating of "Self as Science Teacher" now positioned himself closest to this teacher, before the "good" and "poor" pairs were linked together.

The construct: "Knows and applies content to everyday life - No effort made to make topics relevant" was scored identically with the "effective - ineffective" construct provided, so could be taken at the best indicator of effectiveness for Basil at this stage.

Concept Map

The concept map constructed by Basil at this stage was still relatively simple in structural terms, with the teacher again holding pride of place, this time as the link between the concept "science teaching" and the student and other concepts on the map. The branch of the map below the teacher resembled the first map in including content-related ideas.

This map included many more educational concepts than did the first one. The map is shown as Figure 2 in Appendix 1. The map linked "teaching and "learning" in the context of "relationship".

AFTER ONE SEMESTER OF INDEPENDENT TEACHING

Stimulated Recall Interview

The videotaped lesson used for the stimulated interview after Basil had been teaching independently for one semester was with a Year 8 class, which included a significant number of students from aboriginal and migrant backgrounds. The distribution of comments among categories is shown in Table V in Appendix 1.

The lesson was part of a unit on Electricity. Basil used a range of oral and written student activities and a teacher demonstration. The interview was conducted immediately after the lesson. The pattern of distribution of comments in categories was markedly different from the two earlier ones, with the "Strategies" category now accounting for most comments, followed by "Knowledge of Students" then "Evaluative Comments - Other". Again the comments in the "Strategies" and "Knowledge of Students" categories were frequently linked.

One significant feature of the lesson was the variety of strategies used, and the timing, which reduced "off task" behaviour to a minimum. Basil made several comments relating to this. Most of the comments in the "Knowledge of Students" category referred to general group characteristics, but there were ten which concerned dividuals or specific

groups within the class. The group characteristics concerned such things as interest, enjoyment, the range of ability present and their short attention span. Comments were specific and detailed, and were generally used to explain tactics or models used in the lesson.

Evaluative comments also referred generally to student progress and attention, though they also included evaluations of his strategies and resources. Other comments once more reinforced Basil/s belief in the overall goal of ensuring student learning, the need for variety, student involvement and relevance and the detailed knowledge of students as individuals, as groups and as a whole class.

Repertory Grid Interview

The subject matter, strategies and resources were predominant in the constructs used on this grid, as they were on the previous one. However there was now more elaboration and less overlap of constructs, with emphasis on variety as well as relevance. The teacher's enthusiasm for the subject was also repeated from the previous grid, and student interest again stressed.

The pattern of element links was very similar to that found on the previous grid, though no teacher was now identical with "The Science Teacher I Want to Become". "Self as Science Teacher" was linked most closely to "Good Science Teacher 2".

There was more distinction between ratings of constructs on this grid than on previous ones. Again one construct totally matched the provided "effective" one. This construct, Number 8, seemed to reveal the underlying value of raising and maintaining student interest. The means proposed to achieve this were relevance, variety, an understanding of what interests students, showing enthusiasm and involving students.

Concept Map

The concept Map Basil drew at this stage differed significantly from his earlier ones, though it did continue to present the teacher as central, and to have two major branches. This map had a large number of cross links, and the concepts included several which were much more specific. It is shown as Figure 3 in Appendix 1.

The laboratory seemed important and this map, like the previous one, showed two-way interaction between teacher and students, which was not only indicated by arrows, but specified by the linking words.

THE EMERGING PICTURE - BASIL

The sets of data gathered at each stage with Basil gave consistent pictures of his beliefs about science teaching and the science teacher. Initially it seemed that he judged both science teaching and the science teacher according to their effectiveness in promoting student learning.

Early in his pre-service year the stimulated recall interview suggested that using varied strategies and involving students in the lesson were important means to this end. He appeared to be alert to students within the lesson, and able to adapt his approach according to his observations of students. The data from the repertory grid and concept map accorded with this picture. The concepts used on the first map, and the propositions formed by the linkages of these referred also to communication of information to

students, to "educate/inform to prepare for best performance in examinations" (From Appendix 1, Figure 1).

The theme of ensuring student learning continued to be dominant in the second set of data. The stimulated recall interview at this point showed that "relevance" had now been added to variation of strategy as a means of promoting student interest and hence involvement. Repertory grid data also included this construct, both as relevance and as the use of "everyday examples". Student involvement was again stressed in the grid constructs, as was "interest" which appeared as part of five of the constructs and was closely linked with student involvement. The concept map from this stage again reiterated these emphases. The repertory grid constructs which mentioned students at this stage suggested an implicit concern for their achievement.

The differences between the data collected during Basil's pre-service year and that collected at the end of one semester of independent teaching were rather of degree than of kind. The stimulated recall interview still portrayed, as the aim of science teaching, that students should learn. This learning included sound content knowledge as well as interest and awareness of relevance. The means to this end were virtually identical with those mentioned in earlier interviews. However, at this stage, Basil demonstrated much more detailed knowledge of individuals, groups within the class and the entire class. This knowledge and insight guided his choices in planning the lesson and conducting it, and permeated his discussion of all aspects.

The repertory grid constructs accorded well with the content of the stimulated recall interview, suggesting that Basil was judging science teachers and his own teaching on the same criteria. The concepts used on this third map were consistent with these constructs. The form of the map also incorporated greater complexity and specificity, while reiterating the core concepts identified earlier.

PHILIP

"Philip" had been a high achiever at school and enjoyed science. He had attended an inner-city school for boys with a high proportion of students from backgrounds with languages other than English as the first language. His own background included family use of another language, as well as English.

After leaving school his progress was inconsistent. After six and a half years he had gained a B.A. and B.Sc. degrees, having initially enrolled in a Pharmacy course. Grades awarded through his Undergraduate courses ranged, on a seven point scale, from 6 to 1, with a predominance of Grades of 4 or 5.

His teaching placement throughout his pre-service year was in a small, inner-suburban school for boys from Grades 8 to 12. At the commencement of the following year he was placed briefly in a State high school in a small city, but due to demographic changes was soon transferred to one a smaller town in south western Queensland. Philip's assignment included teaching science to a Year 8 and a Year 9 class, mathematics to one group in each of Years 8 and 12 and physical education to three Year 8 groups, as well as being responsible for several sports lessons each week, with Year 11 and 12 students. He had experienced many difficulties during this first Semester, and had been offered support by both the Deputy Principal and the Principal. Each had observed his lessons, taught his classes as 'demonstration' lessons for him and worked with him in a team-teaching situation.

THE BEGINNING OF THE PRE-SERVICE YEAR

Stimulated Recall Interview

Philip's first stimulated recall interview was based on a Year 8 science lesson on the topic of Cells. He expressed discomfort with the topic as his main background was in physics. This lack of discipline knowledge became apparent during the lesson, particularly when students asked questions or gave responses which indicated lack of knowledge and Philip had difficulty responding.

The most common type of comment described "Strategies" with comments on "Contextual Factors" the next most frequent. Table VII in Appendix 1 shows the distribution of comments. The comments placed in the "Strategies" category were relatively basic classroom "rules of thumb". Most of these comments described what he **should** have done.

The "Contextual Factors" comments covered a range of types of factors related to organising equipment, classroom management issues, the context within the lesson plan and content knowledge issues. Most factors mentioned were those causing difficulties.

Four of Philip's five comments about "goals", began with the phrase: "*I wanted to*", few making reference to the students. Comments in other categories were consistent with this focus, giving a general picture of a teacher largely focused on his own actions within the lesson. Philip stated a concern for clarity, particularly in visual presentation. Definitions were mentioned frequently.

Repertory Grid Interview

The initial Repertory Grid data is shown in focused form in Table VIII in Appendix 1. The actual constructs were fairly restricted and tended to overlap. The grid joined "self as science teacher" to the two "poor" science teachers, though not closely, placing "self" between the "good" and "poor" groups. No actual teacher totally matched his picture of "The science teacher I want to become".

The construct which Philip linked most closely to the provided construct "effective - ineffective" was Construct 1 which had the more "positive" pole described as "share beliefs and attitudes" and the opposite pole labelled "Joke too much". Joking was mentioned twice on this grid. The constructs suggested that Philip was judging the teachers mainly on criteria of relating to students and understanding their subject matter.

Concept Map

Philip's concept map at the beginning of the pre-service year is shown as Figure 4 in Appendix 1. Most concepts dealt with structure and strategies, methods and resources. The concepts related more to the nature of science than to teaching. Philip's comments when discussing the map suggested that he perceived the task as describing the nature of science, though the structure of the map and some concepts dealt with the teaching of science. There was no reference to either teachers or students. The structure of the map was relatively simple. No genuine cross-links were used, though all science disciplines were linked to both "labs" and "classrooms" and also to "experiments.

THE END OF THE PRE-SERVICE YEAR

Stimulated Recall Interview

The lesson on which the second interview was based was a Physics lesson to an able group of Year 11 students. The main goal was to develop the Law of Conservation of Momentum, using several demonstrations and a worked mathematical example. Philip commented on the section of the lesson in which he tried to move from the demonstrations to derivation of the law: *this whole next section is all together as one as far as I'm concerned and like, it was a disaster.*

Initial comments in the interview suggested that indecision in planning was partly to blame for this, Philip commenting: *I was never too sure about which way I should approach* (the derivation). The framing of the situation made the solution impossible, as insufficient data was provided, so neither Philip nor the student he asked to help him out could derive the law.

Table IX in Appendix 1 shows the distribution of comments. Comments about "Contextual Factors" and "Strategies" were again the most frequent categories, with "Contextual Factors" dominating. Only one comment was categorised as "Knowledge of Students" and that was tentative in content. Changes of emphasis from the previous interview included a large relative increase in comments indicating dilemmas and in evaluative comments other than those related to self. These increases may have been due to the difficulties of the lesson.

Many of the comments about context were related to the knowledge component of the lesson, explaining the lack of clarity which occurred. These comments again referred often to factors causing or explaining difficulties. Philip admitted that he had not planned to conduct the derivation section of the lesson as he did.

The "Strategies" comments reiterated some of those mentioned in the first interview, including the importance of using visual methods as well as oral ones. The need to gain responses to understand students' difficulties was a further principle repeated in this interview, though he failed to use this strategy. As in the previous interview many comments described what "should" have happened, including the need for simple, clear examples and the need to emphasise and reinforce key ideas. There were twelve such uses of "should" in the interview. Statements in other categories again indicated Philip's concentration on himself, "Goals" statements, for example, relating totally to the teacher's plan.

Repertory Grid Interview

Changes in emphasis from the first repertory grid in terms of content included the presence, on this grid, of two constructs related to specific strategies and methods. Other changes of emphasis were slight. The links between the various "teachers" were markedly different from those on the first grid. "Self as science teacher" was now linked with the first "poor" science teacher" and these were then linked to the "good" group. Table X in Appendix 1 shows the focused grid. It links construct 3: "good communication, but not succinct - direct in communication of subject matter" most closely with the provided one: "effective" - "ineffective".

Concept Map

Marked changes had occurred in both the content and structure of the concept map compared with the first one. Though only three more concepts were used, there were many cross links. The concepts used included many that related specifically to science teaching, though the breakdown of science into disciplines was still used. Labelling of links was also more extensive and explicit.

Mentions of Students and student outcomes were used on this map, in contrast to the earlier one. The latter represented the second most frequently used concepts. The subject science was again used as the basic structure of the map, but it was broken into fewer content knowledge strands. The map is shown below as Figure 5 in Appendix 1.

The map included some concepts which related to teaching methods rather than to scientific methodology. It was more complex than the previous one.

AFTER ONE SEMESTER OF INDEPENDENT TEACHING

Stimluated Recall Interview

The lesson which was videotaped for the stimulated recall interview was a science lesson, conducted in the second lesson of the day, with a Year 9 low-ability group. Normally there would have been a "double" lesson, but students were required to attend Religious Instruction during Period 1. The duration of the lesson was further shortened by the late arrival of the students, who had to come some distance from the Religious Instruction lesson. The lesson was one in which students performed a laboratory exercise requiring them to observe condensation on test tubes filled with hot or cold water,. The interview took place at the end of the school day.

The usual class size was fourteen students, but only ten were present. This included one student with Down's Syndrome, now "integrated" into the normal classroom. It was obvious that this class included students with poor concentration and of limited academic achievement.

The content of this interview showed a significant increase in comments indicating "Knowledge of Students" and the appearance of more detailed "Strategies". Philip showed the greatest increase of all participants in comments relating to "Knowledge of Students" at this stage. The most frequently found category at this interview was again "Contextual Factors". Frequencies of other types of comment are shown in Table XI in Appendix 1.

The contextual factors mentioned included at least four references to the substitution of Religious Instruction for the first lesson of the day as having a negative effect. Several other factors such as room arrangement, the nature of the student group, equipment limitations and the non-availability of the support teacher were also mentioned as having a negative effect on the lesson.

The comments in the "Knowledge of Students" category now indicated awareness of individuals. Three of the fifteen comments in this category referred to the whole group, four mentioned groups within the class and the others mentioned individuals. Philip commented: *they are a very kinaesthetic type of class. Rather than visual/auditory learners, so but definitely not, I don't think they're very good auditory learners.*

He generalised that they were happy to copy work, but this was qualified by a comment about one student who was reluctant to write anything down. Philip also explained that no more than one or two students would or could read with comprehension. He spoke of individuals by name and discussed different groups within the class. Comments of other types also paid more attention to student activity and learning than in earlier interviews. The self-evaluative comments were generally negative, referring to his rushing of the lesson, failure to gain students' attention, give clear directions or use effective class organisation. These were partially balanced by some positive comments about questioning, and gaining the attention of the class at a particular stage of the lesson.

There were more references than in earlier interviews to what students were to do. However such comments still mainly described what "should" happen. "Goals" statements were still largely teacher oriented, though several statements about goals did relate to students, while still stated as teacher goals.

Repertory Grid Interview

The differences between this repertory grid and the previous one were few. The only change in emphasis, was the addition of two constructs focused on the teacher's role and characteristics at the expense of two mentioning relationship with students. The apparently "new" constructs used here were Constructs 2, and 7, and dealt with organisation, interest and clarity. The focused grid is shown as Table XII in Appendix 1.

The patterns of linkage of elements and constructs of the focused grid showed little change from the previous grid,indicating little change in Philip's perception of his current ability, or his potential relative to the good and poor teachers.

Concept Map

Philip's concept map at this stage was distinctly different from the two earlier ones, which had, as their main sub-categories the various scientific disciplines. The concepts immediately below the central one were "The language of science" (perhaps reflecting the fact that the school stressed a language oriented approach in all subject areas), "Lab room" and "Students". The concept map is shown as Figure 6 in Appendix 1.

Many concepts on this map were much more specific than those used on earlier ones. Both resources and strategies showed this change. This was the most obvious change from earlier maps. No cross linkages were present, though there were several in the second map. Three distinct sequences were constructed below "Science Teaching". This map, unlike earlier ones, did not break science into disciplines, focusing instead on factors involved in teaching than on the nature of science.

THE EMERGING PICTURE - PHILIP

The initial stimulated recall interview suggested that Philip focused on the mechanics of the lesson. He was functioning as a teacher to the extent that he described a set of generalised rules for classroom tactics. He noticed aspects of the lesson, as he viewed the videotape, which he had not observed during the lesson. These sometimes prompted him to make suggestions about appropriate action. Two beliefs he consistently articulated were the importance of clarity in the visual presentation and the importance of definitions.

Philip's view of the science teacher, conveyed by the first stimulated recall interview, seemed to be a functional one. The role of the teacher was to plan and manage the lesson

smoothly, and achieve his goals. These concerned "going through" the content knowledge while trying to ensure that students paid attention. He did, however state his belief that he needed to check for students' current understandings of content knowledge.

The data from the first repertory grid suggested that Philip used communication issues, when judging actual teachers, with content knowledge issues next in importance. This view of science teachers does confirm two aspects noted during the stimulated recall interview. There concern for communication was applied mainly to the visual component of the lesson. The concern for content knowledge was consistent with his emphasis on definitions within the stimulated recall interview.

The first concept map portrayed science teaching through a particular view of science, that which perceives science as composed of discrete sub-disciplines which rely on similar approaches. The link with science teaching was suggested by laboratory and classroom activity, linked finally through "experiments", and leading to a conclusion. Because of its strong focus on "science" rather than "teaching" its links with the other two data sources are rather tenuous. What it did convey was Philip's perspective of science. There may be a connection with his content knowledge focus.

The picture which emerged from the stimulated recall interview at the end of the pre-service year was that Philip still mainly concentrated on his own activity within the lesson. Indecisiveness in planning seemed to cause a lack of clarity. He showed an increased ability to know what **should** be done to improve the lesson, but did not seem able to "rescue" the situation during the course of the lesson itself. There was acknowledgment of the need to ascertain students' difficulties, but an apparent inability to act on this information. Though speaking frequently of the need to emphasise basic concepts he seemed to be at a loss to decide what basic knowledge was relevant and so was unable to achieve this emphasis.

The picture he painted of science teaching was that it was content knowledge based, but involved interaction with students to ensure their understanding and ability to apply concepts. Clarity was a stated value, but Philip struggled to achieve it. His view of the science teacher seemed to be that of the orchestrator of the process.

The traits of science teachers that Philip mentioned on his second repertory grid again included a content knowledge focus together with concern for relationships. Communication was again mentioned. Philip's expressed view of the importance of ascertaining students' knowledge was echoed in his inclusion of "use questioning techniques - don't use them" as one of his eight constructs.

Like the repertory grid data, the second concept map suggested that Philip had, at the end of his pre-service year, considerably more theoretical knowledge about science teaching, and that the knowledge was more structured. The concept map suggested that emphasis on outcomes for students had increased. Results from these two instruments produced a relatively consistent picture of Philip's orientation, and confirmed the picture derived from the stimulated recall interview.

The progress from the first to the second data gathering point seemed to be mainly in knowledge about teaching science. The absence of any awareness of students was significant. Philip made only one mention of interaction with students concerning learning in the stimulated recall interview. His judgment of the quality of teachers included an assessment of their relationships with students, and he mentioned student

activity on his concept map but did not show any understanding of individuals or groups in the stimulated recall interview. This, together with his failure to reach the clarity of content knowledge presentation he sought, seemed to limit his achievement of his stated ideals.

Quite a marked change was apparent in the interview conducted after one semester of independent teaching, with this interview showing an increase in his awareness and understanding of students. His focus on student outcomes as well as his knowledge of their ability and individual differences represented a significant development. Though difficulties still existed with implementation of his ideals, and some comments were still "should" style ones, Philip demonstrated considerably more clarity about the purpose and structure of the lesson and his planning incorporated his knowledge of students. A sense of purpose was conveyed in the lesson itself and in the interview. The goals still revealed a focus on carrying out the teacher's plan, but the plan did involve students.

Philip showed much greater awareness of how the actual students learned than he had demonstrated at the end of the previous year. Highlighting his dilemma as a struggling, beginning teacher probably he summed up his situation with the comment: *I don't think it's the best way to learn, but sometimes, in terms of management of those kids, its the only way..* His statement of the purpose of science teaching was that it should promote student learning, but he was more involved with class management issues.

The third repertory grid data echoed the sense of purpose apparent during the stimulated recall interview. His judgment of a good science teacher still incorporated the concern for content knowledge and relationships seen on the previous grids, but the important change to a "learning oriented environment" as an indicator of excellence was significant, particularly when associated with his use of the construct "organised flow of lessons" as a positive one.

The concept map data, like that of the repertory grid, suggested that Philip had developed a more organised and specific way of describing what teaching science involved. Consideration of students also had a significant place on the map, in contrast to the earlier ones. This matched the increase in consideration of students found in the stimulated recall interview. Science teaching seemed to be portrayed as an activity incorporating specific strategies and resources, and involving consideration of students, again echoing the other data sets.

From the second to the third data gathering point Philip seemed to have progressed from an ability to recognise inadequacies in his presentation of content knowledge during and after teaching, to a limited proficiency in planning and implementing strategies to address these. The other significant change was his development of an understanding of how his students learned science and had developed some strategies enabling him to incorporate this into his planning. He knew and used students' names, and also more about their abilities and behaviour patterns.

POSSIBLE IMPLICATIONS

These pictures and the research methods themselves raise important questions about enabling aspiring science teachers to develop into professionals. The questions that can be asked relate to the selection of candidates for teacher education, and means of enabling

their development through their pre service course and during the crucial first year of independent teaching.

Selection

One difference between the two participants in this study was in their path through their original degree course. Neither was outstanding in terms of academic results, yet Basil's progress through his course was direct, while Philip changed direction in his studies several times. Basil soon showed the ability to use content effectively in planning and teaching. This was an area in which Philip continued to struggle.

Citing Brophy & Good (1986), Lederman, Gess-Newsome & Latz stated that "attempts at correlating measures of what teachers know ... with measures of effective teaching have rarely produced relationships of strong practical significance." (1994, pp 129-130). Yet the conviction that knowledge is an important variable in teaching remains strong, and researchers are still endeavouring to uncover connections as is evidenced by the number and variety of studies exploring the relationship of knowledge to teaching, including the "Knowledge Growth in Teaching" project with which Shulman has been associated. The Lederman, Gess-Newsome & Latz study is another recent example, examining how knowledge of subject matter and pedagogy are linked with teaching effectiveness.

The use of concept mapping may be one simple method of investigating the structure of knowledge about the subject area and about teaching of prospective teachers. The absence of either teacher or student from Philip's initial concept map could be indicative of a weakness in his conceptualisation of the task of becoming a teacher, compared with the more balanced set of concepts used by Basil.

The initial repertory grids of these two aspiring teachers also indicated important differences in their perspectives on teachers. Again Philip lacked the ability to generate ideas about how teacher act, as teachers. This could reflect limited experience of various styles of teaching, or a lack of reflectivity. Either could be a handicap to someone undertaking a pre-service teacher education course.

Development and Change

The videotaped lessons of Basil and Philip and their stimulated recall interviews at each stage demonstrated definite contrasts. Basil, even in the initial lesson and interview, demonstrated awareness of and concern for student learning, and the ability to plan and use strategies to enhance this. He was able to develop and expand his repertoire of strategies, with very little alteration to his perspectives or beliefs. Philip demonstrated and expressed difficulty in mastering and organising content knowledge in a suitable way to engage learners, and attended to details of classroom management and to coping with content, showing little awareness or understanding of students and their learning. Though he developed in awareness of students and stated that his goal was student learning there was limited evidence of an ability to focus beyond "survival" in the classroom.

Again much research has been focused on pre-service teacher education in an effort to discover the conditions which facilitate or retard growth towards effectiveness. Sudzina & Knowles (1993) summarised research into "failure" of student teachers. They organised relevant factors into three sets, personal, professional and contextual. They also examined the records of nineteen pre-service teachers who withdrew late in their course rather than fail or who were failed by their evaluators. They found an over-representation of older students and of male students in the group. There seemed a

greater likelihood of failure if the contexts in which these students were placed were very different from what they anticipated and lower grades in previous studies did correlate with failure. Carter & Gonzalez (1993) also identified clear differences between two student teachers, in the events they remembered from their classroom experience. This contrasting selection of events was correlated with effectiveness. Such factors need to be identified, yet ways of overcoming limiting factors are still elusive.

Studies trying to identify "stages" of development of teachers may also be relevant. Various numbers of stages have been suggested. Some models indicate conflict between the theoretical nature of the curriculum and the concern for survival of pre-service teachers and identify in the in-service phase "early concerns about survival" and "more mature interests in students' learning" (Doyle, 1985). The limited freedom of the student teacher is also often mentioned, as well as their inability to adapt to differing circumstances.

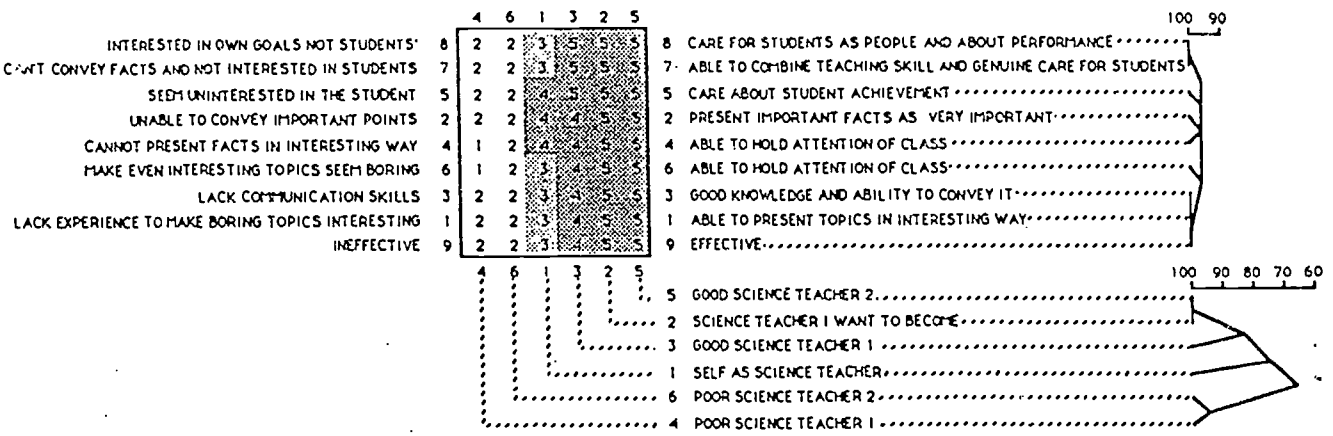
Such conceptualisations indicate the path towards development as a teacher, but fail to indicate means of enabling those beginning teachers who are slow to develop. Recent emphasis on reflection in teaching together with explorations of metaphor may provide one key to this puzzle. Both match well with a constructivist view of learning. Tobin & Espinet (1989) claimed that "research suggests that teaching behaviours can be changed if teachers are actively involved in the process of identifying what needs to be changed" (p 107), yet found it extremely difficult to assist the teacher in their study to diagnose his own needs. In a later study Tobin found the identification of the varied metaphors teachers used, and reflection on their effectiveness to be a powerful tool to enable them to reconceptualise their beliefs and behaviours. A similar conclusion was reached by Griffiths and Tann, who suggested that exploration of their own use of metaphor can assist teachers to link their "personal theories" with those they call "public" ones - those generally accepted as "educational" theories.

The data gathering methods of this study could be effective instruments to assist pre-service and beginning teachers to explore their own metaphors as indicators of their "private" theories. Elicitation and articulation of these may inject new relevance into the "theory" often perceived by pre-service teachers as irrelevant. The constructivist strategy of using both "personal" and "scientific" theories to make predictions, then testing these to see which provide better explanations of phenomena could prove a useful one in pre-service and early inservice education.

Table I Categories of Coded Comments from Basil's First Interview

CATEGORY OF COMMENT	FREQUENCY	FREQUENCY %
Contextual Factors	6	11.11
Goals	2	3.70
Beliefs and Values	4	7.41
Knowledge of Students	8	14.82
Strategies	8	14.82
Dilemmas	4	7.41
Evaluative Comments - Self	6	11.11
Evaluative Comments - Other	16	29.62
TOTAL COMMENTS	54	100.00

Table II: Basil's First Focused Repertory Grid



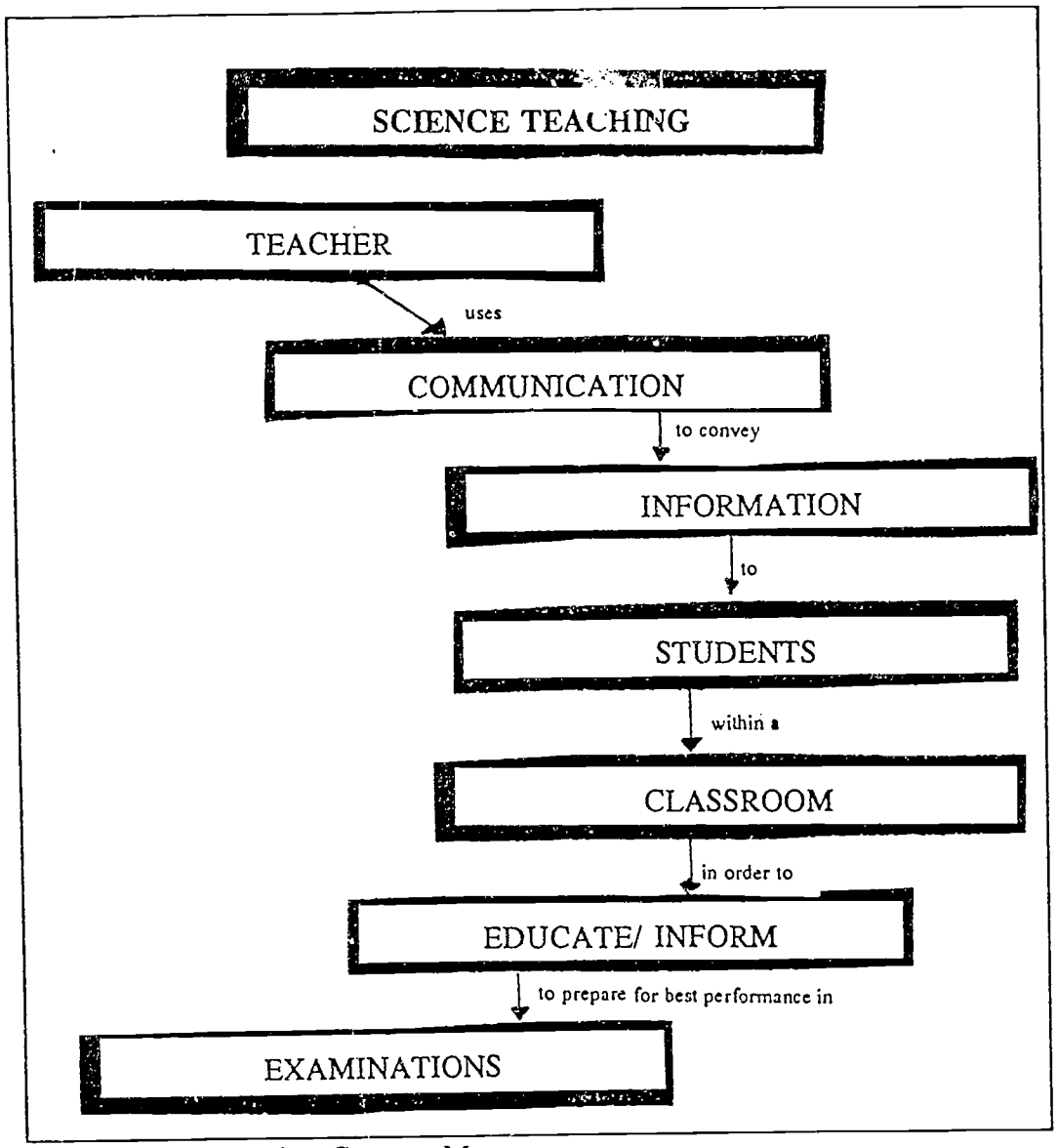


Figure 1: Basil's First Concept Map

Table III: Categories of Coded Comments from Basil's Second Interview

CATEGORY OF COMMENT	FREQUENCY	FREQUENCY %
Contextual Factors	8	20.00
Goals	4	10.00
Beliefs and Values	1	2.50
Knowledge of Students	4	10.00
Strategies	6	15.00
Dilemmas	4	10.00
Evaluative Comments - Self	2	5.00
Evaluative Comments - Other	11	27.50
TOTAL COMMENTS	40	100.00

Table IV: Basil's Second Focused Repertory Grid

		2	5	1	3	4	6		
GOOD CONTENT KNOWLEDGE	1	1	2	2	2	1	5	1	REAL LIFE EXAMPLES WITH CONTENT KNOWLEDGE
EFFECTIVE	9	1	1	2	2	4	4	9	INEFFECTIVE
KNOWS AND APPLIES CONTENT TO EVERYDAY LIFE	7	1	1	2	2	3	4	7	NO EFFORT TO MAKE TOPICS RELEVANT
INVOLVE STUDENTS	3	1	1	2	2	4	5	3	NOT INCLUDING STUDENTS
INTERESTED IN	5	1	1	2	1	4	5	5	NO EXCITEMENT FOR SUBJECT
INTERESTING EXAMPLES	4	1	1	1	1	3	5	4	BORING PRESENTATION
EVOKES INTEREST FROM STUDENTS	6	1	1	1	1	5	5	6	SENDS PEOPLE TO SLEEP
INVOLVING STUDENTS	2	1	1	1	2	5	5	2	BORING LECTURE STYLE USED
INTERESTING PRESENTATION	8	1	1	1	2	5	5	8	UNINTERESTING PRESENTATION

100 90 80 70

100 90 80 70 60 50

2	5	1	3	4	6		
						6	POOR SCIENCE TEACHER 2
						4	POOR SCIENCE TEACHER 1
						3	GOOD SCIENCE TEACHER 1
						1	SELF AS SCIENCE TEACHER
						5	GOOD SCIENCE TEACHER 2
						2	SCIENCE TEACHER I WANT TO BECOME

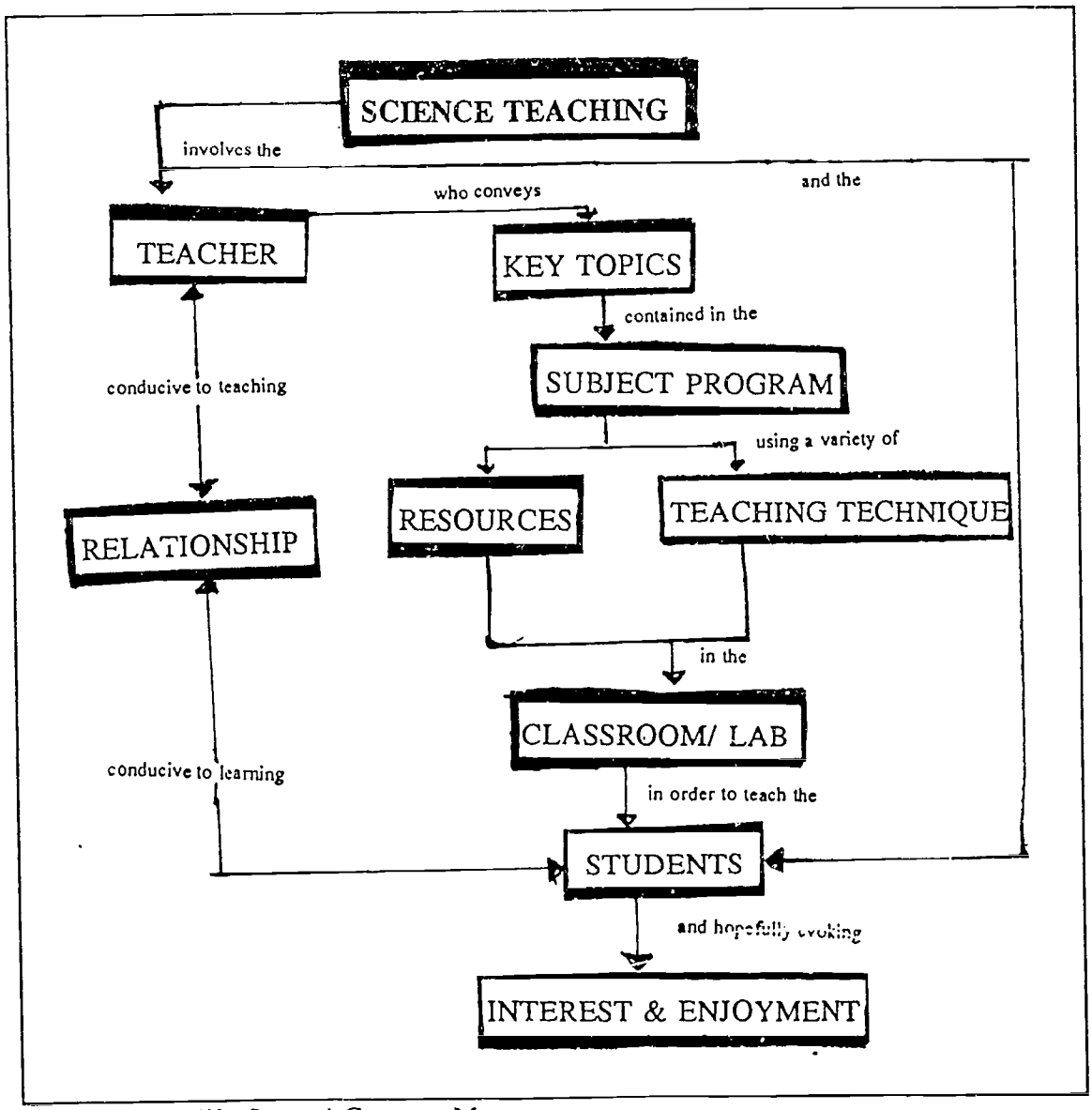
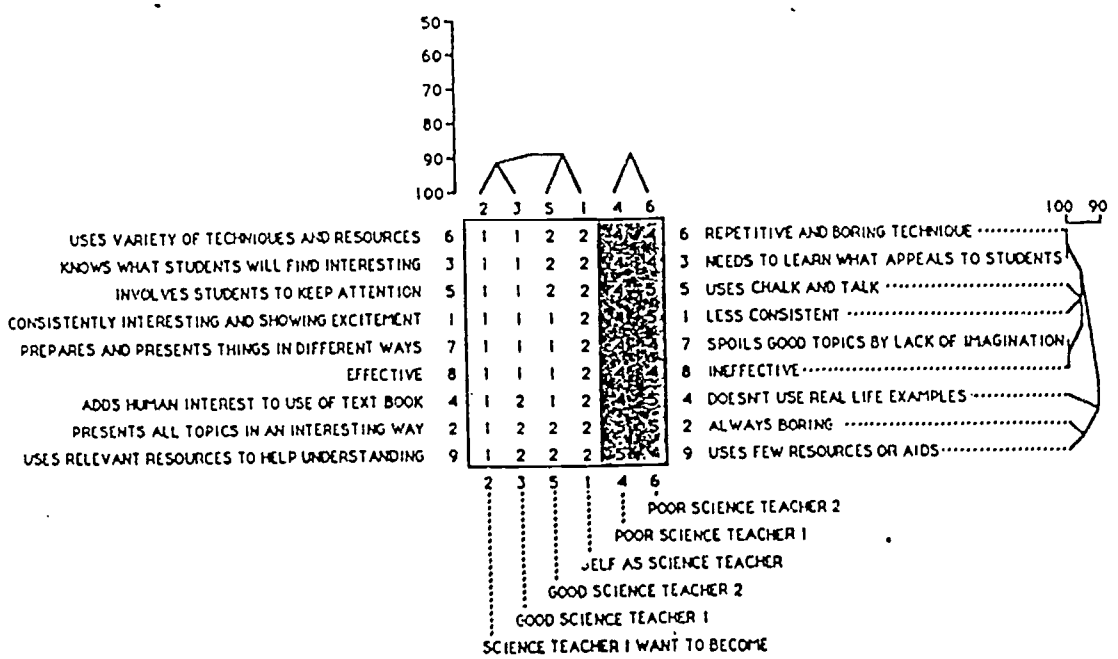


Figure 2: Basil's Second Concept Map

Table V Categories of Coded Comments from Basil's Third Interview

CATEGORY OF COMMENT	FREQUENCY	FREQUENCY %
Contextual Factors	14	13.33
Goals	7	6.67
Beliefs and Values	5	4.76
Knowledge of Students	26	24.76
Strategies	29	27.63
Dilemmas	1	0.95
Evaluative Comments - Self	6	5.71
Evaluative Comments - Other	17	16.19
TOTAL COMMENTS	105	100.00

Table VI: Basil's Third Focused Repertory Grid



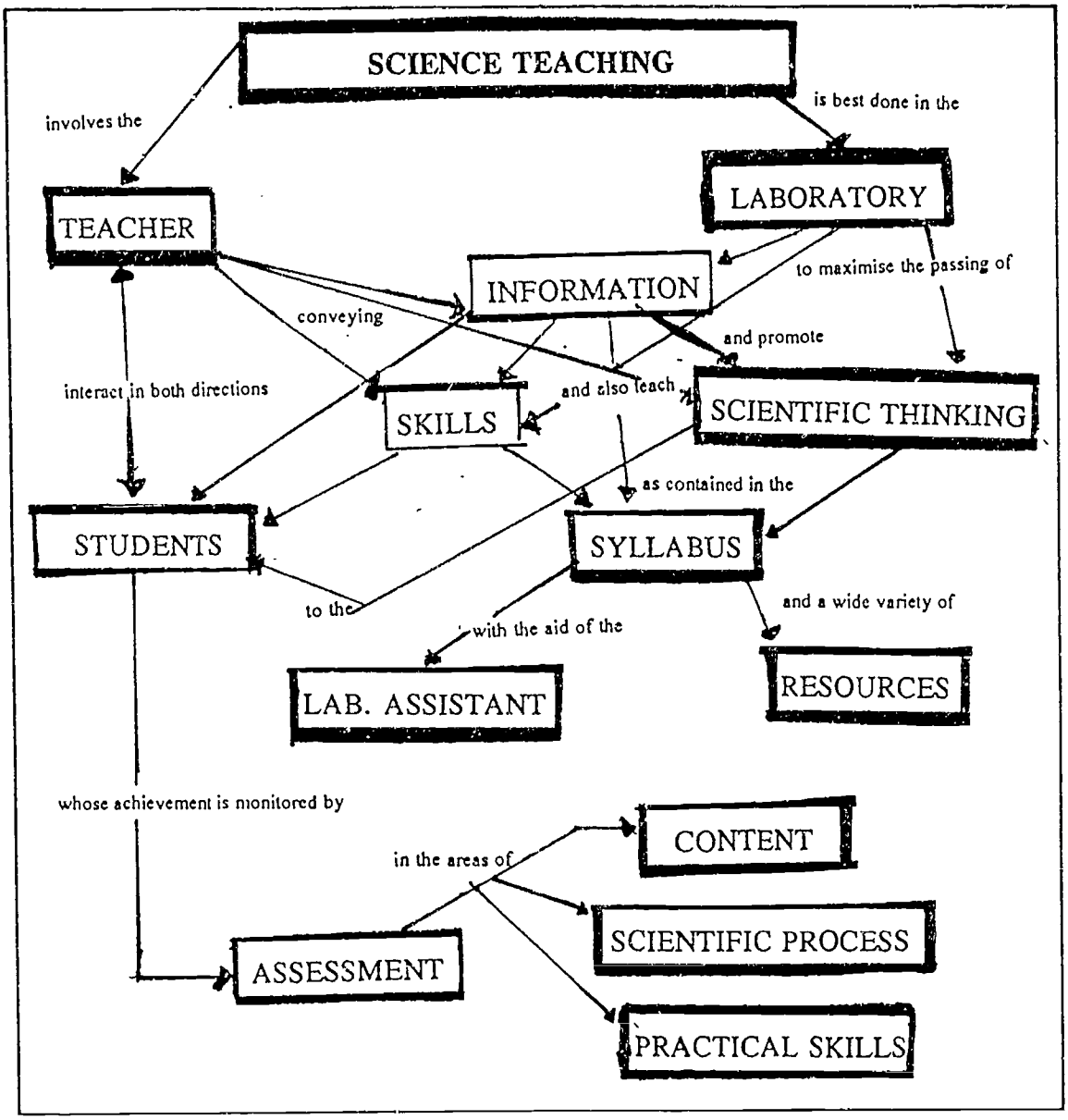
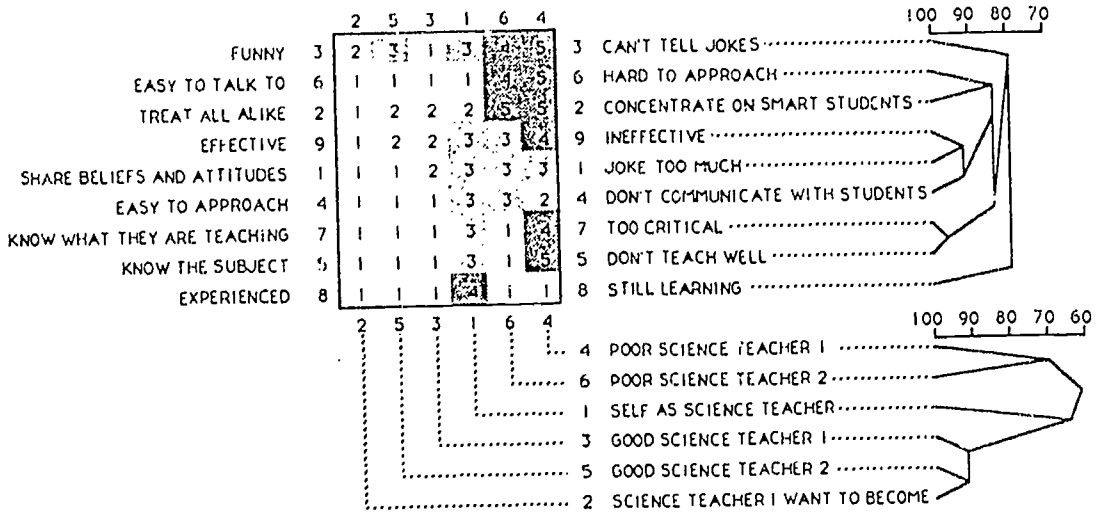


Figure 3: Basil's Third Concept Map

Table VII: Categories of Coded Comments from Philip's First Interview

CATEGORY OF COMMENT	FREQUENCY	FREQUENCY %
Contextual Factors	8	25.00
Goals	5	15.62
Beliefs and Values	1	3.12
Knowledge of Students	1	3.12
Strategies	10	31.25
Dilemmas	2	6.25
Evaluative Comments - Self	3	9.38
Evaluative Comments - Other	2	6.25
TOTAL COMMENTS	32	100

Table VIII Philip's First Focused Grid



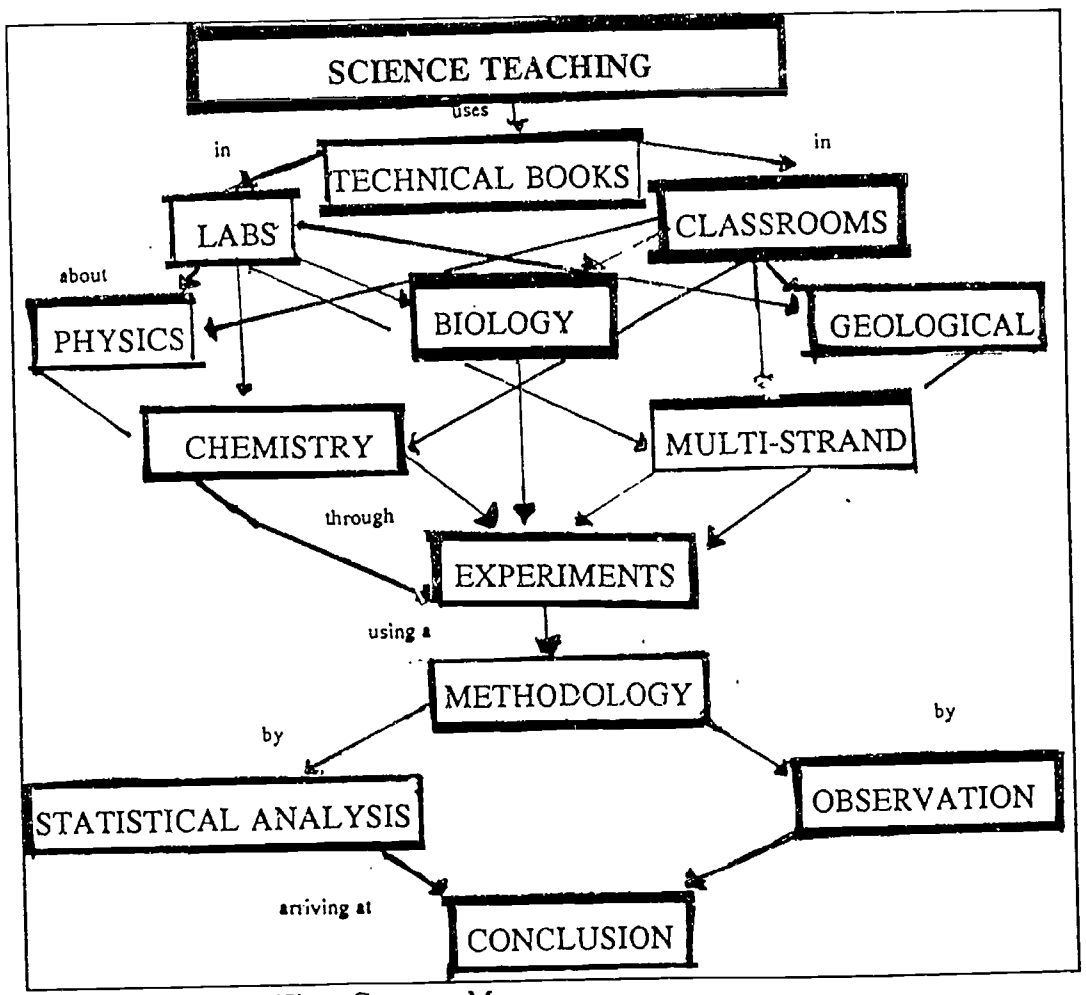
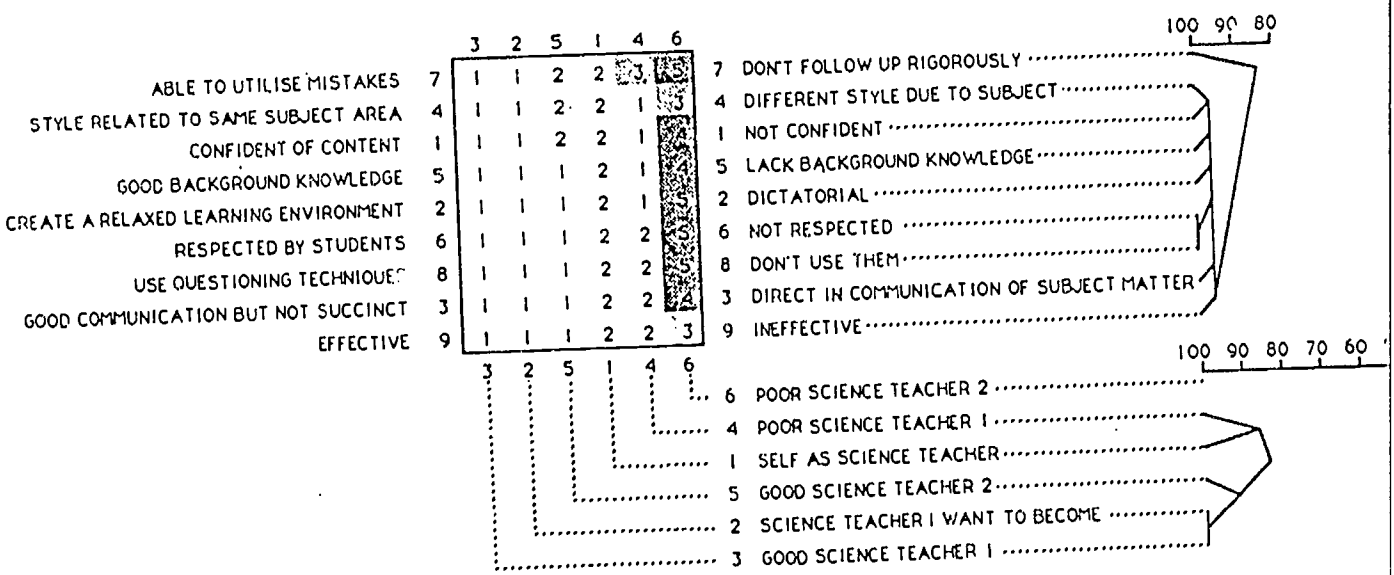


Figure 4: Philip's First Concept Map

Table IX: Categories of Coded Comments from Philip's Second Interview

CATEGORY OF COMMENT	FREQUENCY	FREQUENCY %
Contextual Factors	17	24.28
Goals	6	8.57
Beliefs and Values	2	2.86
Knowledge of Students	1	1.43
Strategies	15	21.43
Dilemmas	9	12.86
Evaluative Comments - Self	10	14.28
Evaluative Comments - Other	10	14.28
TOTAL COMMENTS	70	100

Table X Philip's Second Focused Repertory Grid



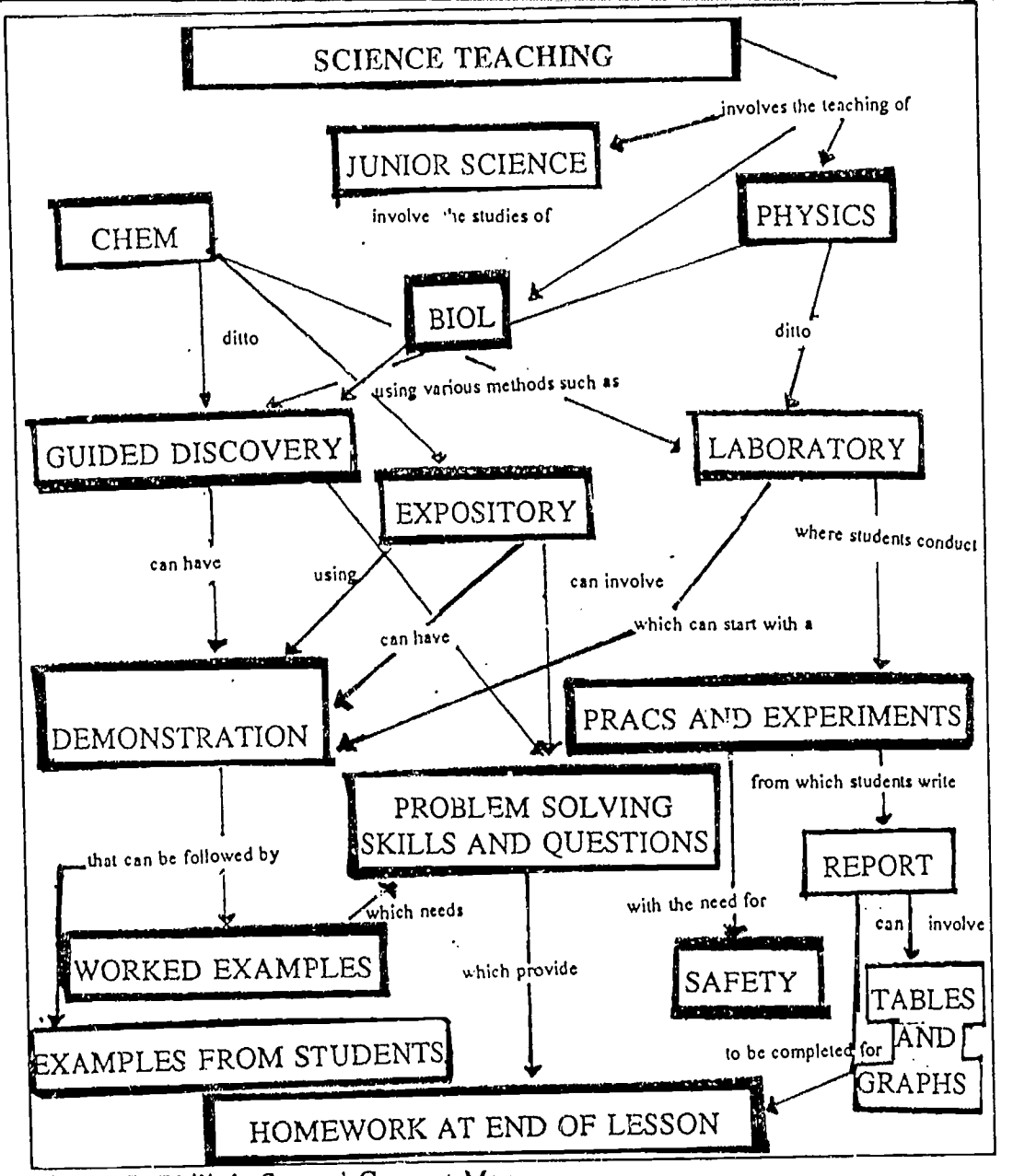
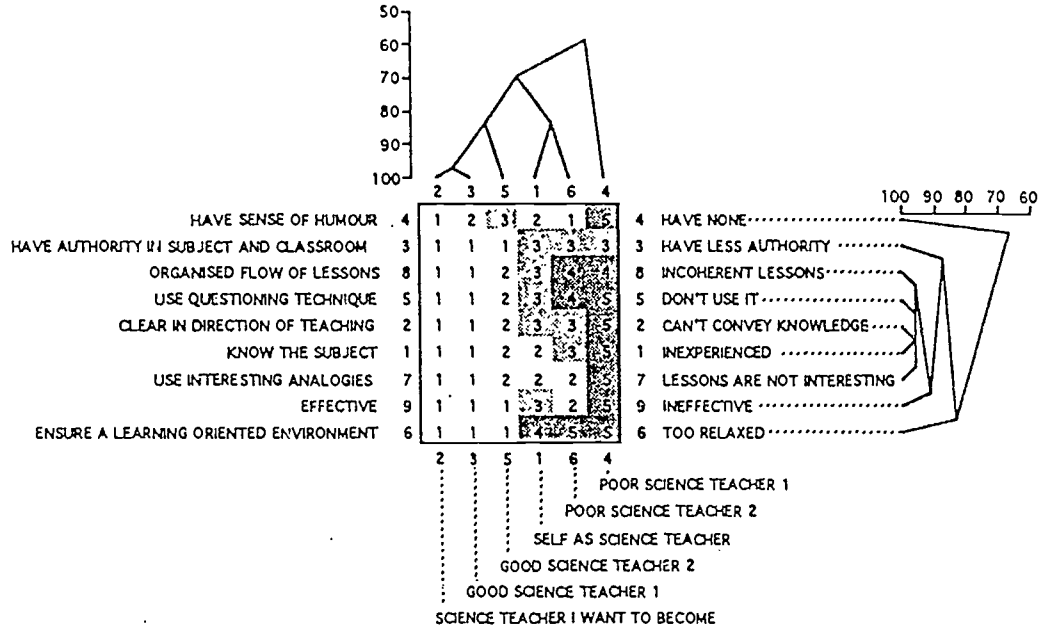


Figure 5: Philip's Second Concept Map

Table XI: Categories of Coded Comments from Philip's Third Interview

CATEGORY OF COMMENT	FREQUENCY	FREQUENCY %
Contextual Factors	19	18.10
Goals	6	5.71
Beliefs and Values	7	6.67
Knowledge of Students	15	14.28
Strategies	21	20.00
Dilemmas	13	12.38
Evaluative Comments - Self	17	16.19
Evaluative Comments - Other	7	6.67
TOTAL COMMENTS	105	100

Table XII: Philip's Third Focused Repertory Grid



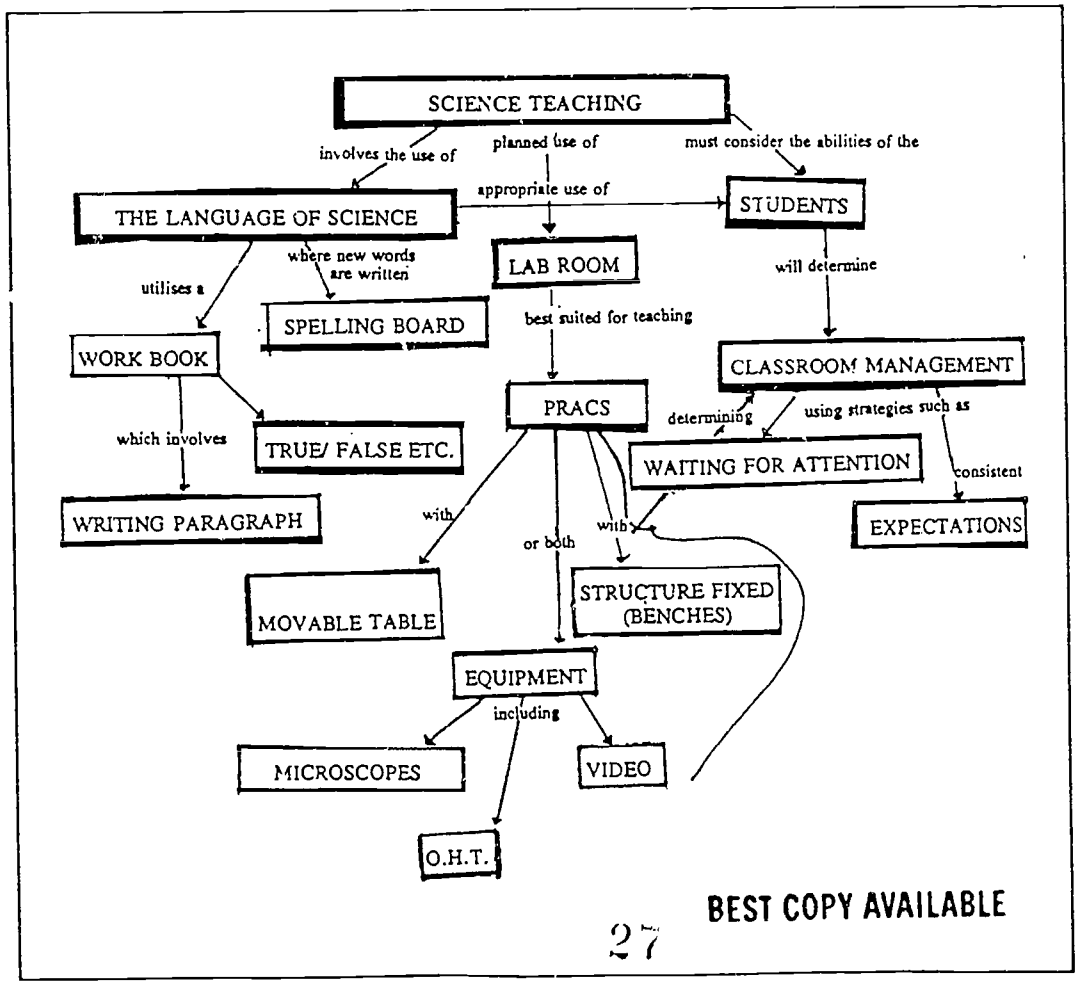


Figure 6: Philip's Third Concept Map

APPENDIX 2

Blank Repertory Grid

NAME_____

On Each line put crosses on the two circles indicating the LIKE pair.

With their characteristics as science teachers in mind what do the pair have in common?	E1	E2	E3	E4	E5	E6	With their characteristics as science teachers in mind what makes the other teacher different?
	O	O	O				
				O	O	O	
	O		O		O		
		O		O		O	
			O	O		O	
			O		O	O	
		O	O	O			
	O		O			O	
EFFECTIVE							IN-EFFECTIVE
	Self as science teacher	The science teacher I want to become	Good Science teacher 1	Poor Science teacher 1	Good Science Teacher 2	Poor Science Teacher 2	

On the left write a description of the way in which the two are alike.
On the right write a description of how the third person is different from the other two.

Rate all six teachers on each description on the LEFT.

Use a 5 point scale:

5= VERY STRONGLY LIKE THIS,
4=VERY LIKE THIS;
3= NEITHER LIKE NOR UNLIKE THIS;
2= NOT LIKE THIS;
1= VIRTUALLY THE OPPOSITE OF THIS.

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