Chapter 4

THE PROBLEM REVISITED

An honest tale speeds best being plainly told.

Shakespeare, *Richard III* [1592-93]

Introduction

The "tale" of the so-called longitudinal research, told in the first chapter of this thesis, is now revisited as five distinct periods. Each of these distinct periods will be described as a case study. These case studies have been documented as technical reports and contain all the qualitative and quantitative data collected during the particular study. The qualitative data includes results of unstructured interviews, field notes, e-mail messages and photographs.

The scope of a case study, according to Yin [1994: 13], is the investigation of a contemporary phenomenon within its real-life context. The periods that will be described fall within this definition in that they describe a contemporary phenomenon and are seen within a real-life context. Myers [http://www.misq.org/misqd961/isworld/index.html] argues that the case study is the most common **qualitative** method used in information systems research. According to Du Plooy [1998] a case study can be seen as –

> *...an experiment, similar in some ways to the typical experiment common in natural science research, conducted in a setting where the phenomenon of interest occurs naturally.*

He suggests that the researcher can, after collecting the data and interpreting the results, deductively or inductively find causal links and thus

arrive at some explanations of the phenomena being investigated. In this thesis both the deductive and inductive approaches are used, and in this chapter, where the different case studies will be discussed, deduction is used to draw conclusions from quantitative and qualitative data collected. In Chapter 6 we will use induction to arrive at a framework for group constitution for small group learning in the field of information technology. Therefore, naming these periods "case studies", although originally not conducted as case studies, is in line with the above description of case studies and allows each period to be demarcated into a separate unique study.

During the period 1995 to 1998, when the case studies were executed, the research approach followed was that of an adaptation of Checkland and Scholes' [1990] methodology as described in Chapter 3. The grounded theory approach (discussed in Chapter 3) was followed to draw inductive conclusions and formulate a framework for group constitution for small group learning in the field of information technology. The five case studies, previously published as technical reports, will now be reviewed – starting with the 1995 period. It must be noted, however, that although these case studies are discussed as separate entities, they are closely related, in a cumulative sense, in that each presents a further intervention. The third case study is the exception, as it compares the "chalk-and-talk" method with teamwork in a different group of students.

CASE STUDY 1 – TEAMWORK AND COOPERATIVE LEARNING IN COMPUTER SCIENCE. THE FIRST SEMESTER OF 1995.

[Venter & Stoltz, 1995]

Study objectives

Students were placed in groups/teams at the onset of the course. Students who lived in close proximity were put into a group to enable them to work after hours, that is, off-campus if they wished to do so. Unbalanced or malfunctioning groups could have a negative effect on the group members' learning experience and it was therefore important to look at the way that groups were constituted. This was done to minimize the exclusion of students, but also to motivate them to study cooperatively – that is, to work independently yet share their insights with their team members.

The definition of group work or teamwork, in this study, is the working together of a team to achieve a common goal such as the presentation of a paper in this particular instance. The task set for the team was almost impossible to attain individually; thus the team had to decide amongst themselves how to share the task load. Each individual was expected to bring his or her share of work back to the group forum, where it could be reworked before inclusion in the final product. The final product was thus a team effort.

Cooperative learning, on the other hand, is defined as the sharing and discussing of personal insights, gained through individual learning, in a group situation for the purpose of conceptual insight, but also to foster effective oral and written communication. A prerequisite for a successful team is that students are committed to the team effort which compels them to develop communication and interpersonal skills.

Course curriculum

The module in which this teaching style was adopted was a third-year Operating Systems module. In this module the students learnt about the concepts that underlie operating systems, concepts such as concurrency, deadlock, secondary storage systems, etc. Furthermore it was expected of the students to be reasonably acquainted with the operating system UNIX. A week after the completion of the course, each team was expected to present a paper on a set topic on new developments in the computer environment.

Two lecture periods were appropriated to explain how to read effectively, how to write up what had been researched and then how to present it. This task was undertaken by the Academic Development's Writing Centre.

The Computer Science major at that time consisted of four blocked modules. Thus approximately six-and–a-half weeks of the academic year (26 weeks) was used for each module. All the lecture periods and practical times in the six-and–a-half-week period were then used for the one module. Five lecture periods of 40 minutes each and a practical period of six hours were scheduled per week.

Students were expected to come prepared to class. The teams or groups sat together and discussed problem areas. The lecturer was called upon to help whenever help was needed. The role of the lecturer was thus just the role of a facilitator. If various groups experienced the same problem, the lecturer would then interrupt the group discussions and a lecture would be given on only that topic.

Design

It was decided to formulate a model of team-based cooperative and action learning based on the insights of Johnson *et al.* [1994], Belbin [1993] and Revans [1980].

Cooperative learning

As described by Johnson *et al.* cooperative learning, in contrast to competitive learning, is the working together -- in a group -- to maximize own and the group's learning. According to them five basic elements form the essential elements of cooperative learning as described before.

Team roles

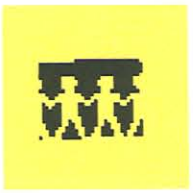
For a team to function successfully, it is important that each individual team member acknowledges his/her own strengths and weaknesses, as well as those of the other team members. R. Meredith Belbin [1993] maintains that optimal team functioning is only possible once team members delegate tasks related to their personal weaknesses to other team members who have these skills as strengths, and when team members accept responsibility for those tasks related to their personal strengths.

These personal strengths and weaknesses are identified through validated and standardised questionnaires measuring stated as well as observed behaviours, and roles in the team are then allocated in accordance with the individual team member's psychometric profile.

Belbin identified these strengths and their associated weaknesses as team roles (depicted in *Figure 14*) and he maintains that each of the nine team roles has a distinctive contribution to make to successful team functioning.

Johnson *et al.* [1994] *allocate* roles to team members arbitrarily. The categories of roles are:

- Forming
- Formulating
- Functioning and
- Fermenting roles.

	Belbin Roles & descriptions	Allowable weakness
	**Resource Investigator**: Extrovert, enthusiastic, communicative. Explores opportunities. Develops contacts.	Overoptimistic. Loses interest once initial enthusiasm has passed.
	**Co-ordinator**: Mature,confident, a good chair-person. Clarifies goals,promotes decision-making, delegates well.	Can be seen as manipulative. Delegates personal work.
	**Shaper**: Challenging, dynamic, thrives on pressure. Has the drive & courage to overcome obstacles.	Can provoke others. Hurts people's feelings.
	**Monitor Evaluator**: Sober, strategic and discerning. Sees all options. Judges accurately.	Lacks drive and ability to inspire others. Overly critical.
	**Teamworker** : Co-operative, mild, perceptive and diplomatic. Listens, builds, averts friction, calms the waters.	Indecisive in crunch situations. Can be easily influenced.

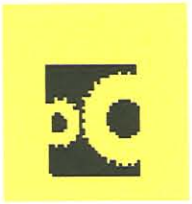
	Roles & descriptions	Allowable weakness
	**Implementer**: Disciplined, reliable, conservative and efficient. Turns ideas into practical actions.	Somewhat inflexible. Slow to respond to new possibilities.
	**Completer** : Painstaking, conscientious, anxious. Searches out errors and omissions. Delivers on time.	Inclined to worry unduly. Reluctant to delegate. Can be a nit-picker.
	**Specialist** : Single-minded, self-starting, dedicated. Provides knowledge and skills in rare supply.	Contributes on only narrow front. Dwells on technicalities. Overlooks the 'big picture'.
	**Plant** : Creative, imaginative, unorthodox. Solves difficult problems.	Ignores details. Too pre-occupied to communicate effectively.

FIGURE 14: A brief description of the Belbin team roles [Belbin, R. Meredith, 1993: 23]

In the Belbin approach team roles (which were identified by the psychometric tests) are allocated to each team member in line with his/her natural inclinations or intrinsic personality traits.

Why the integration of team/group work and cooperative learning?

SYNERGISTIC REASONS

Our experience indicated that many groups fall apart because the members never gelled into a synergistic team. (In a synergistic team, the team achieves collective insights which are superior to any insight that an individual team member can generate.) Senge [1990] sets preconditions for synergistic team functioning (i.e. generative learning):

Systems Thinking: helps the team to see patterns and learn to reinforce or change them effectively.

Personal Mastery. In seeking personal mastery, the team members clarify and deepen their vision, focus their energy, develop patience, and, in general, approach life as an artist approaches the creation of a work of art.

Shared Mental Models. We understand the world and take action in it based on notions and assumptions that may reside deep in the psyche. Once team members suspend these notions and assumptions in front of others to be scrutinized, deeper understanding and new insights may result.

Team Learning. True learning begins with dialogue, in which members suspend assumptions and think together to solve problems.

EDUCATIONAL REASONS

The classical approach of lectures with little contribution from the class, i.e., learning without interaction with peers or the lecturer, was found to be inappropriate as students focused on reproduction of information and rote

learning instead of inquiry and understanding. This resulted in a lack of interest, boredom and perfunctory work.

Although teamwork was used in this course for seven years prior to 1995, it was implemented only for the preparation of an oral presentation. The classical lecture method/style was previously used in class.

The approach of cooperative learning was decided upon for the 1995 academic year, to remedy the above shortcomings and to create a sense of shared responsibility and mutual commitment to each team member's learning experience.

Method

Teams were constituted to allow students in geographical proximity to work together even when not on campus. Care was taken that students within a group were not homogeneous but academically diverse. The number of students per group was governed by the number of groups, namely eight, which was in turn determined by the number of available resources such as computers. (The total number of students in the class of 1995 was 41.)

A consultative session was used to explain to students why they were grouped in this particular way. It was made clear to them that in their work environment they would not necessarily have a choice with whom they wanted to work. Time was appropriated for the explanation of the underlying concepts of teamwork as well as cooperative learning. An undertaking was also given to share with them the results of the respective questionnaires and the study. It was emphasized that the students would gain self-insight and personal growth through this exercise.

Two lecture sessions were appropriated to communicate effective written and oral communication skills to the class. Groups were invited to consult

the Writing Centre should they require assistance with the compilation of their presentation.

After an intensive 7-week Operating Systems course, Belbin's team-role test (Interplace) was applied. No feedback was given at the time, as this information was to be used for team constitution for the second semester at which time feedback and guidance was given to the individuals and newly constituted groups.

Questionnaires were administered after completion of the course to measure the student's impressions of the contents and presentation of the course. Interviews were conducted with individuals and groups using the "reflective conversation protocol" [Schön, 1983].

Main results, findings and discussion

Team functioning

In general the groups reported positively on their team functioning. However, one group (Group 3) expressed their dismay at their group's functioning. Another (Group 6) reported no cohesion; they ascribed it to the fact that they lived close to one another and knew each other too well, resulting in disrespect. Group 7 reported mutual cooperation and satisfaction after excluding a member.

A closer look at the individual team roles of Group 3 revealed an imbalance which can explain the dysfunctional team. Four of the five members had the team role of Plant as one of their dominant roles, three had Specialist as a dominant role, three had the role of Shaper and two that of Monitor Evaluator as dominant roles. Research [Belbin, 1993] found that too many Plants (Innovators) are disruptive to team functioning, as these individuals tend to be unable to listen actively to one another and prefer to do his/her own thing. Belbin also reports that Specialists are no team players, as they

prefer solo performance. Two Monitor Evaluators in a team can lead to excessive analysis and three Shapers can lead to too much argumentation.

Group 6 should have been a well-functioning team, but failed to achieve this, probably due to unknown variances.

After excluding a noncommitted member, Group 7 performed well - they excluded an Implementer-Monitor Evaluator-Shaper. The team roles of the excluded member were dominant roles in the other members' team-role profiles and thus were superfluous. As mentioned in the analysis of Group 3, three Shapers in a team cannot be conducive to a harmonious team. The combination of preferred team roles of the excluded member also indicated a rather egocentric and absolutist frame of reference.

Group-task presentation

In spite of the problems experienced by Groups 3, 6 and 7, all groups were able to accomplish relatively high scores for their group presentations. This confirms the positive effect of cooperative learning as reported by various researchers such as De Villiers and Roode [1995] and Johnson *et al.* [1994]. However, it was our conviction that Belbin's research on teamwork could enhance cooperative learning when balanced teams are constituted and team members acknowledge their own and others' individual strengths and weaknesses, and the contribution each member can make to the successful team.

Course evaluation

An analysis of the individual answers to the course evaluation questionnaire indicated that eighteen members of the class felt positive about the group work and cooperative learning approach. Fourteen class members had some reservations, either on the constitution of teams or cooperative learning, and only five members were completely against both approaches.

The comments of the members who offered positive responses highlight the following aspects as contributing to a successful learning experience [Venter & Stoltz, 1995: Appendix B, 1 -74]:

- active and informal involvement in dealing with new and often complex concepts;
- the sharing of the work alleviates workload;
- gained insight from the inputs of others;
- interdependence requires mutual responsibility and therefore thorough initial preparation;
- exposure to different individual study methods;
- acquisition of tolerance for others' shortcomings;
- makes learning fun and reduces boredom;
- insight into and understanding of the behaviour of other people;
- motivation to read beyond what was expected and to study at own pace;
- learn how to be cooperative;
- initial discussions in class provide a basic understanding of complex new topics;
- broadens own thinking models;
- teaches to deal with conflict/ conflict resolution; and
- bridges classroom experience with the real world.

Even though the following students still felt positive about the new approach, they raised the following points of criticism [Venter & Stoltz, 1995: Appendix B, 1 - 74]:

- due to the fact that the lecturer interacts with individual groups, questions to and answers by the lecturer cannot be shared by the whole class;
- too much time spent on a single topic;
- approach is time-consuming;
- would like more guidance on importance of various sections of work for examination purposes;
- preference for formal lectures;
- time is needed to become accustomed to this approach;
- lack of preparation as well as noncommitted members;
- too little attention to each group by lecturer;
- dominant members highjack group discussions and nonassertive members allowed only low contribution; and
- too much work, for too short a period of time.

Those who indicated no preference for this approach supplied the following reasons:

- lack of co-operation by students;
- inability to understand prerequisite work without the lecturer's input;
- preference for solo study and find group interaction difficult;

- inability to concentrate for an extended period of time on a given topic in an interpersonal setting; and
- unstructured approach makes agenda management difficult.

Interviews

An analysis of the interviews confirmed the findings reported above. However, the following was highlighted [Venter & Stoltz, 1995: Appendix E, 1 - 27]:

> *...it takes the strain out of learning.*
>
> *...it has become more spontaneous, if you are given a topic to attend to, and somebody has read the topic, it is not a question of asking who has read the topic. The person that knows just starts to explain. Then you go home, you read again to verify the explanation, it now becomes part of your knowledge.*
>
> *...if you have a problem, you know that your colleague will probably be able to help you. You know the student-lecturer ratio is very high. It is difficult to get individual attention. It is difficult for the lecturer to solve individual problems, even for 40 students it is very boring.*
>
> *Group work has a responsibility that is associated with it, so once you have a responsibility, there is a certain amount of work you must do in order to make conflict resolution cheaper in business economical terms. So to make that, it forces you to do something.*

Conclusion

The majority of the students in this case study indicated that they did not only gain academically but also on the personal and social levels, by using this method of study. Cohen [1994] is of the opinion that it is necessary to distinguish among different meanings of the effectiveness of cooperative learning.

The following table summarises the intervention and its results.

RESEARCH QUESTION	INTERVENTION	RESULTS OF CASE STUDY 1
TEAM CONSTITUTION How should teams be constituted?	Teams were constituted to allow students in geographical proximity to work together even when not on campus. Teams were academically diverse.	Two groups experienced problems, a third group reported mutual cooperation after excluding a member.
FORMAL/INFORMAL LECTURE RATIO How often should small group learning be alternated with plenary sessions and formal lectures?	No specific decision made on ratio of lectures versus small group learning sessions. Continued mostly with formal lectures.	
SUCCESSFUL LEARNING What could be considered a successful learning experience?	Cooperative learning was introduced.	Students indicated that they: gained insight from the input of others; found this type of learning fun; etc.
MEASURING SUCCESS How is success measured?	▪ Academic achievement ▪ Conceptual learning ▪ Equity ▪ Prosocial behaviour	Could not be determined conclusively. Learnt tolerance Sharing of work
ASSESSMENT How should students be assessed?	Formal examinations	Not changed

TABLE 2: Summary of the results of CASE STUDY 1 in terms of the research questions

According to Cohen it is essential to decide what will constitute effectiveness, namely academic achievement, conceptual learning, equity or prosocial behaviour. At this stage of the research the indication was that the intentions of the study, *to help Computer Science students acquire the necessary skills in communication, written and oral, and to be able to work productively in teams*, were being achieved.

In the next case study the method of team constitution was changed and cooperative learning was introduced.

CASE STUDY 2 – COMPUTER SCIENCE A TEAM EFFORT? USING PSYCHOMETRIC PROFILES IN TEAM CONSTRUCTION. THE SECOND SEMESTER OF 1995 AND FIRST SEMESTER OF 1996.

[Venter & Blignaut, 1997]

Principal objectives

It was noted with concern that third-year Computer Science students (at UWC) often answered examination questions in the exact wording found in the textbook which may suggest that they memorised their study material without the necessary understanding of important underlying concepts. For most of the students (58%) in this case study, the language of instruction is a second or third language. Discussion groups allow students to explore their understanding of the work. This could probably render verbatim studying unnecessary.

It is important to create an environment where students can acquire lifelong skills. A few of these (from a list by Denning [1993: 102]) are:

- Awareness of need to function in international, networked world
- Skills in communication, oral and written
- Ability to work productively in teams
- Flexibility and adaptability in job and career

This study was twofold in that it was directed at understanding the influence of group constitution on group function as well as the influence of teamwork and cooperative learning on the individual's understanding of the subject.

Cohen [1994] suggests that the effectiveness of teamwork and cooperative learning can be measured using the following criteria:

- academic achievement;
- conceptual learning and higher-order thinking;
- equity or equal status interaction within the group;
- positive intergroup relations; and
- desirable prosocial behaviours.

These criteria will be used when measuring the effectiveness of this intervention.

Materials and methods

Design

A different teaching style, incorporating cooperative learning, was adopted for two Computer Science third-year modules, namely Operating Systems (CS314 in the first semester of 1996) and Data Communication & Computer Networks (CS324 in the second semester of 1995). In the Operating Systems module the student learnt about the concepts that underlie operating systems, such as concurrency, deadlock, secondary storage systems, etc. In the Networks module the student learnt about networking protocols, local area networks, wide area networks, etc.

The module on Operating Systems was lectured in the first part of the first semester of 1996 and each team had to present a paper on new developments in the computer environment after the short midsemester recess. For the module on Data Communication & Computer Networks (lectured in the first term of the second semester of 1995) the teams were expected to set up a small network as a practical, but also to write a project on the acquisition of a small network for a fictional (or real) company. Finally each team gave a short (10-minute) presentation on how they

tackled the project, difficulties experienced, and why they decided on certain products.

Two lecture periods were appropriated to explain how to read effectively, how to write up what has been researched and then how to present it. This task was undertaken by the Academic Development's Writing Centre.

In the second semester of 1995 and first semester of 1996, Belbin's [1993] validated and standardised questionnaires (a self-assessment as well as a minimum of four observers' assessment questionnaires) and the software Interplace IV were used to determine each student's psychometric profile. These profiles (without any reference to either gender or academic achievement) were then used to constitute so-called "balanced teams" based on Belbin's team-role theory. Belbin argues that to constitute an effective team, team members should *collectively* have certain intrinsic personality traits. In general teams had five members, with the odd exception where the team had six members. Although the size of the group was not intentional, a group size of six is considered to be the largest group where leadership can be fluid and where it can be democratically shared among the members of the group. Democratically-led groups, compared to authoritarian-led and *laissez-faire* groups, although slower in getting into production, are believed to be more motivated and productive with time and learning [Jaques, 1991]. (In the first semester of 1995, Belbin's method of team constitution was not used but students were grouped according to where they lived to allow them to meet and work after hours. Furthermore care was taken that students within a group were academically diverse.)

A consultative session was used to explain to students why they were grouped in a particular way, at the same time feedback was given to each student on the psychometric tests conducted. It was made clear to them that in their work environment they would not necessarily have a choice

with whom they wanted to work. Time was appropriated for the explanation of the underlying concepts of teamwork as defined by Belbin [1993] as well as cooperative learning as defined by Johnson *et al.* [1994]. Each student received a summarised report of his/her rating of himself/herself compared to the ratings of his/her four observers and a final weighted rating indicating his/her dominant team roles. They received a further personalised report, which highlighted the student's positive contribution to a team as well as his/her allowable weaknesses within the team.

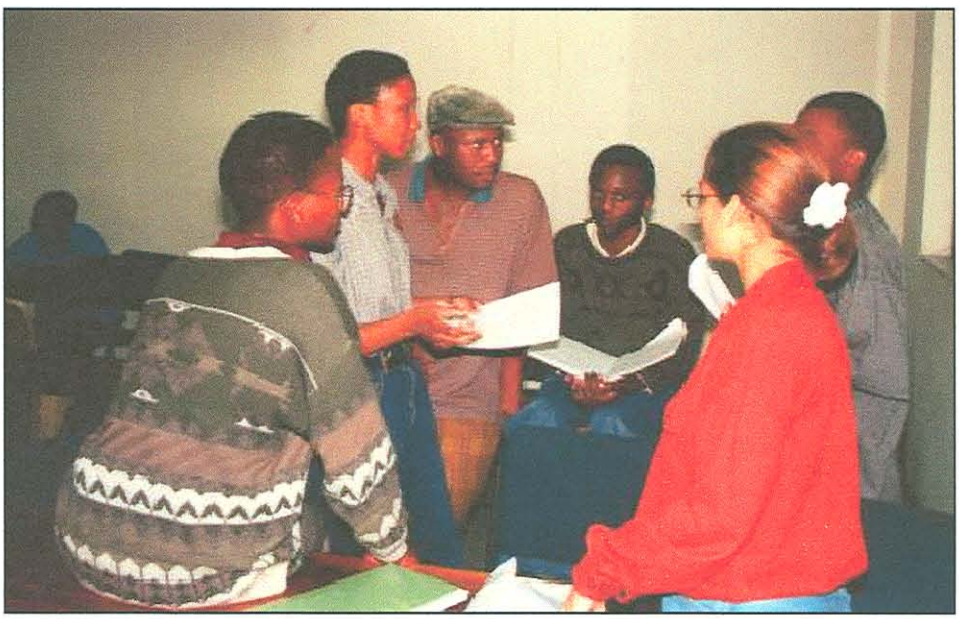


FIGURE 15: Team in session

The cooperative learning approach meant that lectures deviated from the traditional presentation style. Students were expected to come prepared to class and be seated in their respective teams/groups. The groups had to discuss areas that they found problematic. If none of the team members could explain the problem satisfactorily, the team could call upon the lecturer who would then give a brief presentation-style lecture on that particular section of the work.

Cooperative learning was used to share personal insights gained through individual learning in a group situation, for the purpose of conceptual insight but also to foster effective oral and written communication.

The concept of cooperative learning within a team combined with the concept of mind mapping was introduced to help students to get the "overall picture" and not to get bogged down by all the technical detail. (A mind map is a clear and concise graphical representation of relevant, associated, categorized and hierarchically ordered information.) Students were expected to brainstorm a section of the work and to produce a mind map.

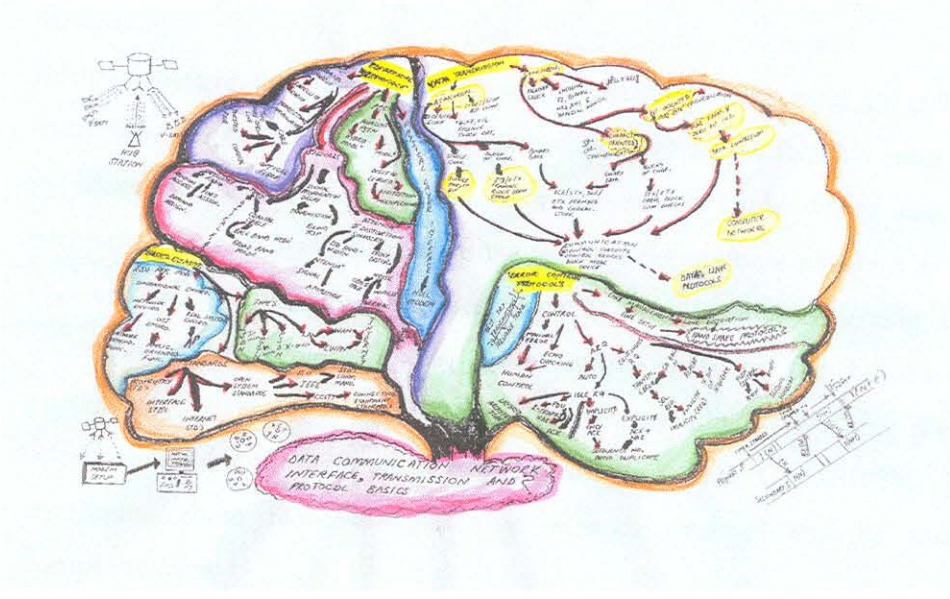


FIGURE 16: Mind map

During the class any member of a team could be called upon to explain his/her understanding of the section of work to the whole class, using the group mind map. The team had to come to class prepared with a transparency of the mind map, in order to present it.

The group mind map could be used during the writing of tests and even in the final examination. Each group/team member was allowed to use a copy of their group's mind map, drawn on both sides of an A4-sized paper (or one side of an A3-sized paper) and covering all the work, in the examination room.

The working together of a team to achieve a combined goal such as the presentation of a paper or the completion of a project is almost impossible to attain individually, thus making the team effort imperative. The progress of each team was carefully monitored. Teams had to report weekly on their progress. This was done via e-mail.

Method

Both qualitative and quantitative research methods were used to collect data. Why use both these research methodologies? It was felt that research in education could be compared to a naturalistic study where inquiry demands a human instrument adaptive to the indeterminate situation he or she will find. Qualitative methods, such as interviewing, observing and taking note of nonverbal cues, come more easily to the human-as-instrument. However, the quantitative paradigm creates many opportunities for the naturalistic investigator [Lincoln & Guba, 1985]. By combining these methodologies the research findings will be more comprehensive.

The quantitative method used entailed the use of a self-administered questionnaire that covered background information such as gender, home language, age, as well as questions on group behaviour, usefulness of the Belbin's team-role classification and preferences for different lecture styles. The data was analysed using the SAS statistical package [SAS, 1989]. Chi-square (χ^2) tests [Zar, 1984] were used to analyse frequency tables. Mann-Whitney and Kruskal-Wallis tests [Zar, 1984] were implemented to test for differences in continuous variables among the various groups.

Semi-structured interviews (where students were asked to reflect on their learning using Schön's "Reflective Conversation" protocol [Schön, 1983]), minutes of team meetings and field notes were used to collect the qualitative data.

Results

Quantitative research findings

Descriptive statistics

A total of 84 students (41 in 1995 and 43 in 1996) completed the questionnaires. All questionnaires could be used for analysis purposes. (Students were asked their matriculation mathematics marks. These marks were correlated with the marks received from the university records. This was done to check the integrity of the data. Data was found to be trustworthy and therefore all the questionnaires could be used for analysis purposes.)

A third of the class (33%) were female. The majority of the students (63%) were between 21 and 23 years old, and 29% were older than 23. Most of the students (74%) were enrolled for a B.Sc. degree, the rest for a B.Com. degree.

It was felt by most students (69.6%) that mind maps gave them a broader perspective of the work, that they learnt new ways of ordering facts and information (68.3%) and that the presentation of the mind map enhanced their understanding of the work (61.6%).

The different home languages of the students (See *Figure 17*) were Xhosa, English, Afrikaans, and languages such as Zulu, Shangaan, Tswana, Ndonga, South Sotho, Siswati, etc.

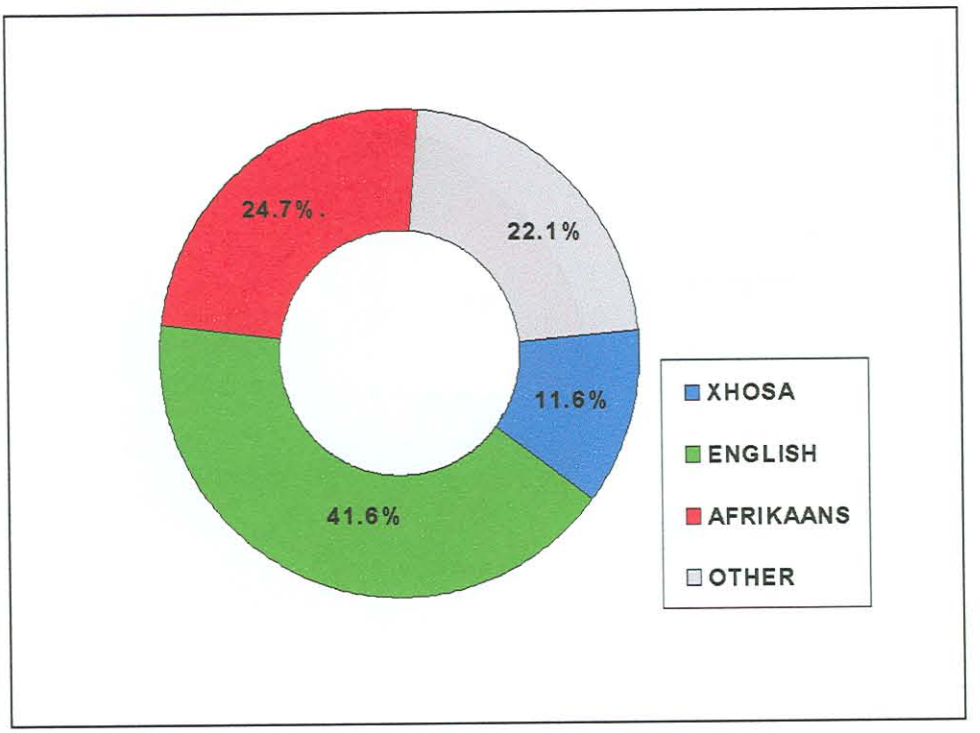


FIGURE 17: Different home languages of the students

The frequency analysis of the questionnaire indicated that most students were positive about their group participation. For example, 83% expressed their willingness to cooperate with their group members but they also expected cooperation from their group members (89.9%). They felt accepted as a group member and felt that their group was cohesive.

The majority (62.5%) enjoyed working in a group, 73.4% indicated that the group motivated them to do their share of the work and 68.4% felt that more work was done faster.

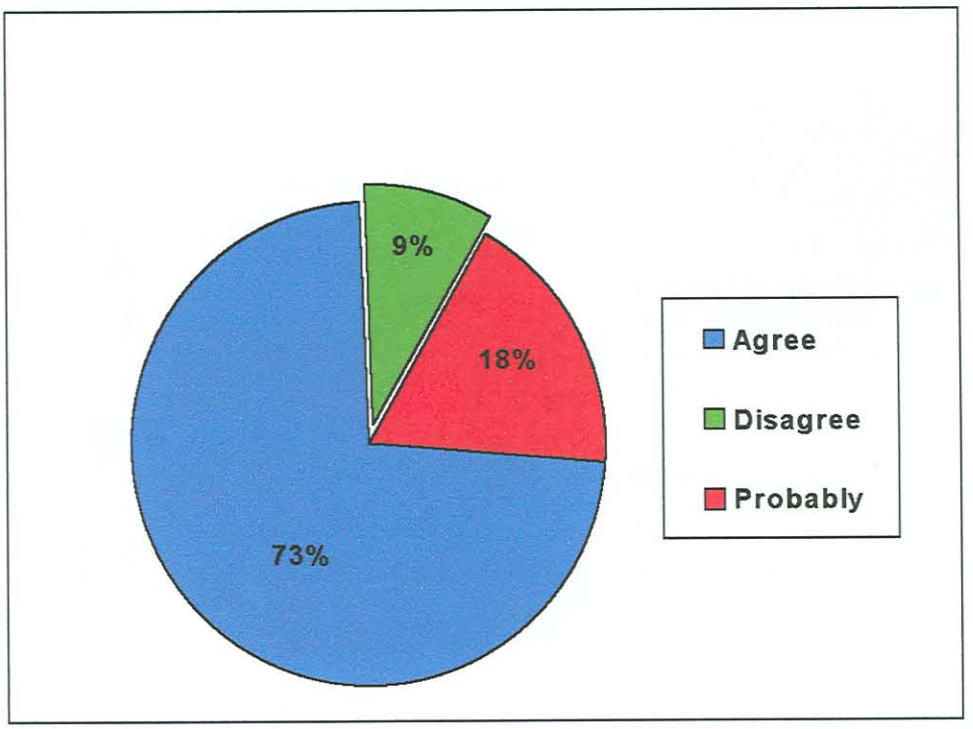


FIGURE 18: Group motivated me to do my share

Most students accepted the Belbin team-role concept. They indicated that they gained insight (68.8%) into the role that they could play within a team. Only 46.8% felt that the team profile was a good reflection of them but most (79.8%) found it interesting to see how their family and friends rated them. The majority (78.2%) felt that they gained insight into their strengths and weaknesses within a team.

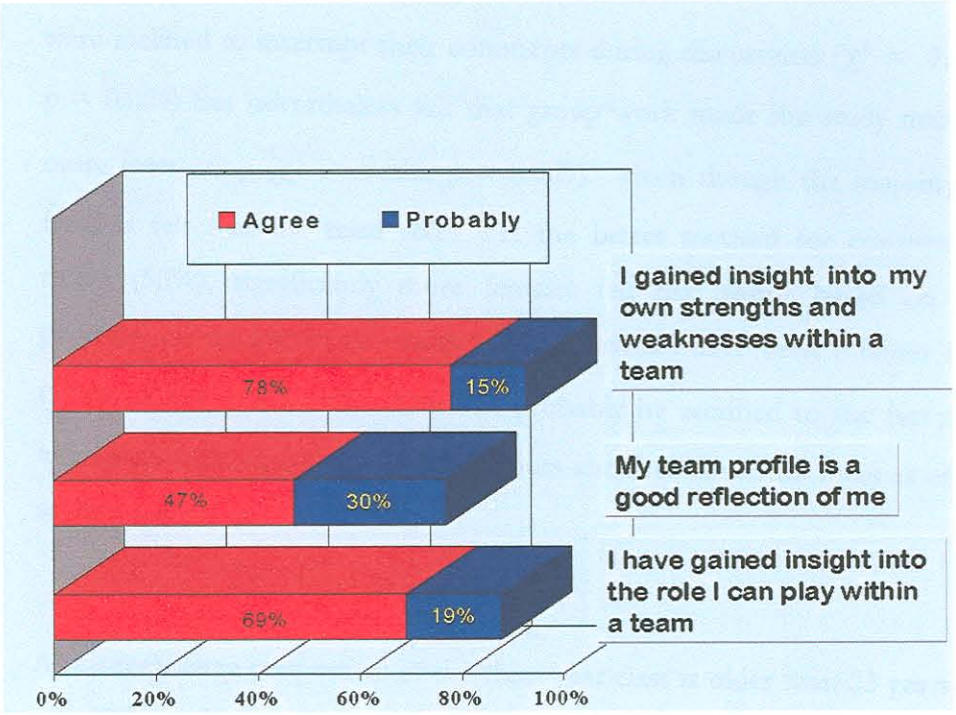


FIGURE 19: Belbin team-role concepts

Students (54.3%) liked the more informal format of the lectures and enjoyed doing the presentation in the Operating Systems course (75%).

Inferential statistics

GENDER

In a recent study by Durndell and Thomson [1997] it was found that over the last decade very little had changed in the relative interest in and involvement with computing of females as opposed to males (in Britain). The fact that two thirds of the study group are male corresponds to the British finding, but in both attitude and achievement we found very few differences between the genders. A few differences were, however, significant.

It is interesting to note that men have the perception that team members do not value their opinion: significantly more males felt that team members

were inclined to interrupt their comments during discussions (χ^2 = 7.452, p = 0.024) but nevertheless felt that group work made the study material more interesting (χ^2 = 9.522, p = 0.009). Even though the majority of females felt that the team roles was the better method for constituting teams (56%), significantly more females felt that teams based on the geographical proximity of students' homes would have been a better idea (χ^2 = 6.354, p = 0.042). This can probably be ascribed to the fact that women feel unsafe on campus after hours and thus could not meet as often as they wished to.

AGE

A relatively large proportion of the third-year class is older than 23 years of age (29%). It may be an indication that students start their university careers at a later stage, which would underwrite the finding that many students are from a disadvantaged background. Or it may be that these students need more than the required three years to complete their bachelor degrees and are thus spending an extra year or two at university because their schooling did not prepare them sufficiently for tertiary education. The language of instruction could probably be a factor too.

Significantly more males are in the age group > 23 (χ^2 = 7.948. p = 0.005). The younger students (23 and younger) scored significantly better in their final matriculation examination (χ^2 = 8.175, p = 0.004) and are mostly English or Afrikaans-speaking (χ^2 = 9.295, p = 0.002).

LANGUAGE

For the majority of students (58.4%) the language of instruction, English, is not their mother tongue. When students whose home language is English, Afrikaans or an African language are considered separately, the students whose mother tongue is a language other than English (χ^2 = 10.100, p =

0.039) need to paraphrase what team members have said before commenting, indicating that students whose home language is not the language of instruction (English) find it difficult to express themselves well in English.

MARK COMPARISONS

Significantly more students who obtained a matric mathematics symbol less than a C indicated a willingness to work in a group ($\chi^2 = 7.942$, $p = 0.019$). A higher proportion of students who obtained an A, B or C for matric mathematics study for the B.Sc. degree ($\chi^2 = 8.737$, $p = 0.003$). A smaller proportion of the students who speak an African language obtained an A, B or C aggregate for their matric mathematics ($\chi^2 = 7.868$, $p = 0.020$). Practically all the students who obtained an A, B or C for matric English feel that the group accepts them as they are ($\chi^2 = 7.264$, $p = 0.026$). The only Computer Science module that significantly correlated with the matric final results is the software engineering course ($p = 0.0169$, $r = 0.2889$). No significant correlation was found between Computer Science marks and matric English or matric mathematics results.

To ascertain whether matric English or mathematics results could be used to predict the aptitude of students in Computer Science, various regression analyses were calculated. It was suggested that the formula ($maths^2$ x eng) could be used to predict Computer Science ability. When calculated, none of these regression equations proved to be useful or statistically significant.

Principal component analysis indicated that the dominant team role according to Belbin did not have any bearing on the achievement of the students.

No significant mark differences were found between the genders.

Students whose mother tongue is an African language achieved a higher year mark for CS324 (Mann-Whitney = 4.8601, p = 0.0275).

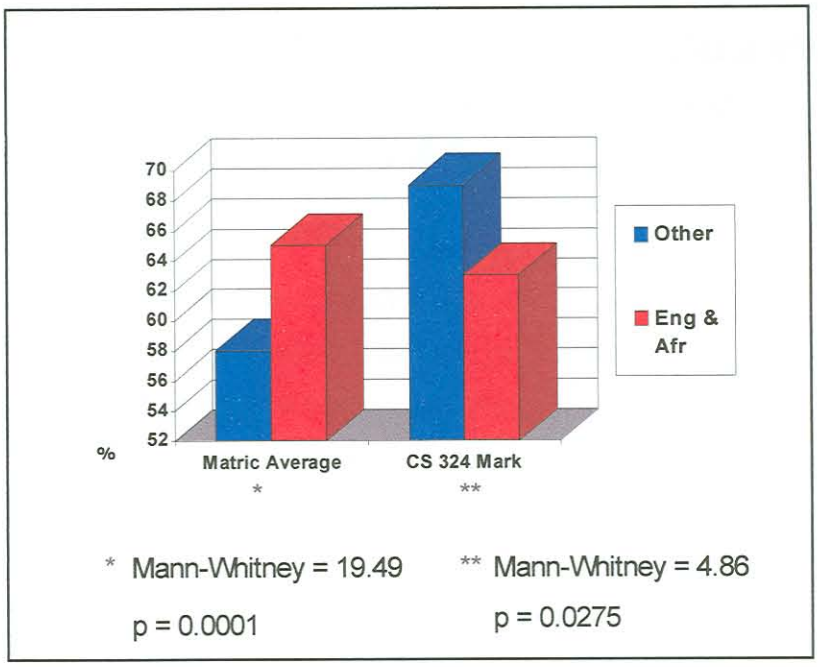


FIGURE 20: Matric average compared with third-year results

As can be seen from *Figure 20*, matric average is no indication of success rate at third-year level. The backlog that African language speakers experience in their first year is eradicated by the time they reach their third year.

The results for both matric average and matric mathematics were higher for English and Afrikaans-speaking students (Mann-Whitney = 19.491, p = 0.0001; Mann-Whitney = 8.5802, p = 0.0034). English-speaking students did significantly better in the CS314 exam; they also obtained a significantly higher CS313 final mark compared to the other students (Mann-Whitney = 8.3992, p = 0.015; Mann-Whitney = 6.1139, p = 0.047).

Younger students (<23) did significantly better than the older students (>=23) in matric average, matric English, CS313 (Software Engineering) year and final mark (Mann-Whitney = 8.0944, p = 0.0044; Mann-Whitney = 4.9727, p = 0.0258; Mann-Whitney = 4.3941, p = 0.0361; Mann-Whitney = 4.7295, p = 0.0296). B.Sc. students achieved higher marks for matric mathematics (Mann-Whitney = 6.0607, p = 0.0138) compared to the B.Com. students.

Students who obtained an A, B or C for their matric average did well in matric mathematics and matric English (Mann-Whitney = 11.036, p = 0.0009; Mann-Whitney = 4.4179, p = 0.0356). These students also scored high marks in the final mark for CS313 (Mann-Whitney = 8.8782, p = 0.0029).

Qualitative research findings

Interviews

To obtain additional information, interviews (using the "Reflective Conversation" protocol [Schön, 1983]) were conducted with the 16 teams and with eight individual members of the teams. Students indicated that they now **reflected more on their learning** [Venter & Blignaut, 1997: Appendix I: 1 – 70]:

> *It helped to get a better overview. Last semester you just try and study one section because we didn't have to do the mind map, we had to cover everything.*
>
> *It is now easier to associate certain things with each other to see where everything meets.*
>
> *When I do it myself I tend to focus too much on the detail.*

The students **preferred active learning:**

> *Oh mind maps, it is a new thing for us and we are not knowing what to do and how to construct the things, how to go about doing it – but later on as we went through the course it became better and you saw the value of it and I think it is actually good.*
>
> *While doing the mind map actually you are discussing it and if I don't know something they (the group) will explain it to me. We actually learnt more in class.*

The students **felt more stimulated**, challenged and satisfied:

> *So I actually like the approach. -- So you learn to stand on your own two feet.*
>
> *We at least came prepared to class.*
>
> *...the lecturer will say something and just go and go on, but while doing the mind map actually you are discussing it and if I don't know something they will explain it to me. We actually learnt more in class.*

Positive interdependence (where the group positively encourages members to work) was highlighted:

> *...nobody in our group is technically orientated. No geniuses that way in our group and I'm so amazed that we actually – did it.*

Some had their reservations about the team roles but the majority indicated that they had gained new insights into themselves and it had made them realise their strengths and weaknesses. As one student said:

> *Well, I thought -- subconsciously I thought, maybe I was like that. It's just that I could look at myself in that light, and the part that I see I should work on. I do have, not inadequacies, but I do have like maybe a fear of pain, something like that. I do have that or try to finish everything fast or make sure that everything is right, and they told me that is the part that I should work on. I do think that I should work on it as well.*

And another:

> *You think you have these strong points, because you don't realise your weaknesses. So if at least anybody else sees a weakness in you, you can work on it. ... you always think you're perfect...*

Team functioning

In general the groups reported positively on their team functioning. Initial problems usually arise from the different interpretations of commitment of team members. However, this is easily resolved by a discussion session between lecturer and team. Minutes of meetings, e-mailed once a week to the lecturer, are also an indication of how well the team functions.

This case study covered the second semester of 1995 (when Belbin was first introduced) and the first semester of 1996. Team functioning in these periods will now be discussed.

THE 1995 STUDY GROUP:

Two teams experienced more than the expected problems. Surprisingly the team which did best in their project, and its presentation, and which functioned exceptionally well as a team (Group 2), eventually excluded two of their members from using the final examination mind map. Even though one member felt that the group was too "strict" with the two expelled members, the majority felt that these two had not contributed their share. After consultation and intervention, one team member was allowed to use the final mind map and the other only half of it. At a meeting with the other (problematic) team (Group 3), the group's problems were not discussed. The intervention was just aimed at salvaging the project by allocating and coordinating the remaining tasks. This was successful.

THE 1996 STUDY GROUP:

Only one team (Group 4) did not seem to form a cohesive group. The groups were finalised in the second week and even at that early stage, this specific group had problems in getting organised. Throughout the course this group experienced difficulties. It is interesting to note that the student who was partly excluded from using the final examination mind map of a group in 1995, was a member of this specific team in 1996. Two teams (Groups 5 and 8) reported that they felt very positive about teamwork.

Discussion and conclusion

UWC students typically come from varied academic and socioeconomic backgrounds, most are first-generation university students and a large proportion come from educationally disadvantaged communities. This is reflected by the large proportion (30%) of the study group that are above 23 years of age. (Interestingly, the majority of these students are men.)

The official language of instruction at UWC is English but for a large proportion (58%) of our students, English is not their home language (see *Figure 17*). It is therefore not surprising that language was again highlighted as one of the factors influencing achievement at university. This has been our finding in an earlier study where language ability was identified as contributing to the success rate of students in computer literacy [Venter & Blignaut, 1996]. The fact that English is a foreign language for most students may have a bearing on the difficulties students experience with verbalising their understanding and why they resort to memorising instead of understanding the prescribed text.

Although no significant mark differences were found between the genders, it is interesting to note that significantly more males felt that the team members interrupted their comments during the discussions. Significantly more students who obtained a matric mathematics symbol lower than a C

indicated their willingness to work in a group. Furthermore, it was established that a larger proportion of students who speak an African language obtained a matric mathematics symbol lower than a C.

No significant correlation was found between third-year Computer Science marks and matric English or matric mathematics results. Thus matric English and/or matric mathematics results cannot be used to predict which students would be successful in their third-year Computer Science.

When using Cohen's [1994] criteria for measuring the effectiveness of teamwork and cooperative learning, the following can be concluded:

- Academic achievement: It could not be determined conclusively that students achieved better when working in groups. However, the majority of students indicated that working in teams contributed to their understanding of the subject, that they gained on a personal and social level and that they had learnt more in the group than they would have had by learning individually. Most (78.2%) felt that the Belbin team profile provided them with insight into the contribution that they could make to a team.
- Conceptual learning: The more informal format of the lectures, and the preparation and presentation of mind maps were positively experienced by most students; they learnt new ways of ordering facts and information which enhanced their understanding of the work.

Apart from academic achievement, some of the other criteria mentioned by Cohen that could be used to measure the effectiveness of this teaching method are:

- positive intergroup relations and
- desirable prosocial behaviours.

If the following remark of a student from the 1995 cycle (Case Study 1) is a measure of this, then the group work has indeed succeeded in respect of these two criteria [Venter & Stoltz, 1995: Appendix E, 1-4].

> *And also the other problems within our institution, students become like strangers. Like, oh, there is the coloured boy, there is a black student. We are all people from a different world. But in cooperating, that is happening in our class, but suddenly we communicate and in one group we have commonalities.*
>
> *The people I have met this year have been in the same computer class since 1992, but we have not even bothered to speak to one another. ... I know the students since 1992, but I don't know their names. The tension is gone -- now that we know each other.*
>
> *...without it being necessary to control your conversation, you know it will be accepted. It has brought one (collective) personality into the class.*

De Villiers and Roode [1995] are of the opinion that the social structure used in tertiary education is out of synchrony with the social skills needed in a technological-based economy. Cooperative learning and teamwork, with the development of positive intergroup relations and desirable prosocial behaviours, can possibly bridge the gap.

Even if the only positive aspect of group work turns out to be that students enjoy learning, which they seemed to do, then this more mature approach to learning is worth pursuing. On the other hand such a conclusion possibly indicates that the present structures of our examinations are failing to adequately test the dimensions of learning we wish them to.

The following table summarises the findings of this case study.

RESEARCH QUESTION	INTERVENTION	RESULTS OF CASE STUDY 2
TEAM CONSTITUTION How should teams be constituted?	Belbin team-role theory used to constitute balanced teams.	In 1995 two teams experienced problems, one of these functioned well until the final mind map had to be prepared. In 1996 only one group experienced problems.
FORMAL/INFORMAL LECTURE RATIO How often should small group learning be alternated with plenary sessions and formal lectures?	Group mind map presented by groups once a week. Formal lectures reduced – given approximately once a week plus *ad hoc* lectures (when students found material difficult).	The majority of students (54%) liked the more informal format of the lectures. *…we at least came prepared to the class…*
SUCCESSFUL LEARNING What could be considered a successful learning experience?	Cooperative learning with mind mapping was used.	Most students (70%) found that mind maps gave them a broader perspective of the work. *…later on as we went through the course it became better and you saw the value of it…*
MEASURING SUCCESS How is success measured?	▪ Academic achievement ▪ Conceptual learning ▪ Equity ▪ Prosocial behaviour	Could still not be determined conclusively. Mind maps improved conceptual learning. *…people from a different world … communicate …*
ASSESSMENT How should students be assessed?	Some peer evaluations introduced but mostly formal examinations.	Largest proportion of marks still individual examination mark.

TABLE 3: Summary of the results of CASE STUDY 2 in terms of the research questions

In the next case study the "chalk-and-talk" method is compared with small group learning. The only variable in this case study was the lecturing method. The class, the subject that was taught (Statistics) and the lecturer in this case study, remained the same.