Scope

Technology Education has gone through a lot of changes in the past decades. It has developed from a craft-oriented school subject to a learning area in which the meaning of technology as an important part of our contemporary culture is explored, both by the learning of theoretical concepts and through practical activities. This development has been accompanied by educational research. The output of research studies is published mostly as articles in scholarly Technology Education and Science Education journals. There is a need, however, for more than that. The field still lacks an international book series that is entirely dedicated to Technology Education. The International Technology Education Studies aim at providing the opportunity to publish more extensive texts than in journal articles, or to publish coherent collections of articles/chapters that focus on a certain theme. In this book series, monographs and edited volumes will be published. The books will be peer reviewed in order to assure the quality of the texts.
Researching Technology Education

Methods and Techniques

Edited by

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HOWARD MIDDLETON

RESEARCHING TECHNOLOGY EDUCATION

New Ways of Understanding Teaching, Learning and Knowledge

INTRODUCTION

This chapter provides an overview of the contents of the book, and a rationale for both the idea of such a book and for the chapters within it.

The idea for this book came from a presentation I made at the 2005 PATT Conference in Haarlem, in the Netherlands, which was subsequently published (Middleton, 2006). The theme of the conference, which was in some ways a celebration of twenty years of PATT, was PATT: Twenty Years in Retrospect. The intention was to present papers that explored changes in the field of technology education, around the world, over the previous twenty years. Thus, most presenters provided details of the development of the field in their region or country. I took a different approach and provided an examination of the development of approaches to research in technology education over the period. This chapter summarises the argument presented at that time and argued that there had been important developments in how technology education was being researched.

In one sense this book can be seen as the research equivalent of what Shulman termed pedagogical content knowledge (Shulman, 1987). Shulman argued that all teachers needed pedagogical knowledge. That is, knowledge of the general things all teachers need to know, how to structure a lesson, organise class activities, etc. However, Shulman argued that, in addition to these general teaching skills, teachers needed to know the best ways to teach in particular disciplines, the most powerful analogies and examples and ways of creating good learning within that discipline. In this book, I explicitly, and the authors, implicitly, are arguing that for us to understand technology education we need to use research methods that are appropriate for technology education. That is, methods and techniques that account for the particular characteristics of technological knowledge and of the process of learning and teaching in technology education classrooms.

You will also find that aspects of each research method or technique are teased out in more detail that is often the case when reporting on research. This is deliberate and done for two reasons. The first is to assist researchers in making decisions about the use of particular methods or techniques. The second reason is that there is increased competition internationally, for such things as research funding and in getting papers accepted for publication. The assumption throughout the book is that we need to justify research approaches at a more fine-grained level that has been the case in the past. The hope is that the book will help
in putting research proposals together, both for research students and those seeking
funding for research. Finally, it needs to be said that these are not a collection of
mutually compatible stories, though of course some are. Some, however, could be
interpreted as contradicting the intention or philosophy of others. I prefer to think
that there are some tensions across the methods and that this is healthy at any time,
but particularly healthy when we are working at developing the best ways of
examining this phenomena, about which we still have much to learn, called
technology education.

RESEARCHING TECHNOLOGY EDUCATION

In 2005, I argued that:

The kinds of research methodologies that have been employed over the last
twenty years have evolved and are evolving in ways that are making them
more suitable for researching the things that need to be researched about
technology education. I am not arguing that all research in technology
education is compatible with this evolution but that there is evidence that it is
happening. My purpose in doing so is based on the belief that using the
correct research tools is as important to achieving the research aims for
technology education as researching the right topics. Further, some research
tools are necessary for the conduct of certain research so that availability of
tools can, to some degree, determine what is researched, and what we are able
to discover. Lastly, evolution can be ordered or entropic. To ensure that
research provides outcomes that allow technology education to evolve in an
ordered and positive way it is important to highlight positive developments in
research methodologies as well as research findings. (Middleton, 2006, 2)

These new ways of researching technology education included methods that can
be considered new, in themselves, such as Richard Kimbell’s e-portfolios. Alternatively, some represent revisions to established techniques such as Frank
Banks or Robert McCormick’s case studies, or Margarita Pavlova’s comparative
methods. Further, some could be considered methods used elsewhere but not
generally used in technology education. These include Lars Bjorkland’s repertory
grid technique and Brad Walmsley’s stimulated recall. However, all are new in
the particular ways in which they are used to help us understand knowledge and
learning in technology education.

In providing an introduction to each chapter, the intention is not primarily to tell
you, in a somewhat condensed form, what you will find in the chapter, although
that is done to some extent. The main point is to highlight the features of each
chapter that made them distinctive and worth including in the book.

Robert McCormick provides a very detailed description of a case study
methodology for researching learning in technology education classrooms. A
particular contribution of Robert’s chapter is the detailed analysis of the strengths
of case study methodology and the detailed description of data analysis. Case
study methods, like most qualitative methods, are subject to the criticism that it is
difficult to establish validity. Robert’s approach to the chapter provides ample material for researchers to use in addressing issues of validity.

In his chapter, Frank Banks extends Robert McCormick’s work to detail the possibilities for international collaborative case study methods. One aspect of Frank’s paper that should be useful is the ways in which the methodology developed. In an era when greater importance is being placed on research that transcends national jurisdictions, this is a particularly welcome contribution.

Lars Bjorklund revisits Kelly’s (1955) repertory grid technique. This is a method rarely seen in technology education research but one that Lars argues is a useful technique to examining constructs about technology education via interviews. Lars argues the technique is useful for tapping into peoples’ implicit and tacit knowledge. Given our emerging understanding of the importance of such knowledge to technology education, this should be a useful chapter. Lars introduces us to software that enhances the process for researchers.

Ivan Chester makes the point in his chapter, if only by implication, that when it comes to researching technology education, we are examining a moving target. This seems to be particularly the case with learning and teaching for computer-based aspects of technology education. One issue that has plagued cognitive research into problem-solving processes has been the effect of the research process on the subject and thus on the data being captured. By using more recent data capture software in combination with older verbal protocol capture and analysis, Ivan provides a method for exploring thinking in this rapidly developing area of technology education.

In arguing for the value of a cultural-historical approach to understanding knowledge and learning in technology education, Marilyn Fleer makes the important point that many popular ways of examining concept formation, rely on an examination of formed concepts, rather than the process by which they were formed and the connections between concept formation in school and children’s everyday concepts. In doing so she applies Vygotsky’s ideas to capture the dynamics of students learning processes.

Richard Kimbell’s chapter is truly an action research project given that he wrote the chapter about a project that was still progressing and not due for completion until 2007. The interesting feature of Richard’s work on e-portfolios is that they address two long-standing problems in technology education. The first is the problem of conventional portfolios that were intended to describe process (of a design project) which were invariably undertaken after the completion of the project. The second is the issue of capturing, in something near to real time, the students thoughts and ideas as projects develop. This is a method in development but one worth knowing about.

Margarita Pavlova describes a new approach to a well-established research methodology, that of comparative research. However, Margarita brings to the method a rigour and purpose that has often been absent in past comparative approaches, which have often relied on simple descriptive analyses. Margarita does this by subjecting the comparative approach to a strong theoretical framework, which informs both the design of the study and of the analysis of data.
REFERENCES


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CLASSROOM CASE STUDIES

INTRODUCTION

This chapter is based on case studies that have been developed over a number of years through examining design and technology (D&T) in secondary school classrooms in England. The focus of these studies was on problem solving, the use of mathematics and science knowledge, and the knowledge demands of electronics. Such case studies are important to capture the pedagogy of the technology classroom and to understand how concepts and processes are made explicit, through the physical and intellectual activities and interactions among students, and between teachers and students.

The theoretical issues of knowledge that these case studies explored concerned firstly the nature of knowledge in the technology classroom. Following McCormick (1997 & 1999), knowledge can be seen in terms of general categories of procedural, conceptual, and qualitative knowledge. However, it will be evident that these categories need to be viewed from particular views of learning (McCormick, 2006). In the context of technology it is also important to see the nature of conceptual knowledge in particular, from the point of view of how students experience knowledge through the related school subjects of science and mathematics and how these might differ from that in technology. The second issue concerns the use of knowledge, specifically the use of science and mathematics in technology activity. The third issue is to look at some of the slightly different issues of knowledge that might relate to social or moral issues, but which occur in the context of apparently technical activities such as programming a traffic light sequence for a pedestrian crossing. The fourth issue is the teacher’s role in, and the strategies for, dealing with these knowledge issues in the classroom; for example, when teachers come to ‘revise’ science knowledge needed at the beginning of a technology project, or the extent to which they rely on providing knowledge on a ‘need to know’ basis.

Some of the studies that this work is based on concern problem solving and the design process, i.e. procedural knowledge. However, in such studies (e.g. McCormick & Davidson, 1996) it became clear that procedural and conceptual knowledge were intimately connected. These studies, and subsequent ones specifically on knowledge, took a situated view of learning with its consequent view of knowledge. This gave particular imperatives to the case studies, and indeed was a fundamental reason for adopting a case study approach. This rationale will be examined shortly, suffice to say that knowledge is seen as intimately tied to the context within which it is encountered (learned), and cannot be seen as de-contextualised and abstract as is usually the stance of cognitive constructivists.

H.E. Middleton (ed.), Researching Technology Education, 6–27. © 2008 Sense Publishers. All rights reserved.
This chapter should provide researchers with ways to undertake international research in technology education that provides important insights into the phenomena being examined.

Observations are a familiar stock in trade for researchers of human activity. However, the important contribution of the chapter by Kay Stables is the detailing of how and why the methods used were developed over time to meet the needs of the situations as they were encountered and developed. Kay also addresses the crucial issue of how to make observations in ways that don’t produce completely unmanageable volumes of data for analysis.

The chapter by John Stevenson might be sub-titled a cautionary tale! John draws on research into the activity that occurs in the front office of motels. The chapter is cautionary because John argues from a cultural-historical activity perspective that meaning is not the same as sense and that actions are not the same as knowledge of actions. John goes further in his cautionary tale to make the point that understanding how one person interacts with the artifacts of one context provides limited clues as to how that person, might interact with artifacts in other, apparently similar contexts. John’s chapter is a particularly useful one for an area where complex interactions are common, but where there is the tendency to push for simplified, overarching conclusions about the nature of knowledge and activity in technology education.

Brad Walmsley presents us with a technically sophisticated method for collecting, coding and analysing the complex data that comes from the interactions within a technology education classroom. Brad refers to a larger study of which his chapter in this book represents one part. Video Stimulated recall is not new and is a method developed with the availability of inexpensive video recording equipment. The particularly interesting feature of Brad’s research is the concurrent capture of both student-to-student interactions and teacher-to-student interactions, and the possibilities these combinations provide for the analysis of the dynamics of the technology education classroom.

My chapter provides a method that attempts to give credence to the particular data that is generated by designing, but which is often ignored by researchers. That is, in the study that the chapter is based on, I used standard verbal protocol analysis of design activity, but added to this an analysis of the visual protocols generated by design activity. The meaningful analysis of visual data is both overdue and one area where there are particularly interesting research possibilities in technology education. It is also an area where research in technology education may result in new insights in other areas where visual data can be generated.

So, the book contains a collection of research methods and techniques that are being used, developed and explored, as the saying goes, as we speak. I hope you find them useful and that they make your research endeavours a little easier and more successful.
McCormick (2006) shows the general view of this stance and some of the kinds of studies that were undertaken within this framework.

In general these studies were conducted by outsiders (i.e. not by teachers themselves) and this has specific implications for how we conducted the studies and for methodological issues such as the role of the researcher and ethics. (These will be dealt with under Case Study Methodology.)

The structure of the chapter follows the major questions that researchers must answer in their decisions and justification for employing case studies, namely why use this approach, what kind of case study, what stance is taken to the major methodological issues such as generalisation, bias, ethics and how data should be collected and analysed?

WHY CARRY OUT CASE STUDIES?

The principal reason for employing a case study methodology is to see a phenomenon under investigation in context. Thus we can set up specific activities to test student understanding of a concept but, unless the activity is encountered as it is in everyday classroom activity, there is no guarantee that it would inform us sufficiently about that everyday activity. This does not preclude such ‘tests’ as one of the methods of data collection, as I will indicate later. Yin (2003, p. 13) gives a second reason for employing a case study, namely when there are unclear boundaries between phenomena and context.

Both of these conditions are important when research takes the theoretical perspective of a situated view of learning and hence knowledge. McCormick argued that:

> Participation, in the situated approach, means more than that learning is not simply ‘in the head’, nor just that it takes place in a social and physical context, but that it is related to action … the relationship between thinking and action is reciprocal. McCormick, (2006, p. 33)

McCormick goes on to argue that seeing knowledge as situated implies that it is interwoven with context. A simple example is the concept of resistance, which in a science classroom will be associated with coils of wire, with longer coils constituting greater resistance. In contrast in the technology classroom, resistance will take the form of small ceramic resistors, all of the same size, but differently colour-coded. To understand the distinctions requires the concept of a material’s ‘conductivity’, not usually dealt with in the science lesson at the stage where students will start to use ceramic resistors. In this situation it is unhelpful to give de-contextualised accounts of knowledge and its use. The way teachers are trained, the way the curricula are formulated, and what students are required (even allowed) to learn at various ages, all constitute ‘context’. This exemplifies the situation Yin had in mind in requiring both ‘real-life’ phenomena and an unclear boundary of context and the phenomena.

Seeing knowledge in context is a general rationale for using a case study, but there are also specific purposes in conducting a case study. Up to now I have
implied that the research in some way leads to a theoretical understanding. Yin (2003, p. 15) gives five reasons in the evaluation research context, where researchers seek to understand, for example, how an innovation might develop (e.g. take root in a school), so that they can evaluate whether it has been successful and help others implement it in their classrooms. The first purpose is to describe an event or an intervention. In our evaluation of a new programme of electronics, we described how teachers used their training, in the many different forms of implementation of the programme in schools, through a number of case studies of their practices in the classrooms (Murphy et al., 2004). This also enabled Yin’s (2003) second purpose for case studies, namely the function of illustration.

From this it was possible to determine messages that emerged about practice and, in the context of this particular electronics programme, the needs that teachers had to implement electronics in their schools. These ‘messages’ moved us beyond description, to explore the outcomes of a real-life intervention too complex to be handled by other research methods (Yin’s third reason). We found that for the implementation of an electronics programme facilities, equipment and resources were important, along with local support for a teacher, the curriculum options and so on. The way these factors (and others) played out in a particular case study varied, but as researchers we could show how, for example, effective practice could be encouraged or limited by examining their relationships.

Although this kind of exploratory evaluation study may not lead to theory building, in other studies it did. For example, how students undertake problem solving and of how qualitative knowledge is used by teachers and students in technology classrooms (McCormick, 1999). These case studies explained causal links in real life activities of the classroom. For example, the teacher behaviours that encouraged various strategies of problem solving that students employed. This is not the ‘grand’ theory that Hammersley (1990, pp. 105-109) discusses when he examines some classic school case studies and ‘differentiation-polarization theory’, which explains the impact of streaming and the like in schools. However, case studies of all kinds can build on existing ideas and emerging theories.

Often those who undertake case studies for the first time treat them as descriptive, and assume they must keep an open mind, unsullied by theory. However, open as researchers we aim to be, we always bring some kind of ‘theory’ to bear in trying to understand what we see. Also, it is hardly sensible to start a study assuming nothing is known, and there is no point in undertaking a literature review of theory to put it aside when conducting a case study, assuming that theory will emerge!

All research needs to be based on some kind of research question, and a case study approach must be driven by the nature of that question or questions. Yin (2003, pp. 5-9) gives a useful way of thinking about these questions. If the question is a ‘what’ question, such as ‘What problem solving strategies do students employ?’ or ‘What science knowledge does a technology teacher assume for electronics projects for 13 year-olds?’, then an exploratory case study is appropriate. Descriptions of the science concepts employed will lead to tentative ideas that might be further examined in subsequent case studies. If the question is a
‘how’ or a ‘why’ question then the case study needs to be explanatory. For example, ‘Why do students use particular problem solving strategies?’ or ‘Why do students solder a resistor along the ‘track’ of a printed circuit board (PCB), rather than across an appropriate gap in the track?’

Many research projects involve intervening in the classroom. The research question might be ‘How can teachers use the science knowledge of electrics that students bring from that subject to technology electronic activities?’ It is possible to try out different strategies, in effect to ‘experiment’. The amount of control over the ‘experiment’ will vary but, unless it is a specific teaching approach (e.g. as in the Cognitive Acceleration Programme; Shayer, 1999), it is likely that its implementation will vary according to the teacher, the type of technology project, and a number of other factors. The result is a ‘field experiment’ or a ‘quasi-experimental’ study (Yin, 2003, p. 8). A case study approach can be the same, but to account for the nature of the interventions and the results of them are demanding. A teacher researching in her own classroom, could use an action research approach, with cycles of action and research each feeding the other (Kemmis, 1993). External researchers, could use a design experiment approach, where theory-led hypotheses govern interventions and research (Cobb et al., 2003).

WHAT IS A CASE STUDY?

I have already examined this question in relation to why and in what circumstances case studies are to be employed; that they deal with real-life situations with unclear boundaries of phenomena and context, gives some feel for their nature. Walker defines a case study in terms of it being an:

‘…examination of an instance in action. The study of particular incidents and events, and the selective collection of information on biography, personality, intentions and values allows the case study worker to capture and portray those elements of a situation that give it meaning.’ Walker (1986, p. 189)

This definition envisages multiple sources of evidence and, in classroom research, this includes the behaviour of teachers and students. Typically, in an investigation of the use of knowledge in a technology classroom, a case study would include observations of all the lessons in a project (perhaps lasting 6-12 weeks of 3 hours of lessons per week), a collection of the products (e.g. design folios and 3-D models), interviews with the teacher at the beginning and end of the project, student interviews and even small tasks (probes) on their understanding of particular ideas. Student questionnaires can be use to ascertain more general views across a class or a year group. All these give a rich picture of the activity, but work done at home is missed. For example, the main creation of design ideas for students is often done for homework, and all that can be ‘observed’ is the results of this work (McCormick et al., 1996). This varied data collection allows for the
triangulation of data, such that no one source is relied upon to provide all the
evidence for the phenomena.

Some of these data (e.g. questionnaires) are quantitative. Case studies don’t
have to include only qualitative data, often seen as a way of avoiding statistical
generalisation; of which more later. Another common misunderstanding is that a
case study is an ethnography, and involving participant observation. Ethnographies
are close up, detailed observation of the natural world and attempt to avoid prior
commitment to any theoretical model; they may not result in case studies (Yin,
2003, p. 14). Case studies similarly don’t have to be bound by these conditions for
ethnographies. There are similarities when classroom case studies are undertaken
by a participant observer; this is but one type of case study. Nor is the use of
qualitative data a defining characteristic, as I have already noted.

What is a case?

It is the focus on a case that gives a case study its distinctive character. Again,
however, we have a source of confusion, as inexperienced researchers often
confuse the setting for the case study with the case itself:

A setting is a named context in which phenomena occur that might be studied
from any number of angles, a case is a phenomena seen from one particular
angle. (Hammersley & Atkinson, 1995, p. 41)

Thus a classroom case study will have the site as the classroom, but the case
could be the teacher, a particular student or a group of students. The case of course
could be a physical classroom if the focus was on how a particular room aided or
not particular kinds of technology activity. In that case the classroom could be
observed with different groups of students in it, say, throughout a day or week.
More commonly, I have studied a project as the case, by considering the way both
teacher and students carry it out. Within this a group or pair of students could be
the focus, to understand their experience of the project. It is still possible to follow
other students and the overall progress of the class, as part of a project case study.
Clarifying the case defines the way data are collected (e.g. what is observed in the
classroom) and the unit of analysis for the data.

The classroom as the site does not bound the research, as the study can consider
the national curriculum, other sources of views of technology outside the
classroom, or indeed the school, which might influence or determine classroom
activity. Similarly school or departmental views on, for example, links among
departments, can affect how related concepts in the subjects are experienced. In a
study of the use of mathematics in orthographic projection in technology (Evens &
McCormick, 1997) the teacher asked students to come to the board to add to a
developing drawing, and was surprised that a student was able to deal with a
hidden element in a drawing (a hole in block). He asked the student ‘How do you
know how to do that?’ to which the student replied ‘We learned it in maths sir.’ In
that school, there was little connection between, the teaching of orthographic
projection in D&T and that of ‘plans and views’ in mathematics.
CASE STUDY METHODOLOGY

In this section I examine methodological issues: quality, through different forms of validity and reliability; the need to minimize bias; sampling; the contentious issue of generalisability; the role of the researcher; ethics.

Quality of research design

Yin (2003, pp. 34-39) deals with quality by applying four tests, those of external validity, construct validity, reliability and internal validity. These cover two of the most important of the methodological issues outlined above, that is, bias and generalisation. He helpfully relates each of his tests to the various elements of the research process (Yin, 2003, p. 34). These are roughly ordered according to the research process elements: research design, conceptualisation of issues, data collection, data analysis and reporting.

External validity

This test requires the researcher to be clear about how the study’s findings generalise. A case study is an instance and so in what sense does it have any lessons for other cases? Usually we think about generalisation from the statistical point of view. If we take a sample of students and test their understanding of a technological concept, and have chosen a sample to represent ‘all students’, then we can have some confidence that, whatever we conclude about this sample, will apply to the population (all students). Of course it is not as simple as that; there are always limitations on the sample and how it will represent all students. The work of Kimbell and his colleagues in the large testing programme of D&T in England, was able to have some confidence in its generalisability to 15-16 year-olds in England because it used large samples (APU, 1991). However, even this robust study had little to say about this age group in Scotland, let alone in other parts of the world; the design processes outcomes for students is dependent on their particular curricular experience. Case studies, in contrast, do not depend on statistical generalisation, rather on analytic generalisation, in other words they generalise to a broader theory (Yin, 2003, pp. 10-11). In technology education this is difficult as we have few theories; for example, ‘a teacher-created problem solving culture’ noted earlier. Walker (1986, p. 191) argues that it is the reader who tests whether it applies in her situation, and is not an author’s problem. This argues for a kind of resonance in the findings, either by appealing to teachers’ experience or to a theoretical position.

This contrasts with the case study carried out by evaluators, who might take a more ‘grounded’ approach, not directed by theory. They may not aim to inform future research work, rather the progress of a curriculum innovation. Nevertheless they will implicitly base their work on implicit theories of change or of the processes they are observing in the classroom. In evaluating an electronics in schools programme, our views on gender effects made sense of the way girls were
treated in the classroom by a teacher, and how they reacted to particular topics.
When discussing a pedestrian crossing, girls would more commonly talk of the
needs of old ladies, or those with young children, to have time to get across (this
affects the wait time built into the programmed sequence). We were appealing to
theories about gender (Murphy, 2006, pp. 227-228).

If there is an appeal to a body of theory, then it should be possible to replicate
case studies. Another researcher studying a technology classroom should, for
example, be able to see issues of students being unable to use their science
learning. Banks (Chapter 2) shows how he and his colleagues moved from a single
case study on teacher knowledge and sought to replicate this in different countries,
giving this work external validity.

*Construct validity*

This is an issue in the data collection phase and requires any concepts of relevance
to the area of research are operationalised sufficiently to allow data to be collected.
Thus if ‘uses of mathematics knowledge’ was important then this needs to
be defined clearly enough to identify its occurrence in the classroom. In the study
of students learning orthographic projection, a teacher described the 45º angle
used to project a side elevation to a plan view (Evens & McCormick, 1997),
but did not use ideas of ‘transformation’ or ‘reflection’, understood in mathematics.
He dealt with it procedurally, and even spoke of it as a ‘magical’ process. The
result was that when children produced their plans and elevations, some didn’t
draw the line until afterwards, having taken measurements and manually
transferred them, some drew it at another angle and produced incorrect plans, and
others did it correctly. Analysing tasks for the potential use of mathematical
concepts, and their technological equivalents, enables the classroom observational
evidence or interviews of children and teachers to be collected. This range of
sources allows another form of internal validity, that of multiple sources of
evidence.

Construct validity is at threat when an observational event is being recorded and
an inference made; for example, when a student draws the 45º angle and correctly
projects the dimensions does she understand reflection? She may be blindly
following the procedure the teacher laid down, with no such understanding. If there
are no other data to support this inference, then alternatives need to considered or
indeed no inference made.

At the global level of analysis, it is possible to feedback to teachers, and
students, the emerging analysis, either in the form of a draft case study, or interim
findings. They can then give a view on how it reflects their understandings. A study by Logan (2005), investigating the knowledge of an art and design course in
a college, started off by analyzing this knowledge in terms of theoretical ideas (e.g.
conceptual and procedural knowledge), but when this was presented to the
lecturers who conducted the course they were lukewarm about it, causing the
researcher to rethink the analysis. Subsequently she re-analysed the observational