Motivation and methodology: perspectives from an ongoing research enquiry into students' conceptions of technology

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Abstract
This paper outlines the circumstances which have encouraged me to develop my interest into 'what makes 'technology' technology', from a reflection on my own practice, to a formal investigation into students' conceptions of technology in my own and other schools.

Although other studies have been undertaken, these have in the main been concerned with values and attitudes towards technology. The methodology reported in this paper enables conceptions of technology to be captured in a form such that a 'conception statement' can be constructed via a predetermined option matrix. This written 'conception statement' enables an individual to confirm that their conception is correctly recorded. In addition to the written form, conceptions held by a number of individuals can be compared both graphically and numerically. The range and frequency of identical conceptions can be determined for any sample of individuals.

The past decade has seen a rapid change in the teaching of technology in schools in England and Wales. This period of change has resulted in many teachers reflecting on their existing practice. The most fundamental question for this area of the curriculum is a deceptively problematic one – what is technology? This can be easily extended to include a consideration of a range of associated questions:

- What do other teachers consider technology to be?
- What do students consider technology to be?
- What do parents consider technology to be?
- What do SCAA and examination board officers consider technology to be?

and focusing on the situation in my own institution:

- What do I consider technology to be?
- What do other members in my department team consider technology to be?
- How do our conceptions match those held by the working party which formulated the National Curriculum Technology Order?

These questions have significant implications for the development of a school's policy statement and curriculum model for the delivery of technology, and the way in which the programmes of study are interpreted in the construction of schemes of work. My appointment to a Head of Design and Technology post in 1990 caused me to reflect carefully on these questions. The development of a departmental philosophy, policies, schemes of work and supporting INSET activities were key aspects of this new post as the Order for Technology in the National Curriculum came into force.

Initially my interest in students' conceptions of technology was supported by investigative activity for an Open University MA module 'Educational Evaluation'. This investigation has now developed into a research degree project being undertaken at Loughborough University. This article charts the journey through the Open University evaluation project to the research methodology which has been developed to 'capture' conceptions of technology as part of the research programme at Loughborough University. This programme is now well underway and it is hoped that colleagues may find this account interesting and even perhaps be encouraged to reflect formally on aspects of their own practice. I am sure that the Department of Design and Technology at Loughborough University would welcome the opportunity to support other teachers who wish to pursue such research interests.

Open University MA study

I had started the MA module coincidentally with being appointed to a Head of Department post and thus the implementation of National Curriculum Technology was at the forefront of my thinking. I decided that a pertinent evaluation project would be to find out what

my own students thought 'technology' was, before my department started to formulate our courses. This was important for a number of reasons, e.g. what preconceptions might students bring with them to the subject which we might need to contend with? Would work with food and textiles be seen as being as much a part of technology as electronics? These were not uncommon questions for that time – but I was in a position to investigate them on a more formal basis.

The collection of data by questionnaire was problematic. Students had difficulty articulating their conceptions of technology without the additional problem of constructing a reasoned statement in written English. Students were also interviewed in small groups. This provided a range of views which informed decisions about future curriculum provision. Some interesting observations were obtained from this investigation both in terms of conceptions and the process of their collection. In particular the way in which the group interview allowed discussion between students, which in turn encouraged them to develop their conceptions further:

> When you say technology you automatically think of electronics – everything we've done so far has been; – but now I'm thinking – all aspects of technology if I had had that picture in my mind before we started talking. (Year 4 (now Year 10) student).

and in terms of their conceptions of technology:

> When someone says technology I don't think about home economics. (Year 3 (now Year 9) student).

> When you think of technology you automatically think of electronics. (Year 4 (now Year 10) student).

> Taking things apart to see how they work. Technology is something you make. (Year 1 (now Year 7) student).

These comments provided an indication of students' conceptions, and, as in the second comment above, identified areas for concern. Although this methodology was sufficient for the module project I felt that further work was possible. The MA programme (involving a further two modules) was completed in December 1992. However, I continued to ponder the issues around conceptions of technology.

The Loughborough research programme

By the Autumn of 1993 I had been accepted as a post-graduate research student by the Department of Design and Technology at Loughborough University, investigating student conceptions of technology.

Although making Technology a foundation subject in the National Curriculum and setting a framework for a standardised experience the Order for Technology published in April 1990 provided no concise descriptors of what technology was seen to be. Any related articulation of a 'vision' of technology would only be possible by interpreting the experience outlined by the Programmes of Study to form an overall view. The non-statutory guidance published to support the implementation of the Orders did provide more explanation of the nature of the new subject. The opening statement in both Design and Technology and Information Technology support materials noted:

> Technology is a new subject, which requires pupils to apply knowledge and skills to solve practical problems. The statutory Order divides the subject into two profile components:
>
> | design and technology capability | information technology capability |
> |---|---|
>
> The reference to *capability* in both components emphasises that technology is a subject concerned with practical action, drawing on knowledge and understanding from a wide range of subjects. (NCC, 1990)

The development of technology teaching in schools is well documented. Before the introduction of National Curriculum Technology courses had been written which reflected the view of technology held by particular schools (by virtue of the views held by members of staff in that establishment) or courses which taught to the syllabus requirements of one of the regional examination boards. Most technology teaching could be identified as being from one of a number of 'traditions', including technology with science, technology with craft and design; and following the introduction of micro-electronics and computers into schools 'technology literacy'. This tradition and the STS movement are also well documented as is the support of the TVEI schemes during the late 1980s. These traditions may still influence the conceptions of technology which are presented to students in school – let alone the influence on students from the wider range of conceptions from outside school evident in published materials.

Confused interpretation and articulation of the different conceptions of technology which are held is in part due to the limited range of language available for description. This issue is explored by Fores and Rey (1986) Many authors provide conceptions of technology which are framed by a number of aspects or activities concerning technology yet only two words are in common usage to articulate these aspects, namely 'technology' and 'technological'. By contrast, consider the physical phenomenon – snow. In this country we have a limited range of words to describe this physical condition. Three words come to mind: snow, sleet and slush. Given the frequency and difficulties caused by snowfall in this country we may argue that three words are enough. Some cultures are more snow dependent than our own. I have been told that Eskimos have twenty-two words to describe snow. Thus in a situation where we might identify snow which 'bonds together and is good for snow balls' Eskimos may name this type of snow with one word. A parallel situation exists concerning technology. Rather than being able to use a single word to identify an aspect or consequence of technology a phrase has to be used.

The words in this limited range have, because of over-use, become associated with a number of meanings. In fact the number of aspects has become so large that these words now convey only a 'global' meaning. This association with a global meaning itself exacerbates the difficulties in focusing and articulating a particular conception. Daamen, van de Lans and Midden note:

> In the end "technology" is an enormous aggregation of concrete applications. (1990)

We lack specific words to describe the small segments or aspects of technology and thus we lack descriptive ability.

This descriptive process is complicated further. 'Technological' as adjective describes the application of technology; therefore, any questioning using the word 'technological' presumes that technology is an activity or product of an activity. This may not be the case for all conceptions. For example for Jünger writing in 1932:

> Technology is the ways and means by which the Gestalt of the worker mobilizes the world. (1983 p269)

The term *Gestalt* is understood here to mean the total world view of the worker class.

Discussions with students in my own school situation have identified that they use a low level of grammatical construction. For example, they are not 'involved in technological activity' but they suggest that they are 'doing technology'. This generalist term for participation in a school subject or activity was extended so that they were for example 'doing maths', 'doing French', and 'doing science'. Presenting only the single term 'technology' to students encourages a view away from an 'activity' focus and reflects their own use of language.

Developing a methodology

Other studies have been undertaken in this field. Typically they fall into one of three categories: perceptions of; conceptions of;

and attitudes towards technology. Whilst the titles of other research enquiries state that perceptions and/or conceptions have been explored, the published reports suggest that no effective distinction has been made. However, in the context of this study a clear distinction is made between these notions. A student's perception is understood by this author to be evanescent in nature, a momentary impression which fades quickly; as the student reflects on these perceptions of technology they form the conception of technology which the student holds. This study is concerned with those conceptions.

Attitudes and conceptions are related but their meanings have to be distinguished. In this study attitude is taken as a 'settled mode of thinking'; thus this study may explore certain attitudes which students hold to aspects of technology, so as to frame or allow students to articulate their conception.

In developing my own research methodology the work of a number of other researchers has been reviewed. Two areas of research are evident. The first group of studies investigates students' rationale for their choice of 'technology subjects' at examination level; a comparison of their impression of these courses with courses in other subjects, also the relevance or influence of 'technology subjects' to future career intentions. The second group of studies explores what students conceive technology to be – albeit at a variety of levels of complexity, and relationships to other experiences. One of the short-comings of my MA study was the inability to compare the conception of one student with that held by another. This would only have been possible using the interview transcripts to review the comments made by the students and produce from these an articulation of their views; to then identify key aspects or attributes to construct a profile of their conception.

Following a review of published literature, the research findings of others and results of my MA research investigation 'key aspects' (ten later reduced to six) were identified which would enable students to frame a specific concept of technology (rather than a broad global one):

- recognising technology activity
- participating in technology activity
- which subjects teach technology
- living with technology
- influence on conceptions from outside school
- the products of technology.

These key aspects would also enable me to construct a profile of their conception. The use of an instrument supported by selective interviews represented the only time-efficient method of capturing conceptions from a large number of students (i.e. all the student population of a school).

In considering the type of questions for inclusion within the instrument, it became more apparent that the use of closed type questions would provide a more reliable and objective basis for comparisons between students than would open questions. In order to obtain increased differentiation between students the use of a Likert scale was explored in the initial piloting. The students would indicate a level on the scale (ranging from strongly agree to strongly disagree) in response to a statement which contained either a positive or negative bias.

Studies which use an instrument with a Likert scale, such as the PATT instrument developed by Raat and De Vries (1986) or studies which require students to select the option which 'best' reflects their view after interpretation of the range of options, have a possible area of weakness. Individual students will place differing interpretations on the stages or options and their judgements will be subjective. Whilst subjectivity on the part of the student may be viewed as 'part and parcel' of that individual's conception, should a number of responses be aggregated (in the sense of the global response to a certain question for example) then the relative importance placed on interpretation of the scale by each student, or the accuracy of the classification

undertaken by the researcher (in studies where an analysis is made of open questions) becomes an important consideration.

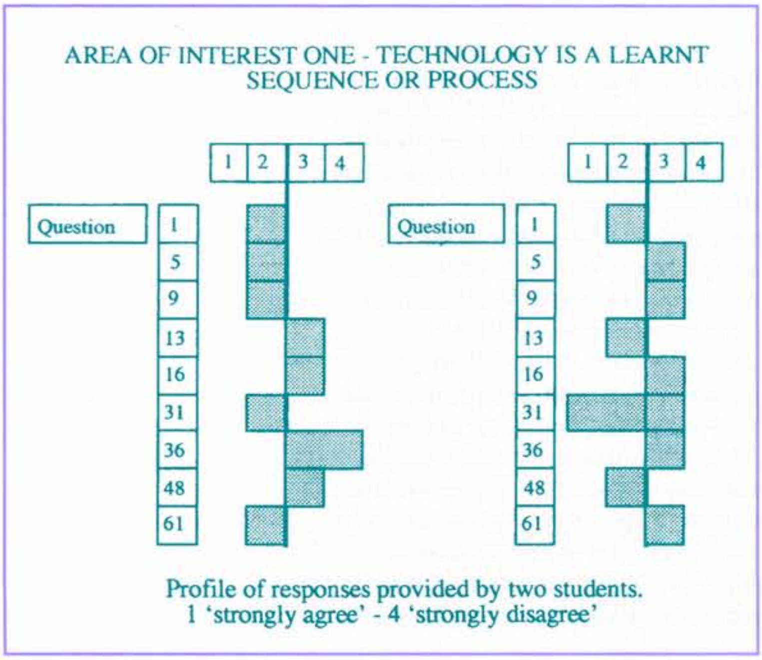
Initial pilot studies

The first draft of the instrument contained 90 questions which were arranged into three sections, 'technology at school', 'technology at home' and 'technology in other settings'. As a result of this arrangement questions related to a particular 'area of interest' were spread through all sections of the instrument and the responses were difficult to collate.

Two versions of the first draft instrument were tested in this author's home institution by two groups of Year 8 students. The groups were of mixed ability containing both female and male students. One group of 20 students was given a four point response scale: 1-'strongly agree', 2-'agree'; 3-'disagree', 4-'strongly disagree', a fifth option was provided with this scale labelled 'U'-'don't understand'. The second group of 23 students was given a five point scale: 1-'strongly agree', 2-'agree', 3-'undecided' 4-'disagree', 5-'strongly disagree'.

Students in the first group who completed the instrument with the four point scale and the 'don't understand' label, were less likely to use this option – 4% of all responses compared to the second group of students who used the mid-point 'undecided' option for 17% of all responses. Students stated that it was often easier to indicate 'undecided' than to make a decision if they found the question difficult. This tendency was also noted by Rennie (1987) considering the PATT study Likert scale.

Figure 1



The responses provided by any individual could be displayed graphically to produce a 'profile' of responses (Figure 1) for the questions related to each area of interest rather in the style of McCarthy and Moss (1990) skills attributes profile. These profiles could be drawn to illustrate the differences or similarities between students. However, whilst providing a comparison, they provide no articulation as to what that conception actually was. In the view of the author this was a fundamental weakness of the instrument in this format; a sustainable argument might also be made in extending this criticism to any study using a scaled method of response which claimed to analyse views rather than reporting comparisons in response rates.

Two other aspects were explored in the first draft concerning the layout of the instrument; sub-headings at the start of each section focus the respondents view of technology to that area, a photo stimulus was included for each section. The intention was to place this focus into a contextual base. This line of development was explored following the author's experience of the use of 'situation drawings and photo' as a stimulus for students to identify problems as a basis for design work. Also research findings pointing to the disadvantaging of certain students when questioning without setting the context, Murphy (1989) and Grant (1986). Whilst the provision of sub-headings was developed further in the second draft of the instrument, the use of 'photo sheets' was not. When students in the trial groups were questioned they felt that the headings had provided some degree of focus and that more should be included, but that the 'photo sheets' were of questionable use; some students had not referred to them at all. Suitable pictures were difficult to obtain and may have provided too much of a focus to the extent that suggestions of expected responses might have been presented to students.

Improving the research instrument

Given the level of interpretation required to produce an individual's conception of technology from the data gathered by the first draft the emphasis of the instrument was changed in the second draft. The notion of producing a written comment about the respondent's conception (rather than a graphic profile) was considered. A written comment would allow that individual's conception to be easily articulated; thus providing more accessible results and transparency to the process of analysis.

The method of obtaining the 'statement of conception' was derived after consideration of the systems used in schools to produce the National Record of Achievement which is 'statement banked'; also the process used by the careers package 'Jiig Cal' in which responses to an attitudes instrument are used to produce a printout of a students 'top ten' best matches to possible occupations. The intention of the second draft was to produce a 'matched' instrument and statement bank. The output from the analysis of instrument responses would be a written statement which could be tested to determine whether it accurately reflected the respondents conception of technology. As with the 'Jiig Cal' process, the production of the 'statement of conception' from the responses to the instrument should be via a precise transcription procedure. The only subjectivity in interpretation of responses lies in the construction of the statement bank and transcription matrix.

Once the statement comments had been produced questions were sorted which related to the subjects of the comments. They were linked by a matrix which could be thought of as a 'truth table'; if the response to this question is this – then the conceptual view must be that. At this stage of development the use of the Likert scale complicated matters, the response options to statements on the instrument was limited to 'agree' or 'disagree'.

A third response option 'U' – don't understand' was also provided, rather than permitting a respondent to guess either 'agree' or 'disagree' if they did not understand a question. The transcription process was developed to accommodate 'U' responses. If a 'U' response was made to a question the transcription matrix would generate the coding for a blank section in the 'conception statement' or a comment that the student was unclear about a particular area. Even if a section was noted as unclear or not mentioned in the 'conception statement' printout for that student, the other information which it contained remained valid and reliable.

A second set of trials were undertaken to establish the title and position of the third option column. As was found in the first draft, if placed as the last option and titled 'don't understand' (rather than 'undecided') the frequency of responses in that column was reduced.

The research methodology was then piloted in another school involving 181 students in Years 7, 8 and 9. Questionnaires were completed by all the students available in school on Friday July 12 1996 providing an opportunity sample containing a mix of ability, social and home backgrounds and gender. The responses of all questionnaire participants were processed and the 'statement bank' codes for their conception of technology were recorded. All students in years 7 to 9 were allocated a personal number (the questionnaires were coded not named); the statement bank codes were recorded against each student number so that the listing for any student could be identified and a description of their conception of technology generated.

The reliability of the questionnaire data and the process of generating 'statements of conception' was supported in two ways; by interviewing a sample of students and reviewing their interview comments against their 'conception statement'. Students were also shown a copy of their 'conception statement' printout which had been processed from the questionnaire responses and were asked to confirm or comment on it. This provided two methods of triangulation for students' conceptions generated from the responses to the instrument. Figure 2 shows the sequence and relationship of the various stages in the final methodology.

Figure 2

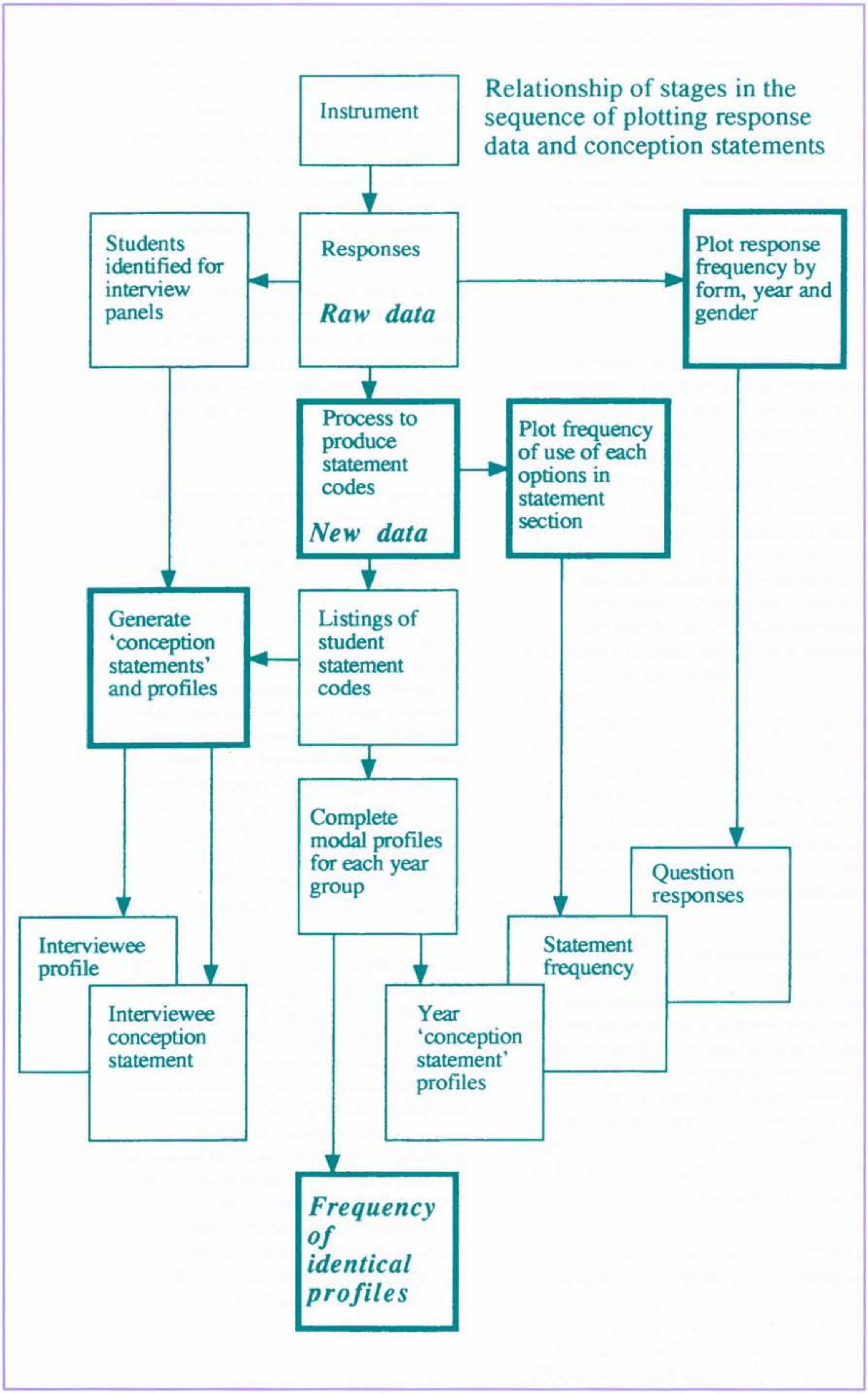
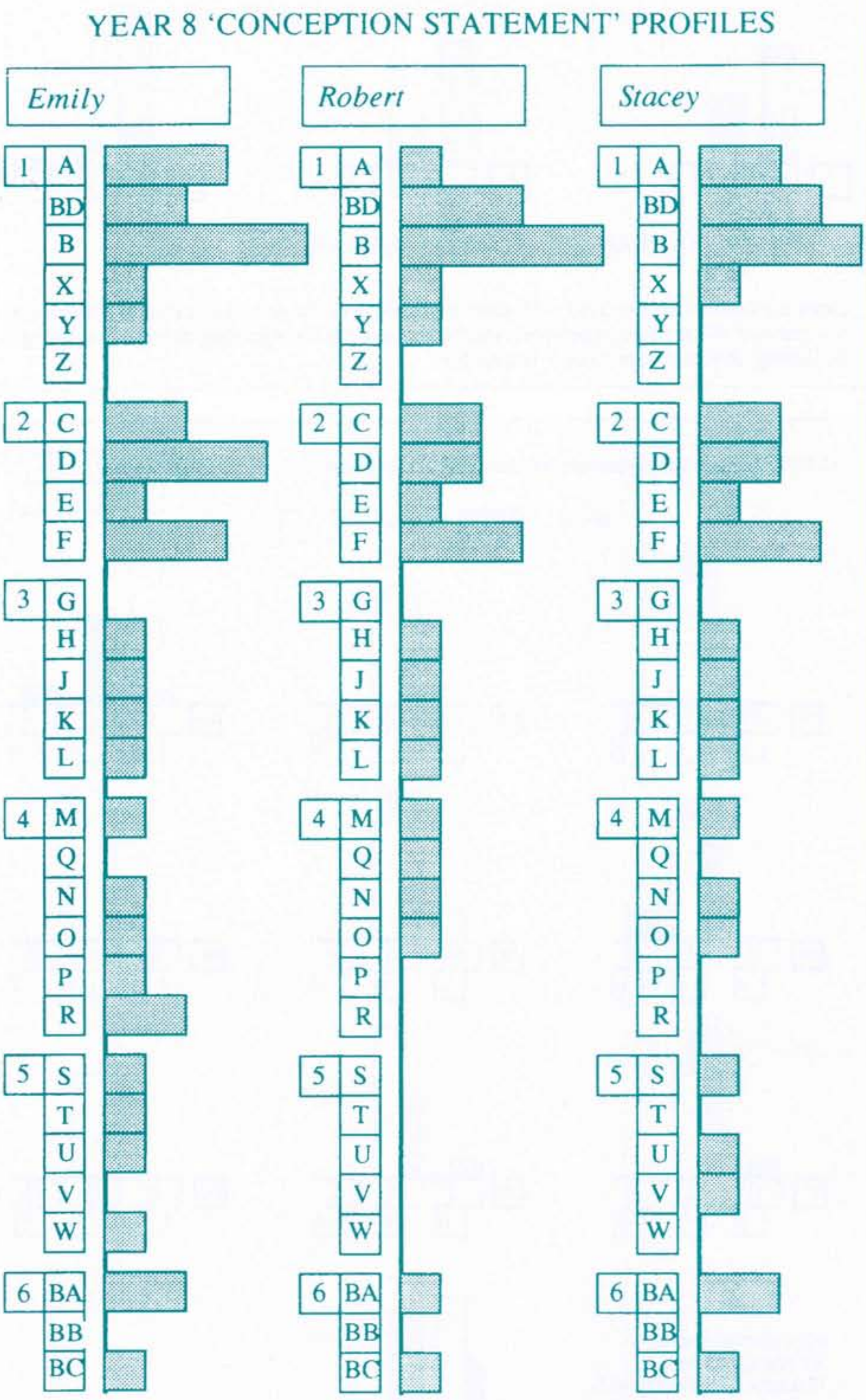

Relationship of stages in the sequence of plotting response data and conception statements
Instrument
Students identified for interview panels
Responses
Raw data
Plot response frequency by form, year and gender
Process to produce statement codes
New data
Plot frequency of use of each options in statement section
Generate 'conception statements' and profiles
Listings of student statement codes
Complete modal profiles for each year group
Question responses
Statement frequency
Interviewee profile
Interviewee conception statement
Year 'conception statement' profiles
Frequency of identical profiles

Figure 3



Numbers 1 - 6 denote 'areas of interest', letter codes A - BD denotes statement sections. The length of each bar indicates the option used within each statement section. No bar indicates the printing of a 'blank' statement.

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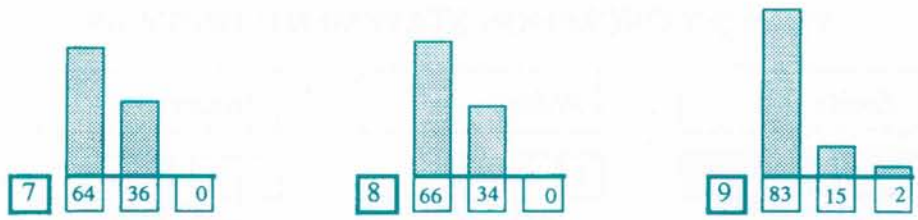
Figure 4

Q.43. Humans *have always* been involved in technology activities A D U

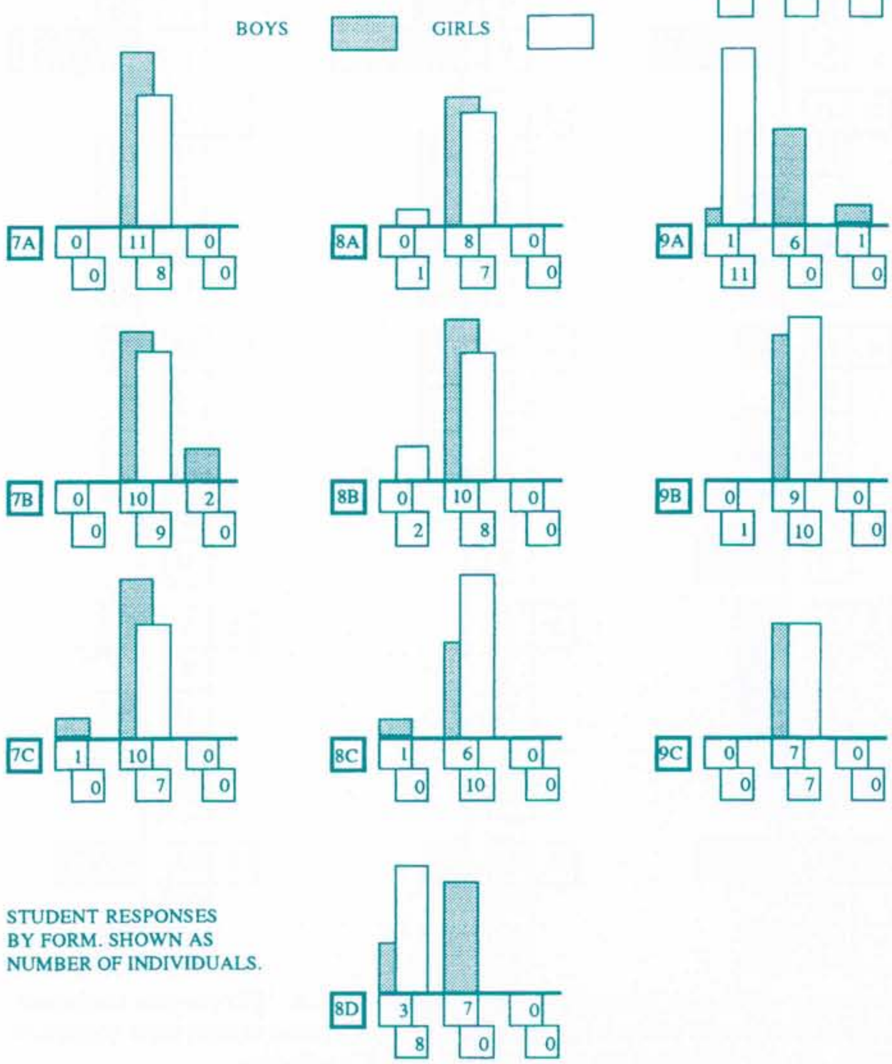


RESPONSES BY YEAR GROUP SHOWN AS % OF EACH YEAR

Does the content of the Year 9 History work explore human tool use or the industrial revolution? What other experience might account for the apparent increase in strength of feeling shown in the Year 9 responses?

Figure 5

Q.49 Only electrical appliances are products of technology. A D U



What experience can account for the view held by the girls in 8D and 9A which is apparently at odds with the rest of the sample? Could this be the influence of a particular member of staff, are they currently working in an IT/electronics module?

Student interviews were conducted with small groups rather than with individual students Adelman and Walker (1975) and Wragg (1987) note the tendency of students who are involved in group interviews to correct each other. The same type of interaction was evident during my MA investigation. The interviews with students were video recorded and immediately following the interview the tape was replayed and the students were asked to point out sections which they felt were significant and to explain why. The practice of asking students to review tapes is noted by Davies (1980) and by Adelman and Walker (1975). The students did not find any section significant enough to draw to my attention. However, the process did provide an opportunity to undertake a rapid review of student comments and to ask supplementary questions to clarify points of uncertainty.

It is possible to use the printed 'conception profiles' to undertake a comparison of the views held by a number of individuals (Figure 3). A comparison could also be made directly from the codings to indicate the frequency of identical conceptions. However with the vast range of possible combinations (29 statement lines, all having at least 2 options, some as many as 5) this is only feasible with computer support. This methodology also enables frequency of responses to particular questions and the frequency of single or combinations of statement comments to be investigated in respect to year group, gender, teaching group or institution.

Figures 4 and 5 are provided to illustrate the manner in which these different 'frequency plots' of student responses provide a stimulus for further investigation.

The ongoing research programme

During the summer term of 1997 this methodology was used to capture the conceptions of students in two schools. A group of 225 students in a rural comprehensive school and 232 students in a City Technology College. Initial analysis suggests that while both groups held the same range of conceptions, the conceptions of the students in one group can be differentiated from those in the other. The detailed analysis will be completed in 1998. Further issues for investigation could be:

- The extent to which the vision of technology held by the school, and the conception held by teachers and the conception by their students match.
- The extent to which exposure to technology teaching in school shapes student conceptions compared to experience outside school.
- The extent to which conceptions of technology are formed by course structure – the units or areas of work and their titles, rather than by the content of the teaching activities.

Findings from these investigations may at least provide some indication as to the most suitable curriculum models for the delivery of National Curriculum Technology and raise issues regarding the provision of INSET and nature of initial teacher training for technology. Finally, as schools become increasingly concerned with the 'added value' of their teaching, the identification of areas of technology 'learning' that may be influenced by our teaching, and those which are set from experiences outside school.

References

Adelman, C and Walker, R (1975) *A guide to classroom observation.* London: Methuen

Davies, B (1980) An analysis of Primary school children's accounts of classroom interaction. *British Journal of Sociology of Education.* Vol. 1 No 3

Daamen, D, Van de Lans, I and Midden, C (1990) Cognitive Structures in the Perceptions of Modern Technologies. In Science, *Technology and Human values.* Vol. 15 No 2

Fores, M J and Rey, L (1986) Technik: the relevance of a missing concept. In Cross A. and McCormick B. (eds) *Technology in Schools.* Buckingham: OU Press

Grant, M (1986) Starting Points In Cross, A and McCormick, B (eds) Technology in Schools. Buckingham: OU Press

Jünger, E (1983) Technology as the Mobilization of the World Through the Gestalt of the Worker. In Mitcham C. and Mackay R. (eds) *Philosophy and Technology.* London: The Free Press

McCarthy, A and Moss, D (1990) Pupils Perceptions of Technology in the Secondary School Curriculum: a case study. In *Educational Studies* Vol. 16 No 3

Murphy, P (1989) Gender and Assessment in Science. In Murphy, P and Moon, B (Eds) *Developments in Learning and Assessment.* London: Hodder and Stoughton

NCC (1990) *Non-Statutory Guidance: Design & Technology Capability.* York, NCC

Raat, J H and De Vries, M (1986) *What do Girls and Boys think of Technology: Pupils Attitudes Towards Technology.* Eindhoven: Eindhoven University of Technology

Rennie, L (1987) Teachers' and Pupils' perceptions of technology and the Implications for Curriculum. In *Research in Science and Technological Education.* Vol. 5 No 2

Wragg, E C (1987) *Conducting and Analysing Interviews.* Nottingham: Nottingham University

RESEARCH