South Africa: North West Province Technology Education Project

Final report on the evaluation

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1 Terms of Reference

Over the period 1996 - 1999, the UK Department for International Development (DFID) has provided £600.000 in support of the North West Province Technology Education Project. The goal of this project was to support technological human resource development in the Province by assisting the improvement of the quality of technology education.

Together with the government of North West Province, DFID commissioned the Technology Education Research Unit (TERU) to undertake an evaluation of NWPTEP in September 1998. A major objective of the evaluation has been to make recommendations as to the nature of any potential future DFID support to education in North West Province in the period after March 1999, when the present project funding ceased.

Following discussion with DFID, the North West Province Education Department, and PROTEC, the specific brief for TERU was agreed to centre on the **impact** that the project has had in schools; on teachers, principals and students, and on project implementation issues - concerning for example the training and preparation of the teachers.

As part of this evaluation, we - TERU - have been asked to make a judgment of overall project success by choosing one rating from the following scale:

Highly successful :
Objectives completely achieved or exceeded and very significant benefits in relation to costs.

Successful :
Objectives largely achieved and significant overall benefits in relation to costs.

Partially successful :
Some objectives achieved and some significant overall benefits in relation to costs.

Largely unsuccessful :
Very limited achievement of objectives and few significant benefits in relation to costs.

Unsuccessful :
Objectives unrealised and no significant benefits in relation to costs.

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[1] Throughout this project we have been ably supported by Mr Olefile Bethuel Molwane, a PhD research student at Goldsmiths College.

In making this judgment, we have been asked to provide a full commentary on and justification for our conclusions and to make recommendations on future strategies for DFID support for education in the North West Province.

2 Designing the evaluation study

In September 1998, Prof Kimbell visited DFID, the NWProvince Education Department and PROTEC for preliminary discussions of the evaluation project. The contribution of TERU within this project was sketched out in four phases.

Phase 1 Preparation - London (to end of Nov 98)
- a) Review of project materials
- b) Review of evaluation materials
- c) Drafting evaluation instruments
  Final versions to be agreed by Jan 1999

Phase 2 Data gathering - in NWProvince (week of 22nd Feb 99)
- a) Pupil performance testing
- b) Pupil attitude evaluation
- c) Interviews with principals, teachers, students, trainers, Province and PROTEC staff

Phase 3 Data analysis and report drafting - in London (March 99)
- a) using quantitative data to explore performance and attitude differences in project and non-project schools
- b) using qualitative data to illuminate any emerging performance and attitude differences
  Interim report to be submitted to PROTEC/DfID/NW Province by end of March 1999

Phase 4 Finalisation (April/May 1999)
- a) Electronic feedback on the Interim Report from PROTEC/DfID/NW Province to TERU
- b) A workshop/seminar meeting (late April) in the NWProvince to debate the Interim report and its conclusions and recommendations
- c) Presentation of the final report in early May 1999.

A number of principles are enshrined in the design of this study.

i) *The desire for pupil data that goes beyond attitudinal factors and delves into real pupil performance*. Moreover, this performance should reflect the active nature of learning experienced by students during the pilot project. The major concerns here are that learning is active, task-based, in groups, and with knowledge seen as a resource for action rather than as an end in itself. These principles rule out most conventional assessment devices - including multiple choice testing. In TERU we fully share the ideals of active learning and capability assessment, and we have (over the last fifteen years) been at the forefront of developing 'authentic' assessment in technology. [2] The performance assessment instrument developed for this evaluation incorporates all these principles and is described fully in sections 4,5,6 and 7.

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[2] See for example Kimbell et al (1991) in which we report our work for the Assessment of Performance Unit in the Department of Education & Science (UK).

ii) *The desire to build capacity in S Africa and particularly in the NWProvince*. From the outset our work has drawn in a team of people from PROTEC, from the NWProvince Education Department, and from the teacher training colleges in the NW Province. The team has been central to the effectiveness of the evaluation process and at the completion of the evaluation they remains in S Africa, with training and experience of project evaluation in general and of performance assessment techniques in particular. This team represents an important resource for future developments.

iii) *The desire to evaluate project schools by fair comparison with non-project schools, but without the assumption of deficit states in non-project schools*. The project is only running in 19 schools in the Province, and - quite rightly - the Province is concerned to learn lessons that are of value to the *whole* Province, not merely to the project schools. This means for example that the assessment instrument had to be equally accessible to all students - regardless of their experience of a technology curriculum. At the same time of course, the instrument needed to be able to demonstrate the enhanced performance of those who can operate at a higher level.

3 The agreed design

Following discussions with the NWProvince, DFID and PROTEC, the following research design was agreed.

i) The evaluation involved ten project schools and ten broadly equivalent non-project schools. The project schools were chosen (from the current list of 19 schools) as the most mature - longest established - schools within the project. The assumption is that the project involves the schools in a good deal of fundamental rethinking of curriculum - and this is more likely to show up in schools where the project has been longest established. For non-project schools, we sought to balance the urban/rural sample in a parallel form with the project schools and we additionally incorporated two technical schools to see how their performance related.

ii) We were interested in the growth of student performance through the programme which runs in years 10, 11 and 12. Since the evaluation ran in February (when the year 10 group had hardly started their programme) we examined performance in year 11 and in year 12 both in project and non-project schools. The plan to involve a group of yr 13 students (returning school leavers) in the evaluation sadly proved to be unworkable.

iii) The performance assessment instrument involved 18 students from each year group in each school. The students (9 girls and 9 boys) were chosen by the school to reflect the group as a whole.

The performance assessment instrument was therefore used with 36 students in 20 schools, ie a total of 720 students.

iv) The 720 students also completed an activity evaluation questionnaire reflecting on the assessment activity and on their performance within it.

v) The 720 students also completed an attitude questionnaire developed from a previous model [3]

vi) Whilst the 36 students were working on their assessment task, interviews were also being conducted in the schools. In each project school we interviewed the *principal*; the *teacher* responsible for the project; and a group of 6 *students* (yr 12). Whilst we had not intended to conduct interviews in non-project schools, it was suggested at a meeting in DFID that the views of *principals* might be important in considering any expansion of the programme. We therefore interviewed the *principals* in all non-project schools.

vii) In addition to gathering data at the school level, we interviewed the NWProvince college *trainers* who had been involved in training the project teachers; the *field officer* for the project; responsible *officers* of the NWProvince Education Department; and the *director* of PROTEC.

4 Developing the performance assessment instrument

The performance assessment instrument devised for this evaluation has its roots in our work for the Assessment of Performance Unit work in the UK in late 1980s. The essential features are as follows:

- a technological task is presented;
- the task must relate to the context of the students and the schools;
- the task is designed to last 75-80 minutes;
- the task is broken down into a series of sub-tasks that last between 5 mins and 15 mins;
- the steps through these sub-tasks are choreographed by a test administrator who reads from a script and times all the stages of the test activity - thus standardising the administration;
- the task is tackled by design teams of 6 students. Each year group has three teams of six (ie 18 students), so in each school 36 students take part in the test activity (6 group of 6: three from year 11 and three from year 12);
- the activity is designed to operate through several phases
    - initial team brainstorming of possible approaches to the task
    - breaking down the task into three sub-tasks that are tackled by pairs of students
    - the three subtasks are targeted at the experimental curriculum; pair A dealing with materials and processes; pair B with energy and power; pair C with communications
    - each pair tackles a facet of the task that can be informed by these areas of expertise
    - the pairs present their ideas back to the whole team and debate them
    - the team then develops a composite solution
    - the team outlines what still remains to be done and evaluates the strengths and weaknesses of the proposed solution;
- the teams respond to the task in specially designed response booklets (A3 size). There is a team response booklet for the start and the finish of the activity, and there are three pair booklets (A,B&C) for these targeted activities.

The object of the exercise is to maximise students' technological response to the task. Questions and prompts are placed into the administration not to provide answers but rather to promote thought on the part of the design teams and to encourage the retrieval of the 'process' evidence that is so central to this

3 We examined derivatives from the PATT instrument and from those used by Dyrenfurth and by Williams in former work for PROTEC in S Africa.

kind of assessment. We are just as interested in *why* students do things (and what they *think* about there ideas) as we are in *what* these ideas are and what they choose to do.

This is the critical precondition of performance assessment. We need to create the conditions that enable the performance to take place, and that maximise the quantity and quality of the evidence of performance.

The second stage of the exercise can then concentrate on assessment; on teasing apart students' performance to illustrate strengths, weaknesses, and characteristic performance types. And ultimately of course we need to score it; to develop an assessment rubric that allows us reliably to translate performance qualities into numbers to facilitate statistical analysis.

Trialling the activity

We took a prototype test into a school in London to assess its manageability and the extent to which it enabled us to derive the evidence we sought. Since the task was located in the S Africa context (transporting medicines across rough terrain in trucks and protecting them from heat, damage and theft) our London students were required to suspend their own reality and - for the purposes of the test - to imagine themselves in the context. This they managed to do quite adequately, enabling us to identify the weaknesses and strengths in the structure we had created, and in the administration script. We were therefore able to redesign the test booklets.

Perhaps more importantly however, the trial created some real evidence of student performance on this task that allowed us to refine our assessment scheme (see section 5).

Task validity

The question of validity is notoriously difficult but very important. If we wish to claim that our activity is *valid* we are making the claim that if a student does well at it, it is because they are good at technology. If they do poorly at our activity, it is because they are poor at technology. So (for example) we believe that a multiple choice test would *not* be a valid test of technological capability as exemplified in the project materials. Such a test might be a valid test of technological knowledge, but it would certainly not be a valid test of (eg) technological problem solving. By contrast, we would wish to claim that our activity *is* a valid predictor of ‘real’ technological performance. The problem however, it that there is no simple measure of validity.

One way to establish validity would be to examine student assessments on technology projects over an extended period using a teacher who is recognised as an expert in the field. One could then create a rank order of student capability. Thereafter, one could administer the activity to these same students, assess the work and create another rank order. If the activity is a valid measure, then these two rank orders ought to correlate well. For many reasons, this means of establishing validity was not available to us and we therefore developed a different approach, based on the judgment of an expert panel. Given a set of experts in the field of technology education, it is reasonable to ask whether they believe that the activity represents what they regard as an authentic technology activity. This is referred to as ‘face’ validity.

In adopting this approach we were able (simultaneously) to address two critical dimensions of validity:

• the validity of the task in the context of South African students;

• the validity of the task in the context of the approach to technology that is enshrined in the curriculum being evaluated.

The expert group we used for this process was the test administrators (see section 6 below). They are experienced technology teachers with detailed understanding of the project materials. And - by virtue of their role as administrators - they came to understand the activity very fully. What follows is a series of comments from this group on the nature and structure of the activity.

• A very appropriate activity; well chosen, everyday situation in S Africa.
• The activity aroused a lot of interest in the students, who were all very engaged.
• The activity was relevant to all students.
• The sub-division into pairs enabled all students to become engaged and to collaborate.
• Everything went well in the classroom in both project and control schools, maybe because of the interest that the activity generated.
• It allowed students to draw on their own experience as well as to use knowledge learnt at school.
• Well structured in relation to the different aspects that needed to be addressed.
• The guidelines were so good....
(administrators PE/TT/CM/ZM/TD. Tues 2nd March 1999))

In the light of these highly supportive comments from the administrator team, we believe we are justified in claiming that the activity is valid for the purposes of this evaluation. The task booklets and the administrator script are included as appendix A

5 Assessing student performance

The model of assessment adopted

The model of technological activity adopted through the project is very much a procedural one, in which students are encouraged to solve problems through the application of technological knowledge. This model flows from our previous research (Kimbell et al 1991) and directed us to a model of assessment that is also procedural. With this in mind, and taking into account the importance of group work in the project, we established three dimensions to the assessment:

• design / problem-solving procedures;
• team working;
• application of knowledge.

Design and technology procedures

Within the heading of procedures, we initially identified four sub groupings that encapsulated the major dimensions of design and technological processes. These four areas were: identifying and specifying, planning, generating and developing and evaluating.

However, because of the nature of the assessment activity (and in particular the short timeframe within which it happened) it was seen as inappropriate to attempt to assess the students' ability to plan, other than in the very general sense of being able to think forward, and so this dimension became subsumed within the identifying and specifying heading. This left of with three procedural headings which we characterised briefly in the following ways:

- identifying and specifying (seeing clients needs, considering issues, seeing the whole task, thinking forward);
- generating and developing (range of ideas, development of ideas);
- evaluating (seeing strengths and weaknesses, dealing with strengths and weaknesses, compromising and optimising).

Team working

Our initial inclination was to explore team working solely through an evaluation questionnaire - to explore the learner's views on this. But following the initial trial of the assessment activity, it was apparent that it was possible to identify evidence of this, and hence make judgments of quality, from the responses in the test booklets. We characterised this dimension in the following way:

- team working (group decision making, addressing the whole task, amalgamation of ideas, supportive interaction).

Application of knowledge

Within this third dimension we were looking to establish the extent to which the technological content identified and taught through the PROTEC materials could be applied to the task in hand. Consequently we structured this aspect of the assessment through the knowledge groupings provided in the project booklets:

- materials and processes (named materials and construction processes, understanding of their properties, application to the task);
- energy and power (mechanical and electrical sources, understanding of their properties, application to the task);
- communications (systems communicating with systems and systems communicating with people, understanding the properties of communication systems, application to the task);

Thus, through the above headings and sub heading we created the parameters of those aspects of capability we would look to assess.

Linking performance evidence to assessment

Evidence of capability should be credited whenever it happens in the activity and wherever it appears in the response booklets. However, the assessment activity was structured with the direct intention of provoking certain dimensions of capability at specific points. For example, at a mid point in the activity students were asked to identify the criteria for the success of their design (*identifying and specifying*) and following this they were asked to identify the strengths and weaknesses of their ideas to date *(evaluating*). In this way we made direct links between the sub tasks that drove the assessment activity and dimensions of capability that were being looked for. Thus the activity broke down into a series of assessment targets;

Task	*Assessment target*
Box 1: early thoughts and ideas	identifying and specifying generating and developing
Box 2: develop design ideas for sub task	generating and developing
Box 3: explain why ideas will work	applying knowledge
Box 4: design specification	identifying and specifying
Box 5: identify strengths and weaknesses	evaluating

Box 6 & 7: sharing ideas and developing final solution	generating and developing team working
Box 8: what still needs to be done?	identifying and specifying
Box 9: how do your ideas measure up?	evaluating

By structuring the activity in this way we were deliberately creating opportunities for students to demonstrate dimensions of capability as they engaged in the task. And of course this does not preclude the possibility of further evidence emerging in a more random way. Our guidance to the assessors (see below) required them to identify and credit evidence wherever it appeared.

Creating the rubric

The rubric for the assessment was created in conjunction with the following principles:

- the quality of response would be referenced, in part, to criteria and we provided four levels of guidance for each assessment heading (poor - adequate - good - excellent). The 4 point scale, and our guidance to assessors, was designed to avoid the trap of 'the middle ground';
- the criteria were derived as characteristic rather than definitive descriptors; they could be seen as indicative of a way of working, rather than as a tight definition that had to be matched exactly by the work;
- the rubric would be illuminated by exemplars of each level, agreed in advance by the assessment team and hence there would be a dimension of norm referencing applied to the criteria.

The rubric was derived from work conducted previously by TERU team at Goldsmiths on parallel projects in the UK and the USA, where we had found the combination of characteristic descriptors linked to exemplars to be a successful way in creating reliability in the assessment of procedural capability. Having developed from previous work, the specific detail of the rubric was finalised in conjunction with an analysis of the specific task and in the light of trial responses from students (initially in the UK and subsequently in Mmabatho).

The assessment rubric is included at Appendix B

6 Training the administrators and assessors

As we pointed out at the start of this report, one of the explicit aims of the evaluation has been to develop the human resources in the NWProvince, and the principal vehicle through which this has been achieved is in developing the team of test administrators and assessors. The six members of this team were drawn from PROTEC, from the NWProvince Education Department and from College of Education staff in the NWProvince. Throughout the evaluation they have been a fully committed and excellent team, and we would like to take this opportunity to recognise their hard work and thank them for their unstinting efforts.

The training of the team as test administrators took place on the Saturday morning prior to the week of testing. Using a group of students from the PROTEC Saturday school, we ran the test activity to demonstrate how it works and what the requirements were of the administrator. The team observed the activity and we then had a preparation workshop in which we discussed and resolved for them all the issues that we believed were essential for the effective administration of the task. This training session was essential to ensure the standardised administration of the instrument in all schools in the sample. At the end of the workshop we distributed all the booklets, administrator scripts, and finalised all the arrangements for the week ahead.

During the following week the administrators visited 20 schools across the Province (10 project schools and 10 non-project schools), testing 720 students; 360 in year 11 and 360 in year 12. As the week unfolded, the administrators built up a store of wisdom concerning students' typical responses to the task, and at the end of the week we reconvened in Mmabatho with all the response booklets. See Appendix C for the schedule of testing and the schools visited.

On the Friday morning we ran a further training session for the team, re-focussing them to become assessors of the work. All the fieldworkers had by this time a very good insight into how the activity was constructed and how the students had responded to it. We were conscious that we were going to be introducing the team to a very different approach to assessment to that which they were used to operating and so we structured the assessment training to have three focuses: first to give them an insight into the *principles and rationale* behind performance (authentic) assessment; second to be able to identify quite specifically the *evidence* in a script that relates to each assessment heading; third to be able (using exemplars) to make *reliable judgments* of the quality of the work.

The key to this training was the second stage - enabling the assessors to identify evidence within students' responses. We made explicit the way in which the activity had been structured to target evidence of capability at particular times, and we also illustrated how evidence can pop up all over the place in unexpected (or at least unplanned) forms. Our assessment guide was colour coded (a different colour for each quality) and we required the team to work in pairs over scripts, highlighting evidence using appropriately coloured pens. For this purpose we used photocopies of a single piece of work so that we could subsequently allow the assessors to feedback to each other on the evidence they had found in the three categories (procedural, team working and applying knowledge). In this way the assessors became skilled in *identifying* the evidence before them.

See appendix D for an example of a highlighted script.

This activity was then repeated with a second set of work on which the fieldworkers were asked first to highlight the evidence, and then to compare with the original one in terms of strengths and weaknesses. We thereby introduced the idea of the relative *quality* of capability evident in the work. This was then supported through the introduction of the rubric, which provided the fieldworkers with a tool to help them differentiate more clearly between the exemplars they were considering. In introducing the rubric, we encouraged the assessors to consider not just the *nature* of the evidence, but the *range*, *depth* and *quality* of capability that was demonstrated. Once they had agreed the assessment in pairs, we opened their judgments up to a discussion with the full team and the level of capability for each assessment heading was discussed until agreement was reached. Through this process we established common understanding of the standards to apply. Initially this standard was based on the exemplars we brought from London, but through the training process we helped assessors to create for themselves their own standardised exemplars of performance based on work from S African students.

We then presented each assessor with a range of work to assess. Each assessment pack had been carefully constructed to represent both pilot and non-pilot schools, year 11 and year 12 work, and to contain a full range of capability. We (RK and KS) had made a quick preliminary review of *all* the work to place each year and school in a band that enabled us to create mixed packages for each assessor. We did not want to create a situation in which an assessor (having been encouraged to use the full four point scale) only received work at one end of the scale. On the Friday evening, at the end of the training session, the assessors took their assessment pack with the agreement that it would all be returned to us for the moderation and debriefing meeting in Johannesburg on the following Tuesday.

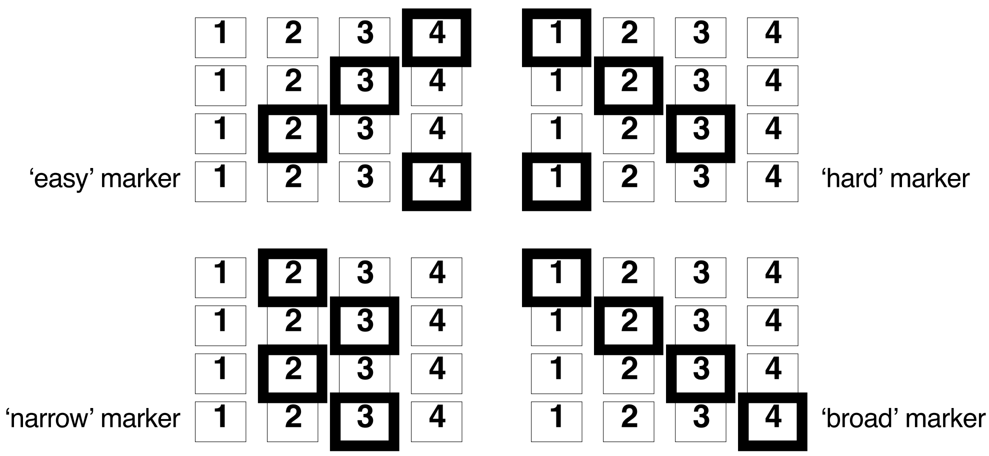
7 Moderation and reliability

An exercise of this kind is critically dependent upon the reliability of the assessments, so however much care is taken with assessment procedures it is also important to moderate the assessment. This process had two distinct stages. The first was for pairs of assessors to ‘second mark’ the work from one activity set (the response of the three teams from one year group in one school). This provided a first level of insight into the consistency between markers, and also enabled the marking to be triangulated between the pairs of assessors and the TERU (Goldsmiths) team.

The second stage involved the TERU team in moderating the marking of each of the fieldworkers to identify the following:

- the ability of the assessor to identify the evidence (indicated by the colour coding on the script);
- the ability of the assessor to ‘rank’ the work (ie to place the three teams from each set of work in an appropriate order of merit);
- the ability of the assessor to align their marking with the criteria (the rubric) and the exemplars.

This process was conducted both in terms of the overall performance of the team and in relation to each of the separate headings from the assessment framework. As a result of this it was possible to identify the ability of each assessor to be *consistent* in their marking and their use of the rubric. There are four possible patterns of marker: the ‘hard’ marker - skewing all their marks to the lower end of the scale; the ‘easy’ marker - skewing all their marks to the upper end; the ‘narrow’ marker - unwilling to spread the marks away from the centre; or the ‘broad’ marker - willing to use the full scale of the indicators available.



The ideal is to establish all of the assessors as being both consistent and able to use the full range of descriptors in the rubric (ie to be a consistent 'broad' marker). By moderating the assessment it was possible to establish the extent to which each assessor fitted this profile and we were relieved and gratified that (in general) the assessors not only agreed in their identification of evidence but were also quite able to spread marks across the scale. This was probably aided by the coarseness of the scale, the exemplars we had chosen, and our exhortations to them to be fair but bold (ie if it's poor, it gets a 1 not a charitable 2; if its really good it gets a maximum 4 not a mean-spirited 3).

Nonetheless some trends were identifiable in the assessors and in dealing with these we could not use standard statistical moderation processes since the samples were not sufficiently large and homogeneous. We therefore used the trends to highlight scripts that might be 'at risk'. For example in a marker with a tendency to be 'hard', we would select scripts at the top of their range to see if they deserved to be up-rated. Through his process, the TERU team remarked approximately one fifth of the whole sample and we are confident that the final assessments are secure.

The moderation and debriefing session also provided us with direct feedback from the markers concerning their impressions of using this system of assessment for the first time.

- The process was very new, but (with explanation of the process - and the rubric) very helpful.
- The model needs to be introduced to PROTEC materials and used for assessing portfolios.
- It needs to be cascaded down to schools.
- At first the model was chaotic, but eventually it made a lot of sense. It was very new but exceptionally good - and was helped by the colour coding.
- The evidence does depend a lot on graphics which is missing from the assessment model and from PROTEC materials.
- The headings worked well - linked to the structure of the test.
- The assessment training was the most important thing for my own development.
- Experiential training worked well.
- Exemplars were very useful as a guide to norm to.
- The colour-coding was very helpful.

(assessors PE/TT/CM/ZM/TD. Tues 2nd March 1999))

The findings on learner performance in the test activity are presented in section 11.1

8 The activity evaluation questionnaire

In addition to collecting performance evidence from students, we were interested in a number of other features, not least their attitude to the activity and their response to being placed in this teamworking environment on a technological task.

Accordingly we created an evaluation questionnaire that every student completed at the end of the activity. This identifies the gender, age, and school of the students and enables us to build a picture of the typical responses of categories of students to this kind of task. The questionnaire is in four sections, the first of which concerns the students' definition of technology. We asked them (on a scale from strongly agree >>strongly disagree) to indicate whether they thought the activity they had just completed was a technological activity, and thereafter we offered a list of reasons for them to indicate why they saw it as technological (or not). For example was it because “it was about materials” or because “ we had to design things”

Thereafter, the questionnaire tackled two basic issues: about working in teams and about girls/boys working together (or not). The section headed “I **don’t** like working in teams” offered a number of options for them to agree or disagree with (eg ‘because I get bossed about’, or ‘because other people are lazy’ or ‘because I can’t work at my own speed’). The section headed “I **do** like working in teams” offered other options (eg ‘because we can divide up the work’ or ‘because people bring different skills’)

The section dealing with gender attitudes to working together, included a free response section in which students are asked to say what are the best things about working with boys and the best things about working with girls. Since we know the gender of the respondent, this provides some fascinating reading.

The findings from the activity evaluation questionnaire are presented in section section 11.2.

9 The attitude questionnaire

A further component of this evaluation comprises an attitude questionnaire through which we sought to tap students’ attitudes to technology. We have explained earlier in the report that this instrument was developed from a version used previously in S Africa by Dyrenfurth and Williams.

The questionnaire begins by addressing the fundamental question of what students believe technology is. A number of options is available to select (including eg ‘applied science’ or ‘problem solving’ or ‘computers’). Students were asked to indicate the three things (out of the list of 7) that best describe technology as they understand it.

Thereafter, the questionnaire analyses attitudes to technology in two basic categories each if which had a series of subsections:

Technology in the world around us
- the value of technology
- quality of life
- prosperity & economy
- environment

Learning technology
- employment
- gender & ability factors
- enjoyment

The questionnaire was completed by every student in the sample (both project and non-project schools) and it represents a very rich source of data. The findings from this questionnaire are presented in section 11.3.

10 The interviews

Performance assessment instruments of the kind we have outlined above enable us to comment with some confidence on the performance of students and hence to venture some comment on the qualities that are developed within the project schools. The attitude instruments provide us with different data that helps us to understand the mind-set of students - which in part illuminates the performance data.

However, data of a quite different kind is required to explain why these differences arise and how they might be maximised in a further development of the project . To this end, we conducted a series of interviews with those that are involved in the project. We interviewed the principals of all the schools, the teachers responsible for the technology programme in the project schools and a sample of 6 yr 12 students in each project school. We also spoke to the project field officer, the director of curriculum development & assessment, the college staff who trained the teachers, and to the director of PROTEC.

The interviews were semi-structured, and, as an example, the *teacher* interview covered the following issues:

- Had you taught technology before?
- What was you previous experience of technology (at home, at school, in employment)?
- What other subjects did you/do you teach?
- What did technology mean to you you before you began the training?
- Has your view changed as a result of taking part in the programme?
- Was the training helpful?
- What were the most helpful things?
- Did you find the training difficult?
- What was the most difficult (technological knowledge, technical skills, pedagogy)?
- Has it been beneficial to take part in the project (to you / to the school / to the students)?
- Have the students enjoyed taking part?
- Have there been any difficulties in implementation?
- What would you do differently next time?
- Do you think the programme should be in all schools, and from what age?
- What are the priority issues for a new school to deal with?
- How best might these be tackled?
- Are there any other things you would like to say about the programme?

In each case the interviews were not recorded, but notes were taken at the time on a prepared response sheet and these sheets were transcribed onto a spreadsheet. We could then combine (eg) all the teachers answers to a particular question to see whether any common issues emerged. The findings from this analysis enable us not only to interpret the performance data but also to speculate on wider issues concerning the further development of the project.

Our analyses of these interviews is presented in section 11.4.

11 Findings

11.1 Findings from the technological activity

Several very interesting and significant findings emerge from analyses of the student performance data. We have organised them in relation to the following three broad headings:

1 Overall differences between pilot and non-pilot samples

2 Differences between yr 11 and year 12 (both pilot and non-pilot samples)

3 The profile of schools (both pilot and non-pilot samples)

Overall differences between pilot and non-pilot samples

To derive these gross differences, we considered the design teams as the basic units of measurement. Each school had three teams (A,B & C) in year 11 and three in year 12. Ten schools (ie 60 teams) were therefore in the project-school sample and 60 in the non-project school sample. Average scores were derived across these 60 teams for all elements of the assessment framework. The data emerged as follows

	proj	non-proj	diff	t test probability
holistic	**2.53**	**2.18**	**0.35**	**0.03**
(procedures)				
identify/specify	2.63	2.32	0.32	0.03
generate/develop	2.43	2.33	0.10	0.50
evaluate	2.38	1.88	0.50	0.00
team-work	2.65	2.27	0.38	0.02
(use of knowledge)				
materials/processes	2.4	2.03	0.37	0.02
energy/power	2.18	1.6	0.58	0.00
communications	2.67	1.7	0.97	0.00

All but one of the assessment heading produces statistically significant differences between the project and the non-project samples. **Holistically**, the project sample averages 2.53 (on a 1-4 scale) and the non-project sample averages 2.18. The average difference is 0.35, and there is only a 3% probability that the two data sets come from the same underlying population [4]. Since a value of 5% or less may be taken as significant, this establishes a statistically significant difference between the project and non-project samples.

Scanning down the list, it is easy to see where the major differences lie. Within the design procedures, *evaluating* is **very** significantly stronger in the project sample, *identifying & specifying* and *team-work* are significantly stronger, but with *generating & developing* solutions there is no significant difference between the samples. In the use of knowledge, *communications* and *energy&power* are **very** significantly stronger in the project sample, and *materials & processes* is significantly stronger.

Based on these data and our observations of project materials and of the programme in schools, we made a series of provisional interpretations in our Interim Report and Professor Kimbell discussed these with project staff during his visit in April. We are confident that these interpretations are well founded.

We are not surprised that there is no significant difference between the samples in relation to *generating*

4 The probability data are derived from a t test, which is used to determine the probability of two samples having come from the same underlying population. We have used the ‘two sample; equal variance’ (homoscedastic) form, that assumes that the means of both data sets are equal.

& developing design ideas, since the programme does not explicitly develop students' ability to do this. Rather it concentrates on the systematic organisation of pre-existing ideas within the project materials (eg assembling existing sub-systems). The ethos of the project materials is closer to constrained problem-solving than to designing. The lack of sketching skills - which are essential for the rapid manipulation of design ideas - exacerbates this tendency. It should be noted that developing students' graphic ability would help them to transcend language problems. We were most impressed at the extent to which students were able to move between Tswana, Afrikaans and English, but graphics - the universal language of design - would be an invaluable support.

At the other extreme, we are clear that the programme has had a dramatic effect on students' *team working*, partly because it is not (we understand) a common practice in schools generally, and partly because the whole pedagogy of the project fosters it. We should therefore expect the differences to be considerable - and they are. Similarly, the cerebral procedures (*identifying, specifying, evaluating*) are strongly in evidence in project materials. Students are familiar with the language and comfortable with the procedures, and this shows up clearly in students' performance. In the use of knowledge we should not be surprised that all the conceptual areas show significant differences between project and non-project samples, since the curriculum deals explicitly with them. Students' ability to deal with *communication* (eg electronic systems), and *energy & power* (eg mechanical and structural systems) are clearly very significantly enhanced, and the slightly lower significance for *materials & processes* is attributable to the fact that this area can more readily be approached simply through every-day experience of the world. Scores in the non-project schools are therefore relatively higher than for the other two conceptual areas.

Differences between yr 11 and year 12 (both pilot and non-pilot samples)
It is a matter of some importance to identify the progression of students' capability within the project, and to this end we examined performance in year 11 and year 12 groups. Since we were testing students in February (the start of the academic year) we had hoped also to test a cohort of (in effect) year 13 students; those who finished school in the December 1998. This proved impossible however, so we were left with testing a yr 11 group who have had one year of the programme - and a yr 12 group that has had exposure to two years of the programme.

We separated the project and non-project samples and then created sub-sets of the data for year 11 and year 12. Thereafter we averaged the team scores in the same way as with the holistic scores (see above) and produced tables of differences and probabilities. The data emerge as follows:

Project sample	yr 12 ave	yr 11 ave	diff	t test prob	
holistic	2.48	2.59	-0.11	0.63	
identify/specify	2.52	2.78	-0.26	0.24	
generate/develop		2.39	2.48	-0.09	0.68
evaluate		2.39	2.37	0.02	0.92
team-work	2.76	2.52	0.24	0.29	
materials/processes	2.52	2.26	0.26	0.24	
energy/power	2.24	2.11	0.13	0.57	
communications	2.76	2.56	0.20	0.41	

There are some differences between the yr11 and yr 12 group in the project schools - but none of them is significant. Generally there is improvement in a majority of the assessment headings, but not of a sufficient order to create statistically significant differences. Initially this might seem disappointing, but two factors enable us to take a somewhat more positive view of the situation.

First we must remember that the year 12 group experienced the project in its infancy. When they were in years 10 and 11, the teachers were struggling with a completely new pedagogy, and - if things in the UK are any guide - it takes teachers a year or two to develop their classroom practice in response to the initiative. This is particularly true where the initiative is based more in pedagogy than in a body of knowledge. Accordingly the current year 11 will have experienced better teaching (simply because the teachers will be a year more experienced) than the current year 12. But the interesting features emerge when we contrast the performance in non-project schools. This is consistent with the data that shows the conceptual areas demonstrating more improvement than the procedural areas. Our interpretation therefore is that this year's yr11 group is procedurally stronger than last year's yr 11 group (this year's yr 12 group).

Second, we can compare the improvement from year 11 >> yr 12 in the project schools with the same data from the non-project sample.

Non-project sample		yr 12	yr 11		t test
	ave	ave	diff	prob	
holistic	2.10	2.27	-0.17	0.43	
identify/specify	2.23	2.40	-0.17	0.39	
generate/develop		2.23	2.43	-0.20	0.32
evaluate		1.87	1.90	-0.03	0.87
team-work	2.00	2.53	-0.53	0.02	
materials/processes	2.00	2.07	-0.07	0.76	
energy/power	1.50	1.70	-0.20	0.35	
communications	1.70	1.70	0.00	1.00	

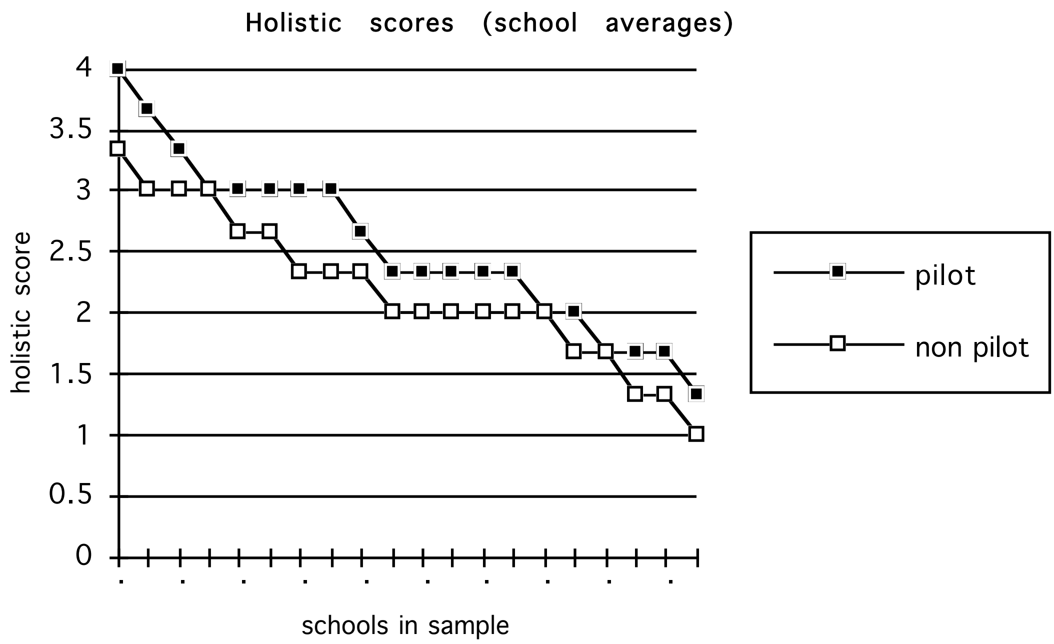
Here we see the yr 12 performance as almost universally worse than yr 11 performance. And in respect of teamworking, this reduced performance is statistically significant. Astonishingly, in non-project schools, school leavers are significantly worse at teamworking than students in the lower year. This is not a healthy condition for students who are (hopefully) about to enter the world of employment.

When seen in the light of these two factors, the findings from the project schools are more encouraging. It would appear that the explicit team-working pedagogy of the project has counteracted this damaging trend and even reversed it - though not sufficiently strongly to reach a level of statistical significance.

The profile of schools (both pilot and non-pilot samples)

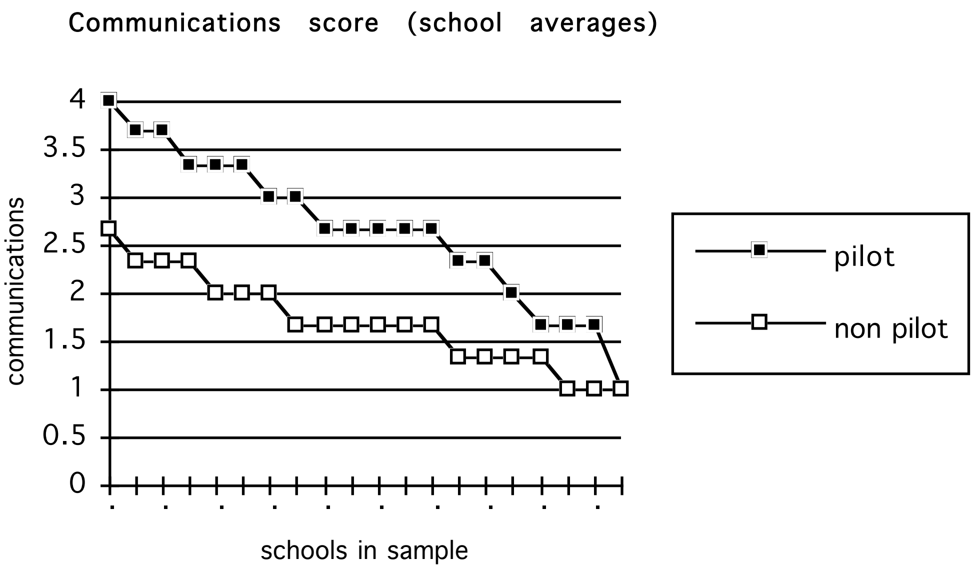
In this third approach to presenting the data, we take a somewhat different tack. Rather than regarding the design team as the data unit, we amalgamate the teams within a year and produce a set of school data for year 11 and year 12. We then separate the project and non-project schools and produce a rank-order of the two sets of scores.These two rank-orders can then be displayed on a chart. In the example below, we compare the rank-order of schools (based on the holistic scores) in project and non-project schools.

These might be seen as the profiles of project and non-project schools.

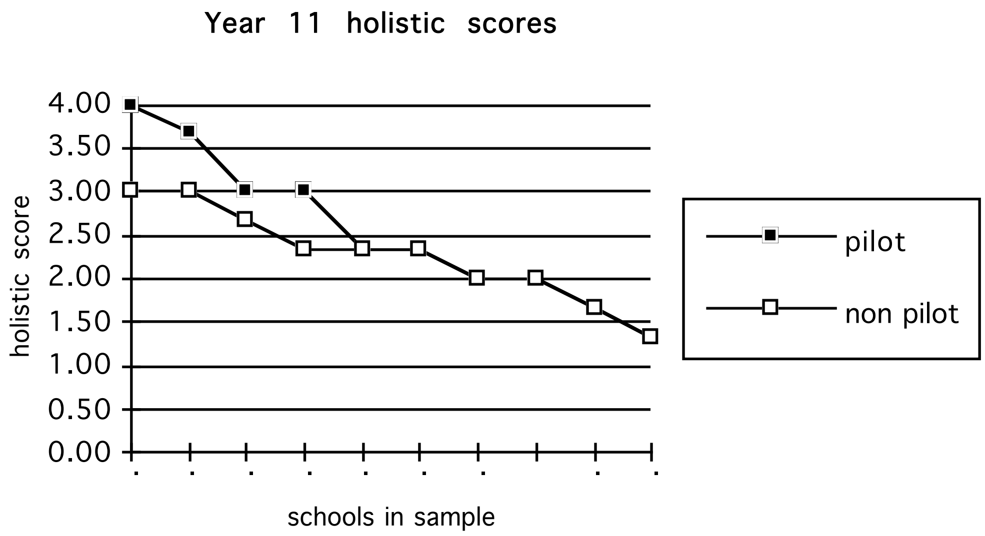


The *holistic* profile of project schools runs from 1.3 up to 4.0 with an average of 2.53, whilst that of the non-project school runs from 1.0 to 3.3 with an average of 2.18. Whilst there are some non-project schools outperforming project schools, the profiles demonstrate the clear advantage of the project schools.

The same process can be undertaken for every heading in the assessment framework, demonstrating greater of lesser degrees of advantage to the project schools. The most extreme case concerns the use of knowledge - especially *communication* (eg electronic systems). This field of understanding is clearly not part of everyday life, so students who do not have access to it through their curriculum are severely disadvantaged. And inevitably, the profiles tell a convincing story.

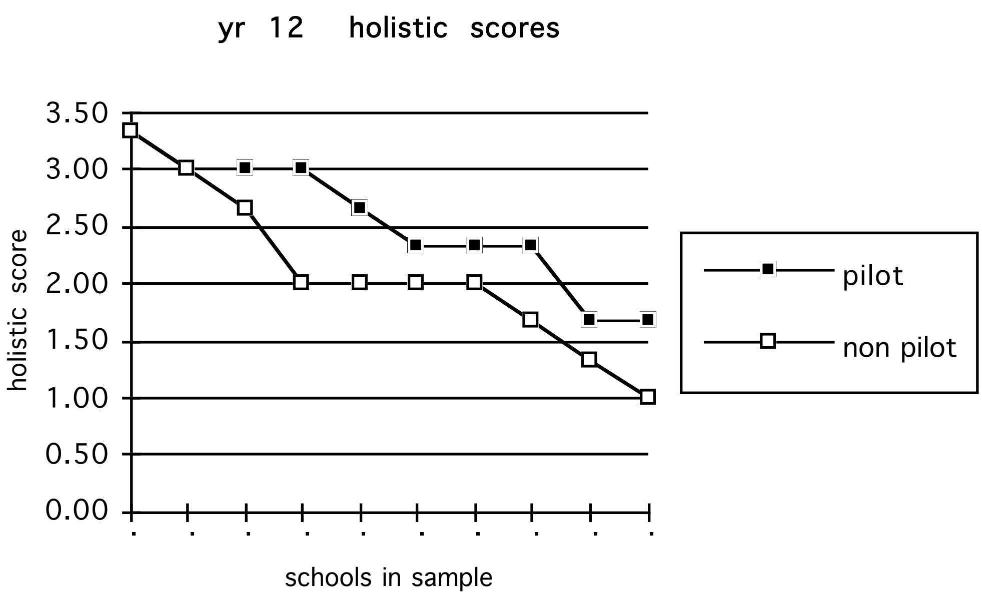


We can also examine these profiles separately for year 11 and year 12, and when we compare the project and non-project samples by year group we see another fascinating factor emerging. We can begin to identify the manner in which the improvement of the project sample takes place.   If we chart the holistic score for year 11 in project and non project schools, we see performance in 6 of the 10 schools is equivalent, but at the top end of the rank orders, four of the project schools lead the field.

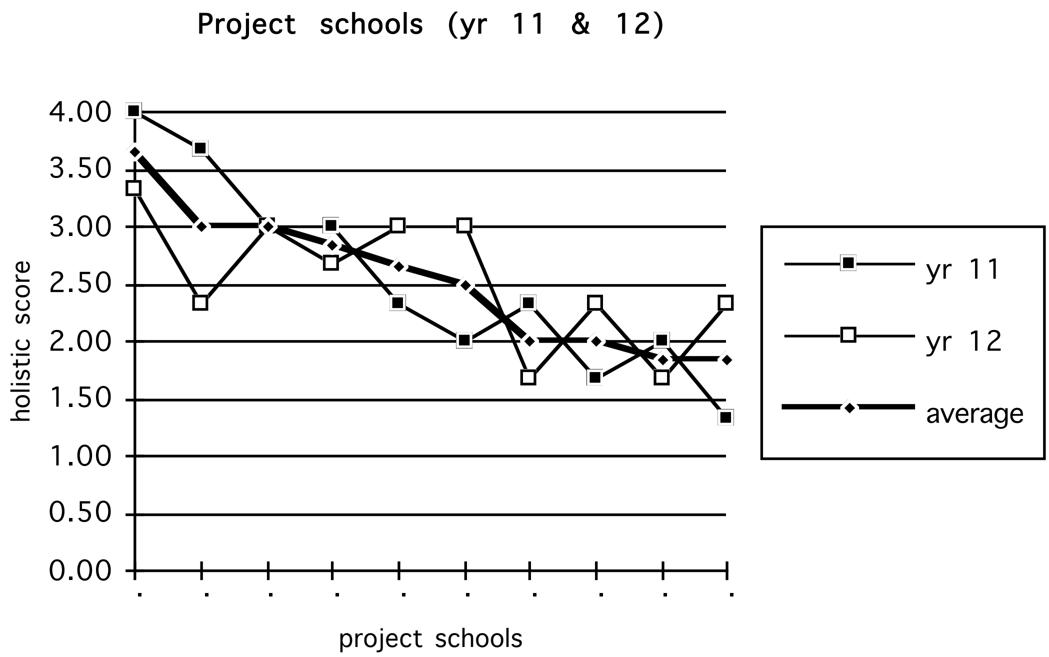


We might speculate that these four schools are the most prepared or the most mature in their approach to their teaching in yr 11. In any event they give their yr 11 groups a flying start.

If we then look at the year 12 data, a different pattern exists. At the top end, the very best of the non-project schools are getting on terms with the best of the project schools, but the bulk of the project schools moves significantly ahead of the non project schools.



For the purposes of this report, we have not identified the schools. However, should it be thought appropriate by DFID, the NWProvince and PROTEC, these data can be used to build profiles of the strengths and weaknesses of student performance in particular (identified) schools. As an example, the project schools are shown below in rank order of holistic performance, and as a point of reference it is worth noting that the two Technical Schools in the non-project sample achieved averages of 3.00 and 2.17 respectively (ie equal 2nd, and 7th out of 10).



11.2 Findings from the Activity Evaluation Questionnaire
This questionnaire was completed by all students, following the completion of the activity, and we have targeted two areas for particular analysis; the views expressed by students on the subject of working in teams, and the views they express on working with girls and boys.

As we described in section 8, the question of teamworking was tackled from both positive and negative positions (what is *good* about teams and what is *bad* about them). Interestingly the data from the first block of questions (positive) is largely inconclusive in terms of differences between project and non-project schools, but (for the record) the strengths are listed in the following order. The scores are averages across the whole sample (720 students) and are on a scale of 1-4.

I *like* working in teams:

because we can share ideas	3.8
because there are lots of different ideas	3.7

because people bring different skills	3.6
because it helps to develop communication skills	3.6
because we can divide up the work	3.1
because you are not marked as an individual	2.6
because other people can do all the work	1.9

This represents a healthy balance of positive attitudes to groupwork, and is reflected across the whole sample.

Intriguingly however, the negative questions expose some significant differences between project and non-project schools. Across almost every question in the negative group, there is a difference, and, without a single exception, the project schools are less negative than the non-project schools.

I *don't* like working in teams:	project	non-project
because I can't work at my own speed	2.2	2.4
because other people are lazy	2.5	2.7
because I don't like having arguments	2.0	2.2
because other people have silly ideas	2.0	2.3
because it is more difficult to make decisions	1.9	2.1

This would appear to be solid evidence that, in project schools, the continual experience of teamwork has enabled the students not only to see the benefits of teamwork, but also to grow beyond some of the archetypal complaints about it.

When we examine the data for gender difference, both the positive and negative data sets appear remarkably homogeneous, with very few significant differences emerging across girls and boys *as a whole*. The only differences (only barely significant) are in two related negative questions; with girls disliking arguments more than boys, and girls saying it is more difficult to make decisions in a team.

We then put these two stratifications together to examine gender groups in the project and non-project schools and, not surprisingly, nothing of significance emerged from the positive question set. In the negative set there is an interesting trend - with girls in the project schools showing greatest advantage. The only significant difference with the boys concerned the difficulty of making decisions in a team, with boys in non-project schools scoring this markedly higher than boys in project schools.

With the girls, virtually the whole spectrum of questions reveal differences between project and non-project samples

Girls don't like working in teams:	project	non-project
because I can't work at my own speed	2.2	2.5
because other people are lazy	2.4	2.7
because I don't like having arguments	2.1	2.3
because other people have silly ideas	2.0	2.4
because it is more difficult to make decisions	2.0	2.2

However, these differences do not arise because girls in project schools are less negative than the boys in project schools. In fact their scores are remarkably equivalent. The differences arise because of what happens in the *non-project* schools. The girls in non-project schools are far more negative about teamwork than are the boys in non-project schools.

If this proves to be true - and continuing analyses of these data will seek to unpick it further - then it provides a somewhat unexpected argument in favour of the groupwork ethos of the project schools. It would suggest that the major beneficiaries of the pedagogy are the girls, who are able to overcome the very negative attitudes towards team-working that predominate in non-project schools.

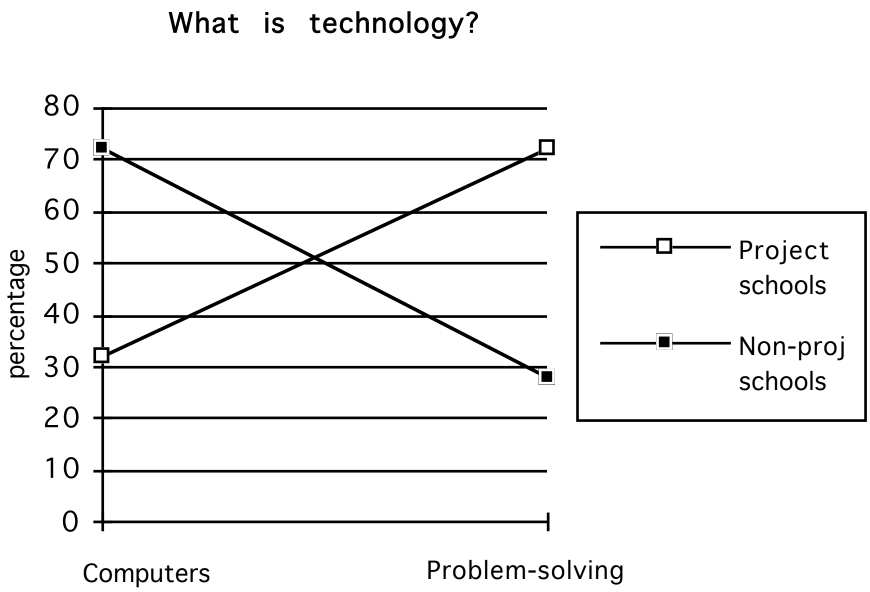
The final section of the questionnaire asks students to comment on the best things about working with girls - and the best things about working with boys, and the following selection illustrates some of the range of thoughts and values being expressed. In the chart, the first column indicates whether the respondent is a girl or a boy, and the second column indicates whether they are talking about working with a Girl or a Boy.

		Project schools			*Non-project schools*
g	B	the best thing about working with boys is that they have good ideas	b	G	girls are very cooperative, they can motivate you and they pay a lot of respect.
g	G	we share the ideas and solve the problems without any disturbance	g	B	they give more ideas than girls (eg a man is head of the family)
g	G	they listen, they work hard and they are responsible. They work towards success	g	G	the best thing is to work with girls because many of them are good at writing
b	B	sometimes we don't want to be undermined, we want leadership at all times	g	B	they are best in drawing and they have good ideas
b	B	because they are quick thinkers and they come up with good ideas	b	B	having ideas, having arguments and making a good decision
b	G	they are good with sharing ideas and some girls are not afraid of electricity	b	G	because when they talk their sweet voice makes you concentrate
g	B	because they come up with the best ideas	g	B	to work with boys is best because they have strong minds and they are not selfish
b	G	girls are good because they don't argue to a fool like boys and they always agree to the ideas given	b	G	they are good listeners and they concentrate more on their work than boys

11.3 Findings from the Attitude Questionnaire

The first section of our analysis has concentrated on the first question - ie about what technology is. Students were asked to identify (from a list of seven options) the three things that best describe technology, and the difference in approach between project and non-project schools was stark. The best way to characterise the difference is to see it as a contrast between those who see technology as being about technological *products* (on one hand) and those who see it in terms of technological *processes* (on the other).

As an example of this, it is revealing to chart the percentage of the respondents (in project and non-project schools) who see technology as being about computers, and those who see it as being about problem solving.

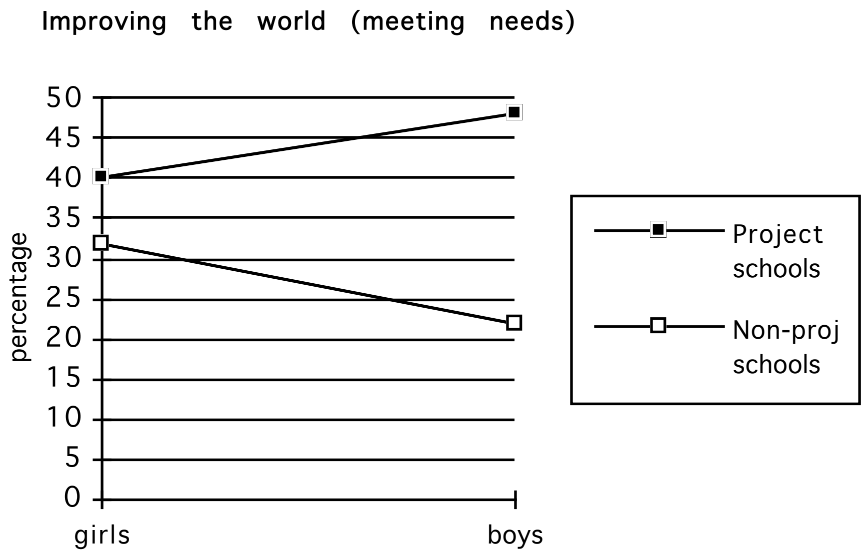


Clearly, in non-project schools the ‘product’ view dominates, whilst in the project schools the ‘process’ view dominates. The data are astonishingly mirror-image like, and such a stark difference can only be explained in terms of the impact of the project on students’ attitudes.

The real strength of this transition from a product to a process-centred view of technology is that the latter is far more empowering. Products (such as computers) are just ‘out there’ produced by someone else, somehow, somewhere. If you believe that this defines what technology is, then you are disempowered; merely receiving the products of technology that get passed on to you. By contrast, the process-centred view puts you in the driving seat. It projects the empowering idea that “I can solve problems”. This finding is consistent with our analysis of the interview data, in which both teachers and students in the project schools refer to themselves as problem-solvers. (see section 11.4)

There is also an interesting gender effect in this transition from a (passive) product to an (active) process centred view of technology. One of the options for students to choose as their defining descriptors of technology was that technology is about “improving the world (meeting needs)”. We can examine the difference in response between girls and boys in project and non project schools, and as can be seen, in non-project schools this is selected by about 28% of respondents, with (predictably) rather more girls than boys. The startling data emerges when this is compared to project schools. The average response here is somewhat higher at 44%, but interestingly the big increase is in the boys in the sample. Whilst only

22% of boys in non-project schools believe that technology is about improving the world by meeting peoples needs, this figure rises to 48% in project schools.



We will turn later to further insights into gender differences that have emerged from the attitude questionnaire. At this stage we need to consider the general picture provided from the response to the further thirty four questions on the questionnaire in terms of the overall picture that is provided.

As is described in section 9, the questionnaire presented statements about technology to the students, organised in a random fashion and the students were asked to indicate their level of agreement to each statement. Some statements were written in a way that could be seen to present a negative view of technology (eg ‘technology is boring’), while others were presented more positively (eg ‘technology improves people’s way of life). Some statements were presented in a more ambivalent manner (eg. ‘technology causes pollution, but we still need it’). In order to gain some insight into the overall response to these statements we calculated the average response from all students (whether from project schools or not) and ranked students’ agreement with the statements. This created a profile of overall response, with “strongly agree” scoring 4, “strongly disagree” scoring1, and consequently an average score of 2.5 can be seen as neutral.

Looking generally at the profile presented, it can be seen that, in overall terms, high school learners have a positive attitude to technology, and within this a strong sense of equity. For example, the statement that is most agreed with is that ‘boys and girls should learn about technology’ (average score 3.74) and the statement least agreed with that ‘technology is only for girls’ (average score 1.21). The statement ‘only intelligent people should learn technology' is also disagreed with (average score 1.53). Further pairs of statements are interestingly polarised:

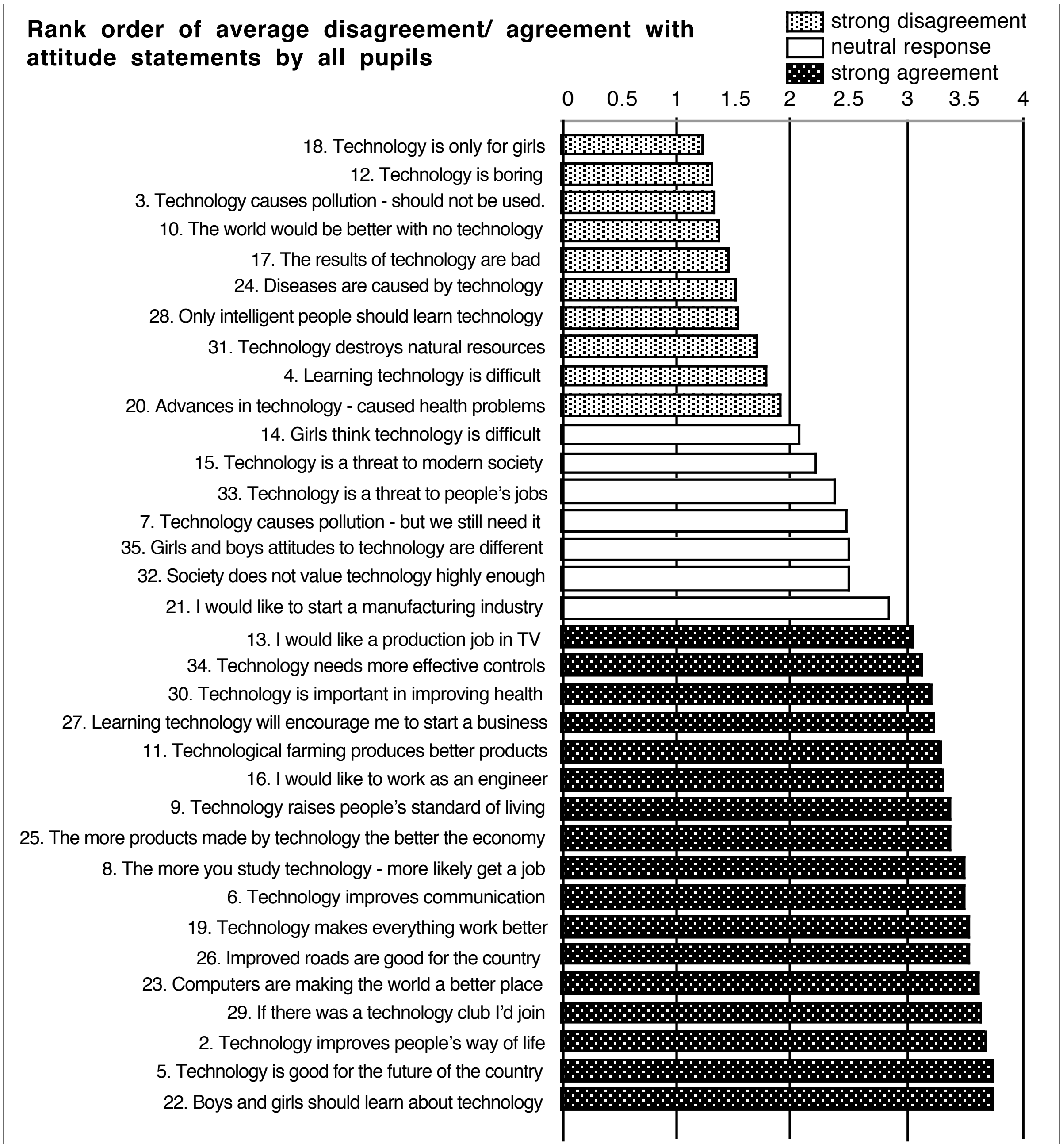
- 'technology is boring' - strongly disagree (average score 1.30)
- 'if there was a technology club I'd join it' - strongly agree (average score 3.63)

and

- 'the world would be a better place with no technology' - strongly disagree (average score 1.37)
- 'technology is good for the future of the country' - strongly agree (average score 3.74)

There are also some statements to which students show either a level of ambivalence or neutrality, eg:

- 'girls and boys attitudes to technology are different' - neutral response (average score 2.48)
- 'society does not value technology highly enough' - neutral response (average score 2.49).

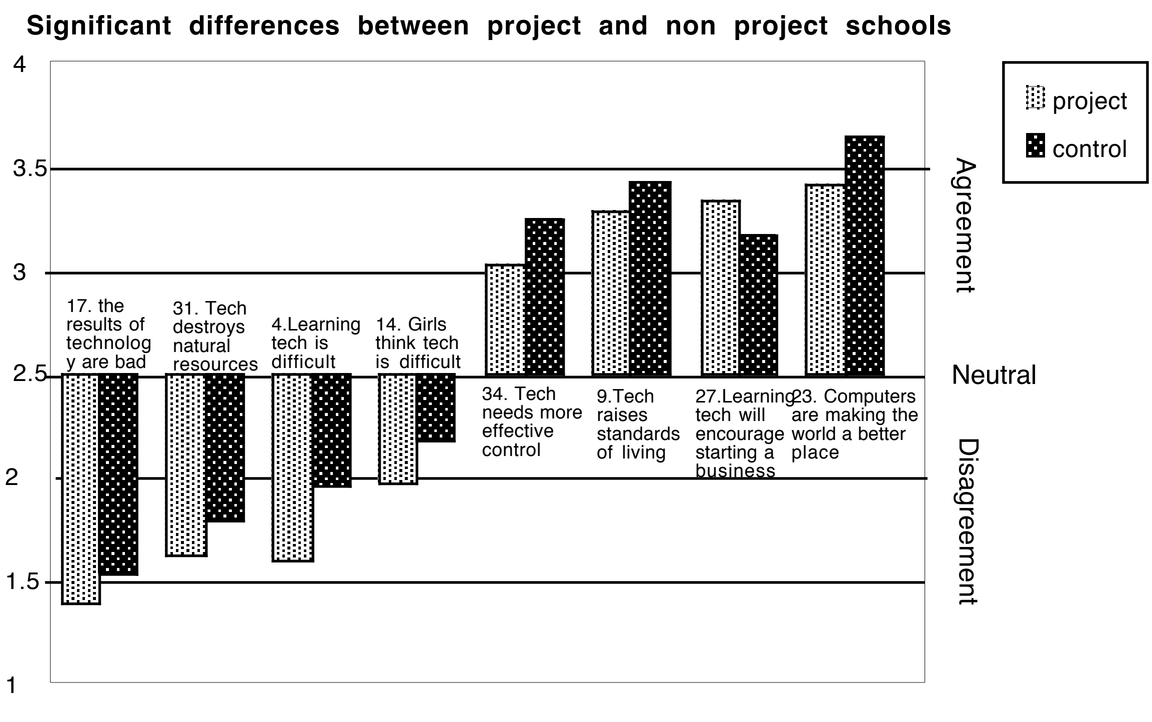


But within this generally positive view there are some significant differences in the strength of agreement or disagreement between project and non project schools and girls and boys. There are some statements where there is a marked difference (t test probability of less than 0.009) between the project and non project schools, and others where there is a marked difference between girls and boys. Not surprisingly there are further statements where these two effects (studying technology and gender) are confounded. The following figures and paragraphs outline the key differences.

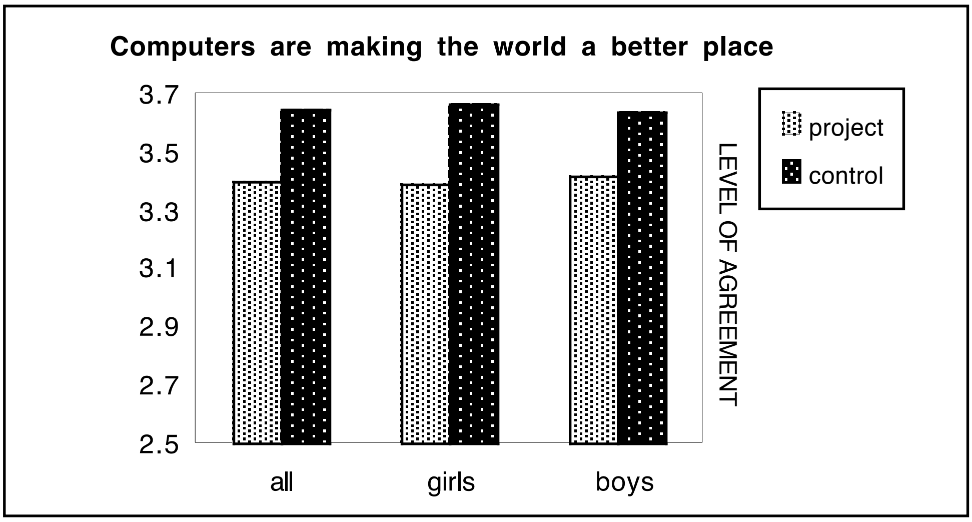
Project school differences

Moving from this general profile of agreement we can also shows those areas within this profile where there is a marked difference between project and non project schools (again using the t test probability measure and showing those statements where the t.test figure was less than 0.009).

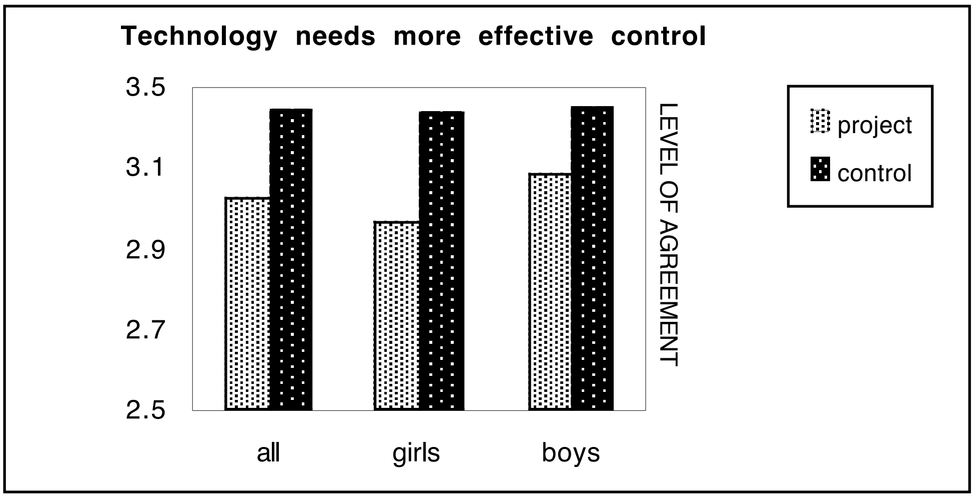
The chart below shows the level of agreement or disagreement away from the central (or neutral) score of average 2.5. As can be seen, none of these differences change the overall profile - no strong agreement from one group is contrasted with a strong disagreement from the other. The difference is in the *strength* of the agreement or disagreement. With certain of the statements there is a marked difference that appears to be particularly affected by the effects of studying technology and this is most notable in statements 23, 34 and 4.



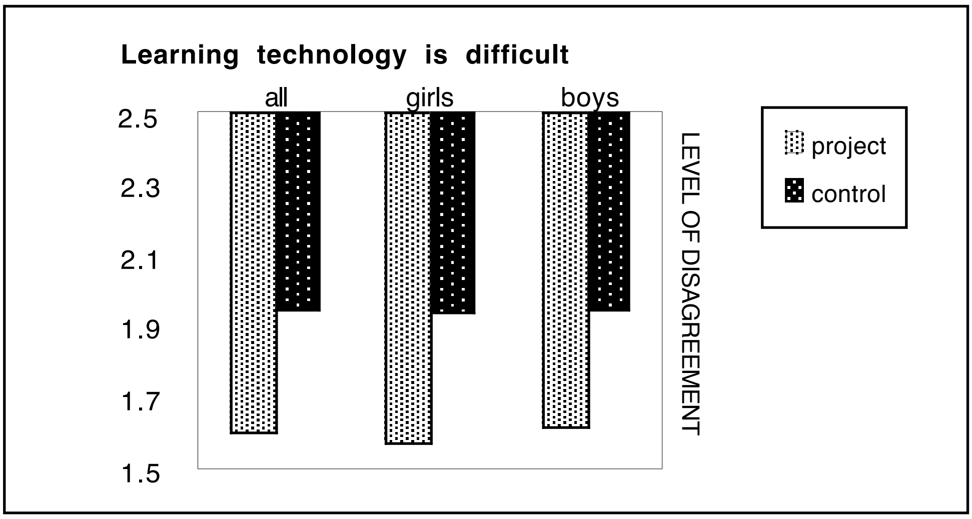
With statement 23 'computers are making the world a better place', we can gain further insight into the findings from question 1 - 'what is technology'. What is shown by this statement is that there is general agreement that ‘computers are making the world a better place (average score 3.53) but that the students from the project schools take a more measured view of this, as was indicated earlier. We can then show how this level of agreement is split between the two groups, with virtually no impact being created by the gender of the students concerned.



In terms of the category *technology in the world around us* there are also indications of differences between the project and non project schools. Statement 34 ‘technology needs more effective control’ shows this difference. Here it is the non project schools who show the most agreement in this statement, which could be seen to accord with the old adage that ignorance breeds fear - those students studying technology have a greater understanding of what technology is and consequently, while agreeing that technology needs more control, show a more measured response.

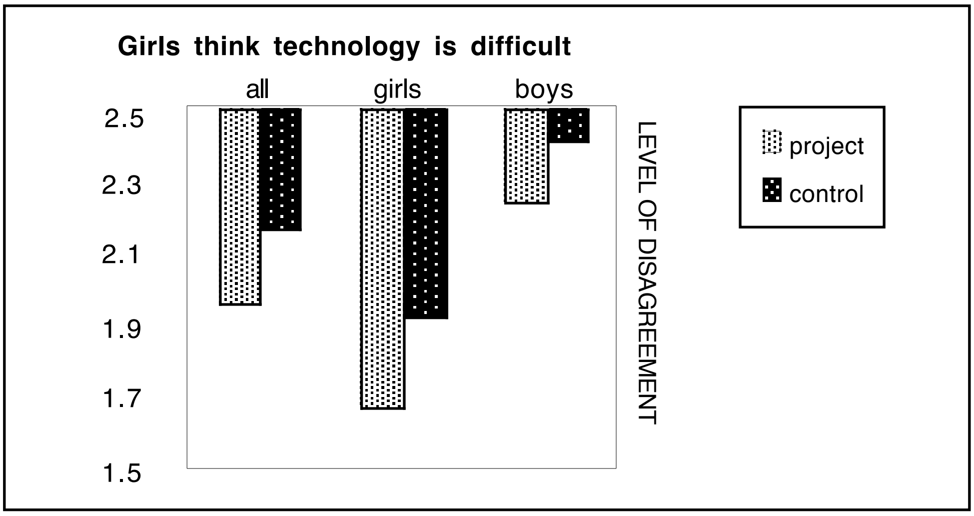


The most marked difference in levels of agreement is shown in relation to statement 4 ‘learning technology is difficult’. We can see the strength of disagreement from students in the project schools and also shows that this difference is not affected by gender. This finding is further illuminated by the interview data, where the students from the project schools are quite clear that technology is not a difficult subject, and that this is because of the way it is taught - through relating theory to practice through hands-on activity, and by working in groups where learners can share ideas and help each other.



Gender differences

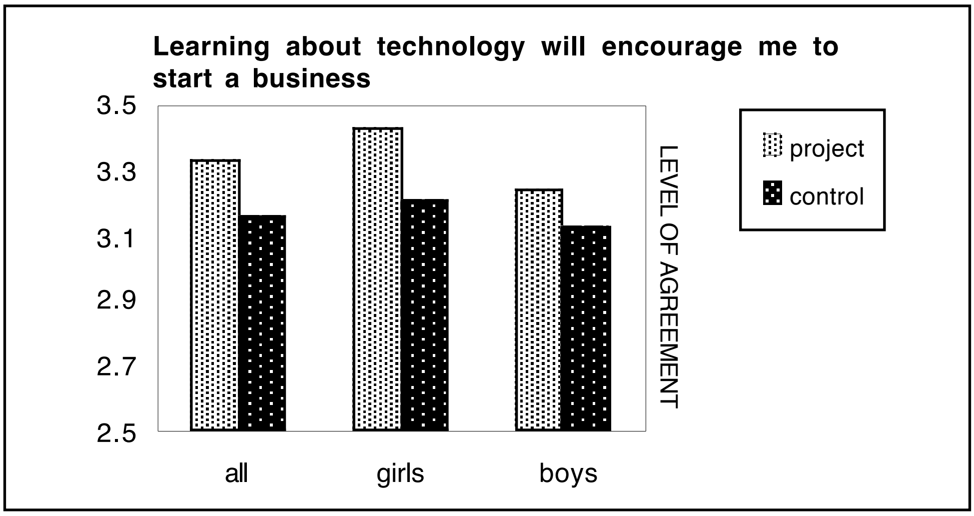
While the above statements show no gender differences, there are those where gender makes a marked impact on the students’ response. Interestingly, following on from the previous statement (’learning technology is difficult’) where there was no gender difference, the most marked difference is with statement 14 ‘girls think technology is difficult’. While in general terms technology is not seen as difficult (average disagreement with statement 14 is 1.78), boys (both project and non project) see this differently where girls are concerned. The greatest difference is between the views of the girls studying technology (average disagreement 1.68) and the boys who don’t (average disagreement 2.42) showing a strength of disagreement that (even between the project boys and girls) is roughly twice as large as on any other statement on the questionnaire. It would appear that studying technology has made a strong impact on the girls’ attitude to their capability.



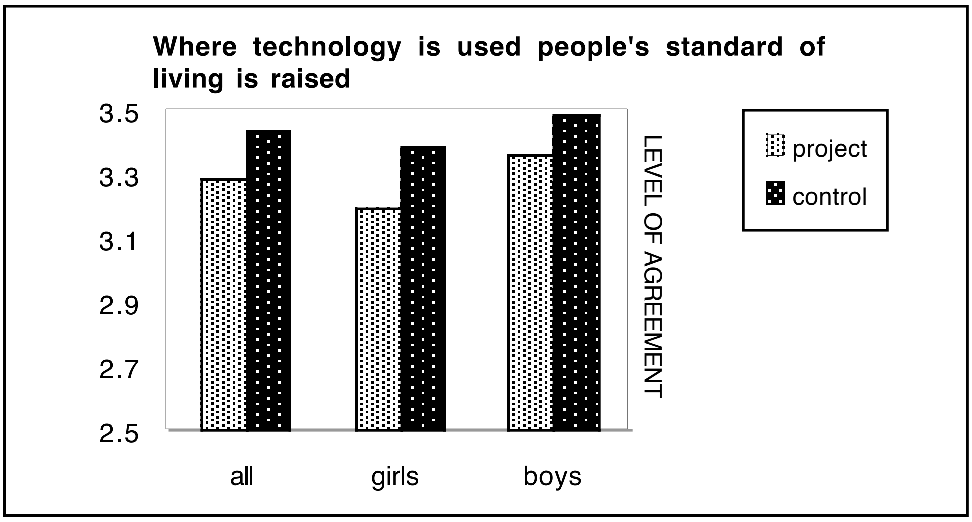
Project and gender differences

With certain of the statements there appears to be a significant difference where both a project and a gender effect can be detected. This is most notable in statement 27, which gives some insight into the impact of technology on entrepreneurship, and in statements 9 and 31 which give insight into quality of life and environmental aspects respectively.

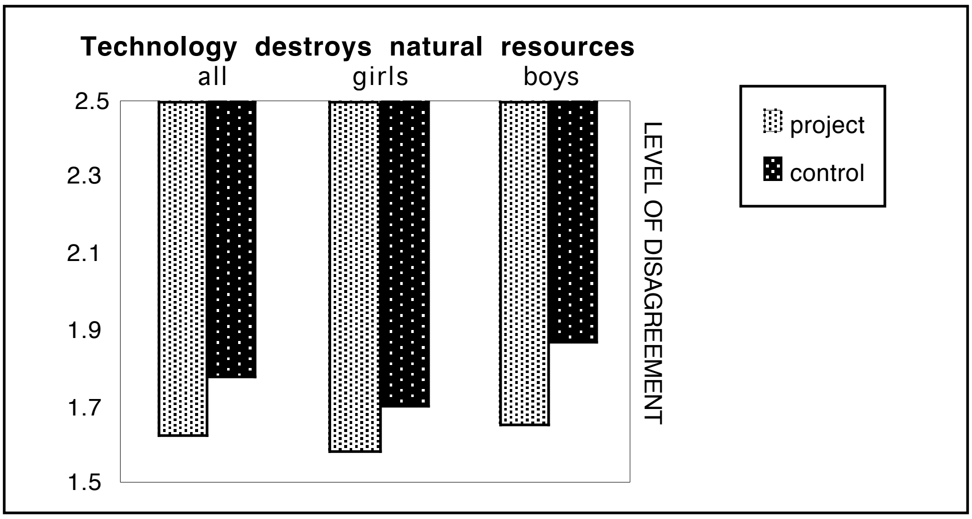
With statement 27 'learning about technology will encourage me to start a business' there is a clear difference between the project and non project schools and this difference is most marked in terms of the girls from the project schools who show the greatest level of agreement with the statement. The project seems to have made a positive impact on the entrepreneurial attitude of the students and once again it would appear that the impact on the girls has been particularly empowering.



With statements 9 'where technology is used people's standard of living is raised' and 31 'technology destroys natural resources' the 'project' effect and the 'gender' effect combine to show girls studying technology to be the most cautious about the impact of technology on the standard of living.



However, they are the most confident that technology doesn't destroy natural resources, and the strongest contrast in both cases is between these project girls and the boys who don't study technology.



Within this section, some indication has been given as to where these findings support or shed further light on findings from elsewhere. We now turn greater attention to this, as we indicate some of the key overall findings that have emerged from different aspects of these data.

11.4 Findings from the interviews

As we explained in section 10, in addition to conducting test activities with learners, and asking them to complete the activity evaluation and the attitude questionnaires, we also conducted a series of interviews with those that are involved in the project. We interviewed the principals of all the schools, the teachers responsible for the technology programme in the project schools and a group of yr 12 students in each project school. We also spoke to the project field officer, the director of curriculum development & assessment, the college staff who trained the teachers, and to the director of PROTEC.

In each case the interviews were not recorded, but notes were taken at the time on a prepared response sheet and these sheets were transcribed onto a spreadsheet. We could then combine (eg) all the teachers' answers to a particular question to see whether any common issues emerged. The findings from this analysis enable us not only to interpret the performance data but also to speculate on wider issues concerning the further development of the project.

Inevitably, many issues arose in the course of these interviews that reflect on the development and quality of the technology programme. We have been selective with these issues and present them here in the following categories:

- concerning the training of teachers

• concerning the pedagogy underpinning the programme
• concerning teamwork
• concerning resources
• concerning the benefits of the programme
  - to learners
  - to teachers
  - to the school
  - to the Province
• concerning the priority issues for a school embarking on a technology programme
• concerning the dissemination of teacher expertise

Concerning the training of teachers

When we asked teachers to reflect on the quality of the training, two contrasted (apparently paradoxical) positions emerged. On one hand teachers comment that the training was highly effective in helping them to completely transform their approach to teaching & learning. This pedagogic transformation was attested to by almost every teacher in the project schools and is observable in comments such as...

• Yes, its a very different style of teaching - but not difficult - its better dealing with small groups - very interesting and effective
• Professionally I am a changed person - its a question of management - I am not oppressed by the dictatorship of the teacher
• In technology you are not spoon-fed - there is no authority there - you are there to help not to control

Moreover, having adopted this quite new (active) form of teaching and learning, the teachers also say that they have adopted it into the other subjects that they also teach.

• I have acquired innovative teaching methods which are transferable to other subjects
• The training enhanced our ways of teaching, and the methods are permeable to other subjects

On the other hand, the small number of teachers that criticised the training do so in terms of the expectation that they had for acquiring more technological knowledge and skills.

• I had more expectation - training was just basic - not deep enough
• But we need to learn more content and skills than students would learn

This dissatisfaction highlights the fact that the training has to do two distinct jobs. It has to help teachers to transform their style of teaching and it has to provide teachers with technological knowledge and skills. The priority of the training (evidenced in the trainer interviews) prioritises the transformation of pedagogy.

• We set up a problem - a forest fire - how would you get the message to those that can help (eg. drums/telegraph/Morse). We gave them (the teacher group) an hour and they have to be able to send the message.
It seemed like chaos at first - especially if you are used to the teacher being the boss - but it has definite advantages.But it is time consuming. We could have gone much deeper into the technology, but I think it was good for them to see technology in everyday problems.
• Shifting teachers' thinking is the big challenge - being a facilitator - groupwork - less instructional - more discussion
• The benefits to the teachers were definitely in learning classroom skills - of groupwork - of questioning and thinking about teaching interactions.

Our interviews illustrate that it is difficult simultaneously to do both jobs; transforming teachers' pedagogy and ALSO making them expert technologists. The priorities seem to us to be absolutely right - for the task of transforming teachers' pedagogy is the key challenge. Perhaps it is also useful for PROTEC to consider how they might help teachers also to extend their technical knowledge and skills, but this must not be done at the expense of the current success in transforming teachers' pedagogy.

Concerning the pedagogy underpinning the programme

Undoubtedly, the single most important feature of the programme - in terms of ensuring its success - has been the active, problems-solving pedagogy that teachers have been trained to use. It is the only pedagogy that is consistent with the nature of technology - and the evidence suggests that it has had a profound effect on teachers and pupils alike. There are several elements comprising support for this new pedagogy:

It makes learning easy and enjoyable

- It is easier to learn because you have practical and theory- put theory into practice.
- Enjoy the teaching styles and interactive learning (participatory learning).
- There is fun.

It is empowering for learners

- In other lessons the teacher says what is right - in technology I find out.
- Technology makes you feel proud - you can do things you didn't think you could do.
- We design solutions to problems
- It has altered my life, knowing how to solve problems. I feel so strongly I want to spread the word

Its encourages entrepreneurial attitudes

- Big impact on business and economics and natural science - pupils are transferring skills...

It supports maths and science

- Technology lessons have very exciting activities and it makes us understand the practical application of mathematics and science.
- As opposed to science which only stops at the experiment level, technology goes beyond, putting theory into practice.
- In science there is instructing/ teaching of Newton's Law. In technology you apply the law and the mathematical principles.

It's good for learners with special educational needs

- Good for slow learners. In technology slow learners can achieve more.

And there is plenty of evidence of teachers developing the approach in other areas of the school

- Methodology translates to all subjects and the majority must do it.
- There have been changes in approach from other teachers e.g. more experiments and practical work in science.
- Encourage problem solving across school curriculum.
- Other members of staff have copied the learner-centred approach from the technology teacher and use it effectively.
- Now teachers have copied the new innovative teaching styles from the technology teacher
- ...technology teachers are taking new teaching styles to other subjects.
- Other teachers are visiting the technology class and becoming interested in the approach.

Concerning team work

One of the many beneficial features of this pedagogy is apparent in the team work spirit of the learners, which not only promotes sharing ideas but also supports learners' reasoning skills and improves their communication skills. The data from the interviews illustrate both the enthusiasm of students for working in groups and the beneficial impact of this approach.

- Lots of experiences, communication is good, helping each other
- We can help people in rural places. Its practical and groupworking is good, sharing ideas - girls and boys together.
- Involves teamwork - it helps communication and you get to know yourself and other people better
- In other lessons you are on your own - we prefer to work together and share ideas
- We work mostly in groups - which is very different from other subjects where we work on our own

Concerning resources

In attempting to solicit from teachers what they believe were the important issues in establishing technology in their school; or the things that they would do different another time (given the chance), a number of interesting ideas emerged. These can be classified into three groups; the importance of the *time* factor (including group/class size), the requirement of fixed *space*, and the matter of *equipment*.

[time]

Most teachers feel overstretched by having to teach technology outside the normal timetable and by having big groups in a single period. It is generally recognised that double periods should be allotted to the subjected because of its practical nature.

- Double periods for teaching
- More time - double periods or last period in a day
- Congested timetables are a problem - overload - having aroused the interest students become demanding and its frustrating when I cannot have time to help them.

The time issue is also supported by the principals from projects schools who present it (correctly) as an issue about timetabling and about the very few teachers available to teach technology.

- Timetabling: you need more time for technology
- Timetabling: one teacher teaches 12 classes and has to make the means of handling those classes.

[classroom space]

In sharing their experiences of the technology programmes, teachers frequently refer to the need for dedicated space for technology. This takes the form not just of teaching space - but also of secure storage space.

- Need better storage system for resources (strong room)
- Specialist room, organised around topics, labelled etc.
- We also need secure room
- Classroom space - to accommodate resources
- The subject has become so popular amongst students .... to the extend that other students not involved want to join in. (The implication is that with enough classrooms or purpose built facilities provided, the enrolment could be greatly increased)

Knowing how expensive and attractive technology resources are, security of facilities is seen as very important. This issue is raised frequently by principals and teachers in project schools.

- Money/resources: must be secure enough
- ....And need our technology room (must be) made burglar proof
- Facilities; a problem with burglary - we lose equipment
- Security - School has to employ night watchman to guard technology equipment

[equipment / books]

Naturally the question of equipment arose throughout the interviews - including the almost inevitable observation that the whole programme was dependent upon regular visits from Mr Tholo, who brought his bucky full of wonderful resources for the teachers and learners.

- I have the skills but I would need the equipment
- we must provide adequate resources

Interestingly however, these observations were moderated by an emergent streak of independence from teachers and in particular these concerned the use of the project books. These books received some criticism for their perceived rigidity in presenting the problem-solving process, and in terms of some of the projects that are designed for learners to tackle.

- I would add more challenging projects and vary the approach. What students are doing is more of a linear design process, working towards prepared solutions. I would like them to generate their own ideas and design solutions to the needs or tasks provided.
- I want to add some new things to the task and teach in a more flexible manner
- Design books ...students deal with preconceived solutions, whereas we need more challenging design and tasks.

This is an interesting issue and one that would be familiar to teachers in the UK. The paradox of teaching problem-solving through technology is that it frequently involves presenting a linear and rigid model of the process that pupils learn to 'walk-through' until it becomes almost habitual. We (Kelly et al 1987 and Kimbell et al 1991) have frequently criticised this position in the UK, and it would seem that the same criticism can be levelled at the PROTEC project books.

Concerning the ***benefits*** *of the programme*

We were interested here in what might be seen as a chain of benefit. We asked the interviewees what they saw as the benefits of the programme to learners; to teachers; to the school; and to the Province.

[benefits to learners]

The benefits to learners are typically stated in two forms; the benefits to them *in school* and the benefits to them *when they leave school.* The following examples illustrate the range of views about the benefits to learners in terms of their school work.

- students' performance - academically - has improved drastically in other subjects
- I used to hate being challenged - now I like challenges (eg the project in the science fairs)
- We are the lucky ones - other are not doing technology
- their reasoning skills have been enriched
- technology encourages their independent thinking
- it gives us a different way of thinking - to see things differently - so solve problems on our own.

But by far the widest range of comments concern the advantages to students who took part in the programme once they leave school. The benefit here is seen in two forms; first the expanded opportunity to gain useful employment, and second, the opportunity to create employment for themselves through expanded entrepreneurial skills.

- learners get important skills - to make themselves marketable and go into the community
- developing entrepreneurship - they can see they they can do things
- it improves our college opportunities; getting first choice with technicons
- good for the future - for getting a job - creating your own job - choosing a career
- they help us become more businesslike - and get rich!
- Its helpful to all, whether going to university, or into work, or whatever

And again (as with the teachers) we heard several comments on the fact that the experience had changed learners' positions - or at least their view of their positions - in their communities

- it has changed their lives - they are out their in the country - in the villages - and they can make things better. They can say 'What is the problem here' . Its a real life benefit.
- we are gaining knowledge that helps to improve our lifestyle

[benefits to teachers]

The benefit of the programme to teachers is universally agreed by the learners, the principals and by the teachers themselves. Stated simply it is that the programme has enriched and empowered them - as individuals and as professionals.

- the opportunity to grow
- the teacher is very much enriched
- it has boosted their morale
- I am more skilful now - I don't watch - I do.
- Professionally I am a changed person. For 13 years I have never had such fun. I feel completely part of the African renaissance
- I have expanded - in my home - my village - we identify the problems we didn't see before. Now I can and we make miracles. I have a name as a problem-solver
- I am professionally improved - I am more popular - my students won a national expo award for science / technology

These benefits to the teacher centre in their classroom practice, but over spill into their personal view of themselves (and their confidence in themselves) as professionals throughout the school. The teachers (and the learners) testify to a completely changed and improved relationship with learners. And the transformation even extends to teachers' personal lives in their homes and villages.

Not one teacher expressed any regret or doubts about having been part of the programme. They all saw it as an enriching and empowering experience.

[benefits to the school]

It was most interesting talking to students and asking them to think about the benefit of the programme to the school - rather than just for themselves. Several quite profound observations resulted.

- its good for slow learners - In technology slow learners can achieve more
- we take more care of the school. The taps and the lights - we see how they work and are interested in them - we respect them more
- it takes the image of the school higher
- having equipment and computers. We get better than other schools in competitions - its good for the school

Interestingly,when teachers and principals are asked the same question a very similar set of observations are made. And to these can be added the value expressed earlier about the enhanced skills of teachers. The benefits here might be clustered into two groups; educational benefit and financial (resource) or influence benefit.

- it has broadened the view of all of our teachers
- there are no discipline problems in technology It makes the school popular for entry in year 8
- it has given all teachers a new vision of the learners
- improved relationships with parents, following an open day and showing pupil's work

- new resources have been donated
- the parents give the school higher esteem
- companies have shown interest in supporting our activities
- it has helped the general working of the school - and helped to raise funds

Once again, it is important to note that we have not received one single negative comment about the programme in schools, either from learners, teachers or principals. There have been comments about some of the difficulties of getting it established (eg concerning the need to create a technology teaching space), but once established in the school the programme is universally favoured.

[benefits to the Province]

It became apparent that teachers, principals and learners could see benefits that go beyond the school, and the following observations indicate some of the common responses.

- the Province benefits from the enthusiasm of the parents
- it has brought additional resources into our schools
- there are now many more trained teachers - we are capacity building - nation building
- the private sector has strengthened its links into education
- the people are becoming more technologically aware
- our learners become independent thinkers which leads to self-reliance in the community

Concerning the priority issues for a school embarking on a technology programme

Given the pilot status of the project, and the fact that if it was successful the Province would be faced with the challenge of spreading the project wider, it seemed to be important that we asked about the things that were seen to be important in getting the project successfully established in schools. To this question we received a host of different answers that we have sought to categorise into two groups - the human issues and the resource issues

- choosing the right teacher - the attitude of the teacher - they must be open to new ways of thinking and prepared to work very hard
- training for teachers - without the training we would not have got anywhere
- the attitude of the principal is critical. It is most important that s/he is positive
- a secure room (for storing resources)
- the equipment and resources
- time: single periods are no good, we need double periods

It is very dangerous to prioritise this list based on just the data from our interviews. However, it is clear that there is a sense of natural priority within it. And at (or very near) the top of the list must come the training of the teachers, for without trained teachers the other problems do not even arise. The teachers were eloquent in their support of the training they had received and many of them felt a sense of obligation to support the dissemination of the programme by become training centres for new teachers. This is the matter that we address in the following section.

Concerning the dissemination of teacher expertise

All the teachers to whom we spoke recognised the scale of the task of training teachers in order to disseminate the technology programme more widely. They also recognised that some of that training would need to remain centralised in specialist centres of training. However, many teachers also felt that a part of that training might involve a form of work-experience in schools - with new teachers working alongside experienced teachers so as to see and practice the approaches taught during the more formal training sessions. The following comments were commonly voiced:

- satellite schools could be grouped around experienced schools
- pilot schools could run workshops - a cascade model
- we could video some of our lessons and send them to other schools
- I could help to train other teachers - it is important for us to help motivate others

Interconnectedness

The reader will have noticed that there is a degree of overlap between the issues we have presented in this section of data from the interviews. When teachers are discussing their teaching methods (pedagogy) they inevitably link their comments to ideas that are professionally interconnected - such as teamwork, space, time, and resources, and equally there is overlap with issues of training and dissemination. This is the nature of qualitative data, and we trust that the material we have presented here is coherent and portrays something of the flavour of the technology programme. In so doing we hope that we have extended and enriched the findings of a more quantitative nature.

12. Recommendations

We fully appreciate the dangers in making recommendations on the basis of the limited experience we have had of the situation in the NWProvince. In line with our discussions with all parties in February, and in Professor Kimbell's subsequent discussions in April, we make the following recommendations.

Recommendation 1 Pursue the project: It is highly effective.

The findings demonstrate that, in a relatively short time, the project has created a quite astonishing impact in schools. This impact has been of several kinds;

on teachers: transforming (in particular) their pedagogic skills
on students: significantly enhancing their technological capability and their attitudes
on principals: who want more of it.

Accordingly, in the context of the grading system we were asked to apply at the outset (see sect 1), we judge the project to have been ' highly successful' . We do this not because it has 'completely achieved' all its objectives; indeed we draw attention in Recommendation 2 to a specific shortfall. Nonetheless, the vast majority of objectives have been met - and with such conviction that we are impressed by the successes that have been achieved.

It is not difficult therefore to argue for continuing support for the further development of a technology curriculum project in schools. The problem lies in deciding on the nature of this further development: what are the priority targets and year groups? Decisions on this matter cannot be divorced from the wider context within which the project is operating, specifically in terms of the OBE initiative and the Technology 2005 initiative, and equally it cannot be divorced from the ubiquitous problem of lack of funds. Any new activity must be targeted to be effective.

Many options for development were debated in a series of discussions with teachers, principals, administrators and trainers, and from our outside perspective two principal options come to the surface.

option 1: Expand the existing project to more schools. It has been so conspicuously successful that it could only do good if more schools were able to enhance their 10-12 curriculum with a version of this technology project. The crisis of employment is so pressing, that anything that might help to alleviate it should be supported. Strategically, some variant on the 'buddy' system might be developed, whereby experienced schools take one (or even more) adjacent schools under their wing to help disseminate practice.

option 2: Refocus the project to years 7-12. This possibility would need to be taken in two parts. The existing 10-12 schools in the project can be maintained but *not* expanded. New resources would be needed to develop a version of the curriculum for years 7-9 in a new (different) set of (20 ?) project schools.

It is our view that option 2 is preferable. However this recommendation is contingent upon our 2nd recommendation.

Recommendation 2 Develop a comprehensive technology curriculum

We recognise that one of the objectives of the current project was to develop and field-test a technology curriculum, and that this has only partially been achieved. Teachers have been trained to work with individual modules of work, and this approach has therefore been reflected in schools. We recognise that it is well appreciated that a curriculum is more than an assemblage of modules, and we fully endorse the need to develop a comprehensive technology curriculum. Since OBE developments require increasingly explicit subject-based treatment from year 7, we recommend that this should be the focus of future work enabling the Province to built a 7-12 technology curriculum that builds from all the strengths of the existing pilot project.

It is essential that this curriculum should maintain the group-work ethos and the gender equality of the existing programme, and it should maintain the active / task-based structure of the existing programme. It should also incorporate assessment within its framework (see recommendation 4). The benefits of this are not simply to be found within technology - but will overflow into wider benefits across the whole OBE spectrum.

2(i) Enhance the place of graphic communication

The current project booklets appear to promote a view of technology that is closer to technical problem-solving than it is to designing. One of the resulting manifestations of this in the test data, is the relative weakness of students in generating and developing ideas in response to the task. There was no significant difference between project and non-project schools. And much of this problem - we believe - is attributable to the fact that students are not sufficiently fluent in the basic language of design & technology - ie graphics communication. On too many booklets, students appeared trapped within an inability to express themselves technologically. They were trying to use words to describe ideas that defy linguistic description.

Our administrators noted this in their observation of the test in action and in their assessment of students' work.

- PROTEC teachers need more training in graphic communication
- student performance depends on graphics, which is missing from PROTEC materials

We strongly urge that this feature be incorporated more fully in the developing curriculum, and it should be noted that at least two major benefits will flow from this. First - since graphics is the language of design - students can be expected to be more fluent in their generation and development of ideas. Second - since graphics is a universal language - it will allow technological ideas to be generated and developed in a way that transcends the limitations of the Tswana, Afrikaans or English languages. By developing learners' ability to communicate graphically, we can provide **all** S African learners with a common technological language.

2(ii) Incorporate performance assessment in the project

The assessor training component of this evaluation has allowed us to model what might be involved in a staged process of incorporating assessment into the curriculum. It is a matter of some astonishment to us that no assessment is taking place in relation to the clearly excellent work that was being undertaken within the project schools. We are convinced that performance assessment along the lines incorporated within this evaluation should and could be introduced. The administrators - who fully understand the curriculum and the realities in project schools - comment that:

- the model needs to be introduced into the PROTEC materials and used for assessing portfolios
- some of the technology teachers could handle the assessment - but not all. Each cluster would need an anchor

We would be pleased to share our thoughts on the matter of how best to develop this element, but, as a statement of principle, the benefits of developing performance assessment within the curriculum are (at least) twofold. First it concentrates the minds of all concerned on what are the essential qualities to be developed through the programme. Second, having clarified these matters, they can be used for direct feedback to students on the strengths and weaknesses of their work, helping *them* to see what is important and valued and what is not. Unless students are clear about the strengths and weaknesses of their work it is difficult for them to progress.

2(iii) Implications for rural schools

We have been asked to comment on the implications of this proposed new curriculum in terms of rural schools. The concern appears to be that such schools are remote from the concerns of technology and that they might find the curriculum inappropriate.

There is great strength in the argument that curriculum materials should be located in and reflect the environment in which learners find themselves. To that extent there has been some criticism of the PROTEC booklets in that they reflect a higher level of technology - and a more urban interpretation of technology - than is appropriate in some of the rural project schools. Teachers have accordingly rejected some of the projects and developed others that fit better to the school and its surroundings.

However, we do not see this issue as providing any rationale for denying access to technology for rural schools. Indeed, we would argue that quite the reverse is true. The project has sought to illustrate that technology is about solving problems in the world, and such problems exist wherever people live - be that in the remotest corner of the Province. To this extent we believe that it would be helpful to separate the problem-solving nature of technology from the hardware (electronics / pneumatics / computers etc) that is sometimes associated with solutions to technological problems. People in all communities need to be able to tackle technological problems, making use of the resources that are available to them.

2(iv) Integration of maths/science/technology

Since we were not aware that this was a major issue of concern to DFID, the NWProvince, or PROTEC, there is little in our assessment framework that allowed us to collect data on the matter and hence we can make only very limited comment on it through those data.

The interviews with learners allow us to say that in technology learners are able to make use of their maths and science. More than that - they are frequently able to make sense of it. The impression we have is of a traditional maths and science curriculum being liberated through practical engagement with technology. The following comments from learners illustrate this point.

- Technology lessons have very exciting activities and it makes us understand the practical application of mathematics and science.
- As opposed to science which only stops at the experiment level, technology goes beyond, putting theory into practice.
- In science there is instructing/ teaching of Newton's Law. In technology you apply the law and the mathematical principles.

However, the issue of integrating Maths/Science/Technology goes deeper than this and presents us with some difficult options that exist (broadly) at three levels of interconnectedness. At the highest level do we want fully to **integrate** the curricula; or (at a lower level) do we want systematically to **link** the curricula; or (at the lowest level) do we want merely to point up convenient **connections** between the curricula ? This matter has been studied exhaustively in the USA and we have undertaken work on the matter both there and in the UK. In the USA, the utopian ideal of full integration has been pursued for some years, but without conspicuous success. In our experience it is neither effective nor necessary nor even desirable to pursue this level of integration. The level of mathematics that is needed even for complex technological tasks is not advanced - and technologists tend to see both science and maths as service disciplines to be picked at as necessary according to the needs of the task. By contrast, science and maths curricula (as well as science and maths teachers) tend to prioritise the discipline for its own sake

- understanding the language and elegance of maths, or pursuing scientific enquiry. Despite years of attempts to bring these together (in the USA and elsewhere) we have not seen a fully integrated curriculum - either on paper or in the classroom.

On the other hand, no intelligent teacher could deny the value of the lowest level of integration - where a topic being pursued in technology can be enriched by reference to connected ideas in maths and science.

It follows from this that (in our view) the most fertile territory to be explored exists at the middle level of creating systematic links (for example within projects) but not with the aim of seeking to create a fully integrated curriculum. So, for example, in the candle making project, it is important and helpful to calculate how much wax is needed for a cylindrical or a square or a triangular candle of a certain size. And to estimate from this how much would be needed to make 100 candles. And then to calculate what quantity of wax to buy (in kgs?) and hence at what price to sell them. These requirements can be systematically linked into the project so that the mathematical ideas (calculating, estimating, modelling) become helpful and empowering. This is important maths for a technologist - but (in the UK at least) maths teachers will not be very interested in it. It is too mundane to be the stuff of interesting mathematics. We recommend that the project materials pursue this middle level of connectedness.

For a fuller discussion of these issues see Technological Maths (Kimbell 1997)

Recommendation 3 A new curriculum development project

As we pointed out above, OBE developments require increasingly explicit subject-based treatment from year 7 and we recommend that this should be the focus of future work enabling the Province to built a 7-12 technology curriculum that builds from all the strengths of the existing pilot project.

In pursuit of this, we recommend that the second phase of this project should centre on a new curriculum project that prioritises technology in years 7 - 9 and leads to the development of a comprehensive 7-12 technology curriculum. This new 7-9 work is a major undertaking that will require external funds to support it.

The essential principles of the existing project should be at the heart of the curriculum, and new yr 7-9 schools should be brought in to pilot materials that will enable the project to develop clear lines of progression across the 7-12 range. We suggest that the materials development process is conducted bearing in mind

- the strengths of the existing materials (eg groupwork)
- recommendations 2(i) [graphics] and 2(ii) [assessment}
- all policy papers (provincial and national) that relate to technology [5]

There is widespread support for this notion - from teachers, principals, AND from students. Repeatedly in

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5 Whilst this curriculum project would be firmly based in the NWProvince, there is every reason for curriculum development in S Africa to reflect (as far as is appropriate) a common national agenda.

our interviews it was pointed out to us that technology was appropriate for all school students, and that it was important to start much earlier than the current project. The project will need careful coordination from someone who fully understands the strengths and weaknesses of the existing project.
The design of the new project will no doubt be agreed between the collaborating parties, but we recommend that three specific features be incorporated:

(a) That the sample of schools in the new project should be composed partly from existing project schools and partly from new project schools. The benefit of having existing project schools involved is that it will be possible to examine modes of dissemination *within* a school - from existing teachers dealing with yr 10-12 to new teachers dealing with yrs 7-9. It will also be possible to examine the transformation of projects materials and methodologies within a single school environment. If schools do not span years 7-12 (ie if there is a change of school after year 9) then this recommendation is modified somewhat so that the existing existing expertise in 10-12 schools should be fed down into the local 'feeder' schools for that high school. We believe that it will be important for the Province to study the different models of dissemination that will inevitably arise when (on one hand) some of the new project schools are closely related to existing project schools and when (on the the other hand) some of the new project schools are starting completely from scratch. We would expect different advantages and disadvantages to exist in these two sub-samples.

(b) That the training model for new teachers should involve *initial* training of a form that is based on that received by the existing project teachers. It was clearly effective and the basic model should be retained. However we recommend that this be *supplemented by periods of observation and joint teaching* alongside existing project teachers. These two modes of training should clearly be monitored and evaluated

(c) The project booklets / materials should project a somewhat more flexible model of problem-solving than is the case in the existing PROTEC project books. This new model must recognise that idea generation, development and exploitation is not a simple linear production-line process, but is rather the result of a combination of creative and reflective operations. Moreover, in applying this more flexible menu of operations, we recommend that the project books encourage learners to find technological problems *of their own* ; in their own communities. These two things (a more flexible process and locally-based tasks) will simultaneously encourage schools to become creative themselves with the materials; will avoid the difficulty of rural schools appearing disenfranchised from urban models of technology; and will eliminate the only two criticisms we have received of existing project materials.

Recommendation 4 Accreditation and certification

On several occasions, teachers principals and learners have all commented on the desirability of official recognition for the studies that they have undertaken and the proficiency that they have achieved. This seems to us to be both proper and possible. Accordingly, we recommend that both the training of teachers and the education of learners be recognised in a model of accreditation and certification.

With regard to ***teachers***, we recommend that the training undertaken for the project should be designed so that it can be accredited for those teachers that wish to pursue their studies. We recognise that this might be at a range of levels. There will be some teachers without an undergraduate degree and who may wish to count their technology studies towards a diploma or undergraduate qualification. Equally there will be some with degrees who will wish to count their work towards a post-graduate diploma or an MA. Naturally the process of accreditation involves a validating body and this matter should be considered carefully. Since there are parallel (though not precisely alike) technology projects running in other provinces in S Africa, the question of validation and certification may be a wider matter than just the NWProvince. But at the least the project should give thought to how its teachers might 'cash in' their enhanced experience and skills if they choose to pursue their studies. It is very much in the interests of the Province for its teachers to be motivated towards elevating their skills and their qualifications. If we at Goldsmiths College can support this process in any way, we would be pleased to collaborate on the matter.

With regard to ***learners***, it would be both appropriate and equitable if their technology work in the final years of schooling was also to be represented within the matriculation process. Whatever the current processes of matriculation, it is very much in the interests of the Province to demonstrate to learners, teachers, parents and employers that technology is a serious part of the curriculum - and one of the most important ways of doing this is for learners to be able to achieve technology qualifications. The matriculation process is clearly the primary vehicle for doing this.

Taken together, these developments would enable teachers and learners to be appropriately rewarded for their efforts, and it would enable the curriculum to achieve the level of recognition (eg from parents and employers) that it needs in order to thrive.

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