Different views, different outcomes: how the views of science and design and technology gained develop and support effective classroom practice

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Abstract
This paper outlines research conducted at Goldsmiths, University of London, into primary student teachers' understanding of the nature of science and design and technology, the relationship between the two subjects and their contributions to the curriculum. Quantitative data collected through questionnaires indicated a conceptual framework describing the interplay between understanding and practice in the classroom whereas qualitative data through interview and reflections developed that framework into a broader model which described the interplay between capability, understanding and practice and the impact this understanding had upon the approach the student teachers adopted in planning their classroom based activities. Evidence from the data gained from our research demonstrates that, in the design of initial teacher education courses, account needs to be taken of the extent to which student teachers have prior experience of the subjects, and the understandings they hold of the relationship between science and technology in society. As a result of this project, we argue that primary teachers can be encouraged to develop their understanding of the nature of, and relationship between science and design and technology thus enabling them to plan classroom activities which effectively link the two curriculum areas whilst maintaining the distinctive nature of each.

Introduction

The three year Bachelor of Arts (Education)BA(Ed) course at Goldsmiths', University of London, involves students in study across a range of primary subject areas in the curriculum, including science and design and technology. Since the start of this degree in September 1996 a major concern of ours has been to more effectively co-ordinate the science and design and technology input received by the students, in order to give them a more coherent picture of the relationship between these subjects in the curriculum. To this end we have established a research project to examine the perceptions of students when they arrive on the course, and to enable them to reflect on their growth in understanding through college input and school experience.

The research project

This research project, a pilot study in the first instance, has involved working with a group of 20 BA(Ed.) Year 1 students to explore the ways in which their prior experience and views on the relationship between science and design and technology influence their classroom planning. Our hypothesis has been that their views *will* indeed significantly influence their planning, and that some views will lead to more effective outcomes than others. This project has implications for the design and delivery of our own, and other, primary teacher education courses, but also for a wider international audience of primary teachers who are required to teach science and design and technology courses under various national curricular including the National Curriculum for England and Wales 1995. We hope to illuminate the relationship between theory and practice in these areas with a particular focus on how teachers make links between these two curriculum areas in the classroom.

Theoretical background

Research on the views held by students and primary teachers regarding the relationship between science and technology has been carried out by, amongst others, Aikenhead and Ryan (1992)[1] and Jarvis and Rennie (1996)[2]. Within the field of design and technology research Thomson and Householder have studied the confusion between perceptions of technology and attitudes towards technology in their efforts to establish a starting point for developing technological capability[3]. Thomson and Householder drew broad categories from their study across a range of target groups which included Bachelor of Education Year 1 students. The results from this group of student teachers indicated technology as new/modern/latest developments, advancement, science related, how machines work, and problem solving.

Aikenhead and Ryan developed an instrument called VOSTS (Views on Science and Technology Society) through extensive fieldwork across Canada. Several items from the VOSTS framework refer to definitions of the nature of science and technology, and to the relationship between them. Extracts from the VOSTS instrument have been used by other researchers, including Claydon (1995)[4], Johnston and Hayed (1995)[5] and all of these studies have revealed confusion about the relationship between science and technology in the minds of many students. None of the projects have researched the effect of this confusion upon curriculum planning, which is where our project is unique. We have, however, made use of several VOSTS items in the questionnaire used to elicit data about the students' views in this area (see appendix 1) while recognising that the view of technology used in these studies may be much narrower that that described by the curriculum area identified as design and technology.

Gardner (1994)[6] has characterised the range of possible views about the relationship between science and technology in society in terms of five categories. They are:

1 that science and technology are effectively *indistinguishable* from each other, or at least different facets of the same activity;
2 that science and technology are so different as to have little or nothing in common with one another, a *demarcationalist* view;
3 that technologists apply the knowledge which scientists produce, a *T.A.S. (Technology as Applied Science)* view;
4 that science relies upon technology for its source of theoretical models, a *Materialist* view;
5 that science and technology feed each other in a close, mutually beneficial way, whilst retaining their individual identities (an *Interactionist* view).

Using aspects of the design and technology course and the science school based assignment to illustrate the relationship between science and design and technology we have used these five categories to inform our analysis of views held by students in our sample. We first chose to represent them on a pair of orthogonal axes (figure 1), since it would be unlikely that any individual's view on so complex a subject would fit neatly within one category.

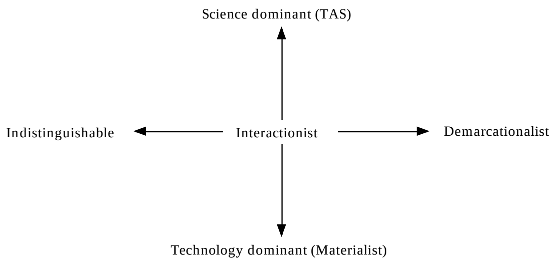


Figure 1 - representation of Gardner's five-view analysis as a pair of orthogonal axes

This would enable a student's perception of the relationship between science and technology to be plotted as a co-ordinate point, depending on the relative importance, or dominance, they attached to each subject (vertical axis) and the degree of distinction they drew between them (horizontal axis).

Research methodology and time scale

In September 1996, on the second day of their university course a questionnaire was given to the target sample of twenty Year 1 BA(Ed) students, eliciting their views on science and design and technology. They were also asked to provide short written accounts of previous experience in learning science and design and technology at school and elsewhere. During the introductory unit of five sessions in primary design and technology the students undertook the design and manufacture of a mechanical toy, inspired by a children's story and incorporating a working mechanism.

Approaches to teaching science through design and technology	Examples (simple electrical circuits)
1. Start with a investigating, disassembling and evaluating activity, using it to teach a scientific concept	Disassemble a torch to find out about simple circuits
2. Start with a science activity to develop a specific concept, then apply it in a design and technology activity	Teach a science lesson on circuits, then design a torch
3. Teach the areas separately and then combine them	Add a circuit to an existing design and make assignment

Figure 2 - Approaches to teaching science through a design and technology context, introduced to students

They were also introduced to a classroom planning format for design and technology.

In November the students started their first year science course. When the topic of electricity was considered the students were introduced to a range of approaches for teaching the scientific concepts through a technological context (see figure 2). They were also asked to bring to the science lesson the working models they had made in design and technology, which were then fitted with simple electrical lighting circuits. This made explicit the links between the two courses, and was exemplified for the students using models of curriculum planning drawn for both subject areas. The students were then set a school-based assignment to plan and teach a scientific concept through design and technology activities in the classroom. The choice of subject content, teaching style and planning format was left to each individual's discretion.

In January 1997 the students undertook the assignment in school submitting it for assessment in February along with a written account of the their classroom projects; the choice of pedagogical approach justified, and the individual scientific and design and technology aspects identified.

A small sub-sample (six) students were also interviewed by both tutors, in order to reflect upon the school-based assignment they had completed, their growth of understanding through the courses attended, and to provide further autobiographical material to shed light upon their views of science and design and technology. These interviews had the added purpose of validating the interpretation of previous data, through reporting back to students for their comments.

Data analysis - questionnaires

The use of quantitative questionnaire data to plot students' views onto the axes in figure 1 proved problematic, so it was decided to group the questions under specific headings (figure 3), to give an indication of the ways in which science and design and technology were felt by each student to be different.

Since each question was coded 1 to 5 for both science and design and technology, using a standard Likert attitude scale, this enabled us to produce a set of bar charts for each student showing how they rated both science and design and technology against these criteria. An example for one (hypothetical) student is shown in figure 4.

This quantitative data was used, along with written statements, to analyse their views using Gardner's categories (Figure 1). For example, a student viewing science as considerably more rational, objective and theoretical, with design and technology seen as more practical and subject to cultural influences could be classified as science-dominant, with design and technology as its application in the world. This would need to be checked against the student's written statements about their views of science and

1 80% (16 out of 20) of the students took science as their starting point for planning the classroom activity. There are a number

Rational/Objective
Describes truths in nature
Value-free and neutral
Trying to describe reality
Following a set working method
Leaving no room for guesswork

Creative
Observe to give us new ideas
Construct models to refine our ideas
Process skills are essentially creative

Human/Cultural
Influenced by politics
Often discovered 'by accident'
Embodies society's values
Many solutions are possible
Arising from human needs
Outcomes might depend on who funds us
Outcomes are compromise solutions
Outcomes are different for different people

Theoretical
Make observations to test out theories
Construct models which are beneficial

Important
Vitally important for our world
Changing our world

Practical/Everyday
Based on common sense
Useful for solving practical problems
useful in everyday life
Observe things to find out how they went

Figure 3 - Clusters of data from questionnaire under 6 headings.

design and technology, derived from their prior experience of both subjects.

Data Analysis - School Assignments

The focus of our research project was the link between the data on students' views and their subsequent classroom planning as demonstrated in their school assignments. We have analysed their written accounts and classroom planning, relating these to the analyses of questionnaire data, described above.

Close inspection of the data in figure 5, supplemented by additional comments within student's written assignments, begins to reveal some significant patterns:

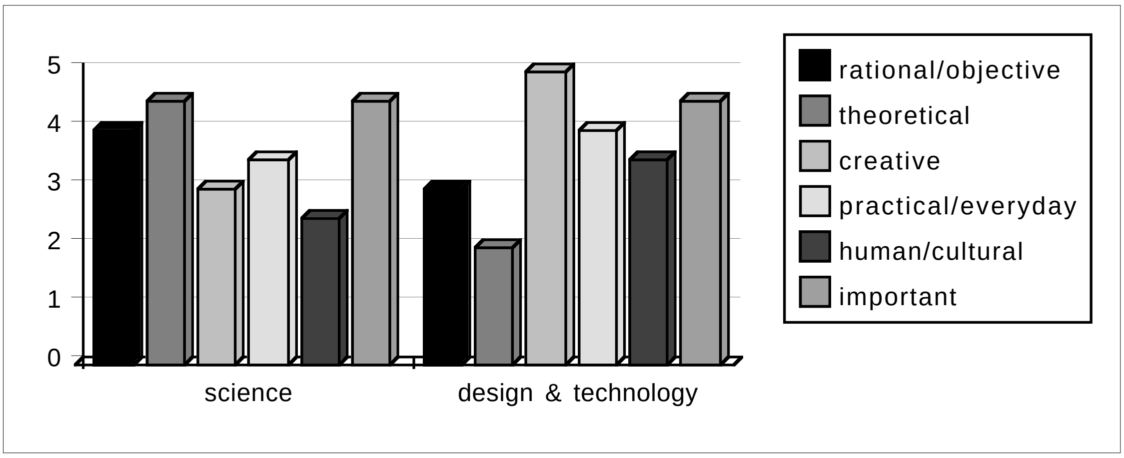


Figure 4 - representation of questionnaire data (hypothetical student)

Respondent	Diagnosis of views (Gardner) from questionnaire and pen portrait	Starting point chosen for school-based assignment	Degree of integration of design and technology within project
Student 1	Interactionist > indistinguishable	Science - forces, wind power	High - planning alongside
Student 2	Science dominant, design and technology as application of science	Science - light, shadows, torches	High, but science knowledge 'not transferred'
Student 3	Interactionist, slightly materialist	Science - gravity, fair testing	High - designing 'took over'
Student 4	TAS, but > indistinguishable	Science, protecting the brain	High - problem solving
Student 5	interactionist > indistinguishable	Science - testing carrier bags	Moderate
Student 6	Science dominant > interactionist	D&T- playgrounds	Moderate - focus on circuits
Student 7	TAS > indistinguishable	Science - thermal insulators	High - designing thermos
Student 8	TAS > indistinguishable	Science - Earth, Sun Moon	Moderate - mobiles
Student 9	Insufficient data	Science - bones and skeletons	Low - few design decisions
Student 10	Insufficient data	Science - light and shadows	Moderate - pinhole cameras
Student 11	Interactionist > indistinguishable	Science - materials	High - waterproof hats
Student 12	Materialist > indistinguishable	No data at present	
Student 13	Materialist > indistinguishable	Science - forces	Moderate - designing buggies
Student 14	Insufficient data	Science - water cycle	Low - no D&T aspect
Student 15	Indistinguishable > TAS	Science - materials	High - linked to parachutes
Student 16	Indistinguishable > interactionist	D&T - bridges	High - but science knowledge 'not transferred'
Student 17	Indistinguishable > interactionist	Withdrawn from course	
Student 18	Demarcationalist > TAS	Science - light	Moderate - making periscope
Student 19	interactionist > science dominant	Science - forces, magnetism	Low - compasses
Student 20	Science dominant, TAS	Science - sound, materials	Low - afterthought

Figure 5 - Analysis of students' approach to school assignment related to a diagnosis of their views

of factors which could account for this, one being that the assignment was set by a science tutor during a science course so students had the expectation that this format was expected of them, despite assurances to the contrary. Of these 16 students taking science as a starting point, 50% (8) were analysed to view science as to some degree dominant over, or more important than design and technology. However, 12.5% (2) of the 16 viewed design and technology as dominant, the remaining 6 being neutral. Only one student viewing science as dominant chose to start the assignment from a design and technology context, but subsequent statements reveal that this was not actually his first choice. From this evidence it would appear that the students viewing science as more important (45% of the sample) are significantly more likely to start with science than with design and technology in a cross-curricular classroom project (8 out of 9, or 89% did so).

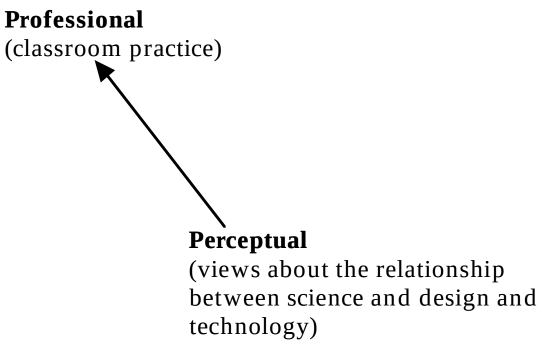
2 From their written assignments it appears that students introduced the design and technology element at different stages during the project, and integrated it to differing degrees. Those who saw science and design and technology as *interactive* tended to introduce a high or moderate level of integration relatively early in the project (6 out of 7, 86%) whereas those with a view of *technology as the application of science* tended to leave designing and making until the end of the project. All the students reported that once children had begun the design and technology activity, this appeared to 'take over' and eclipse the science element of the project. Many students reported that, although children did not conscientiously transfer scientific knowledge into their design and technology , they were acquiring science concepts through the 'technological' context, often in a more meaningful way than in the pure 'science' component of the projects.

Data Analysis - Interviews

One of the primary purposes of the interviews was to validate the diagnosis we had made of the students' views on the basis of questionnaire data. All six interviewees agreed with the accuracy of the interpretations, with some minor adjustments. The interviewees were also asked whether they felt that their views had been significant in their approach to planning the school-based assignment. Most denied that there had been a conscious link, though admitted that they had probably been influenced to some degree by their underlying perceptions. For many of the students, the school-based assignment, together with their college courses, had actually changed their views about science and design and technology expressed earlier in the questionnaire. Generally this had been in an *interactionist* direction, recognising the distinctive nature of the two areas and the equal contribution they have to make to one another.

The initial purpose of our project had been to examine the effect of student's perceptions upon their professional practice (figure 6).
Figure 6 - The original focus of the research

However, the interview data has revealed that there is a two-way interaction between



perceptual and professional practice: students' perceptions about science and design and technology are affected by their experience of teaching children. Their experience, both background and college-based also affects their perceptions. The weight of this data seemed to reveal the interviewees' growth in understanding through experience and led us to propose a model for student teacher learning in primary science and design and technology (see figure 7) which is already informing our future course planning.

As their perceptions sharpen, students are able to reflect back upon their own experience, make more sense of the college course and what is happening in school, reinforcing the links between the perceptual and the experiential/professional.

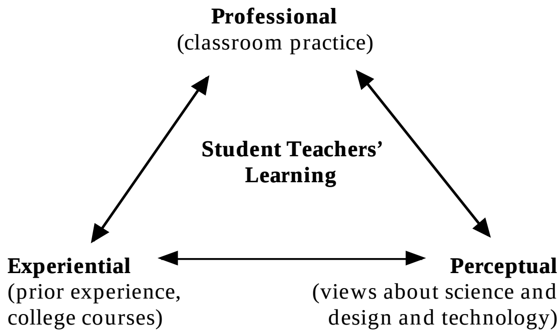


Figure 7 - a model of student teacher's learning in primary science and design and technology

The final link in the model is between students' experience of the college course, and their work in schools. This is the aspect which most courses in initial teacher education would expect to cover in most detail. While our project did not set out to investigate this link, it became clear to us from our data that this link will remain whether or not students receive input from further courses during their degree programme. As to how active it is; this remains dependent on the experiences students gain during their work in schools and their ability to reflect on these and develop their skills and understanding further. The process diary, kept by the students throughout the design and technology course, supported the development of reflective practice as would the evaluation reports completed as part of the school experience file. Evidence from these diaries seems to further develop the model illustrated in figure 6.

Experiential : prior experience, college courses added to by classroom practice
Perceptual : views about science and design and technology which will be developed or not by classroom practice and recorded through the process diary
Professional : classroom practice through: school and college based projects to develop

specific skills and understanding and school experience placements.

Conclusions

Although the above findings are very tentative and provisional we believe that we have found some evidence that the students' background experience and perceptions about science and design and technology *do* influence the approach they adopt to classroom planning, if only at a subconscious level. However, more significant is the realisation that in order to develop as effective teachers of those two areas in the primary curriculum, students need to make links between their experience, perceptions and professional practice as outlined in figure 6. The continual development of the students' understanding over the entire degree programme through their school experience and how that enhances their classroom practices becomes a critical factor when measuring student performance against the competence criteria. There is clearly much to be done in developing a research instrument to investigate this model further.

At one level this research can inform the construction of courses in primary teacher education. If the instrument we are developing can be refined it can be used by course tutors in science and design and technology to find out their students' views and experience, which will enable the tutors to support them more effectively in college and classroom planning. If the students themselves reflect upon their own views and experience, our instrument should enable them to compensate for any bias in their own planning.

The project, however, has wider implications for serving primary teachers, many of whom may have vague or unbalanced views of science and design and technology which are affecting their classroom planning, hence children's learning. If our instrument can be used by in service trainer, or even as a self-analysis by the teachers themselves, it could lead to more effective primary science and design and technology education.

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