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Teaching control technology to girls

R A Sparkes

Department of Education The University of Stirling

Abstract

The reluctance of girls to undertake technical subjects is well known and various initiatives have been tried (e.g. WISE, GIST) to improve the proportion of females studying technology. One common theme of all the 'solutions' proposed so far has been the need to link technology with its social implications - to give it a human face. On this assumption, a project has been started in a local secondary school with 11/12 year old girls to see if their interest in technology can be aroused. One aspect of this has been the development of a common approach to electronic control and control programming that lays emphasis upon the design of useful applications. Although only in its initial stages, this approach does seem to be effective in arousing and sustaining interest. The paper describes the approach taken and discusses the initial results from its use.

Various writers, notably Kelly (1981), have suggested reasons why girls do not opt for physical science or technical subjects. It is important that they do, not just because Britain needs their expertise, but for the sake of women themselves - Byrne (1978) has suggested that the consequence of girls failing to undertake studies in these subjects is their subsequent condemnation to jobs that are temporary, low-status and poorly paid. There have therefore been many attempts to increase the participation rate of girls in these subjects, for example, TVEI (Technical and Vocational Education Initiative), WISE (Women Into Science and Engineering) and GIST (Girls into Science and Technology). There is evidence from current participation rates at Scottish Standard-grade and the 'English' GCSE level that the message is being heeded, but there is still a very long way to go. The following is an account of the beginning of a long-term action research project to achieve the same ends. I have sought to focus on one particular aspect - that of the Conference theme 'Learning through Designing' - since one notable success of the pilot phase was the creation of a design approach to control programming that appeared to be more educationally justifiable than some previous attempts (Booth 1987, Pallister 1988).

Our project aim is to provide learning experiences for girls throughout their secondary school careers that will encourage them subsequently to take up the study of engineering in higher education. Initially, we want to determine the most appropriate learning experiences for this to happen. However, we are aware that there are many other influences which affect girls' decisions and we wanted to reduce the influence of these as much as possible. Appropriate selection of the 'subjects' for this study was therefore considered a priority.

Most researchers point to the unhelpful influence of boys on girls' attitudes to technology. Kelly (1985) cites several examples of the way that boys decry the efforts of girls when they are working alongside each other and the way boys use their dominance to commandeer scarce resources. The first suggestion was therefore to select a school which would agree to the girls being taught separately from the boys. However, preliminary enquiries revealed that it would not be possible to find such a school for the early stages of Scottish secondary education (12 to 14 year-olds), because coeducation is a deliberate policy of all education authorities. It was also impossible for the later stages (14 to 16 year-olds) too, since in no school were there sufficient girls studying technology to warrant their being taught separately. This led to the conclusion that an all-girls school would have to be found.

Another view of the lower participation of girls in technology is the lack of suitable role-models, since most teachers of the subject are men (Kelly, 1985). There is considerable doubt about whether this actually matters, for example, girls opt for biology in large numbers, even in schools where all the biology teachers are men (another part of our research is to determine if it really is a factor). Nevertheless, at the time we began, it was felt important to choose a school where the dominant technology teacher was a woman. This proved to be no easy task! In Scotland, less than 1% of technology teachers are women and very few of these are in positions of authority, nevertheless, one was found, and, furthermore, she was most cooperative in assisting our aims.

She is, in fact, exceptionally competent in the field of technological education already, but lacked any experience in the areas of electronics, microcomputer control and the other 'hi-tech' areas. It was in these areas that the researcher was able to

provide an input, by supplying the equipment, resource materials and an initial input to one of the classes. For the remainder of the week, the teacher taught the same topics entirely unaided to parallel classes. However, what the researcher did not want to do was to 'take over' her classes, thus reinforcing the idea that women are incapable of doing technology. His role was to help her to undertake appropriate activities by herself.

The rest of this paper considers the type of activities undertaken and the reasons for choosing them.

A recurrent suggestion in writings on gender and education is that girls prefer to study science and technology in relation to their purpose, particularly human purpose (Gilligan, 1982; Smail and Kelly, 1984; Jones and Kirk, 1990). This is thought to be one of the reasons why girls opt more for biology than for physics or chemistry. It gave a clear pointer to the need for the curriculum materials to be carefully chosen.

For microelectronics, it was considered that the MFA (Microelectronics For All) resource was superb. It consists of three modules - 'Decisions', 'Counting' and 'Memory'. Although only the first of these was used in our investigation, the researcher had already used this on four previous occasions from 1985 to 1987 on WISE courses for 13-year-old girls throughout Scotland. The early version of the associated curriculum materials had made an attempt to be 'gender aware' by including a girl actively carrying out the suggested investigations. However, the materials were still predominantly concerned with control situations for their own sake, postulated by Kelly, etc. as being a 'masculine' emphasis. (For example, 'Devise a system to switch the lamp off when the push-button is pressed.') The new materials specifically focussed on the use of microelectronics to solve real problems with a 'caring' purpose - controlling the temperature on an incubator for premature babies, developing a calling system for the nurse in the hospital, warning of a reduction in temperature in the Elephant House at night, etc.

A total of eight weeks was spent on this part of the work, consisting of 10 minutes 'introduction', 60 minutes of practical activity and 10 minutes of follow-up discussion. Pupils were encouraged to construct 'electronic sentences' (Sparkes 1992) to describe the systems they were using, such as:

'IF warm AND NOT light THEN heater-on'

Homework questions were based on supplementary prepared by the researcher and asked pupils to

create solutions to similar problems, but without the benefit of the equipment. These proved too conceptually difficult (requiring them to handle the AND, OR and NOT operations in abstract terms), and we received letters of concern from parents who couldn't do the homework themselves and wanted to know what the 'right' answer was!

For the micro computer control section (four weeks), the chosen programming environment was Control Logo. This was predominantly because the pupils had already had considerable exposure to this language and were familiar with its editor and the construction of procedures. There were sufficient BBC microcomputers for the girls to work in pairs and each machine had a Lego interface connected to it. Lamps, motors and buzzers were used as output devices and Lego mechanical and opto-switches as inputs. The latter did not 'behave' as expected; being reflective, they responded to their own reflected light as well as external light and were no use in most situations. In future, we shall not use the Lego interface, but the MFA Computer module, since that can take a range of different sensors, as well as drive the same output devices as the Lego interface.

We were particularly anxious that pupils should design solutions to problems not just 'hack' their way by trial and error. In a control programming project, Pallister (1988) describes the difficulty that pupils had in handling even the most elementary programming constructs, and the examples he provides of the programs developed by his pupils have appalling structures!

'The majority of pupils were unable to design a program which required the use of anything other than simple command sequences' (p 77).

'In all of the practical tests very few groups did any preliminary design or planning before entering a program...' (p 87).

He concludes

'... a more appropriate language needs to be identified, or, if necessary, developed....' (p 110).

In a similar investigation, Booth (1987) also noted that lack of prior planning led to difficulties in problem-solving and many of the programming examples he quotes are poorly structured (although there is a greater use of procedures than in Pallister's case). For example, one example program is given as:

```
'TO LWLIGHT1
SWITCHON [1 4] PAUSE 9 SWITCHOFF 1
```

```
SWITCHON [1 2]
PAUSE 9 SWITCH OFF [1 2] SWITCHON 3 PAUSE 9
SWITCHOFF 3
SWITCHON 2 PAUSE 9 SWITCHOFF 2 SWITCHON
1 PAUSE 9
SWITCHON [4 5] PAUSE 9 SWITCHOFF [4 5]
SWITCHON 6 PAUSE 9
SWITCHOFF 6 SWITCHON 5 PAUSE 9 SWITCHOFF
5 SWITCHON 4
PAUSE 9 SWITCH OFF 4
END'
```

We hoped to avoid the same problem by careful initial instruction. A similar set of control situations was chosen for the 'problems' as had already been encountered with the MFA materials. From the beginning, pupils were discouraged from 'hacking' their way to a solution, they were expected to create programs in a top-down manner, using the 'electronic sentences' already developed, and creating meaningful labels, for example,

TURNON MOTOR, instead of TURNON 4.

This requirement created a particular problem with Logo. For example, the researchers wished the Traffic Lights program to be written as:

```
TO TRAFFIC
TURNON RED
WAIT 300
TURNON YELLOW
WAIT 100
TURNOFF RED
TURNOFF YELLOW
etc.
```

with the labels 'RED', 'YELLOW', etc. defined via functions, thus:

```
TO RED
OP 0
END
```

```
TO YELLOW
OP 1
END
```

Although the pupils were happy to do this, they didn't see its purpose, which rendered it less than satisfactory. An alternative labelling method using the MAKE operator was also tried:

```
TO TRAFFIC
MAKE "RED 0
MAKE "YELLOW 1
MAKE "GREEN 2
TURNON :RED
```

```
WAIT 300
TURNON :YELLOW
WAIT 100
TURNOFF 0
TURNOFF 1
etc.
```

Again, the pupils could handle this, but did not appreciate the use of the "and : symbols, being unsure of which to use on any occasion. It occurred to the researchers that this feature of Logo was an unnecessary abstraction. For the next time, we would like to pick an alternative programming environment (such as CoCo for the Archimedes), but equipment constraints may prevent this.

Some pupils circumvented the conceptual difficulty of labelling inputs and outputs by writing their programs thus:

```
TO RED_ON
TURNON 0
END
```

```
TO RED_OFF
TURNOFF 0
END
```

thus producing the program:

```
TO TRAFFIC
RED_ON
WAIT 300
YELLOW_ON
WAIT 100
RED_OFF
YELLOW_OFF
etc.
```

We were particularly pleased at this (spontaneous) attempt at solving the problem set, which demonstrates the effectiveness of considerable prior exposure to 'ordinary' Logo before undertaking Control Logo. Pupils wrote programs to drive the Lego buggy and to raise and lower a Lego barrier. Their desire was to develop a system to simulate a level crossing with traffic lights, but the limitations of the Lego interface prevented this (another reason for switching to the MFA interface next time). We also ran out of time, having only allotted four weeks to this activity.

As a pilot for a more controlled project in future years, this work was a great success. The pupils showed enthusiasm and excitement in creating their systems and, although some had conceptual difficulties, many showed that they understood the concepts and were able to apply them to new

situations. It will be 1996 before the research reaches any conclusions, but an important first phase has been completed and we have already learned a great deal.

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