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Achieving Education for Technological Capability in Scotland

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A Framework

Technology Education in Scottish Schools: A Statement of Position, an initiative of the Scottish Consultative on the Curriculum (Scottish CCC, 1996), provides the rationale for all curriculum development in technology education in Scotland. It has influenced the Higher Still[1] qualifications entitled Craft and Design, Technological Studies, Graphic Communication, Home Economics, and Art and Design for the Scottish Qualification Authority (1999). The National Guidelines for 5-14[2] Environmental Studies, Technology (2000) has technological capability (see Table1) as its attainment outcome.

Design and technology (D&T) education involves learners coping creatively with complexity. It must take account of a wide range of often apparently conflicting demands and constraints: aesthetic, economic, political, ethical, social, and environmental as well as ergonomic, technical, and scientific. The framework for technology education, described by the Scottish CCC (1996), promotes narrow *proficiency* tasks that provide opportunities to acquire the specific skills, strategies, and knowledge that are required to engage effectively in design and technological activities. These underpinning proficiencies can be developed through direct teaching via closed or focused briefs. This allows specialist inputs and knowledge to develop concurrently with more generic technological concepts and facilitates teaching and learning for transfer. *Creative practical tasks* offer opportunities for open-ended design and realization through practical action in response to perceived needs, wants, and opportunities. *Case study tasks* describe a relatively recent approach to school-based D&T learning. These involve students in the study of technological applications in the wider world and its interactions with society and the environment. A case study can provide the stimulus or context setting for the creative practical task. It can serve as the vehicle for comparing and contrasting different solutions, cultures, or times, or more detailed aspects of design and engineering. Case studies can involve fieldwork and/or incorporate inputs from adults other than teachers and from related areas. They have the potential to raise issues and offer stimuli for alternative resolutions. It is through interactive case studies that teachers are able to make connections between the technology their students are studying in school and the wider society, industrial, and business context. Case studies encourage students to evaluate and make informed judgments about the appropriateness of the technological products created by others and to speculate about possible future developments. Students can begin to consider, critically, the impact and influence of D&T on society and the environment. Students can start to appreciate the consequences of the interaction of D&T with society and the environment.

Case Studies of Design & Technology in Action

As well as being of interest in their own right, the products explored in the CD-ROM *Exploring Everyday Products: Case Studies of Design & Technology in Action* provide examples of how to use a case study approach. The case studies help to explain how to evaluate products in relation to technology in society. They exemplify how to explore the issues and lead into activities to stimulate detailed appraisal and understanding of product, industrial cycle, respective roles of clients, users, consumers, designers, engineers, production team, sales, and marketing.

To ensure that the CD-ROM does not end up as a passive story time, two-dimensional activity, the case studies require pupils to have a hands-on experience of examples of the products under scrutiny, or similar. Therefore, the products were chosen for their accessibility and familiarity. It was also considered important that the products chosen could be explored in stages appropriate to students in the 8 to 16 age group and offered opportunities for individual and

Table 1. *Technology Education in Scottish Schools: Summary of the Aspects of Technological Capability (Scottish CCC, 1996)*

Technological sensitivity:	Appreciate that technological developments have consequences for people and the world in general, apply moral and ethical judgments in evaluating technologies and considering effects that proposed solutions have on the well-being of individuals, societies and the local and global environment; etc.
Technological perspective:	Develop a way of seeing and thinking about the world past, present, future; think imaginatively about better ways of doing things; appreciate the factors contributing to the success of a well designed product; appreciate the relationships between technology and the world of work; bring an inquisitive mind to bear upon the made world; etc.
Technological confidence:	See technological opportunities, identify technological problems and take on challenges presented by these; question ideas, design and products; etc.
Technological creativity:	Make effective use of knowledge, skills and experience; develop imaginative and feasible approaches and resolutions; manage appropriate materials, equipment and human resources; critically evaluate, amend and adapt strategies; design and /or make technological products or modify existing; etc.

group work. A variety of product types was needed so that the chosen products illustrated the technological design issues that are central to this learning resource, such as scientific/technological principle of function; choice of materials; manufacturing processes; obsolescence; environmental and social conditions; evolution marked by historical, technological, and social factors; user analysis/consumer demand; ergonomic values; marketing strategies including advertising; fashion; and variation in scale. This involved detailed collaboration with local and national industries for the case study information.

The process of selection of products resulted in the following:

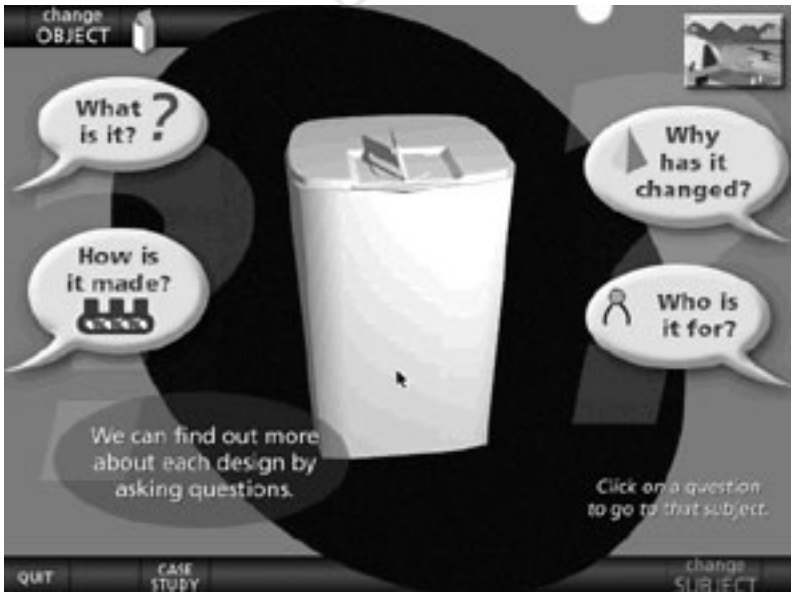
- Packaging for milk—Robert Wiseman Dairies PLC.
- Telephone—Motorola PCS.
- Tents—Vango (Scotland) Ltd.
- Radio—Freeplay Energy.
- Weighing machines—John White & Son (Weighing Machines) Ltd and John White Automation Ltd.
- Tin-opener—Ken Grange Design.

Development and Design of The CD-ROM Resource

The multimedia potential offered by CD-ROM allows access to the information, ideas, and artifacts that would otherwise not necessarily be possible in the classroom. It is intended that the product case studies selected will captivate the imagination of both teachers and students alike. It is anticipated that users will develop a sense of curiosity and be encouraged to delve deeper into the values, attitudes, and influences that lead to the development of such products, innovations, and enterprises. The case studies featured on *Exploring Everyday Products* aim to help pupils to:

- reflect critically and constructively on the interplay between technology, society, and

Figure 2. Example of CD-ROM screen graphics and content.



the environment, now and in the past, locally, globally, and in various cultural settings;
- develop technological capability, particularly focusing on technological sensitivity and perspective;
- explore the interactions of design and technology with society and the environment;
- understand that design and technology activity has a persuasive influence;
- question the appropriateness of products;
- begin to understand the complexity of factors that influence any product, including the role of the media; and
- ask questions about, and consider future possibilities of, the impact of technology on national economies and quality of life.

Exploring The Everyday Products

Pupils are introduced to examining and reading a product through:

- initial emotional response, both their own opinions and judgments and those of others as exemplified by comments from focus groups;
- illustrated historical development of the product;
- detailed product autopsy and disassembly, including identification of materials, manufacturing processes, and assembly procedures;
- analysis of function and its relationship with materials and processes;
- end-user tests and reports;
- environmental audit or critique;
- impact of product on lifestyle, society, the economy, and company portfolio, including discussion of issues and values of the product and its purpose; and
- interactive tasks that involve the pupils in making choices or basic design decisions.

The design decisions for navigation pathways for the CD-ROM user to follow were based on having a common entry point for each different product. This leads the user from the main menu (a campsite) into the product introduction screens before a choice of routes is made available for either a directed path or the possibility of linking themes across the six products, for example, What is it and what does it do? Who is it for? Why has it changed? How is it made? (see Figure 1).

Teaching and Learning Stimulis

Included in the teacher's notes are suggestions for integrated activities, both on- and off-screen learning approaches that vary in scope and duration. These range from ideas for design tasks, knowledge, and understanding focused tasks and skill development tasks to research-informed discussion and report-writing tasks. This guidance aims to encourage teachers to devise programs of work that are informed by

Table 2. Classroom Trial Activities: Focus and Tasks

Activity	Focus	Task
1.Tents	introduction to structures pre-planning scale (1:10) sketch modelling group work	design a structure for 3 campers with belongings and boots
2.Radio	awareness of energy sources used in common domestic appliances and machines finite versus renewable sources sketch design ideas annotation product evolution over time: style, technology and size	design an everyday appliance or machine which is powered by a renewable energy source
3.Milk	Packaging same job, different product driver for changes over time manufacturing process colour and image association market target group role of focus group evaluation	design a milk package for specific target

the content of the CD-ROM or progress into a complementary open-ended creative practical task as a result of studying a specific case study.

McLaren (1997) stressed the importance of giving students the opportunity to reflect on their explorations of a value-based appraisal of technology in society and allow their reflections to influence their own approach to design. She cautioned against reducing the technology curricula to learned sequences of procedures and mechanical application of acquired skills and knowledge and understanding. Design opportunities do not present themselves in neat packages. The CD-ROM case studies/stories illustrate this. The perceived needs and wants from which the resulting products arise must be determined from ambiguous, unstructured scenarios and formulated in such a way as to allow the so—called problem to be solved. The various perspectives, influential factors and constraints, and value judgments of those involved bring a diversity of opinion and interpretation to this front-end process. Often in school-based technology activity, the students are encouraged to follow a design process as an algorithm (McCormick, Murphy, & Davidson, 1994). This over—simplified, ritualistic approach does little to help students appreciate the complexity of decision making involved in design. Many conceptual insights and values are hidden within the end product, and access to the design thinking is not necessarily evident. Creative use of the opportunities offered by information and communication technology media of the CD-ROM and the WWW may help students to dig deeper and begin to appreciate the wider connections and influences the designer has to deal with in the rationalization of the complexity.

Early Stage Evaluations

Central to the development of the CD-ROM was the usability in the classroom by both D&T specialists and primary teachers. The teaching and learning resource was to address areas of concern in current teaching practice and to provide the teachers with a tool to explore environmental, cultural, ethical, economic, societal, technical, and historical issues with their students. It was important not only to ensure that the content and coverage was appropriate but that teachers were involved in the development process. An advisory group of practicing teachers was, therefore, consulted throughout the process. Following the completion of three product stories, class trials were conducted in the schools of the advisory group members. These early evaluations informed the work and enabled certain issues to be identified, particularly about navigation through and between the various product types. It was also apparent that secondary teachers identified more readily with the CD-ROM's content and style than their primary colleagues. Requests were made for detailed guidance on how it could be used in school, with a glossary for design and technology terms and technical vocabulary. At this stage it was encouraging that the teachers were complimentary about the cultural aspects and the industrial and business connections. Many of the issues, concerns, and ideas from this group were addressed and adopted, where budget permitted, and work continued on the development of the remaining three product stories.

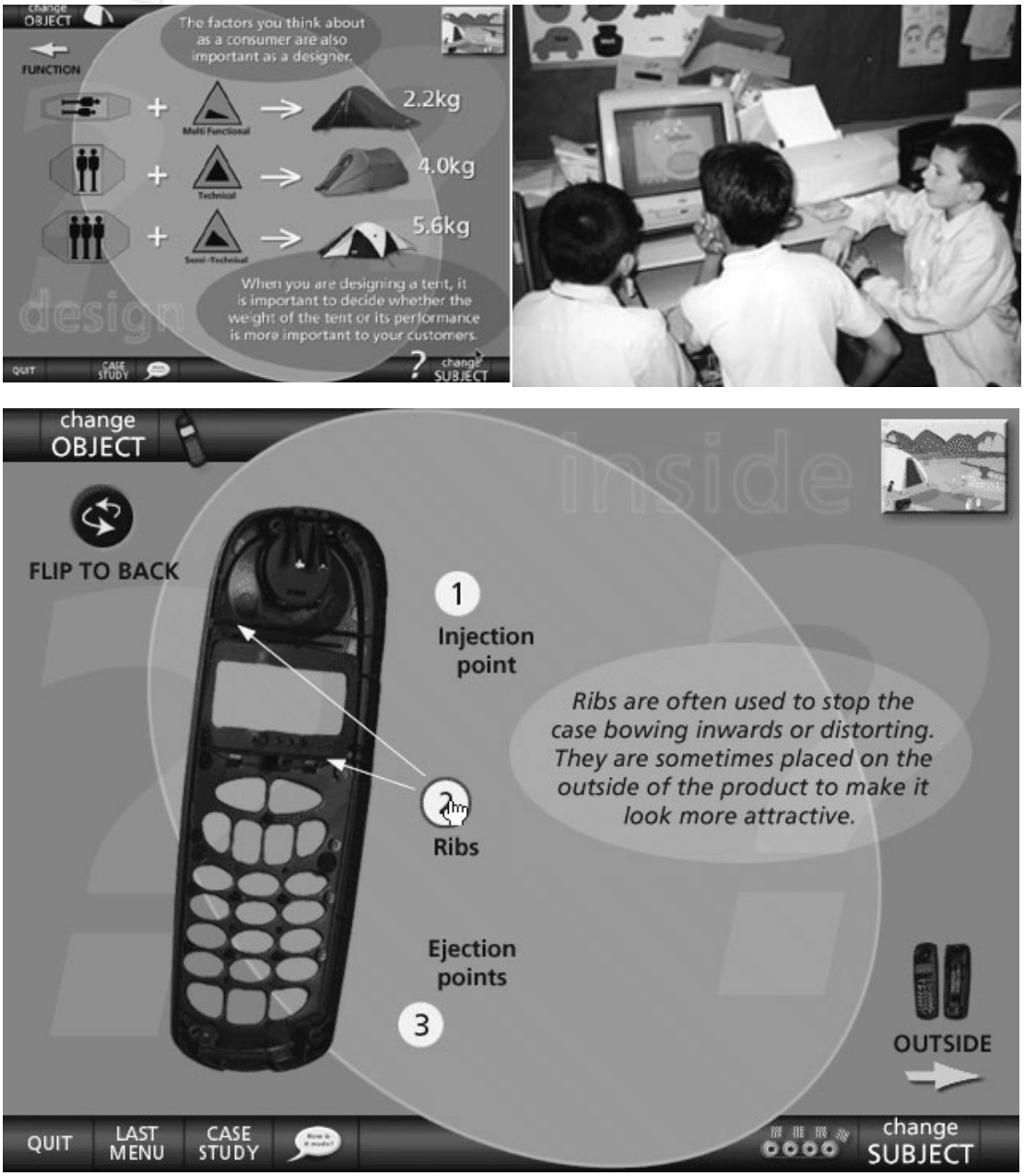
School-Based Trials and Evaluation Responses

In order to gauge the response of pupils and teachers to the content, format, and potential of *Exploring Everyday Products*, school-based trials were conducted in addition to opinions being canvassed from practicing secondary and primary teachers. Since the design of the CD-ROM was based on the concept of mutually supportive and interrelated tasks, both on- and off-screen, each classroom trial consisted of a mixture of CD-ROM viewing/reading and a physical activity such as designing or an integrated design-make task (see Table 3). At the end of the session the pupils completed an evaluation form. The product stories/case studies for class-based trials and evaluation were selected to test ideas for tasks that aimed to develop specific concepts or skills. The format, content, level at which to pitch the tasks, time to allow, and teaching approaches also required appraisal.

Task 1. Tents: This trial was conducted with a class of secondary 3 pupils (14 to 15-year-olds) and repeated with a class of primary 6 pupils (10 to 11-year-olds). Due to the restricted time of the secondary school system, only 53 minutes were allocated compared with the two hours available in the primary school. In brief, the session was comprised of three main components: (a) warm—up task, to make a doweling rod stand upright, using only resources found in a box provided for each group; (b) debriefing by the teacher, to consolidate basic concepts of how structures stand up in terms of equal forces, tension, and compression only; and (c) class viewing of the Tents product story on the CD-ROM, navigation by the organizers: *Why has it changed? What is it? How is it made? Who is it for?* Then a design task was tackled in groups: to design and make a model of a tent-type structure that can accommodate three adults, three rucksacks, and three pairs of hiking boots. A 1:10 scale paper template was provided for pupils to cut out and use in their planning. The pupils were permitted to select resources, tools, and materials from the common pool. It was discernible that the source of the primary 6 children's ideas came from the images and information gleaned from the presentation of the CD-ROM.

The children made comments that they enjoyed the making element of the session. One child particularly enjoyed "deciding what to do." This suggests that the initial concept of designing a CD-ROM that would act as a catalyst for away-from-screen activities was based on a reasonable premise. Another pupil enjoyed "finding out about the tents in the olden days." This aspect of the session took a total of five minutes and yet had clearly been memorable. There were varied opinions on what had been learned, including "how to make a tent and how to support a structure," "how tents were made and used," "how hard it would be to make a tent in so little time," "that you must make sure the tent is the right size," "allot," and "not to put you fingers ner [sic] the ponnt [sic] of the glue gun."

Figure 3. Classroom trial activities: focus and tasks



In response to the question, What did you enjoy the least, there were comments such as "argouing [sic] about who does what," "measuring," "being quick," and "being burned by the glue gun." However, two pupils had liked the CD-ROM the least.

Task 2. Radio: This trial started with a discussion about the types of devices, appliances, and machines the children had used from getting up to arriving into school. A wide range of products including alarm clocks, toothbrushes, irons, refrigerators, toasters, bikes, and cars were mentioned. For each product, the children were asked to note the source of the energy that powered the machine/appliance. This was followed by working demonstration circuits of simple energy conversion using visual aids such as a hydro-powered turbine, a hand dynamo, a solar—powered (photovoltaic) circuit, a fan (wind), a lemon/zinc/copper battery, a steam engine, and batteries.

The group was then introduced to the CD-ROM to view the radio product story/case study. They explored the design and evolution of the radio and had a valuable discussion with each other, stimulated by the on-screen questions and

those posed by each other. Some of the comments illustrated a fair level of awareness. For example, on reading the comment regarding the 1950s styling that was targeted at girls and women and hearing the supplementary information about creating new markets for products, one child exclaimed, "That means that shopping was invented for women!" Others noted that the 1940s style "looks like a juke box." The 1940 bakelite radio attracted the observation, "Why, when it's plastic, have they made it look like mahogany?" One member of the group, on seeing the 1980s model, announced, "They managed to make it smaller, because they made all the bits inside smaller. That's technology."

The How does it work? and *How is it made?* sections were viewed with obvious interest. Some of the screen frames were visited and revisited by the pupils, with a particular favorite being, "You speak in here...and it comes out here." "Why, if we know they're [radio waves] up in the sky, can I not see them from the window of the aeroplane?" and "Is that why the noise is all fuzzy if you move the dial just a wee bit away?" seemed to be evidence of thinking further into the concepts and information being presented to them, stimulating curiosity.

The pupils were then asked to think back to the initial discussion about the various machines and devices encountered in their everyday business. They were to consider how the devices could do the same job using a more sustainable or renewable source of energy than at present. This was a short future-thinking type task, requiring annotated sketches and a debriefing plenary discussion. The specific focus for this trial was to develop approaches to support technological perspective, for example, "demonstrate an understanding of how the made world that they experience has come to be as it is, and indicate ways in which it might be different" (Scottish CCC, 1996, p. 8).

The variety of comments noted on the evaluation forms indicated that there was something to interest and motivate every member of the class and all learning types (Honey & Mumford, 1992). Some preferred the CD-ROM focused work ("doing the radio on the computer," "looking back in time," and "learning about old and new and different"), and others enjoyed the design task more. The intended learning outcomes, related to technological perspective and sensitivity in particular, from the pupils' perceptions seemed to have been met. For example, I learned "there were so many different radios," "how useful heat and water is as a power source," "how radios work," "how a lot of sources of energy worked," "some things don't need a battery," and "how wasteful batteries are and what else you could use."

Task 3. Milk Packaging: This trial involved secondary 2 pupils (13 to 14-year-olds). Results indicated that this task requires a longer time devoted to it (55 mins) in order to introduce, develop, and consolidate the learning outcomes. By way of context, pupils were shown a range of milk packaging types from various supermarket own brands and other producers. After discussing the style of graphics, use of colors, materials, and types of container, the packages were classified using different headings. Although one carton had been deconstructed, pupils presumed that the cartons were made from cardboard and this was used as the cue to visit the CD-ROM case study and explore the key questions posed therein. The third aspect of this session was the task of designing a milk package suitable for young children. The pupils were to consider the use of color, graphics, openings, and manufacturing processes in the same way as they had been introduced to the information by the CD-ROM. In the resultant sketches there was evidence that a number of pupils used the concepts and issues raised on the CD-ROM in their own ideas. The animation of the carton manufacturing processes (with the cross-reference to injection molding processes from the telephone case study) was a definite hit. This is supported by several pupils commenting that they learned "how much effort it takes to make everything possible" and "how milk packs are made." Teachers themselves have rarely been in a manufacturing environment and require materials to convey how things are carried out in the "real world." Introductory teaching materials that illustrate a number of complex industrial manufacturing processes need to be informative, accessible, and realistic without burying the basic information with too

much technical detail (see Figure 2). The difference, and sometimes the similarities, between school workshop and industrial practice is central to the journey of the CD-ROM.

Conclusion

On the whole, these trial sessions were met with great enthusiasm throughout and have provided justification for the final stages of development, prior to distribution to schools.

Appraisals of navigation and presentation issues were favorable. Teachers and pupils found it easy to move between themes. One pupil commented, "It told you where to go, really easy and simple. This is a good thing as it puts you off if something is really complex." The reaction to the animated "campsite" front-page frame was "try to phone," "try the bird," "try the tent," "try the swing," "try the radio. Hey! Cool!" Although initially highlighted as an area of concern by secondary and primary teachers, the written pupil responses complimented the campsite frame. Words such as *exciting, interesting, cool* and *good* were noted. Also, "I wanted to see how it worked" implies that it served its purpose of enticing the user further into the CD-ROM.

From the information collected from the early evaluations, the field trials, and canvassed opinions, the content of *Exploring Everyday Products* is deemed accessible and of value in the classroom. Evidence from the sample, albeit small, suggests that the CD-ROM does stimulate curiosity about how things are and how they used to be, and encourages speculation about how things might be different. Teachers will have access to informative case studies that specifically enable discussion and design thinking about cultural, societal, and environmental issues, which hitherto have been given little attention. The pupils and teachers seem to have connected with the approaches of the industrial "real" world of design and make and were able to relate them directly into the classroom experience as the activities were designed to do. However, it is agreed by all that the CD-ROM on its own is not enough. Teacher input is required and, therefore, the teacher notes and guidance are a central part of this educational resource.

The products selected have provided a vehicle for on-screen exploration of various technical and commercial considerations while stimulating off-screen tasks through which the pupils can apply their own knowledge and understanding, make their own value judgments, and engage in activities that develop all four aspects of technological capability: perspective, confidence, sensitivity, and creativity.

Overall, the selected CD-ROM case studies and associated tasks underpin an active learning approach to developing technological capability and meet the expectations of the Scottish CCC Technology Education Development Program. The involvement of industry and designers who were directly engaged in the development and marketing of the products was therefore an essential part of the project.

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References

Honey, P., & Mumford, A. (1992). The manual of learning styles. Maidenhead, England: Honey.

McCormick, R., Murphy, P., & Davidson, M. (1994, April). Problem solving in design and technology: A case of situated learning? Paper presented at the annual meeting of the American Education Research Association, New Orleans, LA.

McLaren, S. V. (1997). Value judgments: Evaluating design: A Scottish perspective on a global issue. International Journal of Technology and Design Education, 7, 259-278.

Scottish Consultative Council on the Curriculum. (1996). Technology education in Scottish schools. Dundee, Scotland: Author.

Scottish Qualifications Authority. (1999). Higher still design engineering and technology: Graphical communication; technological studies; craft and design. Edinburgh, Scotland: Author.

1 "Higher Still: Opportunities for All" is the Scottish Qualification Authority framework for school and colleges. It aims to provide a more inclusive and progresseive transition between stages of education leading towards qualifications in academic and vocational modules, courses, and group awards at secondary schools and further education colleges.

2 5-14 National Guidelines create a coherent framework for the content and structure of the curriculum for primary schools and the first two years of secondary schools in Scotland. In general this covers the education of students ages between 5 and 14 years old. Although not statutory, the guidelines suggest the dispositions, core skills, capabilities, knowledge, and understanding to be developed. In addition, the guidelines set out the attainment targets for language, mathematics, religious, and moral education, information, communication, technology, and health education. Our subjects are grouped. These groupings are known as Expressive Arts (art and design, physical education, drama) and Environmental Studies (society, science, and technology).