Educational Research as a Foundation for Curriculum Development in D&T

David Barlex and Malcolm Welch
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Abstract: Educational research has been criticized for being inaccessible to practising teachers and both removed from and irrelevant to their needs. Seldom does the research inform curriculum development, the production of learning materials, or their effective use in the classroom.

Earlier research by the authors revealed limitations in pupils' constructional skills, technical knowledge and aesthetic appreciation as they develop a solution to a design and make task. Knowledge of these limitations and the design procedures adopted by the pupils informed the development of a Capability Task and a suite of Resource Tasks so that the same design and make task could be used in a classroom setting. Current research is providing insights into ways in which teachers can be introduced to a pedagogy and the development of curriculum materials. The results of this work are, in turn, providing the basis for the development of more general model for using research findings to inform the design of curriculum materials and associated pedagogy.

160 words

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Introduction

Educational research has been criticized for being both removed from and irrelevant to the needs of practicing teachers (Hargreaves, 1996). Hargreaves (1996) has identified the gap between educational researchers and practitioners as a "fatal flaw" (quoted in Tooley & Darby, 1998, p. 7). It is frequently the case that educational research does not investigate the concerns of teachers, and when it does is often published in a form that is unlikely to be easily accessible to them. Even less frequently does the research inform curriculum development, the production of learning materials, or their effective use in classrooms. This is certainly true in the field of design and technology education, where only recently has a significant body of empirical research become available to curriculum developers.

The design and technology curriculum for 11-14 year-olds in England identifies five categories of knowledge and skills required by pupils if they are to become “autonomous and creative problem solvers” (QCA, 1999, p. 15): Developing, planning and communicating ideas; working with tools, equipment, materials and components to produce quality products; evaluating processes and products; knowledge and understanding of materials and components; knowledge and understanding of structures; and knowledge and understanding of systems and control.

The Ontario technological education curriculum states that pupils must develop the ability to “work creatively and competently with technologies that are central to their

lives" (MET, 1999, p. 2). The expectations of the program are organized into three strands: theory and foundation, skills and processes, and impact and consequences.

Central to both curricula is the activity of designing and making. Pupils are required to demonstrate technological capability, that is, the ability to use knowledge, skill and understanding "to design what they can make and make what they have designed" (Barlex, 1995, p. 1).

Earlier research by the authors (Welch & Barlex, 1999) revealed the process used by pupils to develop a solution to a design and make task (designing and making a toy or game for a bed-ridden child). Examination of the pupil's solutions made evident limitations in their constructional skills, technical knowledge and aesthetic appreciation. Knowledge of these limitations and the design procedures adopted by the pupils informed the development of a Capability Task and a suite of supporting Resource Tasks so that the same design and make task could be used in a classroom setting. Current research is providing insights into ways in which teachers can be introduced to a pedagogy and the development of curriculum materials grounded in research findings. The results of this work are, in turn, providing the basis for the development of a model for using research findings to inform the design of curriculum materials and associated pedagogy.

This paper will describe the early results of an ongoing collaborative study between an experienced educational researcher (in Ontario, Canada) and an established curriculum developer (in England) working on a funded research project, *Curriculum development*

and educational research: Allies in a common cause. The purpose of the study is to develop classroom materials informed by current research findings to meet statutory curriculum requirements in Ontario and England.

The paper begins with a review of the research used to inform the development of curriculum materials. The next section describes the results of a trial in which twenty teacher candidates from Queen's University in Ontario were (a) introduced to the Nuffield approach to teaching design and technology, (b) participated in the development of a Capability Task and supporting Resource Tasks, and (c) were engaged in using research findings to inform curriculum materials development and implementation. The application of the model to a broader audience and implications for further work complete the paper.

Pupils' designing and making: The emerging mismatch between theory and practice

Previous research (Welch, 1998, 1999) identified four very significant differences between the strategy used by pupils to produce a design proposal and the models contained in many textbooks and curriculum documents. First, pupils' strategies are more complex than suggested by any of the linear models. Pupils do not work in a linear way through the steps identified in textbook models: understand the problem, generate possible solutions, model a solution, build a solution, and evaluate a solution. For example, understanding the problem appears to emerge from an exploration of solutions.

Second, the preferred strategy for developing ideas is modelling in three-dimensional form. Pupils do not use sketching as a way to generate, develop and communicate design proposals, but move immediately to three-dimensional modelling. Sketching is not viewed as a mediating instrument between mind and hand, between thinking and doing (Welch & Barlex, 1999). The evidence suggests that pupils are anxious to begin 3D modelling even before a solution has been fully worked out. This modelling serves several purposes: externalizing ideas; testing, refining and evaluating ideas; and stimulating new ideas. Three-dimensional modelling was shown to be a complex activity, more accurately described by a model-test-refine-test iteration. This iteration, a constant toing-and-froing between building, testing, and refining, appears to act as a source of inspiration for new solutions.

Third, pupils do not sketch and evaluate multiple solutions in order to choose and further develop the one with the most promise. No pupils attempted to sketch more than one solution at the outset, and any sketching that did occur was perfunctory. This is consistent with the findings of other authors (Jeffery, 1991; Kimbell, 1997) who refute the "three-ideas paradigm" (Kimbell, 1997, p. 21). Furthermore, novice designers lack the requisite sketching skills to generate, develop and communicate their ideas.

Fourth, evaluating was an integral and ongoing activity. Evaluation occurred not as a summative activity after generating ideas and making a solution, but as an integral and ongoing activity when designing and making. Evaluating occurred consistently from the earliest moments of designing.

A recent study (Welch & Barlex, 1999) showed that for novice designers discussion played a very significant role in their attempt to generate a solution and appeared to provide an informal and supportive way for subjects to develop their ideas. The data showed that pupils need little encouragement to talk about their ideas. There was a dynamic relationship between pupils' talk and three-dimensional modelling. Sometimes changing the model stimulated discussion and helped the pupils develop new ideas or solve problems. At other times the reverse was true and a discussion point led to the 3D model being further developed. This supports the claim of Hennessey and Murphy (1999) that "productive thinking in the context of physical activity is both reflected in and stimulated by discourse between collaborators as they share and assess ideas" (p. 3).

These results, which illustrate the emerging mismatch between theory and practice in pupil's designing and making, raise important questions for the educator developing D&T materials for classroom use. The next section of this paper describes a method by which this mismatch was addressed with twenty teacher candidates through the introduction of a pedagogy and the development of curriculum materials grounded in these research findings.

Closing the gap: Teachers use of research in classroom materials development

Twenty teacher candidates from Queen's University in Ontario, meeting for three hours on three consecutive days, were introduced to the Nuffield approach to teaching design and technology, in which capability is demonstrated through the completion of a Capability Task (a Design and Make Activity) and enabled through supporting Resource

Tasks. The teacher candidates then participated in the development of a Capability Task and supporting Resource Tasks using the same design brief as the pupils in the research described earlier in this paper.

On Day 1 the teacher candidates were given a workbook designed to (a) introduce them to the Nuffield approach and the research findings, (b) involve them in the development of a Capability Task and supporting Resource Tasks and (c) prepare them to complete some Resource Tasks and the Capability Task.

The workbook opened with a copy of the context and design brief (design and make a toy or game that will amuse and intrigue a bed-ridden patient approximately 12 years old and that can be played with on a bed tray) from the research studies referenced earlier. This was followed by a series of questions:

- What learning about designing will be important for the pupils to be successful?
- What learning about making will be important for the pupils to be successful?
- What learning about technical matters will be important for the pupils to be successful?
- What learning about other matters will be important for the pupils to be successful?
- What design decisions (about the product, the user, the performance, the appearance of the product, how the product will work, how it will fit together, and the materials, adhesives, fixings and components required) will the pupils make?

Teacher candidates were also required to consider whether or not the task statement and design brief needed to be developed in more detail, and what performance specifications should be provided to pupils.

The next step required teacher candidates to identify the knowledge, skills and understanding pupils would need in order to be successful in the Capability Task. This led to the identification and development of a series of Resources Tasks to teach simple designing skills, construction skills and technical understanding. Finally, teacher candidates were asked to identify opportunities for using ICT and to consider assessment issues.

Working in groups of four teacher candidates then completed the workbook. At the end of the first day the authors collected the written responses of the teacher candidates. These were collated and written into a second version of the workbook.

On Day 2 teacher candidates used the second version of the workbook as a basis for discussion as they worked in dyads on a selection of the Resource Tasks and the Capability Task. Prior to this activity the two authors had resourced the room with tools and materials required. Teacher candidates each completed two Resource Tasks as individuals before working with a partner to complete the Capability Task. The authors provided technical assistance with practical work and engaged in individual discussion. As a result a variety of toys and games were produced by the teacher candidates,

including a tabletop pool table, a marble maze, tabletop basketball, and several board games (Figure 1).

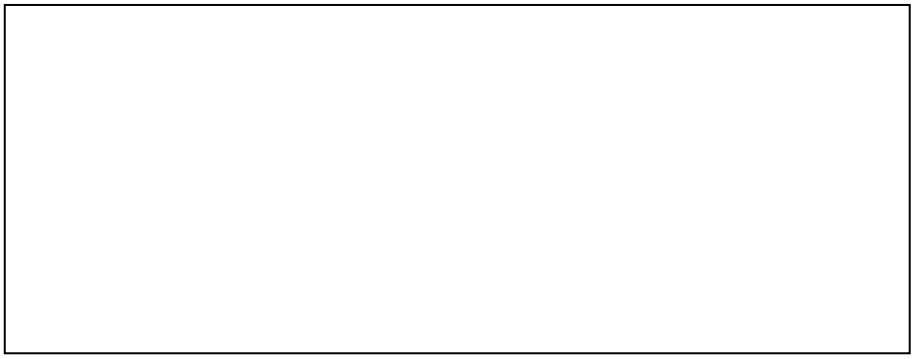

Figure 1. Toys and games for a bed-ridden child

At the end of Day 2 the authors were able to develop a set of questions to help teacher candidates reflect on their work. The questions focussed on:

- The Resource Tasks (e.g., Which resource tasks did you complete? Did they help with the Capability Task? What difficulties did you have when tackling the Resources Tasks? What difficulties might your pupils have?);
- The Capability Task (e.g., How did you generate ideas for the toy or game? How did you record these ideas? How did you develop these ideas?);
- The product (e.g., Does it meet the performance specification? Are you proud of it? Given more time what improvements would you want to make?);
- Assessment (e.g., What do you think you learned? What is the evidence for this learning?).

On the third and final day the teacher candidates, working first individually and then in pairs, developed answers to these questions. A closing tutor-led discussion resulted in a series of conclusions about (a) using the Nuffield model in the D&T classroom, (b) curriculum materials development, and (c) using research findings to inform classroom practice. For example teacher candidates reported a significant level of confidence as they tackled the Capability Task. When questioned they were able to identify their success with the Resource Tasks as contributing significantly to this confidence. They also reported "getting better at design decision making" and "learning new making skills" as a result of completing the Resource Tasks. Conversation around the organization and resourcing of the three days highlighted for teacher candidates the critical importance of the effective deployment of resources. The interaction between the instructors and the teacher candidates while they were tackling both the Capability Task and the Resource Tasks led one teacher candidate to identify the relationship between the teacher and the pupils in the D&T classroom as crucial. Teacher candidates were able to articulate that if pupils are to experience success as they engage in the risky business of developing a design proposal, there must exist a significant level of confidence in and trust of the teacher. Finally, participants identified the discontinuity between descriptions of the linear design process in many textbooks and curriculum documents and the iterative process identified by empirical research.

Curriculum materials and educational research: Continuing the alliance

The study described in this paper has illustrated how twenty teacher candidates at a Faculty of Education were introduced to the findings of a research program that have

implications for teaching capability in D&T. Teacher candidates were able to begin the development of "their own personal construct of the subject they teach" (Banks & Barlex, 1999) by engaging in the process of curriculum materials development grounded in research findings. They were able to engage with both subject knowledge and pedagogic knowledge.

Earlier research provided insights into pupils' strategies for designing and, through the products designed and made by the pupils, limitations in their constructional skills, technical knowledge and aesthetic appreciation. Teacher candidates were able, using a framework provided by the authors, to develop a Capability Task and associated Resource Tasks grounded in these research findings. Equally important, they were able to "live" a pupil's experience, using the knowledge gained to modify the classroom materials.

In the second phase of this study materials written and piloted with teacher candidates will be refined using data collected from the pilot study. Additional tasks based on the model will be produced. Assessment strategies will be investigated and developed, along with a model for the in-service delivery of the classroom materials. Finally, a Teachers Handbook and feedback instrument will be developed.

2294 words

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BIOGRAPHICAL NOTES

David Barlex PhD directs the Nuffield Design and Technology Projects. The Nuffield D&T materials for 11 - 14 year old students were published in May 1995; materials for 14 - 16 year old students from May 1996. He is currently working on the Nuffield Primary D&T Project, a joint Nuffield Foundation - Scottish Consultative Committee on the Curriculum Primary Technology Project, the revision of the Nuffield secondary school materials and developing a Nuffield secondary D&T website. He is a senior lecturer at the Faculty of Education, Brunel University. He has a special interest in the professional development of teachers and teaching methods that develop design and technology capability.

108 words

Malcolm Welch PhD is an Assistant Professor at the Faculty of Education, Queen's University, Ontario where he conducts research and has published widely in design and technology education. Current research interests include 2D and 3D modelling as an educative experience, methodological issues arising from the application of qualitative research methods to the analysis of students' design strategies, how research findings can inform classroom practice, and the development of approaches to the integration of science and technology at the elementary level. His research is conducted with colleagues at the Nuffield Foundation and Brunel University. He has worked on major curriculum projects in England, America and Canada, and has co-authored six textbooks.

110 words