Examining thinking in primary-level Design and Technology learning activities

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Abstract
Most curriculum documents in Design and Technology make claims about how students will develop and learn as a result of engaging in Design and Technology learning activities. These claims will often include the development of creative and innovative thinking, both of which are regarded as forms of higher order thinking. However, there is little research evidence to support these claims and much of what is available is drawn from small-scale qualitative studies and thus subject to the limitations inherent in such research.

This paper outlines and examines the use of an instrument called the Cognitive Holding Power Questionnaire (CHPQ) (Stevenson, 1986) to measure higher order thinking with primary age students engaging in design and technology learning activities. The CHPQ is a quantitative instrument that elicits responses from students on their perceptions about the influence the learning environment (teacher, materials, activities etc) is having on the kinds of thinking they are using during their learning. The instrument is suitable for large scale studies and provides powerful data to support the learning area. The paper outlines a study in which the instrument was used. However, the primary aim of the paper is to explore the utility and robustness of the instrument to provide a better understanding of the kinds of thinking that occurs in Design and Technology classrooms.

Introduction
Much current research in Design and Technology education employs qualitative methodologies such as interviews, focus groups, stimulated recall and observation to uncover evidence to help explain the nature of the teaching and learning that occurs in Design and Technology classrooms. These have been used extensively from primary years to university teacher education levels. There has been a strong rationale for these methods. The activities students engage in, in Design and Technology classrooms are known to be complex in terms of their requirement for students to engage in both visual and verbal reasoning, the solving of complex, ill-defined problems and the need for the solutions to these problems to be new or creative in some way. Because of these factors, it has been necessary to use methods that are capable of capturing this complexity by allowing in-depth studies of limited numbers of students or classes or learning activities. These studies are important in providing research results to inform the direction of further research and practice.

Qualitative methods do, however, suffer from a number of limitations, with the principal one being generalisability. It has generally been the case that qualitative studies have always been regarded as telling us many important things about a particular individual or small sample but there has been strong reservations about the extent to which the results can be argued to be generalisable to larger groups of people, even when the larger group could be regarded as constituting the population represented by the sample. It is for this reason that there has been a move in some areas of education to employ a combination of qualitative and quantitative methods.

In addition, the results of research are increasingly employed to inform decisions made about educational policy and practice. When this occurs, decision-makers who are developing policy that is designed to be appropriate for an education system, have a tendency to prefer research where there is some confidence that the results and conclusions would be applicable to a policy for the entire system. In these instances, quantitative methods where large samples can be used are preferred, albeit with qualitative methods being used to provide explanatory data. It is for this reason and the argument about its applicability for researching Design and Technology education that this paper has been developed. The following section provides a description of the features of the Cognitive Holding Power Questionnaire (Stevenson & Ryan, ND). This is followed by a brief description of a study where the CHPQ was used with upper primary (elementary) age students. The final section draws some conclusions about our efforts to understand the teaching and learning process in Design and Technology education classrooms.

The Cognitive Holding Power Questionnaire

The Cognitive Holding Power Questionnaire (CHPQ) is an instrument designed to measure the extent to which different learning settings press students into different kinds of cognitive activity. The instrument is administered to students and scored for two dimensions: First Order Cognitive Holding Power (FOCHP) and Second Order Cognitive Holding Power (SOCHP). The concept of Cognitive Holding Power (CHP) is synthesised from theories of settings and theories of cognitive structures.

Cognitive Holding Power is a characteristic of a setting. The tendency for a learning environment to aid or impede individuals in achieving their goals has been called **press** (Murray, 1938). Pace and Stern (1958) have extended this concept to include student perception of the atmosphere of a learning institution. Similar concepts have been used in setting theory (Barker, 1978) where it has been argued that settings elicit behaviour from participants. Moos (1979) attributed the behaviour elicited by settings to the participants' cognitive appraisal of the environment which leads to efforts to adapt to the setting to cope with it. A more powerful term used by Kounin and Sherman (1979) to refer to the demands of a learning setting is **holding power.**

Cognitive Holding Power is measured in terms of two kinds of procedural knowledge elicited by the setting. Ryle (1949) differentiated knowledge into knowledge 'that' and knowledge 'how'. Knowledge 'that' is termed propositional or declarative and knowledge 'how' is termed procedural (Anderson, 1990). Procedural knowledge is the ability to perform an action to secure a particular goal, e.g. Anderson (1990). Cognitive Holding Power measures the extent to which different kinds of procedural knowledge are elicited by the setting.

From the theories of Anderson (1990), Scandura (1980, 1981) and Fischer (1980), three orders of cognitive procedures can be differentiated according to the nature of the goals for which they are applicable (Stevenson, 1986a, 1991). Evans (1991) has proposed a similar differentiation of procedural knowledge based on the kind of control exercised.

The **first order** comprises specific procedures which enable the achievement of goals through the performance of an action. For example, first order procedural knowledge includes knowledge of how to hammer a nail, play a familiar piece of music, apply a particular mathematical algorithm, or perform a particular stroke when playing tennis.

Second order procedures achieve more general purposes by accessing both propositional and procedural knowledge, and operating on specific procedures when immediate action goals cannot be fulfilled. They result in relating, combining, and modifying specific procedures so as to produce new procedures which can handle as yet unfamiliar situations. Examples include designing a plan for a new house to meet a client's requirements, interpreting and playing an unfamiliar piece of music, selecting a strategy for the solution of a new mathematical problem, or developing a strategy for winning a tennis match.

It has been argued (Stevenson, 1986b) that engagement in learning activities which demand the use of second order procedures assists students in achieving **far transfer** (Royer, 1979), that is, transfer where there is no clear similarity between the stimulus elements in the original learning and the transfer tasks. Second order procedures can be likened to Sternberg's meta-components of intelligence (Sternberg & Davidson, 1989) which are involved in 'defining the problem, setting up a strategy to solve the problem and monitoring the consequences of one's problem solving' (p.23).

A **third order** of cognitive procedures is conceived as those procedures which achieve overall control of cognition and switch cognitive activity between orders. This third order is variously called a flow of control (Anderson, 1982), a goal switching mechanism (Scandura, 1981), control through procedures (Fischer, 1980), and executive control (Evans, 1991). In addition to these control functions, propositional knowledge is accessed in the control and monitoring of first order, or specific procedures, and higher order procedures are elicited when task feedback indicates a problem state (Evans, 1991).

Setting characteristics which lead to First Order Cognitive Holding Power are those which are concerned largely with the practice of existing specific procedures or are ones in which the teacher, or the lesson, tends to minimise the need for the student to combine and modify specific procedures. The students' tasks are reduced to copying or to the simplest interpretation of information. It is the teacher who takes the responsibility for the second order procedures. Thus, the student may be largely unaware of the thinking strategies used in the lesson and may not be responsible for controlling them (Rigney, 1980; Derry & Murphy, 1986). Such activities tend to short circuit the students' use of second order procedures and include copying directly from the teacher, being shown a procedure explicitly by the teacher, being told explicitly what to do, and acting on information, ideas, and judgements of the teacher. Such activities may foster the learning of target first order skills, but not second order procedures.

A setting with high Second Order Cognitive Holding Power is defined as one which poses goals unfamiliar to the student, and elicits the execution of second order procedures to interpret the situation and to deal with the associated problems. Such a setting promotes the use of second order procedures and impedes the achievement of goals through only the direct application of specific procedures nominated by the teacher. Second order procedures are used to make links between the features of the setting and existing knowledge, to generate ideas, to try out and test problem-solving strategies, to monitor the effectiveness of approaches, and to check results.

The trialling of novel combinations of specific procedures and the monitoring of strategies for attacking the situational problems would also be accomplished by second order procedures activated as a result of the switching function of third order executive procedures. Such a setting is conceived as possessing a high level Second Order Cognitive Holding Power, which encourages students to confront problems and practise and evaluate the assembly of new sets of specific procedures. The utilisation of second order procedures is transferable to other problematic situations and enables adaptation.

Thus, learning settings can be conceptualised in terms of the Cognitive Holding Power that they possess and Cognitive Holding Power can be differentiated as first or second order in terms of the cognitive procedures which learners utilise in responding to setting demands.

Three aspects of Cognitive Holding Power can be distinguished: the teacher may encourage an activity; the learner may feel impelled or have agency to undertake the activity or the learner may actually undertake the activity (Evans, 1991). If these three aspects are all present in the environment, for example, then Cognitive Holding Power may be different from the situation in which only teacher encouragement is present. Therefore, three basic forms of wording are used for items:

- The teacher encourages students to (undertake an activity)
- I feel I have to (undertake an activity)
- I (undertake an activity)

The research project

The research project employed here to illustrate the use of the CHPQ was funded by the Technical Foundation of America and involved six classes from five primary schools located on the Gold Coast, in Queensland, Australia. The schools were chosen as ones that had adopted the new Queensland state Technology Key Learning Area (KLA) syllabus, developed from the national Technology KLA curriculum (Curriculum Corporation, 1994).

The basis of school selection was that the teachers in these schools were regarded by the state Technology Advisor as having developed and implemented good technology education programs. One issue in administering the CHPQ with primary students was in having confidence that their responses were related to technology and not some other subject, given the more flexible boundaries between subjects within primary schools. To reduce any effect, data were collected at the conclusion of a significant technology project and it was made clear to students that the questions were about the technology activity only.

Design activities

There were a range of design activities across the five schools. One activity that was typical of those used, was based around a design brief to research, design and construct a stand and the associated signage for marketing an Australian product to an Asian country of the student's choice. The stand had to be able to be flat packed for air transport and had a number of other requirements. Students had to select a country and research the kinds of products that might be suitable and how they might be marketed in a culturally appropriate way.

Findings

The research project found that students from these Technology Education classes perceived themselves to be engaging in more higher order thinking than lower order thinking. The results were compared with those from another study by D'Netto (2004) (See Table 1 below) where the CHPQ was used to examine thinking among students involved in a curriculum initiative called New Basics. New Basics had similar aims to the new Technology Curriculum in terms of encouraging higher-order-thinking.

Table 1: Cognitive Holding Power in Different Studies
(Means with Standard Deviations in Brackets)

Study	SOCHP	FOCHP
Primary Technology Education (Current Study) (n =139)	3.51 (0.51)	2.77 (0.53)
Middle School New Basics (D'Netto, 2004) (n = 227)	3.35 (0.48)	3.06 (0.51)
Total (n = 336)	3.41 (0.49)	2.95 (0.54)

Students in the primary Technology study reported that they felt they had to solve problems by themselves, that the teacher encouraged them to solve problems by themselves and that they actually did solve problems by themselves. Conversely, they reported fewer instances where the teacher told them what to do, or feeling that they needed to follow directions. These findings suggest that the learning activities drew on 2^{nd} order CHP (Higher order thinking) more than 1^{st} order CHP (Lower order thinking) and to a statistically significant degree.

Why is the CHPQ is good for examining thinking in Technology/Design and Technology?

There are a number of reasons the CHPQ appears to be useful in researching thinking across primary Technology/Design and Technology education students. The language of the questionnaire is very accessible, unambiguous and of the kind students can relate to their experiences in school. 'The teacher encourages me to solve problems by myself' is clear in its meaning. The questions are also ones the students perceive as relevant to their classroom experience. There is also a good match between the questions and tech learning activities. The nature of problem-solving in some school subjects can be abstract and removed from students' experiences, but relating to the statement: 'I solve problems by myself' in Technology education is something students appear to have little difficulty in doing. Two sources of evidence are advanced for these conclusions. Firstly, there were no requests for clarification of questions in the study and an almost zero rate of unanswered questions. Finally, the CHPQ is useful because it provides quantitative data about what is otherwise anecdotal evidence or evidence from studies that cannot rule out bias.

Conclusions

CHPQ is suggesting that higher order thinking is strongly correlated with student perceptions that they have a strong ownership of their own learning (engagement) and that good Design and Technology learning activities that motivate students engage students in meaningful higher order thinking. Design and Technology teachers have known from observation that their students were engaging in activities that were personally meaningful. The problem has often been in convincing decision-makers, school authorities, and policy makers of the value of the learning area. The ability to provide data from large samples that illuminates a central and as it happens, a positive, element of the complex interactions that comprise Design and Technology learning activities is the important contribution the CHPQ can make to Design and Technology education research, practice and advocacy.

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