Investigating an assessment model for a design approach to technological problem solving among senior phase learners in Mafikeng area project office of the North West province

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Problem solving, and technological problem solving in particular, is clearly a critical survival skill in our technological advanced world. Government, business, vocational and technological education leaders have increasingly called for more emphasis on higher order thinking skills and problem solving in both general and technological areas.

The purpose of this study was to better understand the problem solving approaches. An assessment model was developed to capture observable student behaviour that indicates critical incidents in design activities. The methodologies and research instruments used in this study were designed to yield model for assessing student problem solving in design activities.

The study sample was comprised of ninety senior phase learners from grades 7,8 and 9. The sample was proportional in the sense that it comprised of eighteen learners from one school having nine boys and nine girls.

After an orientation to the activity, students engaged in a process of solving the problem. At the conclusion of the activity, each group made a formal presentation in which they described how effectively their design approach met the assigned constraint learner explained their interpretation and refinement of the design constraints and described the process that they used to research possible solution to the problem.

An activity questionnaire was administered to all learners to assess individual student response in technological problem-solving situation. The data were also analyzed by grade level using frequencies and percentages.

Overall group performance was assessed using the rubric. The group overall performance was calculated. The findings of the study indicate that, while some area of performance is strong, other areas could benefit from additional intervention and focus. While the generalizability of the results is limited, the findings suggest that the profession could benefit from more instruction and assessment on teamwork and group processes.

In the group evaluation rubric
- All members of the group contributed to the process
- The group was able to incorporate diverse personalities and idea

Qualitative data was collected from performance assessment instruments, the closed ended questionnaire for learners regarding teamwork.

Purposeful sampling involved five schools. Eighteen learners per schools totaling 90 learners in all. Learners worked in three groups of six, in each of grades 7, 8 and 9. A total of ninety learners were sampled.

The assessment model developed and tested in this study was shown to hold promise as a reliable and useful tool for analyzing important component of technology problem solving activities and should be
of benefit to the profession. The potential benefits range from aiding the identification of quality instructional materials to assisting in the preparation of technology education teachers. Without adequate assessment procedures, technology education cannot reach its full potential and it will continue to struggle for recognition and acceptance with the greater educational community.

Introduction

Problem solving is a set of thinking skill and human activities. Waetjen (1989), for example, proposed a solving model based on the work of Polya (1971); Philpot and Sellwood (1987), involving defining the problem, reforming the problem, isolating the solution, implementing the plan, restructuring the plan, and synthesizing the solution.

Savage and Sterry (1990) proposed a problem-solving model with the premise that humans depend on technical means for survival. Problem solving occurs in various ways, depending on the task and the context. Custer (1995) classified problem solving activities by complexity and goal clarity where design, has become a predominant problem solving process in the technology education laboratory-classroom.

MacPherson (1998) explored factors affecting another form of technological problem solving, near transfer troubleshooting. He developed a rubric to assess critical incidents in various stages of problem solving activities associated with maintenance activities performed by technicians. This rubric contained critical incidents on a continuum from novice to expert levels. Findings indicated that years of experience, cognitive technical knowledge, and critical thinking were effective predictors of near transfer problem solving skills while cognitive style and problem solving style were least likely to predict problem solving activities. Results indicated that novices and experts exhibited different patterns of behaviour. The assessment rubric to be used in this study was based on the MacPherson study model.

Assessment is a process that uses information gathered through measurement to analyze or judge a learner’s performance on some relevant work task. The process can also be applied to a systematic examination of materials, programmes, or activities for the purpose of formulating a value judgment about their suitability for a particular application.

In response to public and political pressure to assure accountability and reduce expenditures, assessment of educational programmes is viewed as being increasingly important (Lewis, 1995; Sewall 1996). It is therefore essential that Technology education professionals be equipped with tools to effectively assess how instructional materials and teaching methodologies are facilitating learning (Custer, 1996).

A key element in the study of Technology and the development of Technological literacy is the task of solving problems. The Technological Method (Savage and Sterry, 1990), described in the conceptual Framework for Technology Education, spoke to the issues of how humans use technology to solve problems. The professional literature in the field of technology education is replete with references to problem solving and the importance of this intellectual process with the contemporary world. Therefore it is imperative that professionals in the field incorporate problem solving concepts and strategies as a significant element in curriculum design and implementations.

The task of solving problems can be undertaken in a variety of ways. Problem solving can be approached from simple trial-and-error efforts and range on a continuum to highly complex approaches. Many Technology educators espouse the need to create opportunities for students to learn multiple approaches to problem solving with movement toward the development of model to facilitate student growth in strong mental methods of inquiry when solving technological problems (Herschbach et al, 1989). Use of technological process, with associated thinking and problem solving skills, is often challenging to measure and accurately assess.
Main Findings

Identifying and specifying

- 27% of learners show limited or no understanding of identifying and specifying the problem or situation. They could not identify whom the design project could be designed for and what needs to be considered for design specifications.
- 40% of learners demonstrated a superficial view of what the problem entails and what is needed to be done. Learners indicated to have a limited knowledge on technical and aesthetic and user concerns
- 33% have good understanding of the task on hand. They demonstrated the capability to see a range of design opportunities and areas to be dealt with across technical aesthetic and use.

Generating and developing

- 40% of learners generate very limited ideas that indicate no development of ideas
- 27% of learners initially generate simple ideas that show limited development of ideas. There is no evidence of new ideas once the first has been presented
- 33% of learners generate a range of ideas which are explored to develop a final solutions

Evaluating

- 33% of learners displayed no attempt to deal with what they think will work well with their final solution and what they would do differently next time.
- 27% of learner indicated some limited evidence of evaluation being considered as work developed
- There is some balance as about 33% of learners showed clear evidence that evaluation is considered in developments. Some weighing of pros and cons.

Team working

- 13% of learners displayed little or no recognitions of the design task on addressing whole task as a group. They have limited evidence displayed of success in integrating ideas. There was no explicit attempt to work as teams
- 47% of learners indicated a patchy coverage of the whole design task. Some learners attempted to integrate ideas. There was some attempt at working as a team
- 40% of learners indicated a good coverage of whole task. There is some display of integrated decision making. Learners showed explicit intention to work as a team.

Materials and processes

- 7% of learners showed no understanding of materials and processes or how they can be applied in their design work
- 33% have limited insight into the types of materials and construction processes. Learners shown no idea of properties and how they can be exploited and applied.
- 60% of learners showed evidence of knowledge of range, but limited detail. They could apply with specific reference to names of materials and properties.

Structures

- 13% of learners showed no understanding of the function of basic structural components.
- 26% demonstrated little or no knowledge that stability is affected by the size of the base angle, base size and distribution of load.
- 53% of learners could demonstrate understanding that load could be static or dynamic and the effect that these have on structure.
- 1% of learners showed good understanding on the use of conventional and composite materials to design structures which are able to meet specific designs

**Communication and graphics**

- 13% of learners showed lack of appropriate technical design and developmental skills, technical language
- 47% of learners lack of meet the given needs, purpose and design specifications.
- 33% learners managed to integrate drawing and notes to affectively communicate and justify design process
- 7% of learners use their understanding of 2D and 3D instrument drawing, visual and spatial perception to produce simple working drawing

**Recommendations**

- Learners should be made aware to explore ways to capture understanding of technological content as part of the problem solving process
- The Department of Education should develop mechanisms for assessing learner over an extended time period to determine to what extent their problem solving performance changes as a result of doing design activities.
- Educators should examine how they currently assess learners and what critical incidents they can identify in their assessment.
- Learners should be exposed to see many design opportunities. They should be shown a good trip of technical, user and aesthetic issues and the need to compromise and optimise
- There is a need for comprehensive coverage of design tasks. Ideas need to be integrated especially for supportive interactions.
- Learners must be supported to develop reflective skill in the way in which they can assess both the outcomes of their task and the progress they have made.
- There is a need to examine the role of group process in assessing learner performance
- An activity must allow learners to develop the problem or task for themselves and on the basis of this perceived task, construct a shared reference regarding the task and its solution

**Conclusion**

In order to achieve the learning goal set out in the Revised National Curriculum Statements, the Technology classroom should change to encourage teamwork, open ended design skill and improved communications, our standard techniques for assessing learner design in addition to the product that results from these processes.

Information obtained from these models of assessment enabled us to construct a more comprehensive analysis of learner performance. Teamwork inherently requires working together with a variety of people; it is reasonable to expect some level of conflict. It is more difficult though to predict when and where conflict will arise. Therefore in order to provide appropriate intervention and instruction it is useful to monitor team progress continuously throughout the design project. In fact the majority of respondents commented positively on the design task and teamwork.
### Table 1. Assessment model.

<table>
<thead>
<tr>
<th>Overall Team Performance</th>
<th>1. All in all a weak performance</th>
<th>2. All in all an average performance</th>
<th>3. All in all a good performance</th>
<th>4. All in all an excellent performance</th>
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</thead>
<tbody>
<tr>
<td>IDENTIFYING &amp; SPECIFYING</td>
<td>e.g. Limited understanding of what is involved in the whole task, who the project could be designed for and what needs to be considered</td>
<td>e.g. Superficial view of whole task and needs to be dealt with. No breadth i.e. technical, aesthetic and user concerns.</td>
<td>e.g. Good understanding of task. See a range of design opportunities and areas to be dealt with across technical, aesthetic and user</td>
<td>e.g. See many design opportunities. Show a good trip of technical, user and aesthetic issues and the need to compromise and optimize</td>
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<td>e.g. Generate very limited ideas that show no development</td>
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<td>e.g. Generate a range of ideas which are explored to develop a final solution</td>
<td>e.g. Prolific, dynamic &amp; innovative in coming up with and taking ideas forward. Confident and persistent in developing final solution</td>
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<td>GENERATING &amp; DEVELOPING</td>
<td>e.g. Only identify S&amp;W when prompted and at a superficial level. No attempt to deal with them</td>
<td>e.g. Identify a small range of S&amp;W. Some evidence of these being considered as work develops</td>
<td>e.g. Identify a good range of S&amp;W. Clear evidence these are considered in developments. Some weighing of pros and cons</td>
<td>e.g. Identify S&amp;W throughout work, across technical, aesthetic and user issues. Addresses them to successfully push ideas forward.</td>
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<td>e.g. Little recognition of duty re whole task. Limited evidence of success in integrating ideas. No explicit attempt to work as team</td>
<td>e.g. Patchy coverage of whole task. Some attempt at integrating ideas, but some being ignored. Some attempt at working as a team</td>
<td>e.g. Good coverage of whole task. Appropriate integration of ideas. Integrated decision making. Explicit intention to work as a team</td>
<td>e.g. Comprehensive coverage of whole task. Ideas integrated especially re issues and S&amp;W. Explicit and effective team work</td>
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<td>- seeing S &amp; W; - dealing with S&amp;W; - compromise/optimize</td>
<td>e.g. Little recognition of duty re whole task. Limited evidence of success in integrating ideas. No explicit attempt to work as team</td>
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## APPLICATION OF KNOWLEDGE

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<td>- types (named materials and construction processes); - properties; - application</td>
<td>e.g. Show no understanding of materials &amp; processes or how they can be applied in their design work</td>
<td>e.g. Limited insight into properties of a minimal range and how they can be exploited</td>
<td>e.g. Evidence of knowledge of a range, but limited detail. Apply with specific reference to properties</td>
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### STRUCTURES

| -types (shell, frame); - properties; application | e.g. Show no understanding of the function of basic structural components | e.g. Demonstrate little/limited knowledge that stability is affected by the size of the base angle, base size and distribution of load | e.g. Demonstrate understanding that load can be static or dynamic and the effect that these have on structures |

### COMMUNICATION AND GRAPHICS

| -types (systems ); - properties; - applications | e.g. Show lack of appropriate technical design and development skills, technical language | e.g. Conventions for product development lack to meet given needs, purpose and design specifications | e.g. Integrate drawings and notes to effectively communicate and justify design decisions | e.g. Use their understanding of 2D and 3D, instrument drawing, visual and spatial perception to produce simple working drawings of prototypes |

## References


