Students as Users and Designers: Product Evaluation and Redesign by Indian Middle School Students

Farhat Ara, Chitra Natarajan and Sugra Chunawala

Homi Bhabha Centre for Science Education, TIFR, Mumbai, India

farhat@hbcse.tifr.res.in, chitran@hbcse.tifr.res.in, sugrac@hbcse.tifr.res.in

This paper describes middle school students' participation in structured activities for testing, evaluating, categorising and redesigning familiar products. Six students of Class 8 worked in 3 dyads each, on a set of 4 products performing similar functions, to evaluate, compare and redesign them. The entire interaction of each dyad was audio and video-recorded. Textual and graphical data were in the form of structured responses and redesign proposals, respectively. Findings suggest that dyads tested the products for their efficiency and generated criteria related to their functions and ergonomics. Their testing varied from the most systematic to unsystematic strategies. They categorised the pairs of tongs either based on their appearance, functions or ergonomics. All students identified features in the products that could be redesigned. Students also showed a tendency to propose their redesign ideas around their selected best product design. The findings in the study are tentative and should be interpreted with caution. Finally the pedagogical implications of the study are discussed.

Keywords: Design and technology education, Indian middle school students, Product evaluation, Redesign strategies

Introduction

We are witness to an ever increasing number of technological products. From the wide range available, we need to make decisions about the kinds of products that we want. What will enable us to have a critical attitude towards technological products and be able to make informed and rational decisions about them? While Senesi (2000) argues for the need of new abilities in the world driven by technological innovations, Jarvis and Rennie (1998) consider design and technology (D&T) vital in developing knowledge, understanding, technical and interpersonal skills essential for future citizens in the present society. The National Curriculum for England (Garvey & Quinlan, 2000) identified ways of developing this D&T capability in students: through *assignments*, which affords designing and making products, through *focussed practical tasks* in which students develop and practice particular skill and knowledge, and through *activities* in which students investigate, disassemble and evaluate different products. The latter affords understanding the designed world through evaluation of products.

Martin (2007) suggests that product evaluation allows students to appreciate the ways in which different products meet the same need, see how their own work relates to the world around them, develop observation and communication skills and widen their 'success criteria'. Besides, evaluation of products raises awareness among students, of the possibilities, the materials and processes used, function and fitness for purpose and the values inherent in the making and marketing of products.

Product evaluation may involve investigation, identifying strengths/weaknesses, justifying, prioritising, recognising conflict, testing ideas and communicating. Systematic and rigorous evaluation is based upon the considered selection of criteria such as, *choice and use of materials*, *aesthetics of the outcome*, *values of the makers and users, quality* and *function* (Ritchie, 1995). Barlex (2007) provides a framework that can be used as an interrogative tool for evaluating any product. The framework consists of a comprehensive list of questions pertaining to the *technology, people's needs and wants, the society* and *the market*.

In professional fields, product evaluation is usually employed by product developers/industrial designers for improving a product line or proposing a new one (Crismond, 2001), or by 'focus groups' including designers and target users to the designer's ability to empathise with a wider variety of users and contexts (Denton & Mcdonagh, 2003). McLellan and Nicholl (2009) found that product evaluation is a starting point in most D&T classrooms in schools. They argue that product evaluation as an idea generation strategy restricts thinking and can lead to fixation among children. Crismond (2001) however, argues for the potential of product evaluation activities in inspiring naïve designers to identify features/ mechanisms in the products that can be adapted/ redesigned while they explored these products. Literature also suggests the potential of product evaluation in developing self-esteem of children (Garvey & Quinlan, 2000), revealing stereotypical views concerning technology from a range of cultures (Siraj-Blatchford, 1995), exploring value judgements (McLaren, 1997),

developing technological literacy (Martin, 2007), identifying underlying socio-cultural factors influencing design (Moalosi, Popovic, & Hickling-Hudson,2007), identifying strategies used by students while exploring unfamiliar products (Ara, Natarajan, & Chunawala, 2009).

The Study: Aim and Motivation

The activity described in this paper was inspired by Crismond's (2001) study. However, while Crismond worked with designers, our study is with middle school students, without D&T in their curriculum. While Crismond observed how the designers learnt and used science concepts while investigating and redesigning products, our study aimed to explore the nascent criteria that students use while evaluating everyday products. Our study also aimed to explore the strategies employed by the students in testing and redesigning the products. The motivation for this study came from our previous work with 25 middle school students who worked in groups to identify the functions of 3 unfamiliar knife sharpeners (Ara et al., 2009). The present work was undertaken to study fewer children (working in dyads, instead of in groups) and explore students' evaluative, testing and redesigning strategies of familiar products.

Research Questions

The following research questions guided the study:

1. What do students employ while testing a given set of familiar products?
2. What criteria do students generate while categorizing the given products?
3. What criteria do students generate for evaluating the given products?
4. What strategies do students employ while redesigning the given products?

Methodology

This was a small qualitative study, wherein students were interviewed in detail and their activities and discussions observed and recorded.

Sample

The student sample for the study was drawn from a school located in the vicinity of the researchers' institution in Mumbai. The sample consisted of 6 students (2 girls and 4 boys) from Class 8 (13-14 years of age). Students' participation in the study was voluntary. The language used by the researcher was English. Students were requested to work in single sex dyads. For the convenience of transcription, each student in all the dyads was labelled as either 'a' or 'b'. The student sitting on the right of the researcher was labelled as 'a' while the one sitting on the left as 'b'. For example, in dyad 1, the 2 students were labelled as D1a and D1b.

Products used in the study

A set of 4 products meant for similar functions (utensil lifting tongs), were used in the study (Figure 1). A pair of utensil lifting tongs is commonly known as *pakkad* in the national language (Hindi). These are commonly used in Indian kitchens for holding and lifting hot utensils without handles. The 4 pairs of tongs were labelled as T_A, T_B, T_C and T_D. While T_A, T_B and T_D had only one structural configuration, T_C could be rotated through 360 degrees to get another configuration which enabled lifting different kinds of utensils.

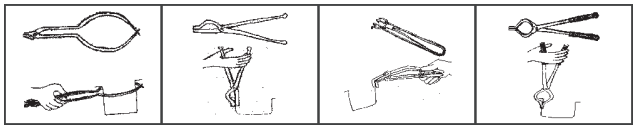

Figure 1: Artefacts used in the study with their working mechanisms

Procedure and Data Collection

The entire activity was carried out for 2/3 hours per day over 3 days. Each day only one dyad met the researcher after school hours. The 4 products were shown to the students and a sequence of activities was carried out as described below.

Identifying the functions of the given products and testing them: Students were asked to identify the functions of the given products. They observed/handled the pairs of tongs and suggested functions for each pair of tongs. If the function of at least one pair was guessed correctly, they were allowed to test the tongs on different kinds of utensils provided to them.

Categorising products: Students were asked to group the given pairs of tongs and provide reasons for their sorting. The aim of this activity was to identify the criteria that students use to classify the products and whether they were based on superficial or functional features.

Comparing products: In this phase students were asked to compare the tongs in each group that they had formed and suggest reasons for considering one pair better than the other/s.

Redesign: Students were asked to suggest improvements and redesign any or all of the four given pairs of tongs by sketching on paper.

Each student had to respond to a questionnaire individually, although they could discuss between themselves. Textual and graphical data were collected in the form of structured and semi-structured responses and redesign proposals, respectively. Students were also requested to think aloud. The entire interactive session with each dyad was audio and video recorded. Portions of the video were transcribed and corroborated with the written responses.

Results

Identifying the functions of the given products and testing them

Students in this phase were asked if they were familiar with the 4 products presented to them. Of the 4 pairs of tongs, T_D the most familiar (known to all dyads) and T_A the least familiar (known to only dyad 3, the girl dyad, who was familiar with all the 4 pairs of tongs). Students were expected to suggest/ predict the intended functions of the given tongs. While identifying the functions of the tongs, dyads 1 and 2 employed what we call *cognitive* and *handling* strategies (Ara et al., 2009). They used cognitive strategies such as suggesting ideas ('T_A is for digging'), using analogy ('T_D is similar to a pair of pliers'), and handling strategies such as probing the tongs with whatever was available at the moment (e.g. holding a pencil or one's own t-shirt with T_A).

Testing the products

A skill very closely related to evaluation is testing (Gustafson, Rowell, & Guilbert, 2000). Testing could involve: 'testing the performance of a product'; 'conducting trials', or 'assessing the effectiveness of a product' (Johnsey, 1995). In this phase, students were provided with 4 kinds of utensils-smaller rimmed and rimless, larger rimmed and rimless utensils. The aim of this phase was to allow students to test the pairs of tongs on the utensils. The 4 pairs of tongs were tested by the researcher on the 4 utensils to check for their ease of handling (Table 1).

Abstracted view of utensils Pairs of tongs	small rimless	small rimmed	large rimless	large rimmed
T_A	✗	✓	✗	✗
T_B (2 orientations)	✓ ✗	✓ ✗	✓ ✗	✓ ✗
T_C (2 configurations)	✓ ✗	✓ ✓	✓ ✗	✓ ✓
T_D	✓	✓	✓	✓

Table 1: Pairs of tongs tested on utensils to check for ease of handling (tested by researcher)

Thus, T_A could lift only small rimmed utensil, while T_D could lift all the 4 utensils. T_B, in one of its orientations (flat side inside the utensil) could lift all 4 while in the other orientation (round side inside the utensil) could lift none. Similarly T_C in one configuration could lift all 4 utensils while in the other configuration (rotated through 360 degrees) could lift the rimmed utensils only.

Variable 1 (pair/s of tongs)	Variable 2 (kind/s of utensils)	Labelled as	Dyads who used it
1	1	1 on 1	dyad 2
	2	1 on 2	dyad 1
	4	1 on 4	dyad 1 & dyad 2 (twice at different times)
2	1	2 on 1	dyad 1 (twice at different times) & dyad 3
	2	2 on 2	dyad 1
3	1	3 on 1	dyad 1 & dyad 2
4	1	4 on 1	dyad 2
	4	4 on 4	dyad 3

Table 2: Testing strategies and their frequency of use by the 3 dyads

The testing strategies of the 3 dyads differed slightly. These strategies spread across the entire activity. Of the 16 possible testing options, 8 were used by the students in the study (Table 2). These varied from the most systematic testing strategy i.e. testing the 4 pairs of tongs on the 4 kinds of utensils (dyad 3) to unsystematic/discrete strategies such as testing only 1 pair of tongs on only 1 kind of utensil and judging about its effectiveness (dyad 2)

An important point to note is that the most 'systematic' testing strategy may not be the most optimal strategy. For instance, a student may visually notice that T_A cannot lift rimless utensils without actually testing it. Also the unsystematic strategies were used by some students to check their predictions about the effectiveness of particular pair/s of tongs in lifting particular kind/s of utensil/s. For example, dyad 2 students checked their predictions about the efficiency of T_B in lifting a heavy small rimmed utensil after filling it with water. Often each individual in a pair tested the tongs independently with the other partner watching. Both dyads 1 and 2 students were not very methodical in the beginning, but later used systematic testing. An important thing to observe was that though students in dyads 1 and 2 used unsystematic strategies, all the discrete strategies used by them taken together compensated for the limitation in one strategy.

Dyad 3 were systematic from the beginning. It was also observed that though dyads 1 and 2 tested the bigger utensils they did not include the size or weight as the criteria for evaluating the tongs in the later phase. Nonetheless, all the 3 dyads used the evidence acquired during testing, in generating both the categorising and evaluative criteria.

Categorising the Products

While sorting the nut crackers and bottle openers, Crismond's sample of designers generated several criteria (Crismond, 2001). The criteria used by the naïve teams were *familiarity, appearance* and *body parts* employed to use the devices. The novice teams sorted on the basis of which devices converted *rotary motion into translational motion.* The expert teams' criteria involved *engineering concepts, rational physics principles,* and a list of criteria such as *durability, manufacturability, quality of performance, complexity of design, context of uses.*

In the present study it was found that all the dyads sorted T_B and T_D together based on different qualifying criteria. Table 3 indicates the 3 dyads' criteria to classify the tongs.

As indicated in Table 3, dyad 1 classified T_B and T_D on the basis of only 1 criterion; *appearance,* dyad 2 used 2 criteria, the qualifying criterion being *function* (which utensils they could lift), and an additional criterion of *materials.* Dyad 3 used *ergonomics* (having a good grip) as their qualifying criterion and the additional criteria of *functions* and *materials.* While dyads 1 and 2 formed 3 groups and sorted T_A and T_C individually, dyad 3 formed only 2 groups by placing T_A and T_C together on the basis of *ergonomics* and *functional* criteria.

Comparing products

All evaluation depends on the ability to make comparisons (Baynes, 1992). These comparisons could begin by asking questions such as 'Which product works best? Looks best? Is most reliable?' etc. In this activity students had to compare the tongs in the groups formed by them and give reasons for considering one better than other/s. Dyads 1 and 2 had only one group which included 2 pairs of tongs (T_D & T_B) while dyad 3 had 2 such groups - (T_D & T_B) and (T_A & T_C).

Dyads 1 and 2 considered T_D better than T_B, on the basis of nearly similar criteria, namely *functional efficiency* (e.g. 'can carry all utensils better'), *multi-functionality* ('can be used for breaking/joining wires or holding/turning chapattis'), and *ergonomics* ('should have a plastic handle' and 'better grip'). Dyad 3, in contrast, suggested that T_B was better than T_D on the basis of only one criterion, *functional efficiency* (e.g. small gap will hold the rimmed utensils tightly or chances of slippage in T_D due to the presence of serrations on the inner side of the gripping part). Besides, dyads 1 and 2 also used another important *ergonomic factor* to suggest the problems with T_B. For instance, while the flat-round gripping part of T_B was intended for a better grip (as suggested by dyad 3 and its design), dyads 1 and 2 considered that a user required some time to consider which side of T_B (flat or round) should be placed inside the utensil for better holding and may therefore be unsafe when used in haste. In the second group proposed by dyad 3, T_C was preferred over T_A because of its *functional efficiency* in lifting both rimmed and rimless utensils.

Redesigning

Students were given the option to redesign any tongs that they thought needed improvement. They were asked to sketch both the original and redesigned versions of the tongs. All the dyads chose to redesign T_A T_B. Redesigning was done independently by each student. However, each student integrated the ideas generated during the evaluation phase. As improvements, students either suggested *addition of a new component* or *modification* in their redesigns.

	Group 1	Basis for categorisation	Group 2	Basis for categorisation	Group3
Dyad1	T_B, T_D	have similar structures (*appearance)*	T_A		T_C
Dyad 2	T_B, T_D	for carrying rimmed and rimless utensils *(functions)*	T_A		T_C
		made from metals *(materials)*			
Dyad 3	T_B, T_D	have good grips *(ergonomics)*	T_A, T_C	do not have good grips *(ergonomics)*	
		for carrying big and small, light and heavy, rimmed and rimless utensils *(functions)*		for carrying utensils which can easily fit in them *(functions)*	
		made from same material (*materials)*		chances of slippage *(ergonomics)*	

Table 3: Categories formed by each dyad with their basis for categorisation (words in italics are researchers' interpretation of students' criteria)

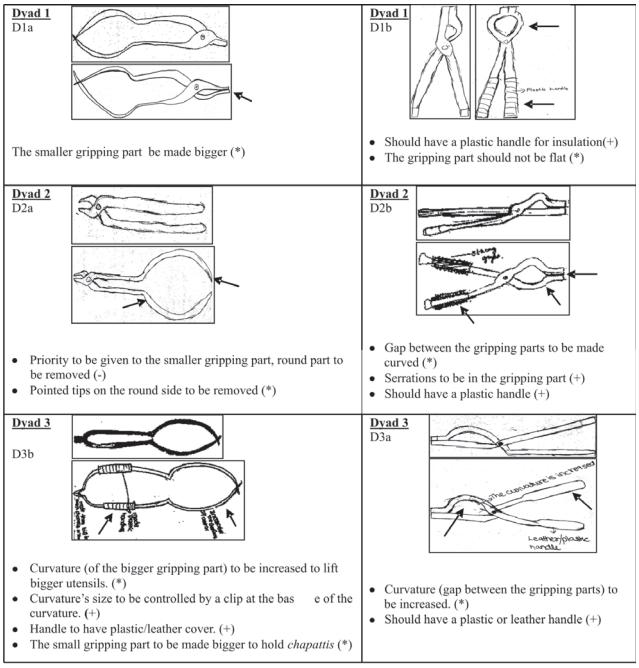

Table 4: Redesign suggestions by each dyad; Original (left/top) & Redesigned sketches (right/bottom) (changes shown by arrows) [parts: added (+); removed (-); modified (*)]

Using their experience and insights gained through the testing of the tongs, students redesigned their selected pairs of tongs by assuming the user's point of view. They mainly focused on achieving *functional efficiency* and providing better *ergonomics* users while using the tongs. Besides, students who were redesigning T_B tended to adopt a *linear redesign process* (non-iterative) by proposing their redesign ideas around their selected best design, i.e. T_D. Hence T_B in the redesigned version actually became T_D. Dyads 1 and 2 redesigned T_A by making it similar to T_D (Table 4). Dyad 3 suggested some radical changes while redesigning T_A such as, *modifications* in the size of the gripping part for lifting/carrying heavier utensils, *adding* an adjustable clamp or clip to adjust the size of the gripping part (not shown graphically but suggested in writing), and *adding* a plastic or leather cover on the handles. They also suggested increasing the gap between the gripping parts of T_B to enable lifting of heavier and bigger utensils (Table 4).

Conclusions

The present study reveals middle school students' varied strategies for testing, categorizing, evaluating and redesigning 4 pairs of utensil lifting tongs. Of the 4 pairs of tongs provided (T_A, T_B, T_C, & T_D), all the 3 dyads were familiar with the function of T_D, while T_A the least familiar pair of tongs. Students checked their predictions about the effectiveness of different pairs of tongs in lifting different kinds of utensils and a few strategies for testing the pairs of tongs ranging from systematic (testing all the 4 pairs of tongs on all the 4 utensils and concluding about its performance) to unsystematic strategies (testing one pair of tongs on only one kind of utensil and concluding about its performance). While studying students' (ages 5-14 years) ideas about how to test structural strength (in the pictures of two bridges), Gustafson et al., (2000) found at least 5 categories of responses but did not find any sequential stages of understanding 'fair' testing through which children progress. They suggest that children, in fact, may show many unanticipated routes to arriving at a full understanding of 'fair' testing.

All dyads used the data obtained during testing in generating both the categorising and evaluative criteria. The 3 dyads sorted T_B and T_D into one group based on different qualifying criteria. While dyad 1 classified T_B and T_D on the basis of *appearance,* dyad 2 used the criteria of *function* and *materials* and dyad 3 used *ergonomics*, *functions* and *materials* (the first criterion being the qualitative criteria in each case). While dyads 1 and 2 formed 3 groups and sorted T_A and T_C individually, dyad 3 formed only 2 groups by placing T_A and T_C together on the basis of *ergonomics* and *functional* criteria.

Of the 2 pairs of tongs (T_B and T_D) dyads 1 and 2 found T_D better while dyad 3 considered T_B better. The 3 dyads came up with several criteria to compare the products. Dyads 1 and 2 used a variety of criteria for evaluation, such as *functional efficiency*, *multi-functionality* and *ergonomics*, while dyad 3, considered T_D better on the basis of only *functional efficiency.*

In the redesigning activity, the tongs redesigned were T_A T_B, by each member of the dyad. As improvements, student either suggested addition of a new component in their redesign or suggested modification. All the 3 dyads seemed to have assumed the perspectives of users and mainly focused on achieving functional efficiency and providing better ergonomics to users while using the tongs. Dyads 1 and 2 adopted a linear approach to redesign and also tended to propose their redesign ideas around their selected best design, i.e. T_D. Even in case of T_A, dyads 1 and 2 redesigned T_A by making it similar to T_D. However, dyad 3 suggested more radical changes while redesigning T_A. They incorporated their insights obtained during the investigation and testing phases and tried to incorporate all the utensils provided (bigger/smaller, rimmed/rimless). Redesign activities provided opportunities for students to critically select features in the products that could be improved.

This being a qualitative study, the results should be interpreted with caution as the findings are tentative. A large number of cases may help in confirming the trends, while a variety of utensils may reveal different strategies. Repeating the study with other products would be enlightening.

Implications

Product and testing involves complex cognitive demands (Gustafson et al., 2000) since they require the ability to form mental models against which to make informed judgment and employ appropriate evaluation criteria (Anning, 1994).

Evaluation is also dependent upon language as it involves thinking and articulating those thoughts (Howe, Davies, & Ritchie, 2001). A range of testing opportunities might help students develop and recognize how a 'fair' comparison between products allows for more critical evaluation of design. Students working in groups can evaluate different sets of products and then communicate their findings to the class and discuss about their categorizing, evaluating and redesign strategies. Testing is also an important aspect of science activities. Setting up a fair test with products would allow students to understand how testing is carried out in science. If the products are unfamiliar, then it will allow students to form predictions regarding their working mechanisms before testing them. Redesigning as a starting point can be useful for children not having D&T in their classrooms. Instead of starting from the scratch by actual designing, which is full of uncertainties and risks and could result in frustrated naïve design students (Schön, 1987 in Crismond, 2001), redesigning could provide opportunities in finding about products, their strengths and weaknesses and suggest improvements.

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