# Brief Podium Papers

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# THE RIDDLE OF DESIGN PROBLEM

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**Abstract:** Problem solving is not a uniform activity. Problems are not equivalent, in content, form, or process. Still very less research exists on the nature of design problems children should be solving to learn the design process or to build a certain kind of creative ability for divergent thinking. In this paper we explore the differences of solving different design problems and its result on divergent thinking in children. The paper presents an investigation of middle school students' difference in design thinking process and design output for four different kinds of design problems. Twenty children of the age 11 to 14 participated in this study in four different groups. Each group solved a different kind of design problem.

A qualitative analysis of the responses was done and participating groups were judged on the parameters of understanding the design problem and ideational flexibility in their responses. Preliminary analysis of the experiment revealed students' lacked motivation to think beyond one solution. But comparative study shows difference between design outputs and number of variety of solutions generated for different design problems. The findings reveal that each design problem has its unique traits and it is difficult to choose one over the other. The paper discusses insights based on the outcome of this study and suggests a novel way of designing the instruction and the design problem in such a way that it encourages children to think creatively and to generate more solutions.

***Keywords:*** *collaboration, divergent thinking, problem solving, design pedagogy*

## 1. Introduction

Problem solving is not a uniform activity. Problems are not equivalent, in content, form, or process. An important aspect of problem solving is problem framing as suggested by Schon (1983). Problem framing involves making sense of the problem by the designer by imposing a frame on the situation and discovering consequences and implications of those chosen frames.

Most of the current research in design education seems to be defining the nature of design problems for high school or undergraduate design students with a focus on entering the professional world of design. Very less research exists on the kind of design problems children should be solving and why?

Many educators and researchers argue that design by students in schools is different from design by professional designers at workplace. Anning, Jenkins and Whitelaw (1996) contended that the constraints present in schools are different from those in the workplace. With constraints such as curriculum, examination and assessment requirements, Anning et al. mention that although the activities in schools are aimed at individual students, the resources are shared among twenty or more students unlike the designer's workplace. It has also been observed that while designers work on real problems in a highly contextualized situation for which they have considerable knowledge (Annning et al. 1996; Hennessy and McCormick, 1994; Hennessy and McCormick, 2002; Hennessy, McCormick and Murphy, 1993) and thereby have predefined goals to resolve, the design problems in schools are artificially constructed and are not relevant to students, thereby becoming meaningless to them. Archer and Roberts (1979) claim that design in schools is different from design in profession because of their different aims. They suggest that the aims of design educational activities are not to produce things and devices but the development of knowledge and understanding about design and the technological world. Children learning design and design thinking have a different goal i.e. to develop their creative, cognitive thinking and social skills to prepare them as creative individuals and not professional designers always. Largely, research on design problems has been in the area of engineering design or software design, which is well-structured than most design problems. It is not a generalizable model for patterning design problems across age groups and disciplines.

### 1.1. Design as a problem solving process

Jonassen (2000) describes a problem asone having two attributes. First, a problem is an unknown entity in some situation. Second, finding or solving for the unknown must have some social, cultural or intellectual value. Mayer and Wittrock (1996) described problems as ill-defined-well-defined and routine-nonroutine. Jonassen (1997) distinguished well-structured from ill-structured problems and articulated the differences in cognitive skills and processing for each. He explains, well-structured problems require the application of a finite number of concepts, rules, and principles being studied to a constrained problem. Ill-structured problems, on the other hand, are the kinds of problems that are not constrained by the content domains and hence their solutions are not predictable or convergent. They possess multiple solutions, solution paths, or no solutions at all (Kitchner, 1983). For many years, researchers (Reitman, 1965; Simon, 1973) have characterized design problems as ill-structured because they have ambiguous specification of goals, no determined solution path, and the need to intergrate multiple knowledge domains. Jonassen (2000) says that finding the unknown is the process of problem solving.

Problem solving is "any goal-directed sequence of cognitive operations" (Anderson, 1980, p.257). The problem solving approach has been adopted by design educators worldwide to teach design. This in turn has led to the development of stage-wise, algorithmic processes of design, from linear design processes (APU in Banks, 2007) to complex loop of interactive processes (e.g. Kimbell, in Banks, 2007). Proponents of design to be taught as problem solving tasks claim that it involves a general strategy which can be applied in a variety of differing contexts, and even in differing domains (Hennessy and McCormick, 2002). Design is not always problem solving it can be purely aesthetic in nature and may need a different type of thinking and skills. McCormick (2002) provides several problematic concerns when teaching design through a general problem solving approach. Teaching design with a general problem solving approach has also led to teachers' emphasis on teaching the procedural understanding rather than the conceptual understanding of design and creativity. Design involves a special kind of problem solving as it resolves ill-structured problems by converting ideas into products or systems. This was the main objective of our study to investigate different kinds of design problems to be explored for children in the age of 11-14 for divergent thinking and collaborative ideation.

### 1.2. Aims of the experiment

The aim of the experiment was to investigate the following:

1. The difference in performance as individual versus collectively solving the problem.
2. The difference in the design output and thinking for four different kinds of design problems.

### 1.3. Sample description

Twenty children of the age 11 to 14 from same socio-economic background, voluntarily participated in the experiment. Four groups were formed with almost equal distribution of girls and boys. Each group was given a different set of problem and each individual got a color coded diary to answer. Each group had five members and was asked to solve the problem individually first. Later, each group was provided a new color coded sheet to be used for collective ideation and presentation of their final solution.

### 1.4. Experiment Design

The experiment was divided into four phases:
Phase one (20 minutes): Introduction to 'What is Design?' Design as a tool for problem solving.
Phase two (30 minutes): Design Activity (Solve individually): Four groups were formed with five children in each team. Each team was assigned a researcher-team member to record and observe the activity. Each child solved the problem on his/her own in their respective diaries.
Phase three (30-35 minutes): (Solve together): They were asked to solve the problem collectively as a team by listing down all the ideas they thought of and then selecting one final idea for presentation.
Phase four (20 minutes): Final presentation: All the groups presented their ideas by first introducing their team members and sharing their problem, followed by the final solution.

The groups were colour coded. They were provided with a pencil and a colour coded paper diary which was folded in such a way that they could either use it like a page wise diary or a single sheet of paper. The method to open and use the diary was demonstrated to children by the researcher. Four different problems were given to children. Each group was given one problem each. One group solved only one problem. All the problems were different in nature as explained below. The problem were given verbally in Hindi and Marathi and then written on the blackboard for reference. Described below are the problem definitions and differences in terms of open-ness of the problem, structure (all the problems were ill-structured and open-ended with no particular procedure to solve), domain specificity and complexity.

**Group 1:** Pink: Product based problem
Design Problem: *Design a new school bag or a water bottle for yourself.*

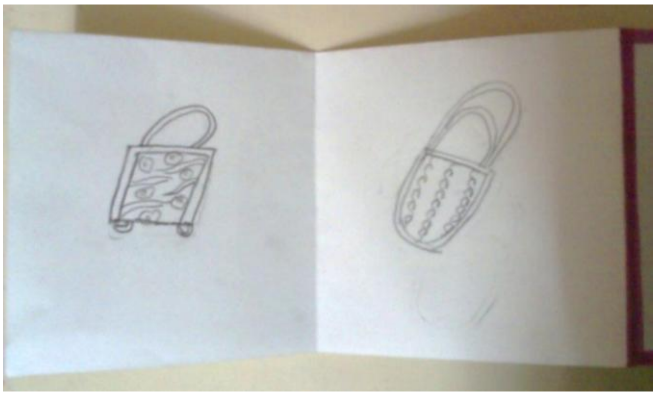

**Figure1.** Samples from product design team members

Definition: Product based problems are the ones where a final product or an artefact is aimed to be achieved. The product to be designed has an assigned and defined function or use which children are fairly familiar with. The product mostly exists, is known and a familiar object of use which is being asked for a (re)design for better performance. Also, there is an assumption that because you are so familiar and use it every day you will be able to think of improving the product as per your own needs.

**Group 2:** Green: Situation based problem
Design Problem: *An old grandmother loves to knit sweaters but her wool roll keeps falling down. Suggest (Design) as many ways to help the old grandmother as she has a severe back problem (she cannot bend).*


**Figure 2.** Samples from situation based problem team members

Definition: A situation based problem is more open-ended than a product problem. This provides the opportunity to the designer to think of a variety of solutions and not restrict to a product/artefact-oriented thinking. There is a possibility of variety of solutions like a service, product, a combination of both etc. The problem is picked from children's everyday life like a classroom, home, problems of people they can easily relate to like a friend, family members or teachers. The main task is to understand the obstacle or the problem which is situated in an existing situation and think of novel ways to improve the problematic situation.

**Group 3:** Red: Edward de Bono's design problem (DeBono, 1972)
Design Problem: *Suggest ways how you would stop a Dog and a Cat from fighting*.

According to Bono [3], this is a basic political problem of how to stop people with differences from fighting each other? The starting situation is very definite- there are cats and dogs which are distinct and which fight each other. The objective is also very definite- how to stop them fighting. What means would children use to try achieving this objective? As there are no traditional, stereotyped ways of stopping a cat and a dog from fighting, the problem is an ill-structured problem where children would have to think and solve the problem on their own.


**Figure 3.** Samples from Edward De Bono problem team members

Definition: According to De Bono (1972), problem solving is quite easy if you are given a definite objective which has to be achieved. Problem-solving is also quite easy if there is some obvious deficiency in a design and you are asked to get rid of that deficiency or fill in some gap. Problem-solving is rather difficult when all you are given is a general idea that you should improve an existing design. This becomes even more difficult when the existing design seems to be a very satisfactory one, as in the case of an everyday object, a bicycle.

**Group 4:** Yellow: Game design problem (Yasmin B. Kafai (Kafai, 2006)- Learning design by making educational games)
Design Problem: *Design as many games as you can, using a ball and three rubber bands.* The game should be played between 2-3 children together.

**Figure 4.** Samples from game design problem team members

Definition: Designing a game is not same as designing a toy (a product). The game will have rules, more participants and social interaction. Games are active experiences which children are involved into almost every day, and they have the capacity to provide intrinsic motivation. In a game design problem children work from beginning till the end, go through the entire process of problem solving, they get to interpret the problem, explore solutions, conceptualize and think of visual design as a package. Hence, as a design problem it offers a diverse variety of thinking strategies and design approaches to enable divergent thinking. Also, a game design problem can be solved in parts and brought together. It also encourages group participation as the task to ideate and produce the game is big and needs to be shared within the team members. Game design also gives more opportunity of combinations of different ideas in a group which may lack in a product design problem.

## 2. Findings and Discussion

Analysis shows a difference in understanding and performance of each group in different design problem groups. The groups have been analysed on their understanding of the task and the requirement that they had to generate as many solutions for the problem i.e, ideational fluency, ideational flexibility within the group and difference between individual and collective sessions.

### 1. Understanding of instruction and ideational fluency

**Table 1.** Understanding the problem and ideational fluency i.e. to think of more than one solution

| Problem | Task | More solutions | Observations |
| --- | --- | --- | --- |
| Pink: Product | ✓ | ✗ | They did not understand what they have to make. They struggled for a long time to think. Almost all of the solutions are on beautification. |
| Green: Situational | ✓ | ✗ | One girl thought of a solution and others followed. Only material changes were made. One boy focused on drawing than thinking of alternatives. |
| Red: De Bono's | ✓ | ✓ | Children understood the problem well and came up with multiple solutions. |
| Yellow: Kafai's game design | ✓ | ✓ | Children understood the task and explored with the material. But not all were able to do the task individually. |

Tick mark in Table 1 above means the children followed the instruction. The colour of the tick mark is like a scale to indicate the scale of understanding i.e. if the problem was partially understood then a light colour tick mark is used. Whereas, a cross implies they did not follow it completely or understanding was not appropriate.

Children with their limited exposure to formal creative problem solving tasks and open-ended design problems tried to solve the problems. There was a clear difference in the nature of problems which led to generating more solutions like De Bono's cat-dog and game design problem when compared to the product and situation problem where not many solutions were generated. Also, children struggled in understanding the task to be performed and how to solve it.

2. **Ideational Flexibility:** number of qualitatively different solutions produced appropriate to the problem

Analysis of the number of sketches, problem solving process and conversations revealed children performed better in problem solving collectively than individually. More discussions and approaches were tried to think of solutions in a group. In the product design problem the score of ideational flexibility was 3 individually and 5 on collective work. The situation team scored a 3 both individually and collective. De Bono's cat and dog fight problem scored an 8 individually and an 11 on the collective session. The game design problem scored 4 in the individual session and a 5 collectively. One of the reasons of better performance in a group could be looking at others solutions in the team and comparing it with your own solution which led to exposure to multiple possibilities. Collectively, they were able to distribute responsibilities, discuss, demonstrate, elaborate and interpret the problem which may be was a limitation when they were solving the problem alone.

3. **Unique traits of different problems**

We found out in the earlier snakes and ladders problem (Malhotra and Poovaiah, 2013) and school bag problem both, the object of redesign was so familiar and probably children were very satisfied with the product that they found it hard to think of alternatives. This may be because a clear gap or a deficiency was not provided as part of the problem and was expected from the children to find their own deficiencies in the product and hence improve. The school bag was sketched as a sling cloth bag and no new functionality was added to the bag. There were only decoration and artistic changes made to the designed bag. The reason for this could be the fact that they carry such cotton bags or polythene bags to schools. Later on talking with them we found that was not the only case but one of the research team members was carrying such a bag so they discussed and thought of making the same with different designs. Everyone in this group chose to draw as against writing.

In the situational problem only one of them (girl) was a thinker for the group and she told everyone to either copy her or make slight changes. The others very comfortably agreed and followed her. All the girls suggested using either a box or a bag (change of material- steel, plastic, cloth) for the old grandmother. In the collective session also, the group did not interact much with each other for ideation or any improvement for their final solution. They did not seem very interested in the task. The De Bono problem group was an active group of five members (two boys and three girls). There was a dislike within boys and girls. It was hard to make them work together. Till problem solving was at the individual level, there was pace at work but collectively they had to compromise and keep their egos aside to work together to win. Main themes were distraction, fear of someone more powerful and greed or by providing something that makes the animal happy (a woolen ball to play with). Another interesting solution was of bonding, love and getting them married. Together in the collective sessions in order to win they worked politely but with differences of opinion which resulted in newer solutions like a see-saw.

In the game design group, the girls were stuck with putting rubber bands on the ball and kept drawing the same, whereas, the boys were curious and attempted to explore options and think from a game point of view. But once they all came together, they started with listing their ideas which led to questions, discussions and explorations as one was explaining his idea to the group members. They started out blank but a lot of demonstration happened to explain each other. This led to discussions, arguments and a few but more ideas.

This study led us to think about the role and need for a 'construction set' in design problem solving process? Is this an important factor leading to solutions? In the game design problem, they may have used the material provided as a lead to design thinking. But on the other hand, there is also a possibility that they were overwhelmed by the materials and kept thinking within the constraints of the material. This may also lead to use of material only once and hence most likely to produce only one solution to an open ended problem. Our aim is to engage children in such a thinking process that they spend more time thinking about the problem and possible ways to solve the problem than to get tangled in the construction sets provided. The design without-make unit was initially proposed by David Barlex and is based on Young Foresight (Barlex, 1999). This is a recent design and technology initiative in England. It challenges orthodox approaches to teaching design and technology which rely on design and make assignments where a construction set is required. The design-without-make units are focussed practical tasks and product analysis exercises where pupils design but do not make; pupils design products and services for the future; pupils use new and emerging technologies in their design proposals; pupils write their own design briefs and pupils work in groups.

Barlex's study is a longitudinal study with a formal 6 weeks training module. Whereas, our study with protocols will focus on short term brainstorming kind of sessions and hence generate insights only on small tasks. The same collaborative conditions and proposed structures will be tested separately for longitudinal studies and formal design education.

## 3. Conclusion

As the first exposure to formal creative problem solving, the children showed a potential for creative work and collaboration. Most of the individuals took time to understand the task and its requirements. The understanding and ideation improved when children formed groups and discussed each other's solutions. Children lacked motivation to think beyond one solution. One solution solves the problem so why think of another one was the attitude. With instruction and exposure to creative problem solving, children should be motivated to think for alternate solutions.

The comparative study clearly shows difference between design outputs and number of variety of solutions generated for different problems. The findings reveal that each design problem has its unique traits and it is difficult to choose one over the other. Each problem type can be designed in a way that it encourages children to think creatively and construct more solutions. Game design as a design problem opens up a range of design elements that can be thought of for creative thinking. In conclusion, we have designed a structure of design problem such that it includes pros of all the problems tested in the study. In our later studies with the same children we are testing combination problems with base as a game design problem which is situation based and familiar to children with a twist of curiosity to solve for the unknown. We also recommend that other problems can also be explored not as combination and tested by improving the instruction and problem.

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