

## EVOLUTION OF A COMPUTER EVALUATION TOOL IN CONTEXT WITH SCOTTISH INDUSTRIES

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### 1. Introduction

Design evaluation in Conceptual design phase is in evolutionary phase in industries. Systematic approaches to concept selection have slowly started finding their niche. The idea of computer-support towards such activity is thought of to expedite this process. In this research paper, we present the current status of a research project that aims at implementation of computers in Evaluation of Concept designs. A Questionnaire was sent to a range of various Scottish industries. The Questionnaire contained 3 sections that threw light on the following:

1. Importance of Conceptual design phase in industries.
2. Knowledge of CAD in the company.
3. Need of computer based evaluation [Mamtani & Green 2003] in the company.

Questionnaire [Robson 1993] approach is a common method used in research to obtain data or information, especially from industries. We look at some of the previous Questionnaire approaches and their results to know the importance of Design evaluation in Conceptual design phase.

Taylor & Ben [Taylor & Ben 1993] investigated the evaluation for conceptual and embodiment phase of design. They prepared a questionnaire for the industrial survey that involved 24 companies. 42 engineers replied to the questionnaire. 70% had replied affirmatively for the difficulty faced during evaluation in early design phases, 45% did for the later phase of conceptual design and 35% for the detailed design process. For the question on the requirement of methods to aid evaluation, 79% mentioned for a need of methods in early conceptual design phase, 74% did in later conceptual design phase and 74% for the detailed phase of design.

The Questionnaire responses also led to the fact that the current evaluation techniques were not being used extensively in most of the companies.

Bjarnemo [Bjarnemo 1991] did a survey of 10 Swedish industries germane to importance of evaluation. The research was carried out for the purpose of establishing the facts for the requirement of an effective evaluation tool. The main topics of the questionnaire were:

1. Characteristics of companies surveyed.
2. Use of formalized techniques in product development.
3. Methods and techniques used during Evaluation.
4. On the need for improving the evaluation procedure in the companies.

Formalized approach meant that the process was documented. The results of the Questionnaire showed a consensus on the requirement of an effective evaluation tool to further the effectiveness of the Evaluation process.

The above references have shown and established the importance of Conceptual design evaluation. Our Questionnaire differs from their approach in the sense that we look forward to the implementation of computers in Conceptual design evaluation. Since it has been shown that formalized methods (Documented method) are not followed in Evaluation, we prepared the questionnaire to know the

acceptance of computer-aided tools in Design evaluation. An assumption is made of the availability of a design evaluation tool that can be embedded in the conventional CAD packages. The CAD tool being envisaged would contain various modules out of which our focus is on the one that would help in Design evaluation in Conceptual design phase.

Evaluation tool here is spoken in terms of evaluation of criteria to select from a range of concepts. This tool is envisioned to either contain rules to evaluate criteria or perform a general design evaluation in conceptual design phase using the available Concept Selection Methods. They were asked if they would use this CAD tool, the aim being to determine the latent need for such a tool within industry. Along with this question, there were other questions that aimed at finding the desired information mentioned earlier in this section.

## 2. Design Evaluation in Conceptual design phase

In simple words, Design evaluation in Conceptual design phase is a decision-making process whereby the concepts are selected using various decision-making models.

Design evaluation by Green [Green 1994] has been defined as:

“The process of trying to determine the results of prior decisions, via analysis, in terms of the design constraints and to provide knowledge and information to enable future decisions. It involves, particularly during the conceptual phase, both the identification of the present state of the design with respect to the desired final state and also the ability to forecast, or predict, the likelihood of the design progressing from its present state to the next identifiable state or to the final desired state, within defined time scales, given knowledge of resources and abilities.”

Bjarnemo [Bjarnemo 1994] writes about Evaluation as a procedure that comprises of Evaluation and decision-making, whereby Evaluation and Decision-making are defined as:

“EVALUATION – Process where the objective is to determine the overall value for each and every one of the available solution proposals with respect to the evaluation criteria, with the objective of achieving a preference order or ranking of the proposals.

DECISION-MAKING – Process during which the “best” solution is identified and selected, based on the results obtained during the evaluation activity.”

## 3. Computer Aided approach to Design Evaluation

Design evaluation in conceptual design phase is either qualitative or semi-quantitative. We are trying to simulate the semi-quantitative techniques using computers to evaluate various concepts against criteria in consideration. This would help to reduce the design time in the Conceptual design phase and increase the accuracy of the decision-making as well.

## 4. Questionnaire results

The Questionnaire was initially sent to 3 companies and with the help of their feedback, the Questionnaire was revised. Then it was sent to 20 companies in Scotland. We received replies from 12 companies, including the first 3 companies. The companies short-listed were design consultancies and manufacturing industries (Large, medium and small) in Scotland.

Table 1 lists the companies that answered the Questionnaire and their types.

**Table1. List of Companies**

Type of company	Name of Company
Manufacturing company	A, B, C, D, F, I, J, K, L
Design consultancy	E, G, H

The companies have been named as A, B, C and so on to maintain their anonymity. A few of the companies that came up with highly positive answers were followed up with interviews so as to get the reasons for their answers. The resulting more detailed information could then be contrasted with the reasons for a negative response from the other companies.

One of the important questions asked was on the importance of conceptual design phase amongst all the phases of design. The companies were asked to prioritise amongst a number of design phases i.e.

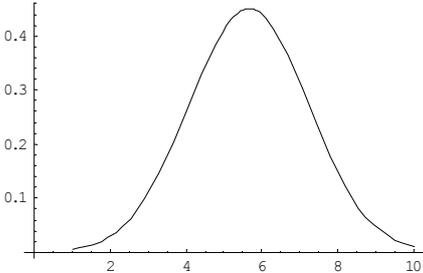
generation of product design specification, conceptual design phase, Embodiment design phase and detailed design phase. All the companies rated conceptual design phase as the most important phase. The other important question asked to the companies was on the requirement of a computer-aided design evaluation tool. An assumption is made of the availability of a design evaluation tool that can be embedded in the conventional CAD packages. They were asked if they would use this CAD tool, aim being to determine the latent need for such a tool within industry. The options given to them were on a fuzzy scale [Zadeh 1965] ranging from 1 through 10. 1 meant Definitely No and 10 meant Definitely Yes. Let us rate the answer to this question as  $\beta$ . Table 2 lists the answers  $\beta$  on fuzzy scale received from the companies.

**Table 2. List of Answers  $\beta$**

S. No.	Company	Type of company	$\beta$
1	A	Manufacturing	7
2	B	Manufacturing	2
3	C	Manufacturing	4
4	D	Manufacturing	10
5	E	Design consultancy	6
6	F	Manufacturing	10
7	G	Design consultancy	6
8	H	Design consultancy	5
9	I	Manufacturing	6
10	J	Manufacturing	5
11	K	Manufacturing	4
12	L	Manufacturing	3

The Mean  $M$  and Standard Deviation  $SD$  for this population are:

$M = 5.66$ , and  
 $SD = 2.46$



**Figure 1. Normal distribution curve for answers  $\beta$**

A Normal distribution curve for the population is shown in Figure 1.

We calculate separate “means” of the answers  $\beta$  provided by the Manufacturing industries and Design consultancies.

$M_m = 5.66$  where  $M_m$  is the mean of the answers  $\beta$  provided by the Manufacturing companies.  
 $M_d = 5.66$  where  $M_d$  is the mean of the answers  $\beta$  provided by the Design consultancies.

We calculate the means based on the size of the components manufactured. We shall not consider the Design consultancies for this estimation and comparison. Table 3. lists the manufacturing companies with their size based on the components manufactured.

**Table 3. Answers  $\beta$  based on the size of components manufactured**

S. No.	Company	Based on the size of components manufactured	$\beta$
1	A	Medium sized (mm)	7
2	B	Medium sized (mm)	2
3	C	Medium sized (mm)	4
4	D	Large sized (lm)	10
5	F	Large sized (lm)	10
6	I	Small sized (sm)	6
7	J	Large sized (lm)	5
8	K	Small sized (sm)	4
9	L	Large sized (lm)	3

$M_{sm} = 5$  where  $M_{sm}$  is the mean of the answers  $\beta$  provided by the Small sized manufacturing companies (sm).

$M_{mm} = 4.33$  where  $M_{mm}$  is the mean of the answers  $\beta$  provided by the Medium sized manufacturing companies (mm).

$M_{lm} = 7$  where  $M_{lm}$  is the mean of the answers  $\beta$  provided by the Large sized manufacturing companies (lm).

Table 4 lists and sorts the companies on the basis of Turnover of the company. Means calculated on the basis of turnover of the company are as follows:

$M_{st} = 5.66$ , where  $M_{st}$  is the mean of the answers  $\beta$  provided by the Small sized Turnover companies (st).

$M_{mt} = 5.33$ , where  $M_{mt}$  is the mean of the answers  $\beta$  provided by the Medium sized Turnover companies (mt).

**Table 4. Answers  $\beta$  based on the turnover of the companies**

S. No.	Company	Based on the turnover of the company	$\beta$
1	A	Medium sized (mt)	7
2	B	Medium sized (mt)	2
3	C	Medium sized (mt)	4
4	D	Medium sized (mt)	10
5	E	Small sized (st)	6
6	F	Large sized (lt)	10
7	G	Small sized (st)	6
8	H	Small sized (st)	5
9	I	Medium sized (mt)	6
10	J	Large sized (lt)	5
11	K	Large sized (lt)	4
12	L	Medium sized (mt)	3

$M_{lt} = 6.33$ , where  $M_{lt}$  is the mean of the answers  $\beta$  provided by the Large sized Turnover companies (lt).

The data accumulated is meant to decipher the variation in the views of various industries with respect to their types. We have received a range of answers, varying from 3 to 10. The answer 10 also makes

us ponder on the requirement of such a tool in that particular industry. This analysis is meant to put forward the type of industries that may look forward to research and progress on this tool.

These companies were also asked to prioritise some important criteria that are considered during the design evaluation. They are Quality, Reliability, Maintainability, Manufacturability, Ease of assembly, Performance and Cost. These criteria were to be rated and prioritised as per the company's importance. Table 5. presents the list of first three criteria prioritised by the companies.

**Table 5. Prioritisation of criteria by companies**

S. No.	Company	First 3 criteria prioritised
1	A	Performance, Reliability, Quality
2	B	Reliability, Cost, Performance
3	C	Reliability, Quality, Ease of assembly
4	D	Performance, Reliability, Quality
6	F	Reliability, Performance, Quality
7	G	Cost, Quality, Manufacturability
8	H	Performance, Manufacturability, Cost
9	I	Cost, Quality, Reliability
10	J	Quality & Cost, Performance, Reliability
12	L	Cost, Reliability, Performance

Companies E and K did not opt to answer the above question.

#### 4.1 Interviews

Companies A and F were visited to know the reason for their assertive answers. When conversed with their personals, it seemed as though design evaluation tool was a necessity and that without which arbitrary techniques were used. These techniques belonged more to the gut feeling and experience of the designers. The companies had to pay for such a technique sometimes when the concept did not ultimately meet the expectations of the Product Data Specifications and the business objectives. They also started realising this and have begun to look forward to applying formalized evaluation techniques for their next upcoming products.

They were also enthused at the idea of using computers during such an activity and it seemed that such a tool was more than welcome, provided it was interactive, user friendly and applicable to the specific industry needs.

#### 5. Conclusion and future work

The research paper reinforces the importance of Design Evaluation in Conceptual design phase. The Questionnaire results from various Scottish companies involved in Manufacturing and Mechanical engineering design have been presented. Various "Means" have been calculated to show the difference in the views of various sub-categories of industries.

The next step of this research project includes developing a software tool that would help to evaluate concept designs. As discussed with the companies' personnel, this generic computer tool would be welcome if it is user friendly, flexible and adaptable to the specific industry needs. Efforts have been put into making such a software tool. The tool would include some existing methods used for evaluating design concepts. It would also contain the six step methodology proposed by Green[Green, 2003] to allow testing etc. in industries before final version.

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