A Novel Frame Work of Design Realization Course at IIITDM Kancheepuram: Critical Evaluation

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Abstract Consistent evaluation and analysis of academic courses is a good practice in order to make the content more relevant to the current needs of industries and academia. In this work, "Design Realization Course" at IIITDM (Indian Institute of Information Technology Design & Manufacturing) Kancheepuram, which is a part of the novel curriculum, framed for the undergraduate engineering studies, is taken as the subject for critical evaluation. A thorough user study is done for 6 months using contextual inquiry and questionnaire methods. We report findings of a survey that investigates how a design course is taught in a technical institute, its limitations and scopes. In order to validate the interpretations a comparative study is made with other reputed design schools. Some of the key findings are that design courses need to emphasize on hands-on way of doing things, students perform better if they are given more time and flexibility and so on.

Keywords Design skill development · Design realization process model · Contextual inquiry · Heuristic evaluation · SWOT analysis

1 Introduction

The Design realization course at IIITDM Kancheepuram helps students to enlighten the creative side of their engineering skill sets during their undergraduate studies. Today, in industries, importance is not only given to technology optimization, but also much emphasis is given on user study, usability evaluation, interaction design

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and design optimization. Product design is a goal driven problem solving process that blends engineering knowledge with creativity in design. This requires professionalism, interdisciplinary skills and knowledge of software and hardware tools. To develop these traits, learning by doing is very important. Hence, the students are exposed to different labs where 'Design Realization Lab' is one of them. Here, the students learn the concepts of product design, product evaluation and model-making using various interactive methods. The course has been designed in such a way that the students learn to prioritize functionalities, process exploration, design aesthetics and quality of implementation. However, the course should be consistently evaluated to best enhance students learning according to the current design trends. It is also helpful in understanding the limitations of the program.

This paper is organized as follows. Section 2 discusses the course structure and course objectives for both theory and lab courses; Sect. 3 presents the methodologies adapted for course evaluation; Sect. 4 shows the statistical analysis done based on the qualitative and quantitative data collected; Sect. 5 deals with the SWOT analysis performed and Sect. 6 concludes and states the future work.

2 Course Structure and Objectives

The primary purpose of a syllabus is to familiarize, what the course is about, why the course is taught and what are the efforts and skills required for a student to complete the course with a passing grade [1]. Therefore, the syllabus should be structured in such a way that the coursework can become clear and easily understood by everyone including those who haven't opted for the course. Optimally, the course syllabus should also generate interest and motivate students to excel in the course and to continue to the next level.

In order to provide the complete knowledge of design basics and processes, IIITDM Kancheepuram offers both theory and practice courses on Engineering Design and Realization exclusively to the 1st year undergraduate students of all disciplines (Mechanical, Electronics, Computer Science and Dual Degrees).

2.1 Theory Course: "Concepts in Engineering Design"

The objective of this course [2] is to introduce the fundamental principles of Engineering Design which is very important and relevant in the context of engineering requirements today. The course is generic to all engineering disciplines and does not require any specialized prerequisites. Case studies and product illustrations are used for better understanding and enhance learning.

The contents of the course [2] are listed below.

- Design conceptualization and philosophy, Original, Adaptive, Variant and Re-Design, Evolution of Concept, Need for Systematic design and Past methods of design
- Product life cycle, Innovation, Types of innovation
- Needs and opportunities, Vision and Mission of a concept, Type of needs, Technology S-curve, Need analysis, market analysis and competitive analysis, Kano Diagrams, SWOT analysis
- Conceptualization techniques—Idea generation—ideation, brainstorming, Trigger session Brain writing, Mind maps, SCAMPER (Substitute—Combine—Adapt—Modify—Put to other use—Eliminate—Rearrange), TRIZ (Teoriya Resheniya Izobretatelskikh Zadach—in Russian acronym) [3], Biomimicry, Shape mimicry, Familiarity matrix
- Concepts screening, Concept testing—exploratory tests, Assessment tests, Validation tests, Comparison tests—Case studies
- Organization of design concepts and design methods, Engineering Design—Descriptive and prescriptive model, Design decisions and development of design
- Group work and case studies.

2.2 The Lab Course: "Design Realization"

The course objectives are listed below.

- To realize the concepts through a systematic problem-solving methodology
- To encourage teamwork
- To improve idea generation by using design principles
- To constructively combine ideas rather than criticizing
- To practice efficient use of design tools for model making
- To have hands-on practice with design exercises and model-making leading to realization of a new product design by the teams.

The contents of the course are listed below.

Exp: 1 Concept selection and model making of simple objects—Plastic model
Exp: 2 Concept selection and model making of simple objects—Sheet metal model
Exp: 3 Clay and Foam model
Exp: 4 Idea generation using SCAMPER, concept screening and design realization
Exp: 5 Adaptive design
Exp: 6 Need analysis and realization
Exp: 7 Morphological analysis and realization

Exp: 8 Concept generation and model realization—TRIZ contradiction and principles
Exp: 9 Modular and integrated architecture—Aesthetic design
Exp: 10 Product dissection and re-design.

3 Methodology of Course Evaluation

Course evaluation has been done using library research such as analysis of historical records and analysis of documents in the literature [4]. This work has been improved by using field research such as participant observation, mass observation, personal interviews and focused interviews [5]. In the present work, user study has been done employing contextual enquiry and questionnaire method.

For each experiment the students follow a general model which is shown in Fig. 1. In the 1st stage, ideas are generated using different design principles such as SCAMPER, TRIZ, Morphological analysis etc. In the next stage, the concepts are evaluated using multi-voting method, benchmark matrices and Pugh charts followed by final sketching and product realization using different materials such as thermocol, clay, plastic, thin metal sheets etc. in the last stage.

The course evaluation has been done by collecting data from students, instructors and TAs (teaching assistants). A total of 110 students have been interviewed with questionnaire method and with scheduled and non-scheduled interviews. Similarly, the feedback has been collected from six teaching assistants and two lab instructors. Contextual inquiry followed by heuristic evaluation has been done by borrowing the knowledge from ethnographic research methodologies [6]. The data is recorded digitally and visualized statistically in the form of graphs and charts. The course is evaluated by focusing on the parameters like course structure, course organization, lab resource availability and utilization, qualitative and quantitative analysis of each experiment, student's performance, students' delight and creativity analysis.

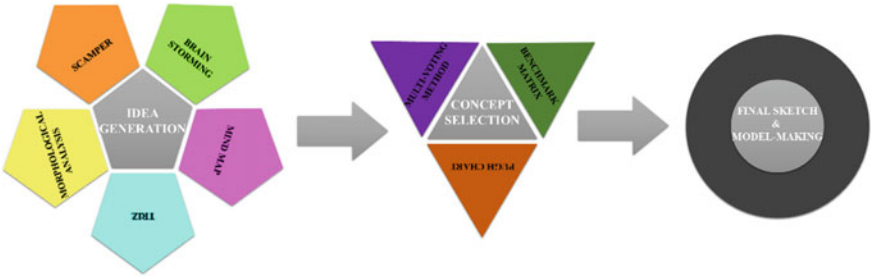

Fig. 1 Design realization process

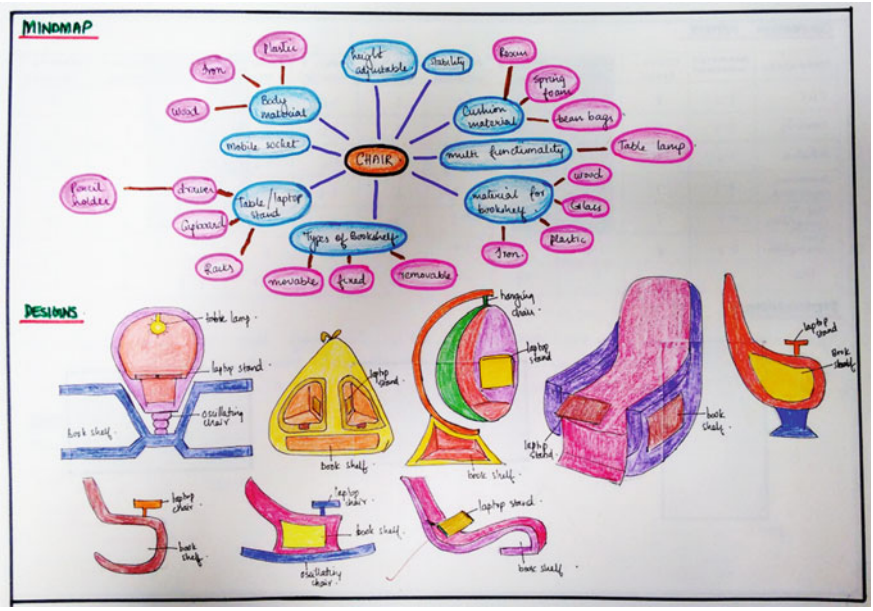

Fig. 2 Integrated design models

A typical image of idea generation and sketching made by a student is shown in Fig. 2. Models designed using TRIZ principles are shown in Fig. 3. Products realized using thermocol and clay are shown in Figs. 4 and 5 respectively.

4 Evaluation and Analysis

At the beginning the students are observed and interviews are conducted to understand their conceptual models about the course and its objectives. A detailed questionnaire is then prepared based on the focused parameters. Some questions are also asked to evaluate the merits and demerits of interdisciplinary course structure [7]. The statistics are shown in Fig. 6.

It is found that 47% of the students are satisfied with the course structure and 8% of the students are highly satisfied. 30% of the students have opted to be neutral. Only 15% of the students are observed to be unhappy with the course structure. Interviews and contextual inquiries are performed to understand the underlying problems. The issues are found to be, insufficient time to finish the experiments, clubbing of various tasks in a single experiment and a repetition of few concepts. Few students are also not happy with the interdisciplinary concepts.

As far as the course organization is concerned, it is very much important to support the course structure. It deals with the sequence of experiments which

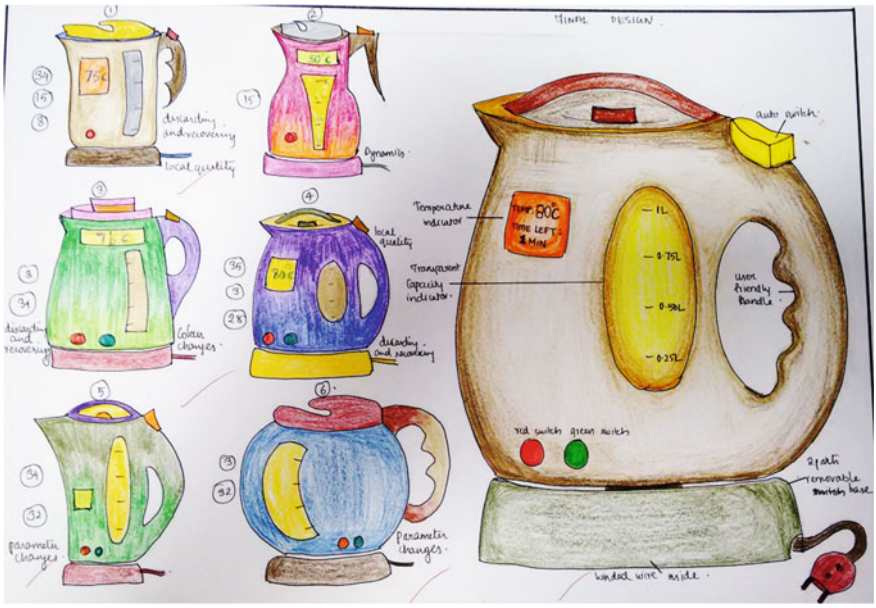

Fig. 3 TRIZ modelling of electric kettle

Fig. 4 Thermocol models

Fig. 5 Clay models

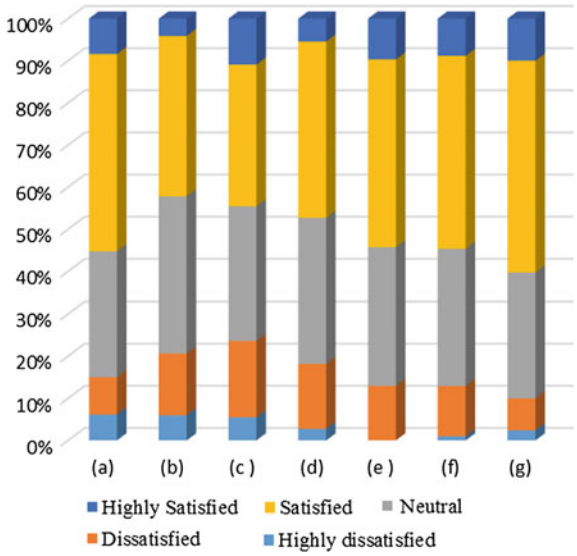

Fig. 6 Graph between students' satisfaction levels with course defining parameters. (*a*) Course structure, (*b*) course organization, (*c*) availability of lab resources, (*d*) qualitative analysis of each experiment, (*e*) skill development, (*f*) students' delight, (*g*) creativity analysis

support the gradual understanding of concepts. It also deals with the quality of materials and handouts provided to the students. As per the survey, 42% of students are satisfied with the current course organization. Only 10% are dissatisfied and 37% have opted to be neutral.

From the contextual inquiry, it is found that 45% of the students are satisfied with the lab resources such as raw materials, tools and devices. 17% of the students still expect more sophisticated resources such as better quality study materials and more spacious design lab. 47% of students have found the experiments to be intellectual, challenging, demanding and creative, whereas, 17% of them are in disagreement to this notion. From the enquiry it is noticed that these 17% students are not so fond of design and the design realization course failed to persuade their interest.

The overall skill development is excellent among 10% of the students and good among 44% of the students. 33% of the students are in the developing stage whereas skill development is perceived to be poor among 13% of the students. Skill development is dependent on the quality of teaching and one's interest to learn. Students from different disciplines, backgrounds, cultures are found to have different cognitions. The skill development also focuses on quality of interaction and competitive excellence.

Overall rating of the feedback given by the students has been calculated. As shown in Fig. 7 five star rating has been given by 8.18% of students whereas majority of the students have opted for 4 star rating. Only 2.72% of people have chosen single star rating. The majority of the students like this course because of its novelty and professionalism. In order to attain five star rating, it is suggested to introduce digital modelling rather than theoretical study. As per the survey, it is found that the experiments 1, 2 and 3 are more liked by the students as these experiments are based on concept selection and model-making with different materials such as plastic, metal sheet and clay. These experiments help them in realizing the products in more artistic way and enable them to exercise their creativity rather than performing complex theoretical analysis. Experiments 4, 5, 10 have received average ratings because they are a mixture of theoretical and practical exercises. Experiments 6, 7, 8 and 9 are mostly based on theoretical analysis and students are not clear about the concepts and hence, the rating is low (Fig. 8).

In order to validate these findings a comparative study is done with the course structure of IDC (Industrial Design Centre), School of Design, IIT Bombay [8]. It is

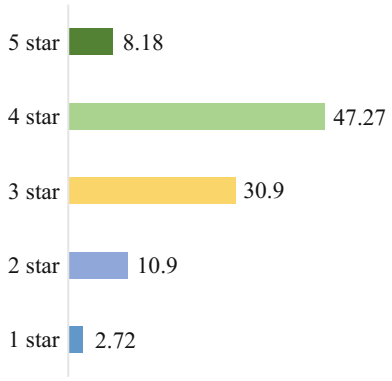

Fig. 7 Overall course rating feedback

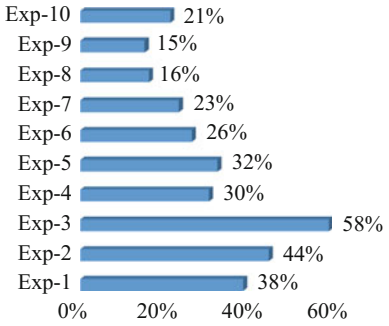

Fig. 8 Students' delight per experiment

found that at IIITDM Kancheepuram all the courses run parallel throughout the semester. Most of the theory courses have labs. But it's interesting to observe that although the theory and lab syllabi are designed to go with sync, if a mismatch happens the students face problems in understanding the concepts. In such cases the TAs (Teaching Assistants) and sometimes the faculties explain the theory briefly in the lab and the students continue to perform the experiments. On the other hand, in IDC courses run one after another. During the first hour of the day theory is taught followed by an assignment and during the second half the students are left free to do the assignments in their respective studios. The important point to notice here is that the theory and practice go side by side and with harmony.

Feedback has also been taken from professors and TAs to evaluate the course from an instructor's perspective. According to them, cons for the course are: students mostly tend to surf net for ideas rather than using their creative thinking, lack of knowledge among students about the motives and future scope of the course, they also seem to lack proper clarity about the objectives of the course, they don't understand and appreciate the advantages of the interdisciplinary design course. The pros are: the course is very different compared to all the routine courses offered. It's interactive, encourages inter-cultural mingling of ideas and improves artistic skills. The theory class in parallel to this lab course helps them to understand the design concepts well.

5 SWOT Analysis

SWOT analysis offers a clear picture for understanding a course or a program [9]. It provides many relevant information to the designer in one window. The SWOT outcome of the current framework is shown in Fig. 9.

As per the analysis, the major strengths of the course are found to be, its novelty in the mixture of interdisciplinary concepts, creative thinking aspects and professionalism whereas under-utilization of lab resources, lack of industrial design content in the syllabus and lack of concept testing before concept realization are noticed to be the weaknesses. There are opportunities to improve upon the current

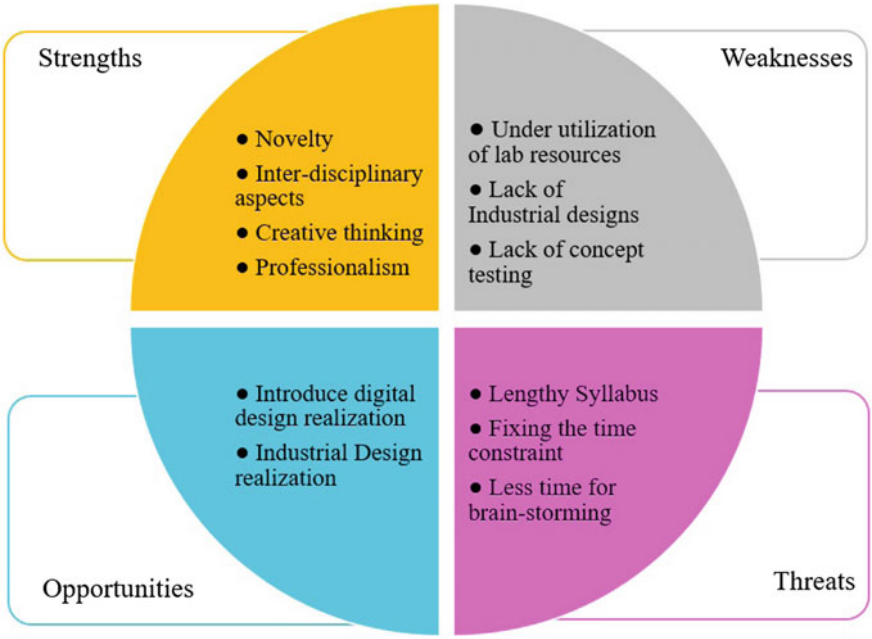

Fig. 9 SWOT analysis of the design realization course

curriculum in terms of introducing digital realization and industrial design realization. The threats are observed to be lengthy syllabus, less scope for brain storming and experiments are highly time constrained.

6 Conclusion and Future Work

IIITDM Kancheepuram believes in interdisciplinary course structure where the students can efficiently implement the design concepts in the field of Engineering, thus, providing a novelty to the Design Realization Course framework. Considering the qualitative and quantitative analysis done in this work, it can be concluded that the effectiveness of a course depends on various factors such as course structure, course organization, course delivery, pedagogical aspects and cognitive aspects of the learner. From the findings of the above work, it can be concluded that the course can be made more interactive and effective by providing flexibility in the time constraint. Theory and practical experiments should be in sync. It can be made more relevant and updated by providing industrial designs to the students as per the global demand. The future work is to invite similar evaluations from industrial experts and to share the improved frame work with the industries, academia and design related R&D establishments.

References

1. Cooper, R.D., Cooper, C.L.: The evaluation of guidelines to aid the information designer. J. Des. Stud. **5**(4), 248–267 (1984)
2. Curriculum & Syllabus for first year (2014 onwards) students at IIITDM Kancheepuram. http://iiitdm.ac.in/DualSyll.php (visited on 30/04/2016)
3. TRIZ in Wikipedia. https://en.wikipedia.org/wiki/TRIZ (visited on 30/04/2016)
4. Biggs, J., Tang, C.: Teaching for quality learning at university, 4th edn. Society for Research in Higher Education, Open University Press, Buckingham (2011)
5. Judith, S.L., Norman, G.L., Stephen, A.B., Selina, L.B., Allison, A.M., Renee, S.S.: Meaningful assessment of learners' understandings about scientific inquiry—the views about scientific inquiry (VASI) questionnaire. J. Res. Sci. Teach. **51**(1) (2014)
6. Crisp, G., Taggart, A., Nora, A.: Undergraduate Latina/o students: a systematic review of research identifying factors contributing to academic success outcomes. Rev. Educ. Res. J. (2015)
7. Certa, A., Enea, M., Hopps, F.: A multi-criteria approach for the group assessment of an academic course: a case study. J. Stud. Educ. Eval. **44**, 16–22 (2015)
8. IDC, School of Design, IIT Bombay, Departmental Timetable, available at: https://docs.google.com/spreadsheets/d/1y01zi2c6Q_BI3CqZpyiK5-w2OgqWPwoB62maAa2uhPU/edit#gid=0 (visited on 28/08/2016)
9. Susan, T., Qiu, T.C., Mathew, A., Sony, J.R., Loo-See, B.: A qualitative review of literature on peer review of teaching in higher education: an application of the swot framework. Rev. Educ. Res. **84**(1), 112–159 (2014)