Teaching Conceptual Design to a Heterogeneous Group: A Workshop Method

Dr. Sangarappillai Sivaloganathan, United Arab Emirates University

Dr Sangarappillai Sivaloganathan – Siva is a Srilankan by birth and a citizen of the United Kingdom. His experience in Sri-lanka started with an year's post-graduate apprenticeship in the manufacturing shops of the Government Railway and nine years in the Cement Industry. He graduated as a Mechanical Engineer from University of Srilanka, and obtained his Masters from the University of Aston and PhD from City University of London, both in the UK. He started his career in the UK as the Senior Research Assistant at the SERC Engineering Design Centre. He joined Brunel University in 1995 where he worked for 18 years before joining United Arab Emirates University in August 2011. During his stay at Brunel he has worked with many British industries. Dr Sivaloganathan is a keen researcher in Design and was the Convenor for the International Engineering Design Conferences in 1998 and 2000. He has been a regular participant of the ASEE annual conference during the past few years. He has published more than 100 papers in reputed journals and conferences.

Prof. Ali H. Al-Marzouqi, United Arab Emirates University

Dr. Ali Al-Marzouqi obtained his Ph.D. in Chemical Engineering from Oregon State University, USA, in 1997. He worked as an Instructor in the Chemical Engineering Department of Oregon State University for three years and then joined the Chemical and Petroleum Engineering Department of UAE University in September 2000. He was promoted to the rank of Associate Professor in 2007 and to the rank of Professor in 2017. Dr. Al-Marzouqi has served as the Assistant Dean for Research and Graduate Studies in the College of Engineering for 12 years until he was appointed as the Vice Dean of the College of Graduate Studies in 2017, Acting Dean in 2018 and Dean of the College of Graduate Studies in 2019. His research focuses on CO2 capture, brine management, conversion of biomass to high value chemicals, the use of supercritical fluid technology in food and pharmaceutical applications, and biodiesel production. Dr. Al-Marzouqi has published over 115 journal and conference papers and achieved four granted patents.

Dr. Essam K. Zaneldin P.E., United Arab Emirates University

Dr Essam Zaneldin earned his PhD in 2000 from the University of Waterloo in the area of Construction Engineering and Management. Dr Zaneldin is a professional engineer currently working as an associate professor of Construction Engineering and Management at the Department of Civil and Environmental Engineering, United Arab Emirates University. Dr Zaneldin is also the head of the College of Engineering Requirements Unit and the Director of the Master of Engineering Management Program at the United Arab Emirates University. In addition to his experience in the academia, Dr Zaneldin has more than thirteen years of work experience in areas related to design, construction supervision, and project management of mega size projects in North America and the Middle East. He has authored and co-authored several journal and conference publications in topics related to engineering education and course management, design coordination, change management, site layout planning, constructability, claims and disputes, and simulation of design and construction operations.

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Sangarappillai Sivaloganathan, Ali H. Al-Marzouqi,
Essam Zaneldin and Nabil Bastaki
College of Engineering
United Arab Emirates University
PO Box 15551, Al Ain
United Arab Emirates

Abstract:
Master of Engineering Management program at United Arab Emirates University recruits students from multiple backgrounds and has product design as its main theme. The pedagogy employed uses Instructivism to teach the theoretical part to the students and permits them to use constructivism approach to build competence. A workshop method was designed and used for the students to gain competence in more than ten conceptual design methods. The students produced the designs in two steps: first as small groups producing the design and presenting to the peers and a panel of judges for critiquing and in the second rectifying the shortcomings identified from the presentations and feedback from judges. In the subsequent examination, majority of the students performed well in the question relating to the activities surrounding the workshop. The results obtained from this study suggest that Workshop method can be an effective method to teach large number of conceptual design methods to a heterogeneous group of students.

Key words: Conceptual Design, workshop method, teaching product development

1. Introduction

Engineering Management can be defined as the art and science of planning, organizing, allocating resources, and directing and controlling activities, which have a technological component. It is taught as a discipline in universities predominantly at the graduate level. A variety of topics are taught in Engineering Management programs and it is not possible to include all of them in a single Master's program. Inclusion of one topic means exclusion of another. Product design and development is included as the main theme of the Master of Engineering Management, MEM, program at United Arab Emirates University, as engineering managers have to be involved in the management of it either as a part of a designing team or as a purchaser of a system that is being designed. United Arab Emirates University is located in a country that is going through rapid development of large and small industries with innovation as a key facet. The program attracts students from a variety of backgrounds and they are heterogeneous because of their, major in undergraduate studies, experience level (fresh or with work experience), working environment (design office, field, factory and fields outside engineering), GPA in undergraduate program etc. Students from other master programs take this course as an elective course and thus add to the heterogeneity. Experience in teaching several cohorts of students in this program shows that, in order to understand and contribute in conceptual design the participant must be knowledgeable and competent in the technologies concerned. In a heterogeneous cohort this means that the examples, narratives and project should be at the Highest Common Factor level for the specific cohort so that the student can focus on the 'Design Method' without getting stuck with technologies. This has been one of the principal considerations when drawing the examples and projects.

The challenge for the curriculum design and delivery is to teach the design process and the outputs at various stages, to the engineering manager emerging from this heterogenous group,

so that he/she can provide effective leadership to a design office or team. Design process is often described as a stage model or activity model. The stage model is static with specified number of stages while the activity model can incorporate several design methods. In this context, design methods are tools and techniques used at different stages of the design process. The prime objective of this course is to equip students with the knowledge, skills and competence in the development and use of design models and methods so that they can handle design process management in their professional careers. In the provision of the learning experience students are (a) given lectures and hand-outs on the theory and methodology in which they have to pass a written examination (so called Instructivism) and (b) apply their knowledge and skills in a project where they exhibit their competence gained (constructivism). Students at the beginning follow lectures and quizzes in the early stages of the design process, from design brief to drawing the specifications. They are then taught conceptual design as the process of establishing a scheme to arrange components in a harmonious manner to deliver the required functions satisfying the originating need. More than ten conceptual design methods and approaches are taught during this stage. Conceptual Design, being a very important part of the design process, a special workshop method is devised and adopted. In its implementation it addresses the research question '*How effective is the workshop method to teach conceptual design methods to a heterogeneous group of students so that they can apply the methods in different situations*'. This paper describes the workshop method developed, its implementation, student feedback and the lessons learned. It endeavours to provide sufficient details for anyone interested in adopting it, as it is grounded in existing Design Methods.

2. The Workshop Method

In the workshop method the students, after their theory lessons, are allowed to propose conceptual designs and they present and discuss their methods and concepts with fellow students first, and critiqued by the faculty member and a panel of judges afterwards. The panel normally comprises of the Dean of the College of Graduate Studies, the Program Coordinator and a senior design faculty. Subsequently they improve the design and submit the design for assessment. The method thus embraces, both Instructivism and Constructivism. Their achievement in the design process is assessed by a written examination. The students in each group, after learning the methods through lectures, apply the conceptual design method by doing their project for the workshop, using a specified design method. They learn other methods by seeing and studying their peers' designs which were conceptualized using other different methods. Figure 1 shows the schematic of the pedagogical model.

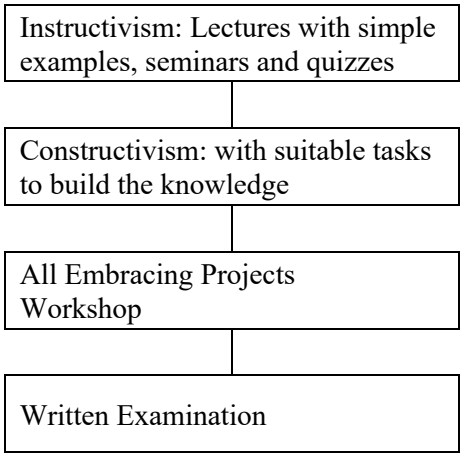


Figure 1: The Pedagogy Model

2.1 Instructed Part

Instructivism places emphasis on the passage of information and knowledge encapsulating activities and other learning events for learning to take place [1]. There is a certain amount of information and knowledge needed for the novice designer to start designing, and the first part is aimed at providing that. The design process taught is a stage model which contains Requirements, Product concept, Solution concept, Embodiment design and Detail design as outlined by Haik et.al [2]. The genesis of the process was seen as the Design Brief describing 'what the product is' given by the senior management of a company or by a client. It gives sufficient detail for the design team to start working. The design team on understanding the design brief prepares a functional representation of the problem. This identifies the information that has to be obtained from the stakeholders. The first stage of the model obtains the prioritized requirements from the customer in terms of 'what the product should do'. The next stage draws the specifications for the product from the two sets of information (a) what the product is and (b) what the product should do, together with the functional representation as developed by the design team. Having thus defined the problem the search for solutions begins and the first and crucial stage is the Conceptual Design stage. French [3] defines Conceptual Design as 'An Outline Solution in the form of a scheme'. According to him a scheme is an outline solution to a design problem, carried to a point where the means of performing each major function has been fixed, as have the spatial and structural relationships of the principal components. Similar definitions are given by other authors [4, 5]. Concepts are the means for providing function. Design concepts are developed in consideration of the function of the device being designed. More than ten conceptual design methods have been taught and summary descriptions are given in Table 1.

Table 1: Design Method and Description

Design Method	Description
1. Starting with an Unacceptable Design	Normally for a product, one could often find a product substitute that can be seen as an easy solution to do the work. In such a situation it is appropriate to start the design process with such a design, keeping the good features and dropping the poor features. Further features can then be added to improve and perfect the new design for the product [6].
2. KJ Method	The KJ method to generate ideas requires, all relevant facts and information written on individual cards which are collated, shuffled, spread out, and read carefully. The cards are then reviewed, classified, and sorted based on idea similarity, affinity, and characteristics. Using the titles of the individual groups as the basis, a morphological chart is prepared and conceptual designs are formed or proposed [7].
3. C Sketch	In 'C' sketch each member of the team starts a sketch of their proposed solution for a predetermined length of time. When the time has expired, the sketch is passed to the next designer who may then add, modify, or delete aspects of the design solution though the entire design may not be erased. The sketches are thus passed sequentially through the design team. At the conclusion of the exercise, a set of solutions will be available, the number of which equals the number of designers participating in the method [8].
4. Brainstorming	Brainstorming is a group discussion method to produce ideas for ideation that is familiar to the majority of novice designers. Hansen [9] specifies the seven steps in Brainstorming as (a) write down a statement of the challenge so it is visible to all (b) remind the group of the Divergent Thinking Guidelines (c) set a quota of ideas (options) and keep going until you meet it (d) gather and record concise and specific ideas; ideas

	should be stated in "headline" form and be recorded in written form so that all participants can see and read them (e) record ideas as they are stated (f) periodically (every 15 ideas or so) check with the client or the group to make sure the ideas are going in the right direction and (g) proceed until the quota is met, or there are enough ideas to answer the challenge [9].
5. Gallery Method	Gallery method is a mixed method where the designers work individually and collectively. In the first phase individuals of a group begin sketching their ideas silently on sheets of paper. This is referred to as the phase of individual ideation. After a set amount of time, individuals display their sketches as a gallery and discuss their ideas. During the group discussion, the members of the group (a) present their ideas to the group; (b) critically evaluate each other's ideas and (c) modify/eliminate/generate ideas as a group. This is followed by another round of silent individual idea generation and group discussion. Both individual and group interactions are important in idea generation process [10].
6. Critiquing	Critiquing refers to receiving input on current design ideas. It is like receiving critique for a research paper from a colleague and one can even do it for his own design. The steps in critiquing involves (a) establishing the goal of the product and the criteria for evaluation (b) establishing the list of components (can be parts or sub-assemblies) (c) evaluating each component for its contribution towards the overall goal and (d) coming up with improvements to the inefficient components [11]. Critiquing is a powerful method for conceptual design especially when next generation products are developed. New technologies can provide openings for new concepts and better manufacturing processes can make previously infeasible concepts feasible. A good example is the use of stepper motors instead of Geneva Mechanism to provide intermittent motion.
7. Morphological Analysis	In the morphological method the problem is broken into independent sub-problems. Each of them would have several conventional solutions. These solutions are generated or written down in the form of a matrix or table. These sub-solutions are combined to form a solution which is a harmonious integration of the sub-solutions. Now there will be several feasible solutions from which one solution can be chosen [12].
8. Analogy	Design-by-analogy identifies an analogous product, which is fairly known, understands and establishes its characteristics and maps a relational structure from base to target. Steps in design by analogy are (a) understanding the design problem and identifying the key characteristic needed (b) identifying a base system that exhibits that characteristic (c) carrying out a mapping between the base and the target and (d) evaluating and consolidating the design [13].
9. Attribute Listing	Attribute listing refers to taking an existing product or system, breaking it into parts and then recombining these to identify new forms of the product or system. Since a large proportion of design problems are development designs where an existing product demands new and better designs this method is very useful [14].
10. Systems Approach	Andreassen divides the system or product into 6 classes of subsystems namely (a) Working system: the sub-system which influences the transformation object and changes it to a new form (b) Prime mover or energy system, which delivers the energy for the transformation (c) Transmission- or energy distribution system that distributes energy to the system component (d) Control system, Composed of sub-systems for controlling, supervising and inspection of other systems' state and performance, creating man/machine interface, and establishing the human

	safety system (e) Frame system that keeps the whole system together in space, and (g) Helping system(s) that Solves different necessary helping tasks [15]. The design process using this method starts with the identification of the sub-systems needed for the product and followed by proposing various alternatives for these sub-systems as in the Morphological chart method.
11. Combining Basic Machines	Literature identifies six machines, the lever, wheel and axle, inclined plane, screw, gears and pulleys as the basic machines. Combining these basic machines is a method of creating more complex machines. For example a wheel barrow is a combination of wheel and axle and lever [2].

2.2 The Constructivism Part

Constructivism process, through which students acquire knowledge (or how students learn), advocates that people construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences. The core elements of the constructivist approach are (a) knowledge is not passively received but actively built up by the cognizing subject and (b) the function of cognition is adaptive and serves the organization of the experiential world [16]. The constructivist theory is built on the concept that learning is something the learner does, not that it is imposed on the learner, and emphasizes that the learner actively constructs his knowledge [1]. In this process the student should be given the opportunity to explore in finding a design solution and learn or construct his/her knowledge in the process.

Facilitating the constructivist learning relates to the choice of learning experience and refers to Vygotsky's zone of proximal development. Chaiklin [17] refers to Vygotsky's work and recall the idea 'what the child is able to do in collaboration today he will be able to do independently tomorrow' and his definition of zone of proximal development, ZPD, as '*the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peer*'. Shabani et al. [18] state that ZPD refers to the difference between what a learner can do without help and what he or she can achieve with guidance and encouragement from a skilled partner. Thus, the term 'proximal' refers to those skills that the learner is 'close' to mastering. It distinguishes and connects the current or actual level of development of the learner and the next level attainable through the use of tools and facilitation by a capable adult. This means that the projects for students should be in the ZPD.

3 Implementation

The implementation followed the pedagogical model shown in Figure 1. The first task was following the Instructivism where the design model, and design methods were introduced. As seen earlier the 11 conceptual design methods also were taught. They were also taught concept selection using Decision Matrix (or weighted sum method) and Pugh's [19] concept evolution method. But the second stage where projects or tasks for the students were chosen and implemented was the crucial one. The first and perhaps the most difficult one was the choice of the projects. It has to be (a) one that cannot be achieved by the student alone in their present level but achievable with guidance and encouragement from a skilled instructor (b) it should provide the experience needed to build their competence in the use of the chosen design method and (c) it should be at the highest common level for the heterogeneous group. The objective of the workshop is to facilitate the learning of the different design methods to the level where the students could attain the competence in using the methods on their own in future.

Thirty-four students participated in the workshop method. Groups of four students were formed and each group was asked to give three choices of the design problems from the list provided. They were then assigned a project negotiated with the instructor and the team. This permitted the consideration of the individual strengths of the team members. They described the method and the conceptual design in a poster and presented their work to their classmates for discussion. Students saw their colleagues' work, discussed and learned from them. The design methods and the projects assigned to the student groups were as follows:

i. *Starting with an Unacceptable Design*: A Dessert Trolley for a luxury hotel, starting with a normal workshop trolley
ii. *KJ Method*: A Table-top Memorabilia reflecting the local culture and the nation's characteristics.
iii. *C Sketch*: A Birthday Cake for a 5-year-old Girl by 3 Aunties
iv. *Brainstorming*: Design of a Rectangular Foldable & Portable Dining Table for Events
v. *Gallery Method*: Bicycle to transport about 250 Bread Loafs
vi. *Critiquing*: Developing Designs by Critiquing Existing Hand lamps
vii. *Morphological Analysis*: A Writing Pen
viii. *Analogy*: Reading Assistant Starting from Lazy Susan
ix. *Attribute Listing*: A Table top Showpiece boasting different conceptual design methods by considering a 'Rotating Globe'
x. *Systems Approach*: A Salt and Pepper Carrier for Dinner Tables
xi. *Combining Basic Machines*: An Integrated Ladder Cart

The students' were offered meeting outside the normal hours of instruction by the instructor to clear doubts and blocks for the thought processes. A cohort of 34 students in 11 groups participated in this workshop. Each group produced an A1 poster and presented their designs to their classmates. After seeing the poster and listening and querying the authors they were asked to answer a questionnaire. The instructor then critiqued the posters and the students were asked to improve the designs and make their second poster which is considered as an assignment. After the second poster the students had their written exam. Eight posters came out more than satisfactory in the first round and ten came out well in the second round. The improvements were mainly due to the questions and discussions by the fellow students and feedback from the judges. The questions relating to conceptual design and posters were answered very well by all in the examination.

4. Conceptual Designs and Feedback by students

All the groups identified the benefits to be delivered from their design briefs. They also established a set of prioritized customer requirements to work with. They combined the benefits to be delivered and the important requirements to establish a criteria and weights for each criterion to help in the concept selection. Majority of them used the decision matrix (weighted sum method) to choose a preferred design but one group used the Pugh's method. The final design concepts are shown in Table 3. The designs can be summarised in the following way:

Palm Dessert Trolley: This is a dessert trolley for use in luxury hotels' restaurants. The design started with a workshop trolley as a product that can be seen as an easy solution. It kept the good features and dropped the poor features of the workshop trolley and added further features to improve the product. The chosen concept is shown in the Figure (a) Table 3.

Miracle Urbanization – A memorabilia, for someone visiting a fast-developing country, the local set up during the undeveloped past and the developed present. The development can be on several facets like local livelihood, infrastructure, buildings as a show of strength, culture

etc, areas of specialities or expertise, new achievements etc. At the beginning the designer had no idea on the feature to build on. The KJ method led them to list the features and sort them into clusters and permitted them to pick features that appeal them to include in the design. The chosen concept is shown in Figure (b) in Table 3.

C Sketch: In the C sketch or collaborative sketching method every member in a team initiated a concept for a birthday cake and contributed to develop other members' concepts. This permitted every member's contribution in the chosen concept no matter which one is selected. The product being very familiar to everyone it explained the C sketch method clearly to everyone during the poster display. The chosen concept is shown in Figure (c) in Table 3.

Brainstorming: This powerful and old technique permitted the team members to come up with original ideas as well as modifications and elaborations of others' ideas for the tables and chairs given on rent for events. The team members were siblings and as such there was no shy and quiet member in the team. They considered the maximum number of concepts before choosing one. The chosen concept is shown in Figure (d) in Table 3.

Gallery Method: Similar to the method of the workshop, gallery method starts with individual members proposing concepts of bread delivery bicycles, put them in the gallery for discussion and move to develop the concept further before firming up the concept. The poster clearly illustrated the method with initial designs from all three members and the way the good features were combined and enhanced in the final concept. The chosen concept is shown in Figure (e) in Table 3.

Critiquing: In this project critiquing method was applied in the evaluation of a hand lamp using a well-defined set of criteria and the identified shortcomings were rectified in the new concept. This can be considered as designing the next generation concept. The improved concept made the hand lamp free from wires, had small LED's to guide movements from place to place and used powerful light using LEDs to light the work area. The improved concept is shown in Figure (f) in Table 3.

Morphological Analysis: Four functions of a pen (i) Transfer to paper (ii) Replenishment of ink, (iii) protection to the writing tip and (iv) Position in the pocket were considered for preparing the chart. Functions were listed on the left side, and on the right-side different means to perform the functions were listed. Conceptual designs were obtained by the harmonious integration of instances of each function provider. Analysis revealed that a replenishable ball point pen which is theoretically viable has not come to the market. The morphological chart is shown in Figure (g) in Table 3.

Design by Analogy: Lazy Suzan, which is a well-known product on the dining table to provide easy access to every food item on it, was chosen as the base product analogous to a Reading Assistant. A reading assistant keeps an already referenced book in open position for cross referencing by a researcher. The designer understands and establishes the characteristics of the reading assistant and maps a relational structure from base to target. The chosen concept is shown in Figure (h) in Table 3.

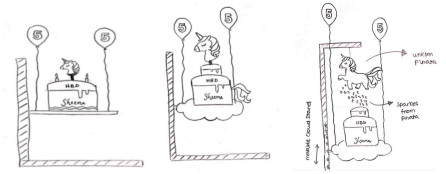
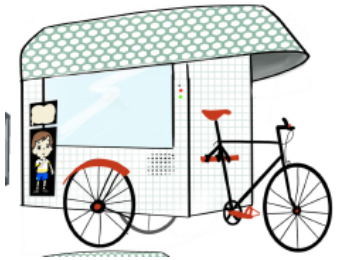
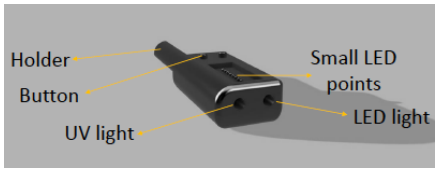
Attribute Listing: In this method a table top show piece, boasting the eleven conceptual methods, was designed using the attributes list of a table top globe display. The globe display was broken into two parts; the display and the base, and their characteristics were studied to simulate them in the new design. A rotating prismatic pencil with spaces for writing the eleven methods on each planar face was developed together with a base to support the pencil and facilitating the rotation. The conceptual design is shown in Figure (i) in Table 3.

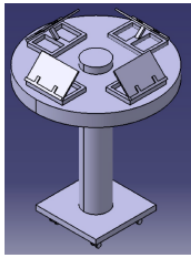
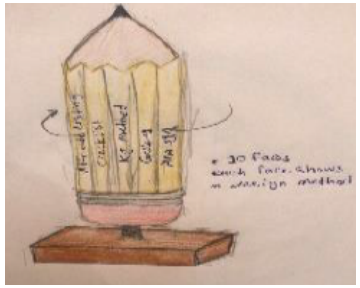
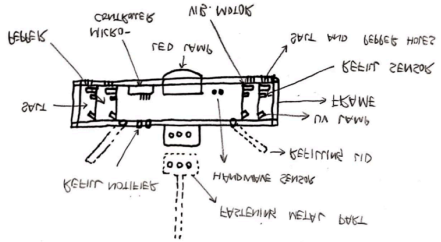
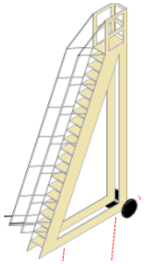
Systems Approach: The systems approach method is based on the six subsystems as identified in Table 1. The concept carried ground pepper in one side of a horizontal tube while salt was carried on the other. This makes the frame system. The waving of the hand under the dispenser forms the control system with a microcontroller that would sprinkle a

predetermined amount of salt (say 30 mg) and a similar approach was taken for ground pepper. The delivery was meant to be carried out by a battery-power assisted vibrator consisting of a 3D printed mesh. The conceptual design is shown in Figure (j) in Table 3.
Design by Combining Basic Machines: Combining basic machines, which are essentially single function providers, is an easy way to understand the harmonious integration of function providers in the design of a product, and this was demonstrated in the development of a ladder cart. The ladder cart is aimed for use by street light maintenance gang to gain access to bulbs for replacing the fused ones.

Table 3: Conceptual Designs by the Student Groups

<table>
<tr>
<td>Starting with Unacceptable Design Palm Dessert Trolley
 

(a)</td>
<td>KJ Method – Miracle Urbanization Memorabilia
 
(b)</td>
<td>C Sketch – Birthday Cake
 
(c)</td>
<td>Brainstorming – Events Dining Table
 
(d)</td>
</tr>
<tr>
<td>Gallery Method – Bread Bicycle for sale/Delivery
 
(e)</td>
<td>Critiquing – Handlamp
 

(f)</td>
<td>Morphological Analysis – Writing Pen
<table><tr><td>Transfer</td><td>Nib</td><td>Ball point</td></tr><tr><td>Replenishment</td><td>Suction</td><td>Replace</td></tr><tr><td>Protection</td><td>Cover</td><td>Retract</td></tr><tr><td>Point Position</td><td>up</td><td>Down</td></tr></table>Analysis reveals that a replenishable ball point pen which is theoretically viable has not come to the market.
(g)</td>
<td>Design by Analogy – Spinning Table
 
(h)</td>
</tr>
<tr>
<td>Attribute Listing – Table Show Piece
 
(i)</td>
<td>Design by Systems Approach – Salt and pepper Dispenser
 
(j)</td>
<td>Combining Basic Machines – Ladder Cart
 
(k)</td>
<td></td>
</tr>
</table>

A wheel barrow is the integration of lever and, the axle and wheel, with the loading bucket placed at the center. In the ladder cart the bucket was replaced by the light-weight ladder. The conceptual design is shown in Figure (k) in Table 3.

4.1 Feedback from Students

The students were very enthusiastic from the beginning. They were eager to display their work in front of their peers and particularly to the judges. The posters were intended to show (a) product description (b) customer requirements (c) design method (d) approach (e) conceptual designs (f) description of the chosen design (g) how the chosen design meets the requirements and (h) the merits and demerits of the chosen design method. After going through the presentations, discussions and questions and answers the students were presented with questionnaire to capture their feelings. The results are given below:

Question 1: What is your well understood method other than your own method?
For this question few students showed preference to more than one method. This might have been due to its relevance to some of their needs for such a method to resolve issues at home and the easy understandability of the product.

Design Method	Number of students
C sketch	14
Brainstorming	2
Attribute listing	2
KJ method	6
Combining basic machines	4
Systems approach	3
Gallery method	5
Critiquing	3
Starting from an Unacceptable Solution	
Design by Analogy	
Morphological Chart	

Question 2: Is the answer to question 1 a result of today's presentation?

Yes with Others	4
Just Yes	29
No	1

The general answer to the question suggests that the workshop presentations and discussions have enhanced their understanding of the methods. One student said that she understood the methods well from the lecture itself. She further added that she enjoyed the presentation.

Question 3: How will you rate the effect of the posters and explanations?

Percentage	Number	Remarks
100	9	Way more fun and useful Very useful to understand
95 - 99	11	All posters well explained Made the method clear and simple Very effective way of learning
90-94	9	
85-89	1	
Below 80	4	Class work was barely enough

Question 4: How will you rate the effect of today's presentation on your knowledge of using concept generation method?

Percentage	Number	Remarks
100	7	It is easy Understand the method when applied Easy to reflect the ideas with products Excellent; Have understood the methods totally through application Helped me understand Design Methods more Helped me understand other methods more
95 - 99	8	Very effective way Learnt how it works in real life Very effective way through peer teaching Understood different methods in a better way
90-94	5	Makes the learning more consolidating Share knowledge of several methods
85-89	3	
80-84	6	Can get a lot of information in a short time Helped to differentiate between different methods
Below 80	3	I like power point presentations

The answers to the question relate to the amount of effort they put to produce their own posters and presentations and the benefits they gained by that as well as from others' posters. A very positive number of students were in favour of the method and this was reflected in their body language during their presentations.

Question 5: Will you recommend poster presentation?

Emphatic Yes	13
Yes	18
No	3

4.2 Exam Performance

A question worth of 15 points relating to the conceptual design methods in the workshop was given in the written examination. The points scored by the students are as follows:

Points Scored Out of 15	Number of Students
15	19
13	3
12	4
10	4
9 & 8	3
Below 8	1
Total	34

5.0 Discussion, Lessons Learned

The main constraints here can be seen as the lack of design process knowledge and experience, and the heterogeneity of the student cohort. The implemented pedagogy relies heavily on the Instructivism for providing the knowledge in design process. The quizzes and seminars somehow compel the students to learn the process or at least get introduced to the process. Having thus initiated to the design process constructivism was brought in, in the form of a workshop, to provide the opportunity to build the knowledge by designing

following the systematic process. The results appear very positive in that the workshop consolidates their understanding of a variety of design methods learned through Instructivism. The heterogeneity of the student cohort permits a small highest common factor of the knowledge and this affects the amount of engineering rigor that can be introduced in the projects. The choice of projects is the key for understanding of the design method. 'If the project's technical content is fully comprehendible to the student, the student can focus fully on the design method' is the hypothesis of the team and it appears to be holding.

5.1 Lessons Learned

From this experimenting of the pedagogical method the following lessons could be learned:

1. Workshop method following the introduction of a topic in theoretical lectures generates enthusiastic participation of students in learning.
2. In workshops students learn from their own projects as well as from their peers' works.
3. Heterogeneity can be handled with the choice examples and projects with the highest common factor in their technical knowledge.

5.2 Conclusions

The paper presents an experimental method, the workshop method, for teaching a variety of conceptual design methods to a heterogeneous group of students. It addresses the research question, *how effective is the workshop method to teach large number of conceptual design methods to a heterogeneous group of students so that they can apply the methods in different situations*.

Some of the special features of the workshop method employed here are:

1. The workshop method was designed to follow both Instructivism and Constructivism theories of learning. The knowledge components were introduced through Instructivism while competence building was achieved through constructivism.
2. It included eleven chosen design methods that can be used in different types of conceptual design problems.
3. Heterogeneity of the student cohort was effectively handled by two specific steps:
    a. Choice of examples and projects in the project list, made with consideration of the highest common factor in the students' technical knowledge and
    b. Allocating projects with discussion and due consideration of individual strengths.
4. It is worth mentioning here that the project 'Salt and Pepper Dispenser' was made a Mechatronic Project during the discussion and project allocation phase.
5. The poster and discussion among peer groups presented an opportunity to see different approaches in the use of the design methods for each of the project.
6. The critiquing by the panel of judges and the instructor, expanding the discussion in different aspects provided a rich experience to the students. However, this is subjected to the richness of the panel members and instructor.

Based on the results obtained from this study, it is safe to conclude that Workshop method can be an effective method to teach conceptual design methods to a heterogeneous group of students. Further similar studies and research with control groups, can shed more light in this area.

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