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Mitigating Engineering Design Fixation: Strategies For Freshmen.

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Abstract: Skills of an engineer are the most important factors to decide how he can perform in various tasks. An engineer's skills can be either inborn or inculcated by teaching during his degree. Engineering education in India has been more theory and less practical since the starting. New age engineers need a different teaching methodology than which is practiced now. Design skills are needed by all the engineers as they face the challenge to design a product or a system at any point of time. The Indian engineering education needs a paradigm shift from theoretical teaching to practical activity-based learning. This paper throws light on various skills that are needed by engineers and the specifically speaks about the design skills. In the papers we discuss about different strategies that should be thought to freshmen students as part of their curriculum so that their design fixation would be limited to a minimum. The strategies discussed are classroom teaching and activities not specific to a single branch. Engineering students at freshmen are chosen because the domain knowledge they have will be less.

Keywords: engineering, design, fixation, freshmen, mitigating.

Introduction:

Albert Einstein in simple word says that engineers identify a problem and come up with a solution often creating something completely new in the process. Engineering is a profession directed towards the application & advancement of skills based upon a body of distinctive knowledge in Science, Mathematics & Technology [1]. Engineering education is the activity of teaching knowledge and principles related to the professional practice of engineering. Science, Technology, Engineering, and Mathematics (STEM) education in primary and secondary schools often serves as the foundation for engineering education at the university level.[2]. In countries like India which produces 4,00,000 engineers yearly. It is found that only 75% of the Indian graduates are employable. There are several studies conducted in India to identify the employability skills of the students. What is the expectation from the employers from the graduates? Are the individual graduates not having the set of skills or the education system they received is at fault? Does the university need a change in it teaching approach towards developing the skills of the graduates?

The main aim of university education today is molding and furnishing students to be ready to face the challenges and responsibilities in their future. The quality of the future engineers depends very much on the quality of engineering education, which is itself dependent upon developments in engineering curricula. It has been very compelling to the university to provide high quality education which meets the international standards. It's a very unfortunate case that Indian universities have not featured in the world top universities list with the main reasons being lack of advanced teaching and learning process. The Indian engineering education is more theoretical and less practical. An engineer needs certain basic skills when he graduates. They current teaching and lecturing is probably the oldest method still used in most of Indian universities. This kind of teaching would just measure the amount of knowledge that is retained by the student at the end of class or course rather than testing his ability of problem solving, thinking or motivation for further learning. Therefore, a new methodology should be adapted in which the lectures are more intuitive and engaging for the student.

Skills:

Skills can be defined as the expertise or talent to do a job or task or the ability to do something well. Businessdictionary.com [3] defines skills as "an ability or capacity acquired through deliberate, systematic and sustained effort to smoothly and adaptively carry out complex activities or job function involving ideas (cognitive skills), things (technical skills) and or people (interpersonal skills)." According to the *Cambridge Dictionary* [4], a skill is "an ability to do an activity or job well, especially because you have practiced it."

Problem-solving skills. The ability to view problems and challenges pragmatically and to have an analytical approach to solve problems and issues is an ability not all candidates possess. It has been documented "employers rarely explicitly list problem-solving as a key skill, but they do frequently mention critical thinking, initiative, adaptability, and leadership" [5]. If the candidate can weigh the situation or analyze it from different angles, he or she can demonstrate problem-solving skills. This, in a way, conveys his or her potential to be a decision maker.

Critical thinking: Critical thinking is that mode of thinking — about any subject, content, or problem — in which the thinker improves the quality of his or her thinking by skillfully analyzing, assessing, and reconstructing it [6]. Critical thinking is self-directed, self-disciplined, self-monitored, and self-corrective thinking. It presupposes assent to rigorous standards of excellence and mindful command of their use. It entails effective communication and problemsolving abilities, as well as a commitment to overcome our native egocentrism and sociocentrism.

Flexibility: This refers to one's openness to new ideas and situations. Certainly, "one of the greatest challenges presented to all employees today is dealing with uncertainty" [7]. With the pace at which technology grows, engineers must adapt to new concepts and, with workplaces expanding across the globe, engineers must learn to adapt to and accommodate any new situations, ideas, technologies, and so forth.

Creativity or innovation. Engineering is synonymous with innovation and, often, the passion to create something new attracts students to engineering. The urge to innovate and translate ideas into reality is the key to the success of any industry, especially engineering. According to Berger, Surovek, Jensen & Cropley , "creativity is a core component for engineering, essential to innovation."[8]

Teamwork: Salas, Sims, and Klein defined teamwork as "a set of interrelated thoughts, actions, and feelings of each team member that are needed to function as a team and that combine to facilitate coordinated, adaptive performance, and task objectives resulting in valueadded outcomes" [9].

Engineers need to work collaboratively for a common goal. Cooperation and mutual respect in a diverse group are seen as a winning combination.

Leadership skills. The ability to motivate people, to assign and delegate work according to the capability of the individual, shows leadership skills. According to Kotter, "leadership is about vision, about people buying in, about empowerment and, most of all, about producing useful change. Leadership is not about attributes, it's about behavior" [10]. An engineer should be able to work in a team but can also motivate and lead by setting a good example. In the present scenario, engineers need to show expertise beyond their regular technical field.

Leadership skills can facilitate them to acquire the desired image suitable for the industry.

Communication skills. The ability to speak and write clearly and concisely is a skill that is most sought-after skill in engineers. *The Hindustan Times* published an article entitled, "97% Engineering graduates cannot speak English fluently: Survey" [11], which stated that most of the students lacked English language proficiency. Furthermore, according to Nguyen, "The desirable skills and attributes for engineers include the ability to communicate effectively, both verbally and in writing, to peers, the employers, client and the community; engineers should be bilingual".[12]

Negotiation skills. According to Fowler, "influence is a broad concept, involving the effect on each person of the whole context in which the discussion takes place". Furthermore, "persuasion involves all those skills of argument and discussion that can be used by one person to obtain another's agreement" They often come with

being well informed and having good communication skills. Therefore, negotiation skills can easily prove the candidate's capability to convince others and help make a unanimous decision

APPROACH

A students creativity levels fall as the domain knowledge increases. So, during the freshmen year if the student is introduced to strategies to mitigate such design fixation then will be easy to increase their creative levels. In this paper I propose few learning strategies that would mitigate design fixation. We have been using these strategies in everyday engineering for better designs and as tools to come out of a fixated situation.

Strategies or Tools or modules

1. **Design process and stages:** The student is taught the whole design process and the various stages of design.

a. *A design process is a systematic problem-solving strategy, with criteria and constraints, used to develop many possible solutions to solve or satisfy human needs or wants and to narrow down the possible solutions to one final choice.*

b. Stages in design process. [13]

i. Identifying problems and opportunities

ii. Framing a design brief

iii. Investigation and research iv. Generating alternative solutions

v. Choosing a solution

vi. Developmental work

vii. Modeling and prototyping

viii. Testing and evaluating

ix. Redesigning and improving

2. **Pain storming**: A simple strategy that engineers use to redesign any product. The process first involves assessing the pains associated with using a certain product, then a design solution should be provided by the student such that the user of that product will not feel or experience any pain while using that product. In the classroom the instructor will explain few products and the pains associated while using the product and a possible redesign solution for that.

Pilot test SAMPLE AND SIZE

The objective was to teach mitigating strategies to engineering freshmen The pilot test was conducted at SR Engineering College Warangal and KUCE&T, Warangal. In both the places where the experiment was conducted a sample of 30 students were considered, we tried to maintain the male to female ratio to a minimum. Consent letters were given to all the participants. And most important, none of the participants had any prior knowledge of the design task to be conducted.

Case study 1: Ketchup bottle: The students are asked to think of a ketchup bottle and list down the problems associated with the existing design and try to resolve them by suggesting a new design.

Example solution by student:

1. Getting the ketchup out in a controlled fashion
2. Ketchup gets dry around the opening

3. Getting the last portion of the ketchup out
4. Glass can break – a safety hazard

Now a sample solution will be shown and asked if they agree to the product

The students will analyze the redesign and how the pains associated with the old design are resolved by using new design.

Case study 2 : Smartphone: The students are asked to choose between a smart phone and shoes and list down the problems associated with design are resolved by using new design.

Example solution by student:

1. Touch screen is not durable
2. Battery doesn't last long
3. Camera needs improvement
4. Confusion because of lot of application
5. Addiction

Painstroming Exercise Part 1

1. Please Circle Your Product: Smartphone / Shoe List as many pains as you can for the product circled 1. Excess usage will cause pain for forehand.

2. Vibrations will affect the heart & most important parts of our body.

3.The facilities provided such as internet etc. are changing the ideas of the youth.

4.Bluetooth holder provided with the smart phones are causing many accidents in recent days.

5.Listening to music in the late night causing various health problems.

6. Children are getting passionate for such products and in turn forcing their parents for this.

7. These smart phones are connected to the systems causing viruses & in turn spoiling the network.

8. It causes frustration to normal people, mainly people dealing with business

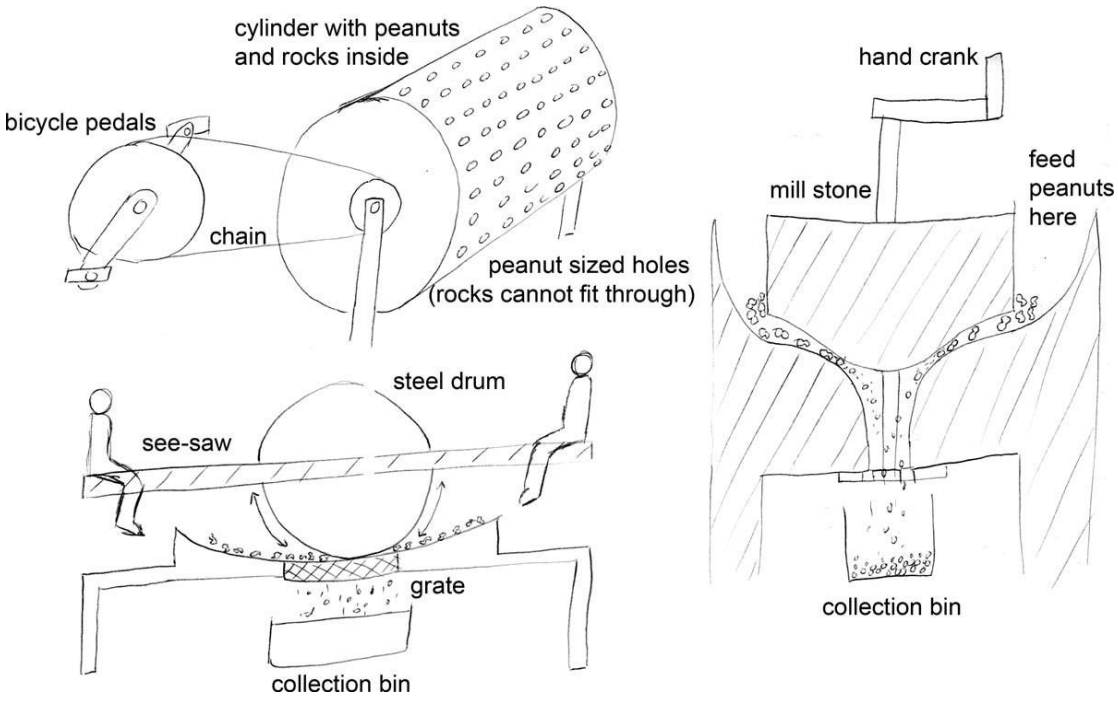
Painstroming Exercise Part 1

Please Circle Your Product: Smartphone / Shoe List as many pains as you can for the product circled

1. Not durable for longer period.
2. Touch not long durable.
3. Charging won't last for long duration.
4. Attacking of virus.
5. No waterproof.
6. Not easy to handle.
7. Not economical.
8. Not easy to type touch.
9. Wastage of time.
10. Radiation effect.
11. Long time uses causing memory loss.
12. Gives more entertainment.
13. Easy to do crimes.
14. Usage of hiding software.
15. Misuse by children by playing games.
16. Confusion of many apps or features.
17. Wastage of time by using social network.

Case study 3: Toy for a blind child: students are asked to design a toy for a blind child. This problem puts most participants in the familiar domain of toys and in the unfamiliar domain of blindness. While the task requires minimal technical knowledge it uses the design skill such as understanding the need and synthesizing alternative solutions. Once they have designed, they are asked to do pain storming for the design they have made.

Case study 4: peanut crusher: All participants are provided with the same design problem. The design problem is to design a device to quickly shell peanuts for use in places like Haiti and West African countries, and is based on a real-world problem posted on ThinkCycle [14]. Participants are told that no electrical energy sources are available and are given customer needs. This problem is chosen because it is a real world problem that is appropriate for an engineer, it has intrinsic incentive for solu- tions given its need-based nature, and the problem has a diverse set of available solutions. This problem has also been used in previous research on idea generation [15,16,17]



VI. CREATIVITY TESTS AND SCORING METHODS

Creativity is defined as the production of novel and practical solutions to a design problem [6]. To be creative one must have the ability to explore the design space from various standpoints. Creative thinking tests measures not only the number of new possibilities that people produce but also the novelty of these possibilities [7]. Of the various standardized tests of creativity available in the literature, we considered Abbreviated Torrance test, Guilford Alternative Uses test and Meekers test to assess the sub skills as mentioned in Table 2. The results obtained for tasks 1 and 2 were validated by both Abbreviated Torrance test and Guilford Alternative Uses test.

Task	**Subskill(s)**	**Test**
Task 1 & 2	Fluency	i) ii) Abbreviated Torrance Test Guilford Alternative Uses
	Flexibility	
	Originality	

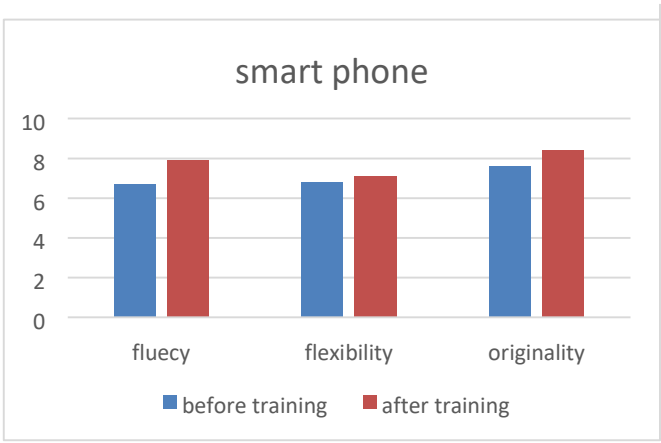
Results

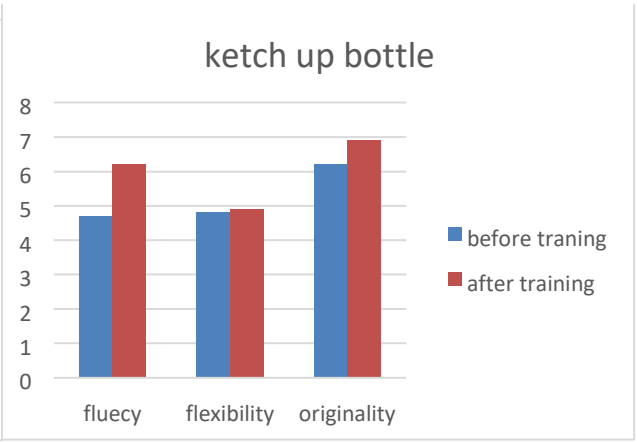
For the data to be reliable and uniformly scored, a set of instructions were formulated and given in hand to the evaluators. At first two evaluators have graded each set of responses independently to eliminate inconsistency or bias. In case of any inconsistency, the set of response sheet is forwarded to the third evaluator. For analysis all the data of different colleges is consolidated at a single place and the means values of fluency, flexibility, originality, detailability and fixation of both the groups are considered to compare working professionals and students. The following observations can be inferred from the data,

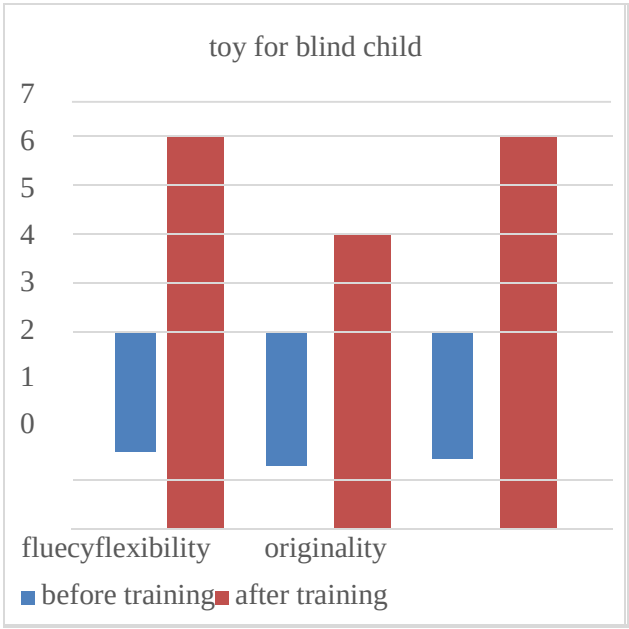
1. Before training: Fluency, flexibility, originality of students is low
2. After training Originality increased

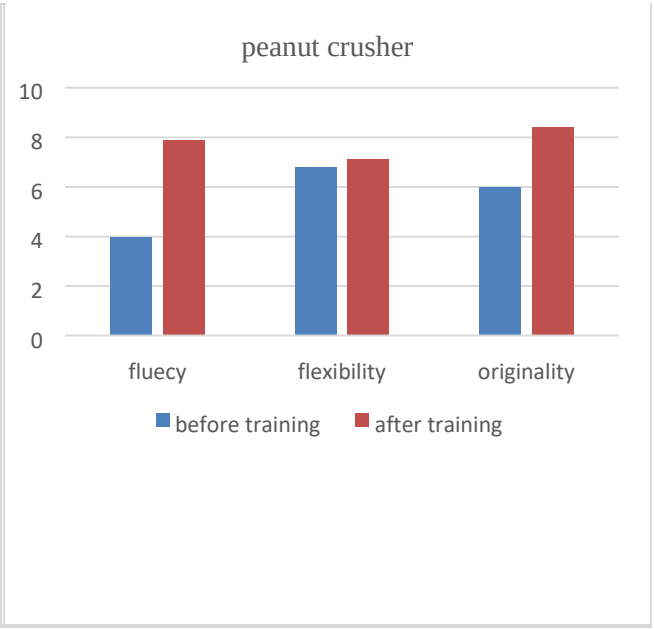
3. The domain knowledge played a key role in the solutions given

4. In response to task 3, a large percentage of students have shown fixation either due to example solution provided or their favorite toy









CONCLUSIONS

The various design skills of engineering students were analyzed using standard creative tests and the results are presented. The results indicate the need for modifying the teaching paradigm for engineering education to increase the emphasis on innovation and creativity in the curriculum. The paper also recommends that engineering faculty be conscious of fixation and its adverse effects and educate students. In the long run, as educators, we must reflect and reformulate the curriculum to balance fundamental understanding with the need to foster creative thinking skills so that the next generation designers can not only analyze designs, but also synthesize innovative solutions.

The present work is being planned to extend to other design skills as well. Plans are also underway to conduct the task in some more Institutes / Universities to observe the variation on a large sample as well as to validate the results.

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