

Sketching – An Iterative Tool For Engineering Problem Solving

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Abstract: Sketching is one of a noteworthy course which aids most individuals to provide lucid communication using visual skills. Arts courses have always created a significant impact on Engineering Education which transcends an Individual's capabilities. The basics of sketching are always deemed necessary for everyone and have acted as a prerequisite for various Engineering Courses along with Design Courses. Since there has been a fusion of Engineering and Design Curriculum trending nowadays, the importance of sketching has heightened up. Many courses like Product Design, Engineering Design Process, Design Thinking, Engineering Exploration demands students to learn the basics of sketching to perform adequately in their courses. Even in the Shear Engineering curriculum, certain parts of sketching are included in Engineering Graphics at a basic level. This paper envisages the probable content and importance of sketching courses in engineering education which enables students to enhance their visual communication skills in various areas of Engineering. Various skills of sketching like doodling, perspectives, finishing, exploded sketches, storytelling boards are predominantly used and explored further in Engineering Education to excel in their projects.

Keywords: Engineering Education, Concept Generation, Storytelling board, Perspectives, Visual Communication, Sketching

1. Introduction

Many recent studies and applications from the past using sketching has served the purpose of creating designs and concepts to ramble the problems. It was advertently practiced to explore multiple concepts, develop and refine ideas to bring a refined form from Crude thoughts. Sketching was practiced widely by most of the students to promote their concepts to their fellow mates and the instructors, to help them understand and conceive ideas [1]. Apart from various tools, sketching acted as a crucial tool, significantly a prerequisite before teaching design thinking. However, it is evident that in engineering education graphics-drawing is taught from the very beginning of engineering courses. Apparently, engineering graphics is more focused on the technicality of the drawings rather than requisite sketching [2]. Sketching in design thinking is promoted as a key skill for student aspirants of designing, engineering and any creative platform where they enhance their ability to convey their ideas/ concepts visually thereby increasing the scope of better communication. Sketching is a difficult and diverse skill that is taught at different levels over educational platforms. It is not that one takes up fine arts to learn sketching, but rather selects a specific domain in the area of sketching which prudently becomes an important skill that aids in developing solutions using the design thinking process [3]. Today various sketching courses are

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widely available both offline and online at various levels. Even information technology has advanced and is constantly promoting by developing various IT applications and tools like smartpen, rendering software's, etc. Also, sketching has become a key factor, especially in rapid prototyping. [4]. Various researchers, instructors, professionals and industrialists have started promoting sketching as a basic skill to enhance efficiency in their performance. Even in collaborative learning sketching has been considered to be one of the efficacious tools to iteratively practice designing [5]. As many individuals opted to learn sketching as a basic skill the medium to learn has seen a rapid growth thereby increasing the demand curve. This obviously instigated the digital era to develop and, advance in the field of sketching using information technology for its ease of access and usability. Many visualization softwares, rendering software, digital tools, etc., were introduced at various disciplines accordingly, to provide efficient results [6]. This paper envisages the importance of sketching in engineering education with respect to alignments towards its curriculum showcasing its various aspects of both engineering and design. Sketching has proved to be an important tool to present and develop concepts especially in a user-centric design approach. Various sketching skills were introduced inclining towards design thinking process which helps in ideation at various intervals [7]. It isn't quite imperative to say that the engineering design process can be learned by skipping basic sketching techniques. It is quite significant that sketching indirectly provides better visual perspectives of an object or more precisely a product that designers study. Though it is quite difficult for engineering aspirants to learn sketching skills especially, those from Information Technology and related disciplines, many students often try to dodge the sketching course due to a lack of awareness and interest. Hence keeping in the purview of interested students a non-credited open elective course for sketching was introduced at the basic level [8]. Sketching has been taken as an important feature, not in the engineering design process but it is extensively and widely accepted in the industrial design process. To bring an understanding, the thoughts and concepts from one's mind were effectively represented using sketching, which acted as a crucial tool as a part of visual communication [9]. Various techniques and tools were put in the course which aided multiple benefits towards design thinking, which exemplified concepts for exploration and refinement. Along with orthographic and isometric sketching taught in the

engineering drawing, perspective sketching, shading, shadowing, and many more techniques were introduced in the course. Doodling has been introduced and is highly practiced to develop storytelling boards that help innovators to explain their crude ideas [10].

2. Broader Context

Engineering is essentially a problem-solving job. Many Engineering institutions in the past have not been phenomenally efficient in turning the aspiring engineers through its course to be a real-life problem solver. They were being given exposure only to textbook problems that help them understand the theory, but not sufficient to solve practical problems. However, the scenario has evolved a bit and the aspirants are being taught the textbook along with some values added, in many institutions. The engineers started to understand that they need to relate several aspects of the problem to come up with an effective solution. There are problems, there are wicked problems, and then there are impossible problems – once the depth of the problem is understood. The students then solve the problems – by creating solutions from different angles. But, these ideas are alive only for some time and unless timely recorded, the essence of the idea is lost. This is where Sketching helps the problem-solvers and the aspiring Engineers. It acts as a tool for them to externalize their solution, and let alone communicate it to others verbally for evaluation. Hence, sketching has become one of the most effective tools for engineers to capture and record their mental process and also to provide visual clues for themselves or to others while communicating their ideas in an effective way. It helps them construct a visual understanding of their own ideas for any design related solution. It is usually a quick, rough, freehand drawing, with not many technical details roughly representing the key features or aspects of an idea. It can be used at different stages while the solutions are being conceived explored, developed, detailed, visualized, and even executed.

Good Product Rendering requires both practice and skill. Proportionate, well-defined sketches and renders communicate best. Pencil sketches done using good shade, shadow and highlight techniques or renderings in crayons, dry pastels, etc. are highly effective visualization tools for the designer. Various angles of projection provide better and maximum information, which is considered to be most ideal. Many a times, students opt for more than one view,

depending on their product, to communicate all aspects of their concept well.

3. Course Overview

Sketching, more contextually, Object drawing is essential for the representation of 3 Dimensions of an object. Students, through this audit course, will gradually grasp an understanding of how best they can communicate their ideas through a sketch in the most appropriate way. A Good Sketching is one that Communicates, looks Proportionate, is Three-dimensional & Resembles the real object or product concept.

A. Objectives and Outcomes

i. Course Objectives

Students shall learn:

- The importance of sketching in Engineering Education
- Various types and forms of sketching.
- How to Draw basic shapes and analyze various aspects of sketching like symmetry, axis, and proportion.
- To identify various tools used for various forms of sketching.
- How to organize and relate concept sketches to the real world.
- How to draw the component-wise sketches used for production.

ii. Course outcomes

Students shall be able to:

- Use various lines, shapes, patterns, textures, and highlights to produce an effective Representation.
- Compose three-dimensional sketches using several techniques.
- Illustrate using storytelling boards.
- Deduce various ideas by iteratively

developing concepts using doodling techniques.

- Differentiate one point perspective sketches and two point perspective sketches by understanding the Projection Profiles
- Apply various methods like shading, shadowing and highlights to provide better finishing effects.

B. Course Modules

i. Module–1 – Introduction

Introduction to Sketching – Why and Where – Types of Sketching – Tools and Materials

ii. Module–2 – Drawing Techniques

Basic of Sketching – Practice – Lines – Geometrical Shapes – Patterns – Consistency – Proportioning – Symmetry – Contouring – Simple to Complex – Rendering

iii. Module–3 – 2D-Drawing

Orthographic Projection - Views – Basic 3D Shapes – Products

iv. Module–4 – 3D-Drawing

Isometric Projection – Perspective Views – One Point Perspective – Two Point Perspective – Three Point Perspective

v. Module–5 – Light and Shadow

Lighting – Shading – Shadowing – Object Drawing

vi. Module–6 – Finishing

Concept Sketching – Storytelling – Doodling – Exploded Views – Product Detailing

4. Sample Works

Since sketching is treated as one of the most efficacious tools in representing and communicating the respective work, it becomes significantly important for the young engineers to be learned. Every individual needs to know certain aspects of sketching

where it plays an impactful role in exercising their work. Though sketching hasn't been considered as a credited or mandatory course for engineering students, yet, a club with respect to sketching has been initiated where an individual from any engineering discipline can register and complete the course which is an audit course. The following gives the respective methodology and a few sample works in line with the course.

i. Module – 1

During the initial lectures of the course, every individual's skills are tested and the expected outcomes of the students are envisaged in the introductory session of sketching, various roles and importance of sketching for engineering students are explained. It is quite firmly portrayed that sketching is to be treated as a prerequisite and has many credits in

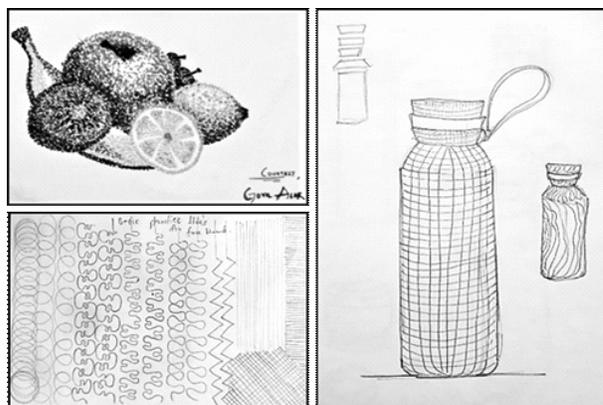


Fig. 2 : Pointillism, Contouring, Patterns Practice

engineering subjects like product design studio, engineering design process, design thinking and innovation, etc., which are mostly PBL based courses. Also, various types of sketching as shown in Fig. 1, line drawing, doodling, cartoon illustrations, pointillism, hyperrealism, anamorphic, fashion-product illustrations, architect, along with different types of sketching various tools and materials associated with the type of work is briefed.

ii. Module – 2

In the second module, various basics with respect to sketching were taught by practice. Various tools usage and techniques to use them were illustrated. Even, holding a Tool in the right way and right place is to be considered of utmost importance. However, some people organically develop skills to use tools. Various basic practice concerning pencil drawing is taught. It includes Lines, patterns, textures, symmetry, continuity and contouring. For example, to coordinate the Hand-eye movements, contouring of a basic object is practiced, where an individual sketches the outer line of the object in a single stroke by only keeping his eyes towards the object while executing their work as shown in Fig. 2. Students are generally made to

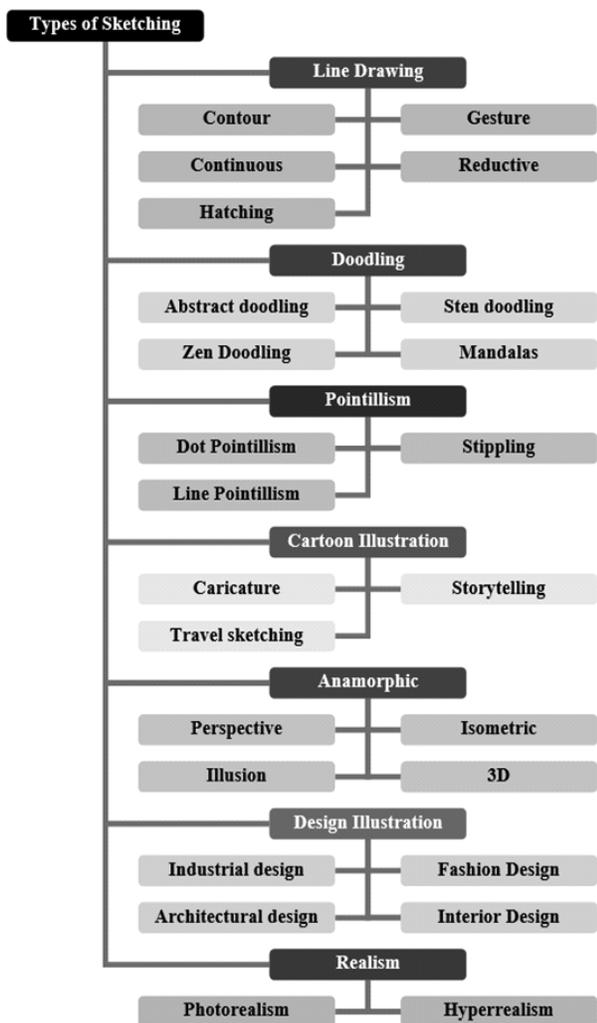


Fig. 1: Types of Sketches



Fig. 3 : Caricature and Object Rendering

practice Rendering of the objects using basics shapes from which they bring the Final form and detailing using varied textures or materials as shown in Fig. 3. They also explore caricatures.

iii. Module – 3 & 4

As things grow better and when students get the hang of making random sketches, the art of perception with respect to dimensions and scaling things is brought into the picture. Here in modules, three and four various methods of drawing views are explained. The Human Eye captures everything, but it is very difficult to represent it on paper. The differences between 2D and 3D drawing are illustrated and explained. Hence perspective views are taught following orthographic views. An orthographic view is also taught in Engineering Graphics as well, hence more efforts are put into the perspective drawings. Initially, students are allowed to look at a particular portion of the room and are asked to represent it over the paper, in which they face lots of difficulties. Later they are instructed to take some pictures of rooms or things from a distance and are said to draw, by looking at the picture, which eases a bit of effort. Finally, the pictures are converted to perspective views and explained, how one can draw the views using Perspective Drawing Techniques. Also, many key elements like Foreshortening (how the corresponding distortion of images occur giving it a compressed look) and Vanishing Point (the consequence of Foreshortening which is basically a point from where all the line origin which are tangential to corners of the image) were explained. Fig. 4 and Fig. 5 Illustrates the difference between One Point Perspective and Two Point Perspective.

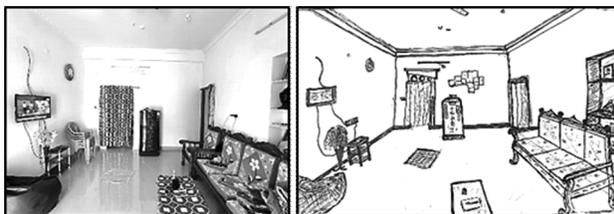


Fig. 4 : One Point Perspective

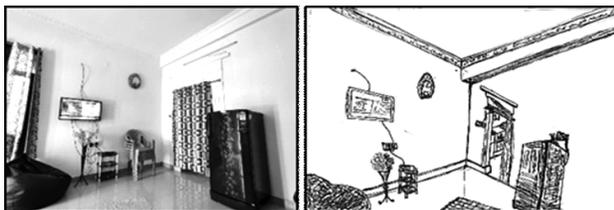


Fig. 5 : Two Point Perspective

iv. Module – 5

In the fifth module importance of finishing the sketches was explained. Converting a basic sketch into more thematic and connecting it to the real-world was considered essential. Different methods of shading and strokes were illustrated. Shadows help the sketches to give themselves a sharp and more jut appeal thereby giving it a more three-dimensional feel. The effects of lightning were considered to make the sketches more realistic and were practiced by changing the position of the light source in the sketches. The basic way of making shadows is to draw a line tangential to the corners of the Product from a single source of light falling towards the object. Shadowing became important as it played a vital role in making the objects look real and effective. Not only it provides the aesthetic appeal, but it also adds various values to it by providing indirect information with respect to the surface, Position, etc., various objects were kept under artificial light and were practiced. Even highlights were introduced to tint and tone the sketches which were from the brightest side to the darkest side of the Object. These provided a greater appeal in fulfillment of the Product Sketches showing the reflections of light which gives the Human eye effects in the sketches as shown in the Fig. 6. For rendering, one good technique taught, is to select a base color that comprises most part of the product's body. This allows the students to just play with the shadows and highlights, instead of bothering about the fill. Also made them observe how a reflection on an object will follow the contours of that object.

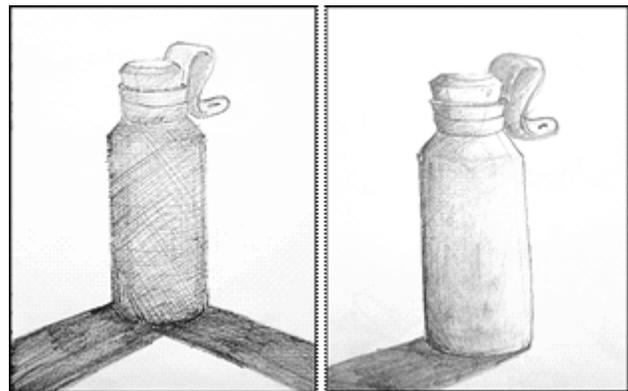


Fig. 6 : Shadow Tracing of Object

v. Module – 6

In the final Module, all the skills learned are utilized as required to get the final outputs. Various

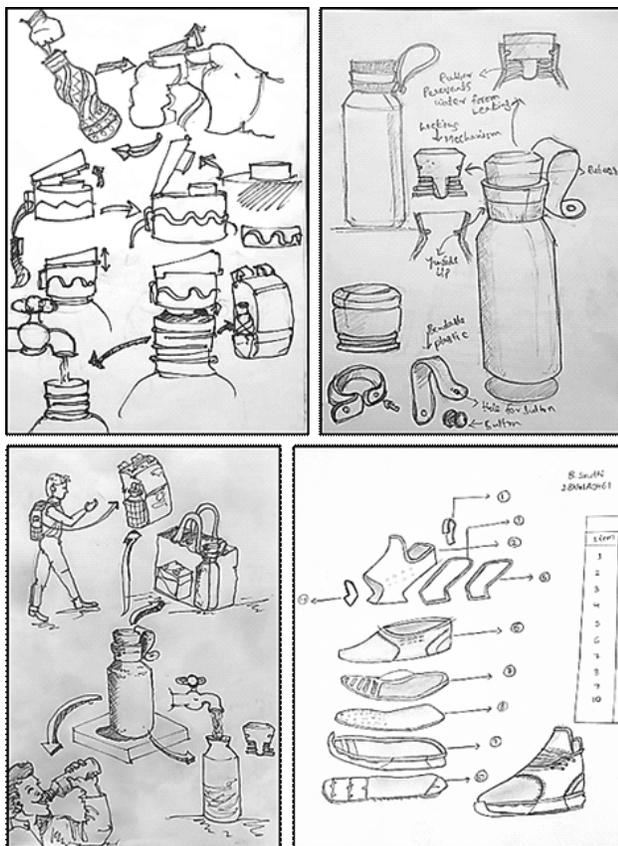


Fig. 7 : Doodling, Concept Sketching, Story Telling, Exploded View

types of Doodling practices are made to get the framework of one's sketches. Doodling provides the skeletal scope for the Sketches, giving a brief idea and process to make it. Later Storytelling is introduced which is indeed one of the good visual communication tools. Many storytelling practices are led in the classroom like 'Old Man rocking in a chair and imagines the Incident of Past', 'An artist enjoying the music while sketching' and more. These practices make students understand the art of communication for example Old man (common representations – Bald Head, Big Glasses, Walking Stick, Wrinkles on forehead, a dhoti in Indian Context, etc.,). Storytelling is considered of more importance as students are expected to use this visual communication tool in their various course works to showcase their Problem Statements, Need Statements and Solutions depicting in Sketches. It gives great value to one's work and is very helpful for any common person to perceive, understand, and give their valuable feedbacks during Surveys and Research. Storytelling also serves as a great way of showing the process or flow of the

product/project to use. Many products we use have the same storytelling leaflets to represent the working of their product step by step as shown in Fig. 7.

At the later stage Exploded View Sketching is introduced which is significantly an important and crucial part of product architecture. It is good to have an idea about exploded views as they come in handy while detailing out various parts of the product concepts and communicating as to how they connect to become a single entity. They represent the relationship or order of assembly and contain all details of the product's component parts. It lays a pathway for the Manufacturer to produce the required Components using adequate materials, in order to make the Product. The students were asked to draw a daily life object they use, to verify if they understood the essence of sketching as a tool for understanding the features of an object visually.

5. Course Assessment

Since the Course offered is an Audit Course, the Assessment were based on Graded Quiz and Peer Graded Assignments. The weightage for Grading is as shown in Table. 1. The Minimum criteria for passing the course is 60%.

Table 1 : Weightage for Grading

Module	Assignment	Weightage
Module 1	Graded Quiz	5%
Module 2	Graded Quiz	5%
	Practice Assignment	-
Module 3	Graded Quiz	10%
Module 4	Graded Quiz	10%
	Peer Graded Assignment	20%
Module 5	Graded Quiz	5%
	Peer Graded Assignment	10%
Module 6	Graded Quiz	5%
	Instructor Graded Assignment	30%

All the Assignments were graded as per the predefined Rubrics. The Rubrics were prepared as per the type of Assignment and its outcomes. For Example the Instructor Graded Assignment is graded as per the standard rubric as shown in Table. 2. The Assignments are graded for requisite skill parameter based on their level of attainment as Excellent, Good, Average and Poor. These are summed up and released.

Table 2 : Instructor Graded Assignment rubrics

Parameter	Weightage (%)
Creativity	20
Craftsmanship	20
Drawing Elements	10
Completion	20
Organization	10
Communication	20

6. Conclusion

Due to the sketching course, the students were able to make their product better at different stages during the design of the product. During ideation, they were able to understand and relate to various situations surrounding the problems through sketching. During Concept generation and building solutions, the sketching helped them to understand the shapes and techniques of making their product beforehand. The perspective drawings gave them an understanding of how the finished products look like in a real-time environment. The Positive inferences could be indirectly seen in their post credit courses like Product design studio and Engineering Design Process, where product architecture and concept sketching plays a Vital role.

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