

DEVELOPING A DRAWING CULTURE: NEW DIRECTIONS IN ENGINEERING EDUCATION

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ABSTRACT

Sketching is integral to the design process, as it allows reflection in action, enables ambiguity and abstraction, encourages the unexpected, externalises mental imagery, and provokes creativity through analogical reasoning and reinterpretation. The articulation of the concept facilitates a discussion not only with peers and clients, but more importantly with oneself in a reflective practicum. In the context of engineering practice, sketching serves multiple social and cognitive functions throughout all stages of the product design and development process.

Fundamentally sketching is the 'first language' of all designers and it is apparent that the design process can be limited by one's capacity to use drawing for cognitive exploration. It is therefore essential that development of drawing skills is integrated throughout engineering education.

This paper discusses curriculum initiatives aimed at developing a drawing culture amongst product design engineering students. 'SketchFest' is a sketching and ideation program that augments existing drawing skills, introduces new techniques and promotes student awareness of the value of sketching in product design and development.

Keywords: sketching, engineering design, creativity, product design, engineering curricula

1 BACKGROUND

Observation of students and graduates together with feedback from industry partners has indicated that many design engineers are weak in sketching and ideation skills. Engineers play an increasingly important role in the product design and development process (especially the product design engineering graduates) and consequently graduates must be highly competent in investigative drawing, technical communication and functional explanatory drawing. The SketchFest curricula initiative aims to address student and graduate deficiencies in perspective drawing, through ideation sketching, styling and form-giving, and explanatory and technical sketching.

2 INTRODUCTION

Product Design Engineering is a unique engineering pedagogy as it incorporates 'designerly ways' [1] into engineering curricula through integration of industrial design and mechanical engineering curricula. This multidisciplinary program derives sixty per cent of its engineering content from the standard mechanical engineering curriculum; with the remaining subjects offered through the design faculty, taught by industrial design lecturers. The design subjects focus on the acquisition of design skills, and the fostering of creativity through experiential learning design studio projects, open-ended problem solving, and the application of engineering science to real world design problems.

Design acumen and creativity is enhanced by sketching and ideation activities. It is essential that engineering curricula fosters creativity and focuses on design, if our graduate engineers are to be not just technically competent, but innovative. "Creative engineers are "driven to seek uniqueness, have unusual ideas, tolerate the unconventional and seek unexpected implications." [2]

The focus on creativity and sketching within the product design engineering program has underlined the contribution that design thinking and design aptitude can make to traditional engineering curricula.

A comparative evaluation of problem solving between final year mechanical engineering and product design engineering students [3] found that the inclusion of 'designerly ways' into the engineering curricula does not compromise the integrity of the 'science' of engineering; rather it has enhanced the 'practice' of engineering. It is also evident that sketching and design activities can be a motivating factor in engineering learning thus developing more creative and adaptive design engineers.

The 'SketchFest' sketching and ideation program was conceived with two primary objectives in mind; firstly the enhancement of existing freehand sketching skills (within the product design engineering student cohort) to a level where creativity and conceptual design processes were not impacted by drawing skill limitations, and secondly to lead by example in actively promoting a culture of drawing throughout the engineering student community.

3 WHY DO ENGINEERS NEED TO DRAW?

Sketching enables abstraction of idea development and is therefore not just a documentation or communication process; instead it facilitates the creative process through external representation of the iterative design ideation process. Without sketching ability, many engineers struggle to find the unintended consequences that stimulate the design exploratory process in what Schon and Wiggins [4] called the 'reflective conversation with the situation'. This is supported by Ullman who surmises that "in engineering education, results point to the importance of being able to represent design concepts graphically. It appears that the very design process is limited by the ability to use graphics as a cognitive extension." [5]

Yet although there is significant evidence that sketching is at the heart of design and creativity, it is unusual for engineering curricula to develop the freehand sketching skills essential for design ideation and communication; this limits the potential for engineering graduates to explore design possibilities.[2] This disregard for the benefits of teaching design conceptualisation and articulation tools such as sketching, is consistent with a lack of design emphasis in most engineering curricula as identified by Dym et al.[6]

The importance of sketching to the creative process, was evident in studies of industrial design students by Verstijnen & Hennessey which compared skilled and unskilled sketchers, and found that "the skilled sketchers benefited from the externalisation of mental imagery." [7] The 'expert' sketcher benefits from an unencumbered progression where the translation of thoughts to design intent occurs via a fluid evolutionary process. The ability to generate and articulate abstract concepts without excessive concentration on the mechanics of drawing afford the designer a higher level of both abstraction and reflection, facilitating creativity and innovation. "This implies the need for training... not only in the standard drafting skills, but additionally in the ability to represent concepts that are more abstract and best represented as sketches" [5]

As sketching facilitates "the creative shift to new alternatives"[8] it is vital that engineers develop into competent sketchers, capable of coherent expression of unformed ideas and design intent. Yet many engineering students disregard the exploratory possibilities that sketching offers in the creative process relying instead on CAD; denying them the opportunity to unlock their creative potential.

4 THE IMPORTANCE OF SKETCHING IN PRODUCT DESIGN

The ability to articulate ideas and design intent through sketching is one of the most valuable tools a product designer or design engineer can possess; not only is sketching the 'first language' of design, (transcending linguistic and cultural barriers) but it also the quickest and most efficient designer tool for problem definition, ideation and the development of form and function.

Whilst there is no doubt as to the impact and influence of CAD in the product design and development cycle (particularly for detail design and documentation), drawing is still a powerful tool in the hands of the engineering designer; free of the constraints of the sequential and logic based processes of the digital interface, it allows multiple iterations to occur simultaneously and almost instantly.

4.1 The power of the design sketch

It is imperative that students are fluent at creative exploration and critical reflection, and are effective communicators of design intent. [9] These activities usually manifest in sketching activity addressing a variety of situational or design progression needs. Sketching in a product design context allows the designer to externalise ideas, convey ideas metaphorically and express abstract elements and relations.[10] It also opens internal and external communication paths, legitimises or verifies concepts and promotes new ideas.

Sketching is not only integral to the design process, but closely related to developing a creative process as it allows the reflective practice, analogical reasoning and reinterpretation of the sketch that provokes creativity. [4, 8, 11, 12] Sketches help the designer to achieve not only 'vertical transformations' in the sequential development of a design concept, but also 'lateral transformations'

within the solution space; the creative shift to new alternatives.[8] Goldschmidt refers to the dialectics of sketching as the oscillation of arguments resulting in gradual transformation of the images until the designer is satisfied with the coherence of the design; a dialogue between reflective criticism (seeing that) and analogical reasoning and reinterpretation (seeing as). She proposes that “the inherently creative process of form production seems to result from a special, systematic causal relationship between two modalities of visual reasoning, induced by sketching.” [11]

This is supported by Fish and Scrivener who opinion that “sketching amplifies the mind’s ability to translate abstract propositional/descriptive information into concrete visual/depictive information.” [13] Sketching is a fluent and flexible process, producing implicit, abstract and inexact representations of possibilities, rather than well defined solutions. This inherent inaccuracy and ambiguity allows greater freedom for the designer to discard designs to pursue alternatives and allows a free-flowing ideation process that is unconstrained, fast and enables uncommitted exploration and analysis. This enables the designer or engineer to explore many possibilities before committing to a singular design direction. Ambiguity early in the process is important to avoid premature crystallization of ideas which may constrain creativity by restricting divergent thinking, preventing the emergence of new possibilities.[8]

4.2 The functions of sketching

Sketching has many purposes in product design and development (PDD) including:

- investigative and explorative drawing (ideation)
- technical and functional drawing (resolution)
- explanatory or instructional drawing (communication)
- form giving or aesthetic styling
- persuasive drawing (the hero or ‘sell’ contextual image)

The ideation stage of PDD uses investigative sketching initially as the designer researches and defines the problem, before moving into concept generation through explorative sketching of solutions, functions and form proposals.

Technical sketching is investigative or communicative of features and functional design through the use of exploded perspectives, mechanical design sketching etc and can be utilized in both the ideation and design embodiment stages.

Explanatory or instructional drawings are communicative and are used to impart function, assembly or user sequences. These drawings are typically not part of the PDD process; rather they exist to provide information to users and may involve sequential explanation or product interaction description.

Form-giving involves the development of aesthetic styling for the appearance of the product and may occur simultaneously or sequentially with functional design in the ideation, design development and embodiment stages.

Persuasive drawing involves the generation of detailed high quality contextual images which are used to ‘champion’ the proposed design; it is in this area that 3D-CAD rendered images have had the most impact on design studio drawing practice.

5 DEVELOPING AN ENGINEERING DRAWING CULTURE

5.1 New engineering curricula

In response to the need for product development teams who integrate the skills of both industrial designers and mechanical engineers as noted by Cross [14], innovative multidisciplinary engineering pedagogy has emerged to educate a new engineering discipline – product design engineering (PDE).

This new breed of engineers emerging from approximately 28 universities worldwide, respond directly to industry requirements for what Eekels described as ‘integralists’ [15] - engineers who are fluent across all facets of product design and development. This new discipline emerged originally in Scotland in the late 1980s, where a changing manufacturing landscape prompted new directions in engineering curricula aimed at delivering graduates competent in both engineering and design.

5.2 A cultural shift

The impact of these ‘new’ engineers has been significant with many challenging the composition and internal roles of product design and development teams. The design aptitude and sketching acumen of

these engineering graduates has seen them occupy roles traditionally reserved for industrial designers and this has resulted in the need for a greater emphasis on drawing skills within the curriculum. The emergence of this new paradigm of design engineer has revealed that many engineering graduates are typically poorly equipped for the practice of engineering in a product design and development environment; lacking the obligatory creativity and design ability. Rapidly changing industry requires “a new generation of adaptable, flexible, well rounded and innovative professionals.” [16]

5.3 Expectations

It is apparent that visual ‘artistic’ skills are important to engineering design processes and it is recognised that cognitive functions and creative pursuits may be hampered by the introduction of CAD too early in the design process. [17, 18]

Consequently in the PDE curriculum perspective, sketching and rendering are integrated into the learning experience from the initial semester through to the final year, with a shift to CAD only at the stage of product definition and documentation.

At Swinburne the success of the PDE graduates, particularly in product design environments, has led employers to expect fluency, if not a high level of expertise in both engineering and design, including front end conceptual design. This changing or emerging role for engineering has driven the recent introduction of a new sketching program ‘SketchFest’, which aims to develop and strengthen the drawing culture amongst the engineering student community.

6 SKETCHFEST V1 – THE INITIAL TRIALS

The initial SketchFest modules were delivered to final year product design engineering students in response to evidence of a lack of sketching prowess in earlier projects. It was felt that whilst the students were extremely competent in design development and the use of 3D-CAD, there was a lack of demonstrated skill in the ‘fuzzy front end’, possibly exacerbated by previous reliance on CAD and a lack of explorative or reflective practice. Although these students had been exposed to ‘designerly ways’ since the beginning of their course, it was apparent that they valued the contribution of sketching to their design process less than industrial design students, perhaps feeling that expertise in sketching was not critical to their overall ability or employability- however academic staff and industry representatives disagreed.

Whilst design engineers typically are not expected to be able to produce ‘persuasive’ or product hero drawings (such as those generated by industrial designers for client or investor approval) there are many forms of sketching that are essential to the effective conceptualisation, technical development and implementation of a product; predominantly ideation, resolution and communication.

The four teaching modules were designed to provide a range of sketching experiences, with students in each session being offered one of four distinct product categories from which to choose a product challenge; these were not revealed until the start of class to ensure that outcomes were representative of the allowed timeframe. Differing materials, user needs, environmental and ergonomic constraints and functional requirements ensured that the challenges, whilst relatively constrained, encouraged creativity, innovation and originality. Students were expected to produce new designs and to not fixate on existing solutions. Due to the short lead-time it was anticipated that outcomes would be highly conceptual and may lack technical exploration; this was acceptable as the exercises aimed to stimulate creative and explorative activity and develop confidence and acumen in sketching.

6.1 Initial instruction

The first session consisted of a briefing session and introduction to quick sketching techniques.

Initial tutoring utilised in-class lecturer expertise combined with on-line tutorials from the excellent ‘ID Sketching’ website, <http://www.idsketching.com> which includes the ‘sketch-a-day’ gallery and drawing and rendering demonstrations by Spencer Nugent. <http://vimeo.com/idsketching/videos> Students used this time to practice and refresh techniques before the assessable activities commenced.

6.2 Activity

SketchFest was run as a four part intensive course, primarily aimed at improving graduate skills in sketching and quick ideation through intensive real-time design activity during final semester design studios. The ability to deliver quick and timely conceptual designs is an essential industry skill for product designers and acumen in this area greatly improves employability.

Each SketchFest session occurred solely within the two hour design studio during which students responded to a simple brief with a series of hand-drawn perspective ideation sketches. Students were mentored and tutored throughout each module by two experienced industrial designers who suggested and demonstrated drawing and ideation techniques as appropriate. Sessions concluded with a brief pin-up review and reflective discussion session. The first two modules were run on consecutive weeks, followed by a week of review and individual consultation before the final two exercises.

It was anticipated that the exercise would also generate not only useful content for graduate portfolios but more importantly, evidence of the ability to deliver design ideation in industry appropriate timeframes. Students were encouraged to incorporate SketchFest pages into their portfolios and to further develop their designs at a later stage using 3D-CAD or digital visualisation tools.

6.3 Design challenges

In each session students were introduced to a specified product category from which they could choose one of four design ideation challenges. Challenges were relatively simple exercises involving familiar products which did not require prior research; however students were required to produce three A3 pages of fresh and original designs, not adaptive iterations of existing product solutions. The product categories were:

- Exercise 1: consumer electronics – one of either headphones, digital video camera, video game controller or webcam
- Exercise 2: industrial equipment –safety helmet / facemask, cordless drill / screwdriver work lantern or lawnmower (hand-powered or motorised)
- Exercise 3: apparel – sunglasses/ski goggles, backpack/courier satchel, binoculars or wearable communications device/watch
- Exercise 4: packaging - reusable water bottle, 2lt milk bottle with integrated pourer, easy open can (for elderly users) or men’s cologne bottle

Whilst it may be observed that these products did not represent significant engineering or technical challenges; this was a calculated decision. As the primary aim of SketchFest was to improve sketching and to develop quick ideation skills (within a two-hour timeframe), it was crucial that students could start the ideation process immediately upon receiving the brief. Resultantly, the design exercises were not open-ended or poorly defined problems that would require time consuming investigative or problem scoping processes.

Deliverables included both perspective and elevation sketching and specified the application of colour through quick marker rendering techniques. It is intended that these ideation pages be of sufficient quality of execution to be suitable for discussion with a client, not just for personal reflection. Product concepts were to be communicated in context with the inclusion of a human figure, hand etc as appropriate to communicate product interaction and functional sequence as appropriate.

7 ANALYSIS OF PROCESS AND OUTCOMES

7.1 Studio observations

Students responded to the teaching module initially with some hesitation and uncertainty. Whilst sketching had been part of their product design and development process for many years, it was not since first year that they had been specifically assessed on drawing output – all assessments involving sketching were typically part of other deliverables. Accordingly many poor sketchers had been able to progress through the course unimpeded by lack of drawing skill, and dependent on competency in 3D-CAD, satisfactory product resolution skills and long project lead-times. It was lecturer awareness of these deficiencies that prompted the introduction of the SketchFest program, with a stated aim to take students out of their comfort zone, make them work to tight timeframes and deliver on demand. It was believed important to:

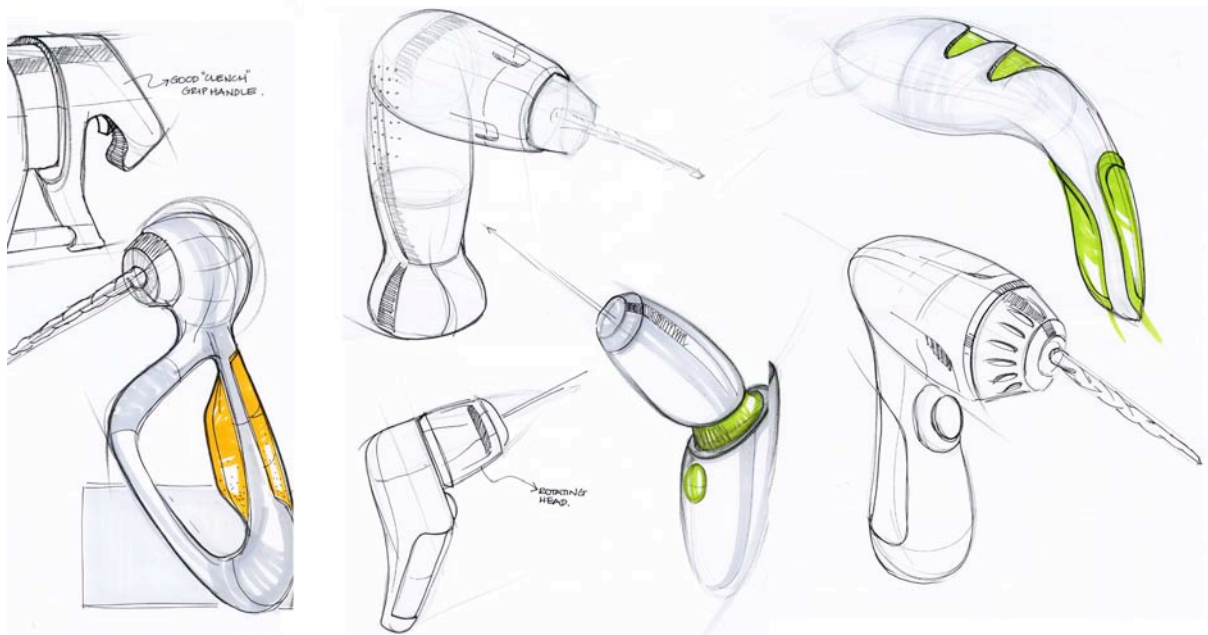
- enhance and develop existing skills,
- focus solely on ideation and sketching (independent of normal design project constraints),
- introduce commercially realistic pressure and time constraints to the students design processes,
- raise awareness of the importance and value of sketching and to
- show the students (highly skilled in most areas of PDD) where their skills deficiencies lay.

What was immediately apparent in exercise one was that many students with a history of competent drawing and product solutions struggled to articulate their ideas within the two-hour timeframe. This was principally due to one of two main reasons:

- the pressure of the timeframe adversely affecting their ability to abstract and ideate (“I just don’t have any ideas”) or
- difficulty with expressing complex forms in appropriate perspective viewpoints leading to a slump in the quality of drawing (“I usually spend time setting up perspectives, templates etc”)

The introduction of the program was justified by the initial findings which supported the lecturers’ perceptions of students’ abilities, but lecturers remained dismayed that so many students (close to graduation and employment) were unable to deliver quality design concepts, on demand, on time, in what was considered to be an appropriate measure of required industry skills.

However, more encouraging was the evidence that the good sketchers were able to consistently deliver well considered product ideation (as well as good drawings), supporting the findings of Verstijnen and Hennessey, Fish and Scrivener, Ullman and others. These students were able to reflect upon and refine their designs and explore variations of feature and form, different configurations and consider user interface in the time that for the poor sketchers was spent merely expressing the form. (See Figure 1)



*Figure 1. Proficient ideation sketching – time to develop and detail the design
(Image source: student generated sketches from two hour classroom exercise – student 1)*

Whilst some may believe the tight timeframe to be unnecessarily restrictive, it was necessitated by the studio class timetabling requirements, but was also felt to be an accurate representation of the time and budget driven processes of many product design consultancies. It was also considered to be appropriate industry preparation for final year students who typically were complacent within long project gestation periods and had not yet developed efficient and industry-relevant working practices.

7.2 Assessment criteria

Assessment of the exercises was divided into two main categories; the quality of sketching and the quality of ideation. Sketching was assessed against criteria that measured:

- accuracy and appropriateness of chosen perspective
- quality and hierarchy of linework and use and technique of marker application
- page layout – composition, use of negative space, graphic devices
- context – positioning of product in context to show product interaction (including explanatory or instructional drawing),

whilst the ideation criteria assessed:

- quick conceptualization – generation of multiple concepts
- diversity of ideas – investigative and explorative drawing
- innovation - unique design proposals without fixation on existing solutions
- aesthetics – quality of form giving/styling

Lecturing staff were looking for personal development in quick perspective sketching and rendering across the duration of the program, an improvement in student confidence plus resultant enhancement of ideation quality and product communication resulting from increased drawing competency. (see Figure 2)



Figure 2. Example of ideation sketching with strong contextual definition
(Image source: student generated sketches- student 2)

7.3 Analysis of outcomes

A review of student grades clearly shows the development of skills and improvement in both drawing and ideation quality. Seventy percent of students achieved higher marks in the last two exercises than the earlier ones, and achieved an average mark across the four exercises that was significantly higher than in the initial exercise. In a majority of cases, students improved their marks by at least ten percent and one fifth of students improved markedly with greater than twenty percent grade improvement. More significantly, was the observed increase in student confidence and the ‘relaxing’ of both technique and approach. It was apparent even during the individual exercises that students were becoming more comfortable and confident and this was evident when the three A3 pages were reviewed at the end of each session. Initial pages tended to be ‘scratchy’ and undirected whilst later pages (even though completed only an hour later) showed greater control, foresight and ideation competency. Also encouraging was evidence of reflective practice as subsequent pages demonstrated refinement of initial ideas and variations of earlier concepts. (see Figure 3)



Figure 3. Confidence and proficiency emerging during two hour session - earlier drawings at left.
(Image source: student generated sketches – student 3)

7.4 Student feedback

Despite early issues of low self-confidence and concerns regarding assessment, students applied themselves well to all of the exercises, arriving to class early and well prepared to maximise session productivity. Almost all of the students' clearly demonstrated improvement in perspective sketching and resultantly their ideation skills also improved, for which they were grateful. Students appreciated the effort to introduce this curricula innovation and felt the results validated the intent, but many questioned the timing, believing that it should have occurred much earlier in their course.

Most encouraging was evidence that students had been independently working to improve their drawing skills outside class, and that they were beginning to realise that sketching aptitude was an essential industry skill, rather than a historic anachronism.

They also benefited from the generation of new folio content, and responded proudly to their new found ability to provide efficient and timely design solutions, under pressure.

7.5 Industry feedback

Industry response to the SketchFest program has been positive with both the course industry advisory committee and other employers welcoming the initiative, indicating that skills in quick sketching and ideation will greatly enhance graduate employability and productivity.

Discussions have directed that future drawing exercises be focussed on the areas of investigative and explorative drawing, technical and functional resolution and explanatory or instructional drawing; these being the main areas of activity for design engineers. Much was made of the need for engineers to be able to communicate their thoughts quickly and effectively though drawing in a variety of environments, ranging from the meeting room through the factory floor to the end user, without dependence on digital media.

8 SKETCHFEST V2 – A HOLISTIC APPROACH TO DRAWING

The success of the initial initiative has demanded a deeper and more thorough approach to developing drawings and ideation skills. Consequently 2011 will see the introduction of SketchFest Version 2 with four new plug-in modules that will be progressively delivered into design studios in both semesters of second and third year; continuing and enforcing the introductory first year experience. These independently assessable modules will have distinct themes, thus providing each semester with a clearly defined drawing agenda for students to master before progressing. Assessment weighting will be significant enough to ensure that failure to reach the prescribed minimum competency will inevitably result a significant loss of overall subject marks, and possible failure to progress. It is anticipated that this concentration of delivery and assessment will result in students placing greater value on the importance of developing strong drawing skills and the early development of a new drawing culture amongst the engineering student cohort.

8.1 Themed modules

The proposed modules, to be completed in sequential order, aim to develop confidence and aptitude progressively throughout the course and to redefine sketching as the primary form of design communication to meet all situational or design progression needs.

8.1.1 SketchFest 1: Investigative drawing

This second year module explores investigative and explorative sketching techniques used in the ideation process; sketches used to explore solutions, functions or forms.

- week 1: ideation sketching 1 (primarily using coloured pencil)
- week 2: ideation sketching 2 (using fineliner and marker)
- week 3: exploration of form (development of form, use of curvature and blends)

8.1.2 SketchFest 2: Technical drawing

The second year technical drawing module will focus on drawing exploration of functional design through exploded perspectives, and mechanical design sketching.

- week 1: exploded perspective 1 (single axis deconstruction)
- week 2: exploded perspective 2 (multiple axis deconstruction)
- week 3: functional mechanical design (representation of mechanisms, component relationships)

8.1.3 SketchFest 3: Explanatory drawing

This third year communicative drawing module will focus on drawing that imparts functional understanding, assembly sequences or user interaction. Typically explanatory drawing is not part of the PDD process, but communicates specific information to production and assembly staff and end users and utilise sequential progressions or product interaction description.

- week 1: operating sequences and product interaction drawings
- week 2: user focused assembly instructions (8-10 steps)
- week 3: storyboards (e.g product system services)

8.1.4 SketchFest 4: Advanced styling

This advanced module explores form-giving through advanced drawing and ideation techniques.

Whilst outside the scope of most design engineering activity, it is recognized that many product design engineering graduates are often employed in dual design and engineering roles where they may be required to take responsibility for product styling in lieu of using an industrial designer. It is hoped that these more advanced exercises extend the students and further reinforce the culture of drawing.

- week 1: surface development
- week 2: contours
- week 3: detailing / product variation

8.2 Delivery:

The SketchFest modules will be delivered as in-class activity during two-hour design studio sessions with continuous lecturer engagement and feedback. Students will be expected to work productively during the studio session, continue work on the exercise outside class and submit final drawings via a ‘pin-up’ review at the beginning of the following week’s class. Although conceived as an in-class activity, it is critical that students engage in extra curricula drawing if we are to develop a ‘drawing culture’ that is independent of project deliverables - providing the opportunity for students to continue their work in their own time aims to achieve this.

9 CONCLUSION

The SketchFest program although in its infancy, has already proved successful and has been received favourably by staff, students and industry. It is anticipated that its continued implementation will assist in developing a passionate and robust culture of drawing dependence throughout the design and development process. Student progression will be carefully monitored to ensure that the program reaches its objectives - to ensure that all product design engineering students are efficient and accomplished sketchers and reflective practitioners. It is essential that our engineering graduates are effective visual communicators and can translate abstract and exploratory concepts into definitive product solutions through the medium of sketching.

10 DISCUSSION

Cropley and Cropley [2] in their investigation of engineering student creativity suggested that many engineering graduates are unsuitable for employment because of ‘skill deficiencies’ in creativity and problem solving, and Dym has stated that “we do not teach the language of design, preferring the language of mathematics.” [19] This suggests that creativity and design acumen are valued industry skills, but not always reflected in traditional engineering curricula.

There is little evidence that sketching, the primary tool for engineering designers to articulate their thoughts (for problem framing, discussion and reflection) is valued in traditional engineering education, despite significant research linking sketching to creativity. [3] Yet it is imperative that engineering students become proficient in sketching and ideation techniques if we are to develop a new generation of creative and reflective engineering design practitioners. Efforts must be made to decrease the reliance on CAD which (although invaluable in the detail design process) imposes a structured methodology upon the user, restricting exploration and abstraction; stifling creativity. Sketching and ideation, are not only the tools of creativity and communication, but can also be a motivating factor in learning, resulting in more creative engineering graduates.

The product design engineering program is a new teaching methodology that responds to the changing roles of engineers in product design and development with a focus on fostering creativity through a focus on design and the language of design; sketching.

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