SKETCHFEST: EMPHASISING SKETCHING SKILLS IN ENGINEERING LEARNING

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ABSTRACT

Sketching is often described as the first language of designers and it is a critical skill for engineers and designers as it enables the multiple social and cognitive functions represented by drawing within product design and development. Drawing acumen is considered by industry as a core and indispensible skill in product design, highly efficient and free of the constraints imposed by sequential and logic based digital processes. It enables abstraction, embraces ambiguity, facilitates exploration and unexpected outcomes and provokes creativity through reflection and reinterpretation. It is apparent that any lack of ability to use drawing for creative exploration, reflection or communication can limit creativity, and constrain innovation and the efficiency of the design process.

However digital design processes (i.e. CAD) have significantly impacted on the sketching skills of design and engineering students. The persuasiveness of screen-based outcomes has led a decline in drawing skill acquisition to the detriment of both design creativity and design communication.

The resultant lack of sketching skills has impacted on students' academic performance, their design confidence and creativity and their future employment potential.

This paper describes SketchFest; a curricula initiative aimed at re-establishing drawing competency amongst engineering students in direct response to industry expectations. This new curriculum addresses industry concerns regarding graduate attributes through a targeted program that embeds sketching skill development throughout the learning journey.

Keywords: Sketching, creativity, product design and development, engineering curricula

1   INTRODUCTION

Engineers contribute to the product design and development environment with new roles and increasing responsibilities. Graduates of new engineering disciplines such as product design engineering (which combines mechanical engineering and industrial design curricula) are expected to be creative designers, highly competent in drawing for explorative and investigative processes, technical communication and functional explanation. These skills introduced to the product design engineering curricula through the 'industrial design' course component are supplementary to traditional engineering skills but are increasingly required by all engineers engaged in product design.

However students have become overly dependent on digital process (in particular 3D-CAD), seduced by the immediacy of on-screen product depiction, at the expense of developing traditional drawing expertise. Consequently, industry consultants engaged in product design and development have observed a deficiency in sketching skills amongst engineering and design graduates; resulting in limited capacity for creative ideation, technical resolution and design communication and a reliance on CAD leading to inefficient working methodologies.

The 'SketchFest' curriculum initiative described in this paper addresses students and graduate deficiencies in perspective drawing and creativity, through modules that teach ideation sketching, styling and form giving, technical sketching and explanatory drawing. The modules are delivered to both Industrial Design and Product Design Engineering students albeit with differing emphasis; the product design engineering SketchFest modules focusing more on the use of freehand-drawing for technical resolution and explanatory communication, rather than aesthetic styling.

SketchFest was conceived with two primary objectives; the development of drawing skills to a level where creative ideation, product innovation and design communication were not limited by drawing competency, and to actively encourage a new drawing culture amongst the student cohort.

2   IS DRAWING A REDUNDANT SKILL FOR ENGINEERING?

How important is drawing in a digital age? Is traditional perspective sketching still important or have it been made redundant by ideation software? Do engineers need to be taught to draw?

These questions although not without merit in an environment of increasingly capable digital design tools, ignore the basic tenement that sketching allows abstraction of idea development; facilitating the creative process through external representation of mental imagery and design ideation. There is evidence that that sketching plays a significant role in design creativity; free of the technical constraints imposed by digital tools, it allows multiple and simultaneous iterations to occur promptly.

The externalization of thoughts plays an important role in the design process allowing designers to reinterpret their ideation; this interaction between designers and their sketches was seen by Purcell and Gero [1] as essential to creativity. Sketching is not merely a documentation process; rather it affords a "higher level of abstraction and reflection, facilitating creativity and innovation." [2] Without sketching ability, engineers may not unearth the unintended consequences that inspire the design exploratory process through what Schön and Wiggins [3] described as "the reflective conversation with the situation." Ullman et.al [4] found that "results point to the importance of being able to represent design concepts graphically," surmising that the design process can be limited by inability to use graphics as a cognitive extension. This is supported by the findings of Verstijnen and Hennessey [5] who compared industrial design students and found that "the skilled sketchers' benefited from the externalization of mental imagery." It appears that 'expert' sketchers more easily translate initial thoughts to design intent though a fluid and unencumbered progression. Engaging in the ideation process without excessive concentration on drawing technique, frees the mind for abstract exploration and reflection; facilitating "the creative shift to new alternatives." [6]

"This implies the need for training…in the ability to represent concepts that are more abstract and better represented as sketches." [4] Yet despite the findings linking drawing and design creativity, it is uncommon for engineering curricula to specifically foster freehand drawing skills; limiting the potential of engineering graduates to fully exploit their creativity and explore design possibilities.[7]

In a comparative evaluation study of the problem solving abilities of final year mechanical engineering and product design engineering students [8] it was found that the inclusion of 'designerly ways' into the product design engineering curricula had greatly enhanced engineering student creativity. It was evident in that evaluation that trained sketchers' were more comfortable (and confident) with creative design process; easily articulating and developing their ideas into technically well-resolved product concepts. It was also apparent that sketching can be a motivating factor in engineering learning.

So despite the increasing contribution of digital design tools to product design and development there appears to be a persuasive argument for the inclusion (or retention) of drawing teaching to enhance engineering creativity and facilitate student confidence and design articulation.

3   THE FUNCTION OF SKETCHING IN PRODUCT DESIGN

In product design it is critical that students are proficient at creative exploration (welcoming ambiguity and uncertainty), critical reflection and are articulate communicators of design intent. Sketching activities addressing a range of situation and design progression needs allow designers to externalize ideas, convey ideas metaphorically and express abstract elements and relations.[9]

The contribution of sketching in product design and development is not limited to creative ideation, but impacts throughout all stages of the product design process. Drawing contributes to the quick and efficient resolution of technical and functional details, graphic representation of user-product interaction, form refinement and communication though explanatory drawing. Sketching can open communication channels, validate conceptual designs and advance new ideas.

Sketching is essential to the creative design process as it facilitates reflective criticism (seeing that), analogical reasoning and reinterpretation (seeing as) [10] and "amplifies the mind's ability to translate abstract propositional / descriptive information into concrete visual/depictive information." [11]

Goldschmidt [10] proposes that "the inherently creative process of form production seems to result from a special, systematic relationship between two modalities of visual reasoning, induced by sketching." The fluency and flexibility of sketching produces implied, inexact or abstract representations of design possibilities affording the designer greater freedom for experimentation, exploration and discarding of ideas to pursue new possibilities, than is evident in CAD processes. This early ambiguity avoids premature crystallization of ideas which may constrain creativity by restricting divergent thinking, preventing the emergence of alternatives. [6]

3.1 Roles of Sketching

Ferguson [12] identifies three kinds of sketches in creative design; the thinking sketch, the talking sketch and the prescriptive sketch. The thinking sketch supports and focuses individual thoughts, the talking sketch supports discussion (amongst the design team) and the prescriptive sketch communicates design intent to those outside the design process. To this Ullman [4] adds storage; the drawing's purpose to "archive the geometric form of the design."

Sketching in product design and development has many functions which embrace and extend Ferguson and Ullman's characterisations. Drawing activities can be defined into specific roles and contexts which occur in specific stages of the design process as follows:

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

4   SKETCHFEST – A NEW DRAWING INITIATIVE

The emergence of the product design engineering (PDE) discipline has had a significant impact on the composition and roles of product design and development teams. The PDE's design acumen has seen them employed in roles typically reserved for industrial designers; resulting in a greater emphasis on design skills in the curriculum. Industry expectations have driven the introduction in 2010 of a new teaching module 'SketchFest'- a curricula 'patch' intended to correct the decline of drawing standards.

4.1 The initial trials

The initial SketchFest modules targeted final year product design engineering students whose earlier projects indicated a lack of sketching competency. Whilst these students were proficient at technical product resolution it was evident that ideation and form giving was being limited by drawing ability.

As the ability to rapidly generate conceptual designs is an essential industry skill for product designers the first SketchFests were run within a two-hour design studio as intensive ideation sessions.

By limiting available time, SketchFest aimed to introduce industry pressure and time constraints into students design processes. In this short timeframe it was anticipated that outcomes would be highly conceptual and may lack technical consideration; this was deemed acceptable as the main purpose was to develop sketching confidence and ability and stimulate creativity through explorative ideation.

Each week featured a different design challenge, followed by a pin-up review and reflection session.

The design challenges were not open-ended problems that would require time consuming investigation or problem scoping; instead they focused on familiar products within established product categories. Whilst not engineering challenges, these tasks were facilitated quick ideation sketching with students able to immediately commence conceptual design after receiving the brief.

4.2 Analysis and observations

Students responded to the initial SketchFest with hesitation and uncertainty. Although their drawing had been critiqued in previous years, it was a long time since they has been assessed purely on drawing output, rather than project outcomes. Consequently poor sketchers' had been able to progress through the course unimpeded by lack of sketching acumen – it was these efficiencies that this new drawing curricula sought to address. The need to produce 'on-demand' with tight timeframes took students out of their comfort zone and highlighted individual skill deficiencies.

Whilst most students struggled initially to deliver quality ideation, it was encouraging that the good sketchers' consistently produced well considered (and well drawn) product ideation supporting the findings of Verstijnen and Hennessey [5], Fish and Scrivener [11], and Ullman [4]. These 'expert' sketchers had time to reflect upon and refine designs and explore many more variations of features and form than those students who struggled to externalize their thoughts.

4.2.1 Assessment was divided into two main criteria: quality of sketching and quality of ideation. Sketching criteria included accuracy/appropriateness of perspective, line work quality and hierarchy, marker application and contextual citing of the product (to show user interaction), whilst ideation was assessed against quick conceptualization ability, diversity of ideas, innovation and aesthetics.

A review of grades indicated clear evidence of skills development across the student cohort with improvement in both ideation and sketching quality evident between the first and last exercise.

Seventy percent of the thirty-one students achieved higher marks in the final exercises, most students improving marks by at least ten percent and a fifth experiencing greater than twenty percent grade improvement. Also rewarding was the increase in confidence exhibited by students in later exercises.

4.2.2 Feedback from both students and industry employers was universally positive but although students appreciated the curricula innovation, most believed it should have occurred earlier in their course. Students reported that their sketching skills had been enhanced and this was reflected in increased confidence and a more relaxed approach leading to faster and more diverse ideation. Student gains in confidence could even be observed during the two-hour studio with early pages scratchy and undirected, whilst later pages showed greater control and ability.

5   SKETCHFEST v2 – NEW CURRICULA

Following the success of the initial trials, it was apparent that a systematic embedded approach to sketching instruction was required across all years of the curriculum. As we were fortunate to have many skilled sketchers on the teaching team, it was decided to implement a new drawing program.
SketchFest version 2 was introduced in early 2011 as a series of four modules integrated into the 2nd and 3rd year Industrial Design and Product Design Engineering design studio subjects, (and also in fourth year product design engineering as a remedial measure). Student and graduate deficiencies in perspective sketching, ideation, styling, explanatory and technical sketching are addressed through stand-alone teaching modules that 'plug in' to existing design studio units. These independently assessable modules have distinct themes, providing a progressive learning experience with each semester having a unique module with a clearly defined drawing agenda for students to master before progressing. These intensive sketching modules have now run for four semesters and have created a renewed interest in freehand drawing and enhanced students ability to ideate and communicate design intent quickly, without resorting to digital media.

5.1 The SketchFest teaching modules

The sequential modules aim to develop confidence throughout the course and to redefine sketching as the primary form of design articulation for design progression and communication. Each three-week teaching module targets specific industry-relevant sketching functions; the distinct content of each semester negates content duplication and develops sketching skills progressively over four semesters.
Modules typically occurred within the timeframe of a two or three-hour design studio class, however as the intent was to develop a drawing culture, extra curricula development of sketches was permitted with students submitting work through a pin-up review session during the following weeks class.
The additional time allowance which enables students to rework drawings and improve technique (without the pressure of in-class completion) has encouraged students to commit more time to drawing activities, resulting in greater confidence and increased desire to attain sketching acumen.

5.1.1 SketchFest module no. 1 - Investigative and explorative drawing (2nd year)

The ideation stage of product design uses investigative drawing initially as the designer researches and defines the project, before developing concepts through explorative sketching of possible forms, functions and solutions, this second year module focusing on exploration of form and function.
In week 1, students engage in ideation sketching using coloured pencil, before moving to fineliner and marker in week 2. In week 3 students explore form development using curvature and blends.
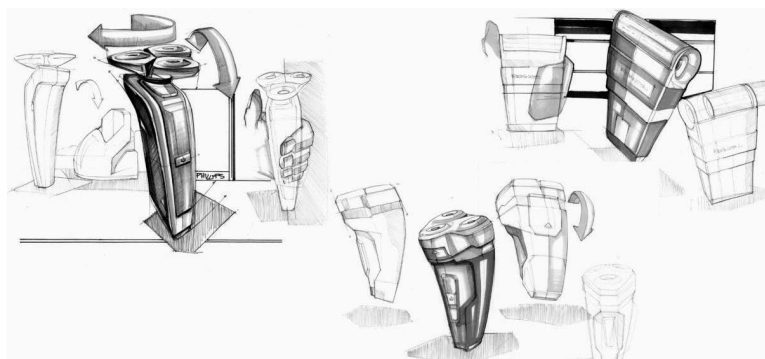

Figure 1. Examples of investigative and explorative ideation sketching (2nd year student)

5.1.2 SketchFest module no. 2 - Technical and functional resolution drawing (2nd year)

Technical (or mechanical design) sketching is either investigative or communicative of features and functions using exploded perspectives and sections in both ideation and design resolution stages. In this module students develop exploded perspectives moving from single axis deconstruction in week 1 to multiple axis deconstruction in week 2 and finish with representation of technical mechanisms.
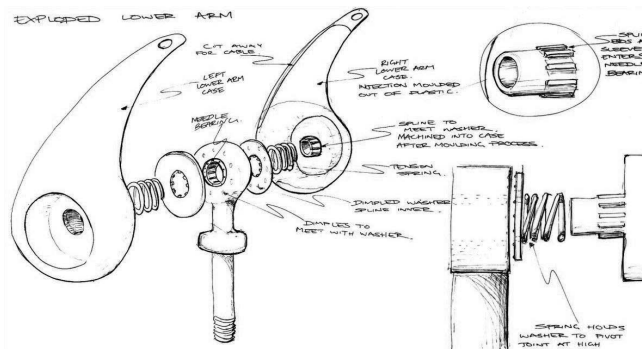

Figure 2. Technical sketching showing the resolution of technical and assembly details (2nd year student)

5.1.3 SketchFest module no. 3 - Explanatory or instructional drawing (3rd year)

These communicative drawings are used to impart function, assembly or product-user interaction sequences. These drawing are not typically part of the product development process, but used by the designer to impart product information to users, often as a sequential description. Students gain experience in sketching operating sequences and product interaction drawings in week 1, user focused assembly instructions (8-10 steps) in week 2 and storyboards (e.g. product system services) in week 3.
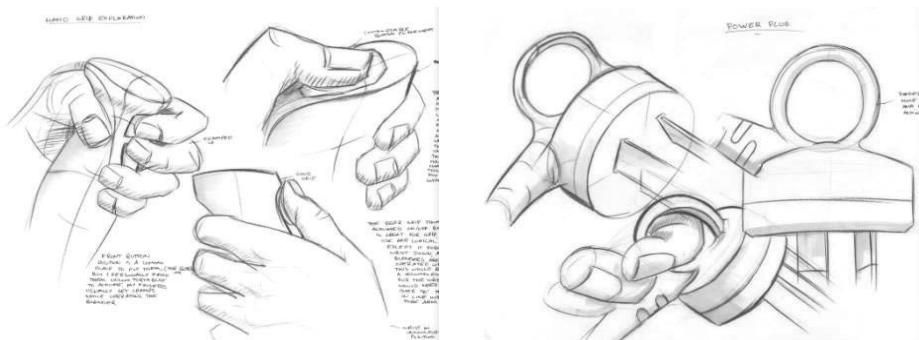

Figure 3. Examples of explanatory sketching for product interaction (3rd year student)

5.1.4 SketchFest module no. 4 – advanced styling

Form giving or styling drawings enable the development of product aesthetics simultaneously or sequentially with functional design drawings in the ideation, development and resolution stages.
This advanced module whilst outside the scope of many engineering activities, responds to the broader employer expectations of product design engineering graduates, and the need for advanced skills.
The module develops skills in surface development, contours, detailing and product model variation.

5.2 The impact of the new sketching curricula

The introduction of SketchFest into the existing Industrial Design and Product Design Engineering curricula was not without its problems. Taking three weeks out of the twelve-week semester studio program significantly impacted on the time and staff resources available for design project activity. There was initial resistance from staff who were reluctant to sacrifice such a large amount of design studio time although they understood the necessity of the sketching initiative. Projects timelines were shortened, placing additional pressure on students who were already feeling the burden of extra assessment tasks and the need to rapidly improve drawing skills.

The SketchFest modules were allocated significant assessment weighting; 20 percent of the overall subject marks for 2nd year modules, and 30 percent for 3rd year. This weighting combined with the separation of sketching assessment from the design projects, meant that students with good academic

records (but poor sketching skills) found themselves unable to hide behind CAD skills and proficiency in product development and resolution and thus vulnerable to poor marks and possible subject failure. Whilst this was not unexpected, it was felt critical that student deficiencies in these essential industry skills were addressed promptly; this importance outweighed any short-term logistical concerns.

5.3 Reflections

Overall the SketchFest curricula has been successful with student skills and creativity improved, increased industry demand for student interns and evidence of a rejuvenation of student interest in drawing skill acquisition. As a remedial 'patch' solution it has not without implementation issues; however the results have justified the continuation and expansion of the initiative.

6 MOVING FORWARD

Whilst sketching on traditional paper media is quick, effective and inexpensive, the emergence of new digital media tools is impacting on product design and development. The utilisation of new sketch-to-digital products including drawing tablets and digital sketching pens (such as Wacom's Inkling) are changing the ways designers ideate and communicate, yet even in this new digital age of product development the importance of sketching ability is unchallenged.

In response, we are developing a new digital sketching curriculum, one that will satisfy the expectations of both industry and staff in respect to graduate drawing skills, facilitate creative practice and re-energise student interest in sketching whilst embracing emerging digital practices.

7 DISCUSSION

Cropley [7] suggested that many engineering graduates are unsuitable for employment due to skill deficiencies in creativity and problem solving. It is possible that limited instruction in sketching techniques in education may be restraining the creative potential of engineering graduates. Without sketching ability, engineers cannot benefit from externalization of mental imagery, the abstract exploration and reflection that facilitates "the creative shift to new alternatives" [6], the emergence of unintended consequences and the fluid, unencumbered progression from idea to design intent that is facilitated by drawing.

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