Are you a designer or an engineer? We are both. An insight into Product Design Engineering through graduate reflection

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Abstract

This study was developed to understand the relationship between Product Design Engineering education and Product Design Engineers in industry. It is the intention of the authors to communicate data gathered from Product Design Engineering graduates from Swinburne University of Technology in Melbourne, Australia, to better determine the roles and responsibilities of a Product Design Engineer in the workforce. This information provides a learning platform for other Product Design Engineering programs, as well as create a greater understanding in industry as to what a Product Design Engineer can contribute to product development or manufacturing industries.

The overall objective of this research is to continually improve Product Design Engineering education around the world to align closely with industry expectations and to differentiate Product Design Engineers from Industrial Designers and Mechanical Engineers. With this aim, a focus group and survey-based data collection of Product Design Engineering graduates was completed to provide a greater understanding of the roles a Product Design Engineer has in a professional context.

Keywords
Product Design Engineering; Graduate; Industry; Survey

Introduction

Product Design Engineering is a relatively new engineering discipline. The emergence of this field has created graduates who can successfully combine the creative thinking of design with the analytical thinking of engineering (Kuys et. al., 2012). The question posed in this paper is how much of this knowledge is applied by graduates in their respective employment? To achieve this, a focus group and a survey-based study were completed with Product Design Engineering graduates and results are presented in this paper.

Product Design Engineering is the convergence of two diverse disciplines — Mechanical Engineering and Industrial Design — with the intention of training a qualified engineer with a comprehensive understanding of applied Industrial Design. It must be noted that Product Design Engineering is not two courses (Mechanical Engineering and Industrial Design) combined to create one degree. The structure of successful Product Design Engineering programs around the world intertwine the curriculum between engineering studies and design studies to ensure students understand how to apply engineering theories to tangible design outcomes. To put this in context, an example seen within the curriculum at Swinburne University of Technology includes engineering subjects that teach theories of thermo-fluid systems; while in the same semester design studio subjects teach projects that directly link to the engineering content. In this example a portable
refrigeration system is developed that includes functional thermo-fluid systems directly applied from the engineering subject. Other examples over the past five years include bone marrow transportation devices and portable air conditioning units – all applying engineering theories for a functional design outcome. This enables the course design to provide engineering knowledge in time for its implementation through ‘Project Based Learning’ in a design studio environment. Another example includes studies in machine design before designing a sustainable vehicle. It is important to make this distinction, as there are double degree programs that teach Industrial Design and Mechanical Engineering but these are often separate entities that do not cross paths during the course of the degree. The benefit of interlinking these traditionally separate disciplines is to ensure a Product Design Engineer can directly apply engineering theories/knowledge to product outcomes by having the ability to think creatively and analytically at the same time. This single most important characteristic is what differentiates a Product Design Engineer to a straight Industrial Designer or Mechanical Engineer. This is not to suggest that Mechanical Engineers and Industrial Designers will become obsolete; the role of a Product Design Engineer in the design process fills the gaps between both disciplines to appreciate the aesthetic qualities and user interactions of a product, while at the same time having a primary emphasis on functional utility and manufacturability. Figure 1 visually represents where Product Design Engineering fits within the context of other discipline areas. This visual (In Kuys et. al. 2012 adapted from Dixon, 1966, in Hundal 1997, p. 38) is widely recognised as an accurate visualisation of where Product Design Engineering ‘fits’ within other disciplines.

![Figure 1. The place of Product Design Engineering in the technological and cultural world. (In Kuys et. al. (2012) adapted from Dixon, 1966, in Hundal 1997, p. 38).](image)

Product Design Engineering by nature is multidisciplinary merging engineering sciences with design, manufacturing and social sciences. It is important however to continuously evaluate and moderate the contribution of these disciplines to Product Design Engineering curriculum. Furthermore it is also necessary to understand industry requirements and thus what is actually being done in industry when students graduate from a Product Design Engineering program. Hence, this study pursues a focused understanding of the role of a Product Design Engineer to better shape curriculum and to educate others in the wide field of Product Design Engineering.

The offerings of Product Design Engineering education around the world has increased over the past 10 years, while at the same time industry becomes more knowledgeable on
what a Product Design Engineer can bring to a company. Identified by de Vere et al. (2010) the offering of Product Design Engineering programs is expanding internationally with similar programs being taught in many universities as outlined in Figure 2. While there is still a concentration of schools offering Product Design Engineering in the UK, the geographic coverage is now wider, including Europe, North America, Australia and South America (de Vere, et al., 2010).

Figure 2. The Product Design Engineering global landscape (In de Vere et al., 2010).

This paper represents the findings of 44 Product Design Engineering graduates from Swinburne University of Technology who completed surveys containing 10 detailed questions to understand the role(s) a Product Design Engineer plays in industry, with the intention of better understanding if what is being taught at an undergraduate level is aligning correctly with industry expectations and needs. Previous publications relating to this issue tend to consist of qualitative descriptions of the development of courses (Koen, 1994) (Dym et al., 2005) (Diehl et al., 2005) (Lamancusa et al., 1997) (Dieter and Schmidt, 2009) (de Vere et al., 2010). This paper provides an insight into what is currently occurring in industry from a graduate perspective. This is important to ensure Product Design Engineering curriculum is relevant to appropriately educate future students for graduate employment, while at the same time enhancing and developing graduate skills/tools to broaden the understanding industry has on where a Product Design Engineer can fit within a manufacturing, engineering or design team.

Study aim

The aim of this study is to better understand the nature of work graduates are engaged in, as well as to understand how these graduates apply what they have learnt during their course; to subsequently provide a reflection on how the course has been of use to a Product Design Engineering graduate in their current workplace and what can be further applied to improve the curriculum according to industry demands.
A visual representation of the intentions of this study, which is to understand expectations of both graduates and employers in the field of Product Design Engineering, is showcased in the figure below with an aim to identify what is missing in the current undergraduate offering.

![Diagram showing alignment of Product Design Engineering between universities and industry](image)

**Figure 3.** Alignment of Product Design Engineering between universities and industry.

**Methods**

The methods used for this study involve:

A. An initial focus group discussion guided by the authors with the aim of obtaining an insight into the opinions of Swinburne Product Design Engineering graduates in relation to the applicability of their program education to their current industry environment. The objective of performing this focus group was to allow and structure the design of a follow up survey identifying areas of improvement for the Product Design Engineering curriculum. The focus group was planned and performed as an online open forum with a series of guided questions to generate discussion. Four Product Design Engineering graduates (n=4) were approached to work with the three authors of this paper to set out appropriate questions to create greater knowledge and exposure for those interested in this field.

B. An online survey of 10 questions in total and structured according to discussions developed through the focus group. The design of this survey was aimed at understanding the relationship between Product Design Engineering education and Product Design Engineering employment. The relevance and structure of the questions in the survey was validated through the preliminary observations provided by the focus group discussion. These questions were then used to better understand the positive and negative aspects of Product Design Engineering graduates in industry.

It must be noted that Product Design Engineering at Swinburne University of Technology, Melbourne, Australia is strictly governed by the university to maintain the quality and integrity of the program. This study aims to continually enhance this by going beyond the program/university level to further understand the transition of skills into industry. To maintain the quality of the program, annual reviews of course content by the discipline leader in consultation with the course coordinator and staff takes place. This is done in conjunction with a review of course content by an industry advisory committee that consists of industry representatives and senior academics from other universities.

**Results**
The focus group was comprised of Product Design Engineering graduates (n=4) with an average of 7.5±2.4 years of industry experience. Initially, an enquiry of current job titles and professional role descriptions provided an insight of the range of placements available to Product Design Engineering graduates and clearly identified distinct roles within the Mechanical Engineering and Industrial Design fields. Congruently, responses to further queries in relation to work activities showed that practices and skill engagement are specific to the industrial field; and perhaps not expected across the end-to-end product development process. Hence, the need to identify a representative sample of the skills that are expected of Product Design Engineering graduates by current industry becomes very relevant in order to match industry demand to Product Design Engineering curriculum.

The insight gained through this focus group further allowed the formulation of a set of questions to be used in the following online survey. The online survey contained 10 questions that explored in depth the exposure of Product Design Engineers in a professional context. It was decided that 10 well-constructed questions was adequate in providing enough insight for this study, and was deemed an appropriate amount to have higher response rates by limiting the time it takes in completing this survey by the graduates. The reliability of survey research findings is largely a function of response rate. Findings must be a true representation of the population size as low return rates are presumed to suggest biases in data or variance effects in survey results (Edith et. al., 2005). To prevent any form of bias the survey focused on the responses obtained from graduates over the past 6 years, as this made up 93.18 % of responses.

The survey was made available online over a two-week period and yielded (n=44) responses from recent Product Design Engineering graduates with an average of 3.5±1.3 years industry experience.

Only three Product Design Engineering graduates out of the 44 who responded had more than six years experience, therefore the majority of respondents (93.18 %) graduated from 2007–2012. Focusing on this period a total of 129 students graduated, giving a response rate of 31.8% of the specific sample. While a higher response rate would have been desirable, 31.8 % of graduates captures sufficient data for this study, equating to just under one in three graduates over the past six years of the program.

Specific responses to this survey are as follows:
**Question 1**
How many years have you been working in a relevant Product Design Engineering field?

![Bar chart](image)

Figure 4. Question 1 results.

Results obtained from Question 1, (presented in Figure 4), show the number of years experience in industry of graduates who completed the survey. It is observed that the majority of responses are from graduates with up to 4 years experience in industry (2009 – 2012). This indicates that results from subsequent survey questions are most relevant to recent graduates and thus the immediate contribution that they make, and demands on their capabilities on entry to industry/professional practice.

Additionally, these results further corroborate the greater efforts in recent years directed at maintaining relationships with Product Design Engineering alumni, which is reflected in the majority of responses being from recent graduates.

**Question 2**
In your current job, to what extent are you a Mechanical Engineer?

![Bar chart](image)

Figure 5 (Left). Question 2 results.
Figure 5 shows the percentage of graduates who classify themselves as a Mechanical Engineer according to the type of work they develop every day in industry. The reasoning behind the following two questions is to understand where Product Design Engineers fit within industry. The Product Design Engineering bachelor degree program is fully accredited by Engineers Australia\(^1\) and students graduate with an engineering degree, not a design degree. Therefore, it is not surprising that over half of the respondents work in a capacity where at least 50 % or more of their current job activities involve using their Mechanical Engineering skills. It is interesting however, to see an even coverage of graduates 93.18 % work across 10 % – 90 % of a Mechanical Engineering capacity. This result shows that Product Design Engineering graduates are not categorised exclusively as Mechanical Engineers or Industrial Designers.

**Question 3**

In your current job, to what extend are you an Industrial Designer?

![Figure 6. Question 3 results.](image)

It is interesting to observe the outcome of this question by finding a clear distinction with Question 2 showing a greater percentage of graduates working more in an engineering capacity than a design capacity. There is however, clear alignments with the middle two responses (30–50 % and 50–70 %) for Mechanical Engineering roles and Industrial Design roles – concluding with the same result for each respective section. Due to the fact Product Design Engineering students graduate with an engineering degree they see their formal qualification as an engineer, more so than a designer. Therefore, although they may be doing more technical activities in industry — which could be classed as an Industrial Design activity — respondents perhaps believe their role is favouring engineering.

\(^1\) Engineers Australia is the national forum for the advancement of engineering and the professional development of members. With over 100,000 members embracing all disciplines of the engineering team, Engineers Australia is the largest and most diverse professional body for engineers in Australia.
On top of this, a recent search of Seek\(^2\) showed a greater percentage of jobs available for Mechanical Engineers as to Industrial Design and Product Design Engineering as follows:

- **Mechanical Engineer** – 935 Jobs available Australia-wide
- **Industrial Design** – 686 Jobs available Australia-wide
- **Product Design Engineer** – 675 Jobs available Australia-wide

One of the many positive attributes of a Product Design Engineering degree is the diversity in graduate employment. Figures 4 and 5 suggest graduates have the skills to work across all areas of Mechanical Engineering and Industrial Design, with the majority working in both capacities in their current job.

**Question 4**
Please select the typical Mechanical Engineering activities that you most frequently engage in during your current job.

To provide greater insight into the specific activities a Product Design Engineer has within their respective employment, the following question shows the typical Mechanical Engineering activities that currently take place. In analysing the results it is evident that a majority of Product Design Engineering graduates are competent in the Mechanical Engineering activities.

The strongest results within this question, manufacturing liaison (75\%), research and development (72.73 \%), and project management (68.18 \%); demonstrate

\(^2\) SEEK is Australia's number one job site with over 150,000 jobs online and visited 14.7 million times each month. www.seek.com.au (October 28, 2013).
multidisciplinary attributes of a Product Design Engineer. In particular, having the ability to be the link between members of a product development team and being able to undertake development direction and decision making roles with a high level of responsibility. The diverse Mechanical Engineering activities a Product Design Engineer boasts is evident in Figure 7, showing all areas having at least one in three responses except for quality function deployment.

**Question 5**
Please select the typical Industrial Design activities that you most frequently engage in during your current job.

![Figure 8. Question 5 results.](image)

Question 5 shows that Product Design Engineering graduates are capable of typical Industrial Design activities in their respective employment. Typical Industrial Design activities are usually reserved for an Industrial Designer, however with the increasing growth in Product Design Engineering, relevant companies are realising the contribution a Product Design Engineer can make. This is not to say an Industrial Designer will become obsolete, it merely shows how a Product Design Engineer can work collectively with other associated disciplines – evidenced with the highest response to this question being the more technical aspects of Industrial Design activities: Engineering Liaison (70.45 %).

Additionally, it is evident that Product Design Engineering graduates make full use of their reinforced engineering problem solving skills through exploration and refinement of ideas and communication of concepts, which are activities typical to the industrial design field; this reinforces the synergy of skills gained through the Product Design Engineering program curriculum.
**Question 6**

Please select the typical Mechanical Engineering skills/tools that you most frequently engage in during your current job.

![Figure 9. Question 6 results.](image)

Questions 4 and 5 give accurate data about the activities graduates engage in within their respective Mechanical Engineering or Industrial Design roles. This helps frame the discipline activities to provide a better understanding of the general areas of employment. In order to expand this further the following two questions seek to understand the specific skills/tools that graduates use in for both their roles as a Mechanical Engineer and their roles as an Industrial Designer – with the intention of understanding if what is being taught within the university context is appropriate to what students require in industry.

An analysis of the results shown in Figure 9 express great importance to the skills required to successfully manufacture a product. Within the university context CAD programs (in this case Solidworks) have always been a high priority as this is communicated to the university through the program industry advisory panel.

It can also be seen that the skills/tools attracting the lowest rate of responses (FEA, Failure Modes and Effects Analysis, Testing) are typically those used towards the end of product design and development processes. Conversely the skills/tools with the highest response rate are those commonly applied more or less from the start of the process. The implication of this finding is aligned with those of Question 3 in suggesting graduates are actively applying engineering skills at early stages of the product design process in order to solve problems, make decisions and guide the development of the design from the manufacturing perspective.
**Question 7**

Please select the typical Industrial Design skills/tools that you most frequently engage in during your current job.

As with the previous question, the most important skill used in an Industrial Design capacity is 3D computer modeling/CAD. Almost all respondents selected this skill as frequently used ranking almost 30% higher than the next greatest response. While all skills are important to industry, it is clear that the ability to successfully use 3D CAD software will put students in a good position for graduate employment and perhaps can be considered as a standard requirement for the Product Design Engineer professional profile.

Additionally, results from this question further cement the implication of graduates’ involvement at an early stage of the product design process but in the capacity of directing development from the perspective of materials and manufacturing. This is shown by higher response rates in CAD and hand sketching, but substantially lower response rates to elements of the design process relating to product communication and visualisation (highly typical Industrial Design activities).
**Question 8**

Are there skills/tools or activities that you have learned in industry that you wish you had learnt during your Product Design Engineering degree?

![Figure 11. Question 8 results.](image)

Question 8 and 9 were open-ended responses that required survey participants to add comments about the positive and negative aspects of the Product Design Engineering degree in relation to what graduates are currently doing in industry. In order to evaluate these results, a coding was used to group the responses to these open-ended response questions. This was based on keywords that were interpreted as falling within skill/activity categories. Grouped responses to the question concerning skills/tools and activities that participants wished they had been taught as part of their degree, are shown in Figure 11.

Within these responses there is not one area that is dominant. It is contended that this may reflect the different specialisations or biases of the current jobs of graduates. A better understanding of the precise role/nature of each respondent’s job would provide further insights in this matter. It is however noted that the category with the highest response rate is “Manufacture” (20 %), which previous questions show as being an important skill for all Product Design Engineering graduates. Thus this skill will be carefully considered for improvement within the current program by further emphasising this area in final year projects and professional attribute subjects.
**Question 9**

Are there skills/tools or activities that you were taught during your Product Design Engineering degree that you find unnecessary for your current job?

![Bar chart showing the percentage of responses for each category](chart)

The negative response category covers responses that indicate that no skills were wished for or that no skills/activities taught were deemed unnecessary. The “Other” category shown in the responses for this question was included to count responses that only one participant mentioned and do not fit within any of the other categories.

Grouped responses for this question concerning skills/tools and activities that participants had been taught as part of their degree that were deemed unnecessary are shown in Figure 12. In disseminating the information gained from this question, it is pleasing to see 55 % of respondents thinking nothing was unnecessary about the program they graduated from. As previously stated, a majority of survey participants are recent graduates (0–4 years), giving greater relevance to the answers in this study as they are closely aligned with the program that is currently being taught. On top of this response, 12.5 % of respondents provided comments associated with the coded statement – “Appreciative of breadth regardless of use”, showing that 67.5 % of respondents feel there is little deemed unnecessary about the program. The remaining categories had minimal response rates with no particular area highlighting major concern – most likely due to the different positions Product Design Engineering graduates hold in industry.

Figure 12. Question 9 results.
Question 10
Is sustainability considered and applied in your current job?

Figure 13. Question 10 results.

This question was asked as a response to a previous study by one of the authors of this paper looking at how sustainability is embedded and applied in Swinburne’s Product Design Engineering curriculum. In this paper (Kuys et. al 2012), a similar survey-based study was completed to understand the impact of sustainability pedagogy in Product Design Engineering undergraduate programs around the world. While this final question does not directly link to the core intentions of this study, it is still interesting to see the transfer of knowledge from an undergraduate program into industry.

The results for this question are rather predictable, however, it is somewhat disappointing to see one third of respondents saying sustainability is rarely considered or applied in their current job. The reasoning behind a majority of these responses was cost implications and the fact that many respondents are junior members of staff who are not in positions to influence change. Product Design Engineers — like many other professions — need to prioritise sustainability and while over half of respondents “sometimes” consider and apply this, it is anticipated that this figure will grow, as the graduates grow within their respective employment.

Discussion and Conclusions
The ‘design process’ between an engineer and a designer shares common ground but has a lot of differences. An Industrial Designer is constantly thinking about the final product outcome and its communication throughout the whole design process with a stronger ability to tackle the front-end of a design project. A Mechanical Engineer is more concerned with the product functionality/performance with the anticipation of developing

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conceivable outcomes in preparation for the product’s manufacture. Product Design Engineering can be seen as a dialogue between both disciplines with expertise in both the development and execution of a product. This study concludes with a view of the contributions Product Design Engineers can make to both industries based on survey responses.

The primary contribution drawn from responses is in the integration and application across both disciplines – Mechanical Engineering and Industrial Design. This is demonstrated in the balance between Mechanical Engineering related skills/tools and activities and Industrial Design related skills/tools and activities engaged in. This shows that a Product Design Engineer by majority is capable of working across both areas successfully. More specifically major findings from Questions 3–6 show explicitly that the application of these skills begins at an early stage of the design process (Industrial Design related), with an emphasis on driving the design forward from a problem solving, materials and manufacturing perspective.

The survey-based method used to gain data in this study — like all surveys-based studies — has some discrepancies with the results. In this case, the majority of differing opinions are likely due to the different roles a Product Design Engineer has in industry. In comparing the different roles a graduate has in Questions 2 and 3 in this study, with the positive and negative aspects of their Product Design Engineering degree in Questions 8 and 9, it is clear there will be certain respondents that are employed in more of a Mechanical Engineering position or more of an Industrial Design position. Therefore, certain areas of the Product Design Engineering program that are extremely useful to certain graduates may not be used at all by others. A further consideration is in possible biases of responses dictated by the perceived role/job or employer of graduates. It is thought that the current role of a graduate may bias the interpretation of activities or skills. For example a Product Design Engineer employed in an engineering firm may believe some Industrial Design activities are not undertaken or irrelevant by virtue of the fact that they perceive their role to be as an engineer. This creates a need to establish clear definitions of skills and activities that transcend subjective definitions within the disciplines of Mechanical Engineering or Industrial Design and improve objectivity of responses.

There is a concern that a Product Design Engineer covers a broad range of skills without necessarily being an expert at any. From the results of this study it is possible to conclude that a Product Design Engineer is exceptional at Product Design Engineering. This is shown in the way Product Design Engineers work cohesively with other disciplines while maintaining integrity in their own field as a subset of engineering. Thus it is also concluded that the notion that a Product Design Engineer is half a designer and half an engineer is false — they are not solely designers or engineers — they are Product Design Engineers. The knowledge within industry of what a Product Design Engineer is has become increasingly popular as there is now a realisation that the need to better connect traditional fields of design with engineering is a response to the changing landscape of product development and manufacturing companies.

The intentions of this study was to focus the education in this field to better understand the positive and negative aspects of Product Design Engineering education, while also understanding the specific roles graduates play in industry. The survey responses have helped do this by clearly differentiating the total skill-sets of a Product Design Engineer from a traditional Industrial Designer and/or a Mechanical Engineer, which is seen in the breadth of skills from both disciplines applied by graduates. Thus, it is further concluded that a Product Design Engineer has the necessary knowledge, technical skills and generic skills to carry out research, conceptual design, engineering design, detailing, manufacturing, and project management in the development of products.
It is the authors’ anticipation that other universities around the world learn from the success of this program and consider introducing something similar where a Mechanical Engineering and Industrial Design program already exist. Product Design Engineering in Australia has found a niche by filling the void between the analytical engineers and the creative designers – it makes sense for the future success of product development and manufacturing companies globally and the authors’ are optimistic this discipline can grow on a global scale.

References


