The role of the industrial design educator in equipping design students to be ethical decision makers

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Abstract

The role of the design educator is to mediate learning and equip students to effectively contribute to their specific field once they graduate. With an ever-increasing demand for the ethical consideration of the sustainability of products and the impact of the manufacture thereof, so too the role of the educator should compensate and prepare learners accordingly. This paper aims to investigate the social and environmental responsibilities of industrial design professionals by referring to the works of key authors as well as current industry practices. Inquiry into suitable sustainability assessment tools which are used by designers and manufacturers is undertaken in order to identify appropriate assessment procedures which can be adapted / incorporated into design course content. This allows design educators to effectively prepare students for their future roles as ethical decision makers, conscious of their impact on the sustainability of the future. Within the field of industrial design a graduate is required to possess the ability to conceptualize, develop, and resolve problems during the development of products to a suitable manufacturable outcome.

As many developed products are intended for multiple units in manufacture, sometimes into the tens and hundreds of thousands, designers are largely responsible for what happens to these products once they are no longer used for their primary purpose due to obsolescence or failure.

Decision-making within the product design process has a direct impact in the suitability and sustainability of the outcome and there is a large amount of concern being placed on the suitability of the outcome with regards to its impact on the triple bottom line, being social, environmental, and financial implications. The designer therefore need to be an accountable decision maker, equipped to develop holistically considered products from conception through to long term impact, resulting in items which will benefit society and the environment. Design students who are able to interrogate their own design decision making against impact assessment scales will be able to better defend process, material and composition while still within the institutional environment, preparing them for their professional role as mediator between client, manufacturer, society and environment.

***Keywords**: Industrial Design, Manufacture, Environment, Sustainability, Life Cycle Assessment*

Introduction

This paper aims to provide insight and recommendations to educators within the field of Industrial Design, regarding the suitable application and incorporation of sustainability assessment and sustainability tools able to be incorporated into current syllabus. Aspects of this paper will be applicable to other fields within design education, depending on the accessibility and utilization of suitable sustainability assessment tools and appropriate computer software packages.

This paper will begin with an explanation of the industrial design process, explaining how products are developed for intended users. The stages within the industrial design process will be covered, from conceptualization, through to the explanation of the life cycle of the product. The process of product manufacture will be explained, where the finalized design is batch/mass manufactured. The link to sustainability assessments will then be made, where the manufacture and choice of materials has a direct and often negative impact on the environment. An explanation of various impact assessment methodologies will be presented, focusing on methods and tools appropriate for industrial designers and product manufacturers.

These tools will then be linked back to the current tertiary educational institutions within South Africa which offer formal qualifications in the field of Industrial Design, drawing parallels between what is available and utilized by practicing professionals versus what is available institutionally within the local design schools.

Finally, suitable and applicable tools will be identified as being appropriate for immediate inclusion in current coursework in a manner which will allow students to effectively apply viable assessment criteria in student product design projects. This will grant students the opportunities to better understand their possible impact on the environment once they receive their qualifications and begin practicing as professional industrial designers.

The Industrial Design Process

The industrial design process is a creative and inventive process concerned with the synthesis of such instrumental factors as engineering, technology, materials and aesthetics into machine-producible solutions that balance all user needs and desires within technical and social constraints (Fiell & Fiell 2006, p.6). This involves a systematic process initially starting with an identified need or evident requirement, which proceeds with conceptual ideation of solutions. These are then explored and refined through design sketching, model-making, prototyping and technical refinement of these prototypes. The final outcome is to be able to tackle the initial problem, providing an adequate solution. With industrial design, these solutions are generally manufactured physical products which are intended to be made using either batch or mass production. This can be anything from a single one-off manufactured solution, to mass manufacture of hundreds of thousands of replicas of the same product.

> Designers have the chance to make something new, or to remake something so that it is better. Design gives the deep satisfaction that comes only from carrying an idea all the way through to completion and actual performance. It can be compared to the emotions aroused by making a kite and then being able to fly it in the sky: a feeling of closure, pleasure and achievement (Papanek 1995, p.9).

As many reproductions of the products are manufactured, it is extremely important that the designer does his/her best to assure the product is best suited to the intended end user. Designing meaningful and innovative solutions that serves the intended users begins with understanding their needs, hopes and aspirations for the future, and following qualitative research methods allows for the designer/design team to develop deep empathy for people for whom they are designing (IDEO 2011, p.41). This is a product design methodology which is called User Centred Design, placing the user at the centre of the design process (Figure 1).

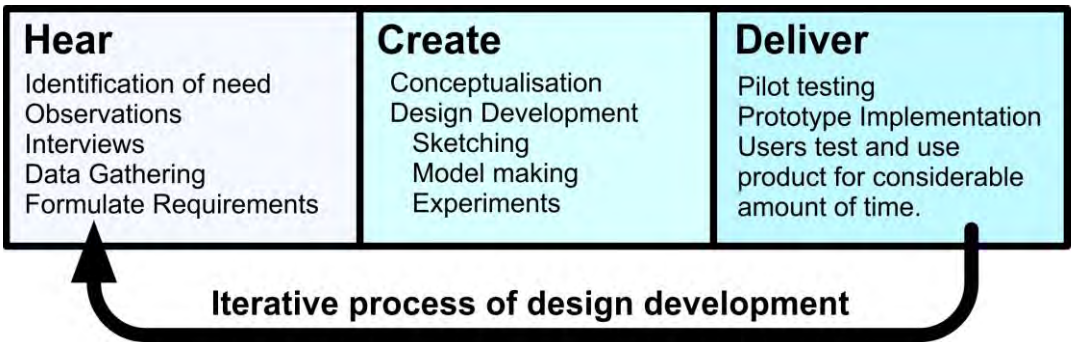

Figure 1. Steps of the design process. Adapted from IDEO 2011, p.8.

Once a design is at a point where it can be physical tested and prototyped into a usable item, this can be provided to intended users to offer them the opportunity to provide personal opinions regarding various aspects such as desirability, feasibility, viability, personal preference, usability and functionality (IDEO 2011, p.7). Only when the design reaches a point where it suits the intended users can manufacture begin. Although this manufacture is not personally undertaken by the designer who developed the product, the materials, manufacturing processes and assembly are all pre-determined by said designer during the design process. Being able to develop a suitable product for an intended end user is quite a task, keeping in mind that this end user is not a single person using a single product, but rather products can be mass produced for a mass group of intended end users. Furthermore, the products need to be able to be manufactured at a low enough cost to allow for profit to be made. This invites many areas of consideration for the designer to consider before a product is able to reach the market, be desired by the intended users, and still be able to make profit for the product manufacturer (figure 2).

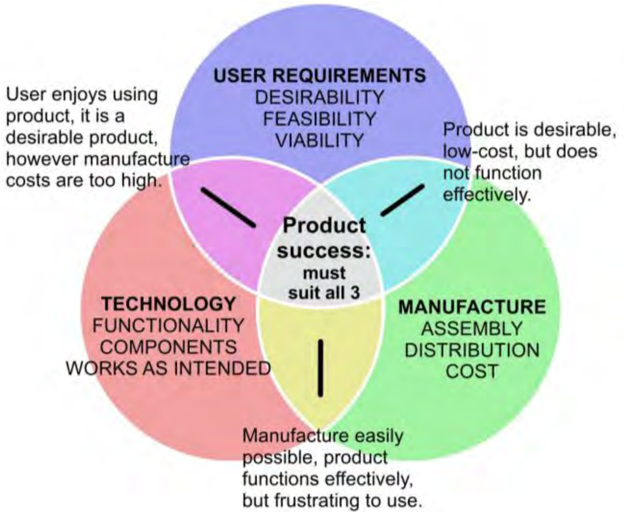

Figure 2. Product Success: Outcome must suit all 3 areas: User Requirements, Technology and Manufacture.

This brings a concern with the designer not only being responsible for the development of a product which is adequately able to meet the three areas of product success as mentioned above, but also the responsibility of the types of processes and materials used in the manufacture of these products, as these materials and manufacturing processes have a direct negative impact on the environment. 'Despite how optimistic, idealistic, and future-oriented most designers are, design has sometimes created big problems in the world. Even where our best intentions have been engaged, our outcomes have often fallen short - sometimes making matters worse - because we didn't see the whole picture when creating what we envisioned' (Shedroff and Lovins 2009 p.xxxv). It is evident that the industrial designer is responsible for decision making around the composition of the products and their methods of manufacture. Designers require an extremely diverse skill set which will equip them for this task. An inquiry into the different industrial design courses will provide an overview of what South African design graduates are equipped with.

Industrial Design Schools in South Africa

Currently there are three schools across South Africa which offer accredited qualifications within the field of Industrial Design. These are listed in order of increasing distance from the Johannesburg, being the main manufacturing district in South Africa. The three schools are the University of Johannesburg (UJ), Tshwane University of Technology (TUT) and the Cape Peninsula University of Technology (CPUT). The three schools however are situated in different Universities, in different parts of the Country, and each situated in a different faculty, and offer a range of different qualifications. UJ Industrial Design falls within the Faculty of Art Design and Architecture, TUT

Industrial Design within the Faculty of Engineering and the Built Environment, and CPUT Industrial Design within the Faculty of Informatics and Design. For understanding the roles of the different courses, the departmental websites and course information brochures provided some insight into the departmental focus as well as an explanation of their position regarding the role of the industrial designer.

Institution	**Explanation of the course on the associated departmental website**
University of Johannesburg	"Industrial designers use drawings, models, and computer programmes to design products, which will ultimately be made in factories. Such factory-made products range from mobile phones to furniture or even cars. Industrial designers also design products which will be made as one-offs, such as craft products, trophies, or models and full-scale mock-ups for a movie. They can also use their skills to invent completely new products, to do computer modeling and animation, and to propose new ways of doing everyday things." (Department of Industrial Design - University of Johannesburg, n.d.)
Tshwane University of Technology	"Industrial designers typically create finished products that emphasise the look, feel, safety and convenience of a product. They also understand manufacturing materials and processes making sure that products can be manufactured at the right price for the intended target market." (Industrial Design @ TUT, n.d.)
Cape Peninsula University of technology	"We are called Three-dimensional designers; Product designers and Industrial designers. Our graduates design anything and everything that is mass-produced – from BMWs to iPods; from couches to TVs. We turn good ideas into real products. Our department is a vibrant and dynamic space where emphasis is always placed on our students and graduates to become designers who are conscious of the needs of communities around them. We provide the opportunity for our students to learn using state-of-the-art equipment and software. Our biggest resource however, is a team of dedicated lecturing staffs who are experts in their respective fields and provide our students with a wealth of invaluable experience. Where it fits in with our curriculum, we partner with industry to run projects with our students. The benefit for students is the "straight talking" response from industry. This approach enhances teaching and learning for both students and staff." (Industrial Design - Cape Peninsula University of Technology, n.d.)

Table 1. The three institutions within South Africa which offer industrial design qualifications.

As is evident with all of the course descriptions, students learn how to develop products through from concept, to a level which is able to be manufactured. The understanding of manufacturing methods and processes is however part of the course with students understanding how to develop products, what tools are required to develop these products, and how these products are to be manufactured, and how this manufacture impacts the environment. Specific course module breakdowns of each of the institutions was not obtained, however this would provide useful future benchmarking opportunities between these institutions.

Responsibilities of the Industrial Design Professional

Industrial designers need to understand that they are directly responsible for the impact caused to the environment due to the manufacture and distribution of the products they develop. It is therefore one of the responsibilities of the designer to anticipate the environment, ecological, economic, and political consequences of the design intervention (Papanek 1995, p.8). This has lead to a methodology of product development titled Design for Environment[1], where the environmental

[1] Design for the Environment is also referred to as Green Design and Ecodesign.

impact of the products and the manufacture thereof is carefully considered as to prevent unnecessary negative impact. This opens industrial designers up to a world of Impact Assessment Tools and guidelines which are easily overwhelming in the attempting to splice this into the holistic product design process. This is due to the fact that industrial activity has the most significant effect on the environment (Giudice, La Rosa, Risitano 2006). It is explained that the main environmental issues concerned with industrial processes and products can be summarized as

1. controlling and limiting the consumption of resources;
2. avoiding the saturation of waste dumps;
3. achieving maximum energy conservation in production processes;
4. reducing as much as possible all types of emissions, whether inherent to the process or accidental; and
5. intensifying the processes for the recovery of resources (Giudice, La Rosa, Risitano 2006).

The designer needs to be aware of the impact that the decision making in the design studio, has knock-on impact on many different areas of the economy. The process followed in the development of a beautifully considered plastic water bottle may be an interesting process; however when the plastic bottle ends up floating across the ocean and polluting the environment, the designer should be aware of this.

Design for environment – Sustainability assessment

In the Environmental Impact Assessment Review journal, sustainability assessment is described as a process by which the implications of an initiative on sustainability are measured and evaluated (Pope, Annandale, Morrison-Saunders 2004). These initiates can be in the form of a process, policy, plan, product, project, piece of legislation, or an activity. This definition covers a broad range of different processes, many of which have been described in the literature as 'sustainability assessment' (Pope et al. 2004).

This allows for the bigger picture to be observed, not limited to the industrial designer and the product which is being developed, but rather the environment, the economy, and society. Furthermore it is not limited to the here-and-now, but to the future. This is what is known as the Triple Bottom Line (Figure 3), where the three pillars of Economic, Social and Environmental considerations are pivotal for the pursuing of a sustainable future. This stems from the most agreed-upon definition of sustainability from the *Brundland Commission as "[Use and] development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Pope, Annandale, Morrison-Saunders, 2004 p.597. quoting the World Commission on Environment and Development WCED 1987).

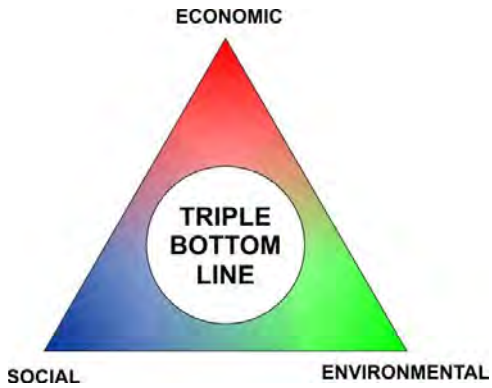

Figure 3: Triple Bottom Line

This three-pillar or Triple Bottom Line approach to sustainability assessment distinguishes between economic and social needs, in part to emphasize that material gains are not sufficient measures or preservers of human well-being (Gibson 2001 p.10). This approach as an overarching theory is not difficult to grasp, however between 1987 and now, many different sustainability assessment tools have been developed all which are very similar to one another. For instance, in an overview of sustainability assessment tools from Ness et al (2007) a total of 32 different tools are mentioned. However not all of these are suitable for the manufacture of products. A flow diagram was used for arranging and classifying the various tools, which were divided into *indicators*, *product related assessments*, and *integrated assessments*. A cropped section of this table is included below, showing the tools which are most applicable for pairing up with the industrial design process, being the product related and integrated assessments (figure 4).

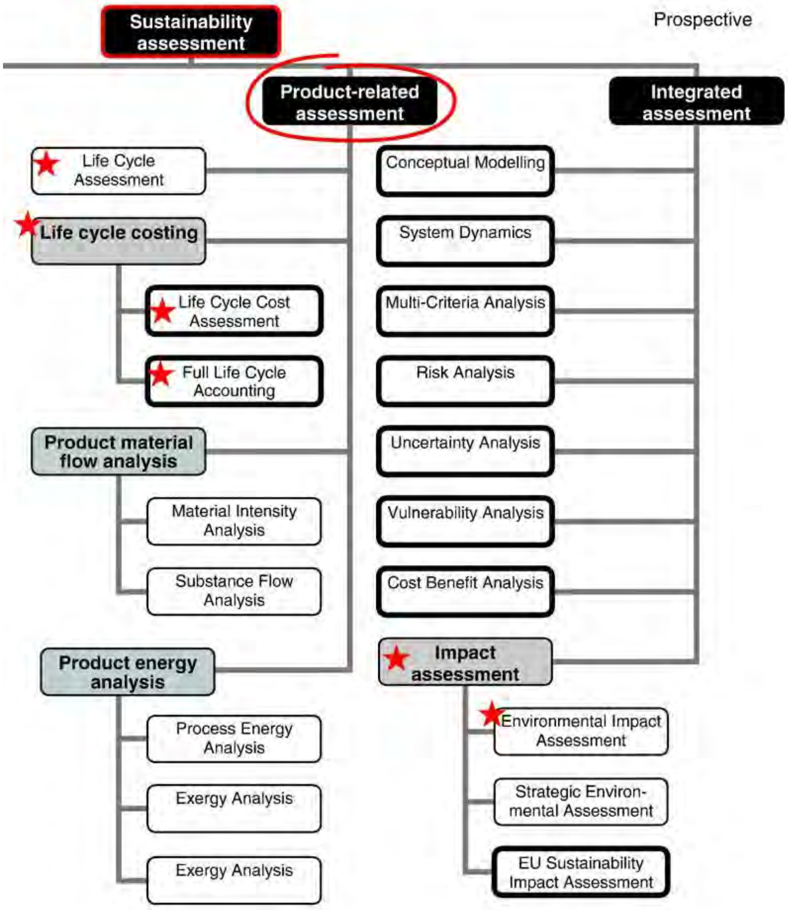

Figure 4: Sustainability tools, adapted from Ness et al., (2007 p.500)

Although there are many sustainability assessment tools and methodologies available, the most suitable for the industrial design process are those which carefully consider the manufacture of the products, energy consumption, material choice, as well as what happens to these products once they are no longer used for their intended function, i.e. disposal, repair, failure etc. The most suitable of those mentioned above seems to be the Life Cycle Assessment within the Product-Related Assessment (figure 4). Environmental Impact Assessment, within the Integrated Assessment section will also be extremely suitable as it allows for the assessment of the impact on the environment of manufacturing processes, energy use, choice of materials, and how products effect the environment once they are disposed of.

How Industrial Designers approach the issue of sustainability

'There are few tools in existence that wrap these issues together. Instead, designers must learn to patch together a series of disparate approaches, understandings, and frameworks in order to build a complete solution' (Shedroff & Lovins 2009, p. 3). There are several approaches which have been developed by practitioners within the Industrial Design profession, to allow for the development of products and services with the role of creating more sustainable outcomes. These are different methodologies which can be utilized in the Industrial Design process and may or may not include sustainability assessment tools. Examples of these approaches are Natural Capitalism, Cradle to Cradle, Biomimicry, Life Cycle Analysis, and Social Return on Investment to name a few. As is now evident, the Sustainability approach of Life Cycle Analysis, as well as the associated sustainability impact assessment tools relating to this, allows for the realization that this is an industry standard method for measuring sustainability, as well as a currently practiced methodology utilized by industrial design professionals. For this reason, this measurement tool should most likely be the most suitable for attempting to match up with current design school curriculum.

Life Cycle Assessment

As is evident above, Life Cycle Assessment, Life Cycle Cost Assessment, and Life Cycle Accounting are very similarly named, providing proof of the confusion between different sustainability tools. Although these may differ slightly, understanding the life cycle of the product is beneficial for sustainability assessment. Life Cycle even has an ISO standard definition as "consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to the final disposal" (Giudice, La Rosa, Risitano 2006 p.88 quoting ISO 14040 1997). This Life Cycle Assessment is also mentioned in product design and industrial design specific publications, but with another additional name to add to the list, being Life Cycle Analysis (Shedroff & Lovins 2009 p.121). A Life Cycle Analysis is illustrated in figure 5, taken from a book titled Product *Design for the Environment: A Life Cycle Approach,* which effectively bridges the gaps between sustainability tools and industrial design practices. This provides the opportunity for assessing and measuring impact during each of these stages, informing appropriate decision making. This in turn provides the necessary information for understanding what can be changed to allow for a more sustainable product solution.

Figure 5: Life Cycle Analysis, adapted from Giudice, La Rosa, Risitano (2006 p.88)

1. Raw Material Acquisition, includes all activities and processes required to obtain material and energy resources from the environment starting from the extraction of raw materials.
2. Processing and Manufacturing includes all the activities and processes required to transform resources into a manufactured product.
3. Distribution includes all the activities of transport, warehousing, and distribution that allow the product to arrive at the end user.
4. Use, Maintenance, Repair includes the entire phase of product life, including all typologies of servicing operations. This can be considered the time from when a user obtains a product, through to the dis-use of the product.
5. Recycle consists of the last phase of product use and indicates the recycling options, both internal (closed loop) and external (open loop) to the life cycle of origin.
6. Waste Management concerns the non recyclable fraction of the product and consists of the management of the final waste disposal (Giudice, La Rosa, Risitano 2006 p.88).

It is evident how different decisions made in each of the above steps can provide more suitable solutions. Each step can be tackle in an attempt to improve sustainability, for example: Manufacture information provides indication of excessive waste produced. What can be changed or developed with the product or manufacturing process to decrease and ideally eliminate this waste.

Software Tools for measuring impact

The methods of measuring impact become problematic as is evident by the numerous assessment tools.

> … it should be noted that in order to calculate the sum of the wide variety of resources and emissions involved in a product's entire life cycle, it is necessary to acquire detailed information on a vast range of production processes, materials, and energy flows, and to make predictions regarding the product's use and the process it will undergo at end-of-life (Giudice, La Rosa, Risitano 2006 p.103).

This has lead to the development of numerous software programs and electronic databases of information which proves useful. There are many types of software tools available to businesses, manufactures, and designers[2] (Loijos 2015). The impact of the systems, processes and manufacture can be assessed and simulated prior to the manufacture of any items through the use of these software packages. *GaBi Sustainabiliy Software*, considered the number 1 sustainability software, is a product sustainability solution with a powerful Life Cycle Assessment engine. This software provides an easily accessible and constantly refreshed content database that details the costs, energy and environmental impact of sourcing and refining every raw material or processed component of a manufactured item. In addition, it looks at the impact on the environment presenting alternative options for manufacturing, distribution, recyclability, pollution and sustainability (Gabi 2015).

This helps guide the design and manufacture process, attempting to decrease negative impact. For incorporation into the industrial design schools, the costs of these software packages may be considered relatively high (in the terms of multiple seats requiring being purchased for educational institutions), with one of the *reasonably priced* packages*, Quantis Suite* costing R56 576.00[3]. This may be too expensive for incorporation into industrial design syllabus as the use of the software has not been piloted. Educational institutions can however apply for free educational installations of some of these packages which will provide access to the databases, and should be pursued.

The utilizations of computer software for product development

Luckily, the purchasing of additional software packages may not be necessary as many of the current Design Software packages used by industrial design schools and professionals alike include embedded sustainability software. Understanding the types of software that is utilized in product development will provide better insight into how the sustainability software can run within. Computer Aided Design (CAD) Packages are already pivotal components of the product design process which allows for the development of accurate virtual 3D computer files. These files are used for many applications including but not limited to prototyping, tool-making and manufacture. Two of the main software packages used by the industrial design schools are SolidWorks, developed by Dassault Systèmes, and Autodesk Inventor from Autodesk. There are however other CAD Packages[4] used by industrial designers, however the two mentioned above are currently used by design schools and professionals alike, throughout South Africa. The balance between the software capabilities and the purchase cost allows the educational institutions to utilize the software as well as for it being affordable enough for young graduates to purchase once they begin their career. The sustainability tools within Autodesk packages are not well documented in publications and websites and have

[2] Several of these software packages *SimaPro 7, GaBi 5, Umberto, Quantis Suite 2.0, EarthSmart, Sustainable Minds, Enviance System 6.4*, mentioned by Loijos (2015).
[3] USD4420 at R12.80, 01 July 2015
[4] Other widely used CAD Packages include *SolidEdge*, *Rhinoceros* 3D, *CATIA*, *CREO* and *Unigraphic*.

therefore not been expanded on within this paper. The applicability of SolidWorks however for utilizing sustainability software is more extensively documented and provides clear explanation of how the software links to various sustainability tools. This allows for a clear understanding as to how this can be used in design schools.

Product Design software with included Life Cycle Assessment engines

Within SolidWorks, a sustainability component uses the gold-standard GaBi Life Cycle Assessment environmental impact database, against which it simulates the product being developed[5]. It includes diverse tools of with the additional capability to assess both parts and assemblies, using parameters such as transportation mode and distance, assembly energy, and use-phase energy consumption. (SolidWorks 2015b). This is extremely valuable to the product designer as variations of products can be developed and weighed against each other in terms of the various assessment criteria or areas of impact. Through the utilization of this built-in Life Cycle Assessment tool within SolidWorks it can allow students and graduates to engage with a software package they are already accustomed to. In figure 6 it has been illustrated how the Life Cycle Assessment software forms part of the SolidWorks CAD software, allowing for it to be utilized with the computer development of products.

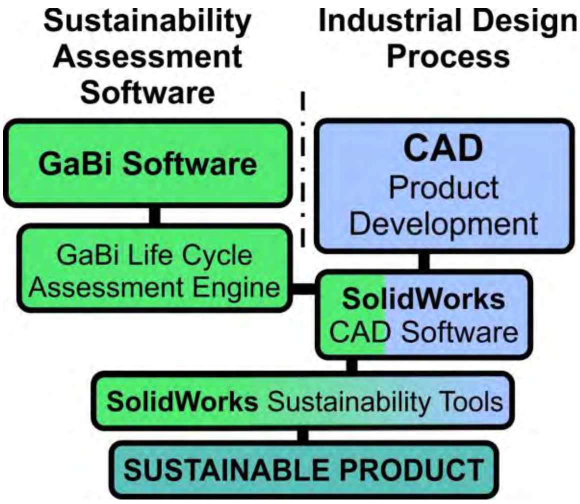

Figure 6: Developing a sustainable product using SolidWorks Sustainability tools. Diagram by Author.

Incorporating the use of these tools into industrial design syllabus structure is as easy as linking it to the CAD software, engineering and manufacturing components of student projects. Depending on the course structure, there are many opportunities for effective incorporation of this software. For example, the designer (design student) is able to develop a product which may comprise of multiple components. This would be a virtual product, constructed from virtual materials. The CAD Software would be able to simulate and indicate what areas of the product may be considered creating a negative impact on the environment (figure 7). The student could then further development of the design by simulating alternative materials, remodeling components in a manner which utilizes less material, or omit components which may be unnecessary. As stated in the SolidWorks sustainability tool within the CAD Package:

> When determining the environmental impact of a product, Life Cycle Assessment looks at what happens in the production, use, and the final disposal of the product. This even includes the transportation impact that occurs between the stages. Decisions on the material used, how it is manufactured, and other factors can result in vastly different

[5] The GaBi environmental LCI database is a peer-reviewed set of environmental impacts obtained through a combination of scientific experimentation and empirical results obtained in the field. Nearly all SolidWorks materials and typical manufacturing processes for each material are mapped to the equivalent GaBi material and process (Solidworks.com, 2015a).

effects on the environment. SolidWorks Sustainability shows you these impacts and helps you improve your design (SolidWorks 2014).

Figure 7: Screenshot of SolidWorks Sustainability tool which runs within the CAD program (Solidworks 2014).

This can easily tie back across to appropriate industrial design theory or technology, or business modules within current design curriculum. Students will be able to apply theory of sustainability directly into the CAD environment with the products they have themselves developed. The iterative process of design refinement and engineering, allows for multiple cycles of product refinement to take place, with each step becoming more sustainable, and impact the environment less than the one before. This would also assist in indicating to the student that the industrial design process, if undertaken carefully, is able to yield products which do not negatively impact the environment

Educational Institutions should also pursue free versions of sustainability software, for inclusion into their existing toolbox of software packages for students. Ideally this is to be incorporated directly into coursework. Furthermore these software companies should be approached for the possibility to undertake training basic training with their software (GaBi, 2015).

Conclusion

Through the analysis of the various sustainability approaches which have a direct correlation to the decision making of industrial designers, it is evident that currently there are in fact accessible and suitable sustainability assessment tools at the disposal of the industrial design schools within South Africa. These tools allow for the development of more sustainable product outcomes, without the need for the product to even begin its life. This virtual simulation allows the designer to learn through trial and error gaining knowledge on how to develop sustainable products, practically applying what is learn in theory modules. The designer therefore is able to graduate as a more accountable decision maker, realizing the impact of the decisions made throughout the design process. The design student will be able to interrogate their own design decision making through the utilization of appropriate sustainability software and be able to better defend process, material and composition while still within the institutional environment, preparing them for their professional role as mediator between client, manufacturer, society and environment.

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