Transforming Mind-sets of Product Design Students Towards Sustainable Product Service Systems: The Case of the University Of Botswana

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ABSTRACT

Current business models have over the years led to increased consumption of resources; energy and materials. The concept of Sustainable Product-Service Systems (S.PSS) could be more meaningful when applied to Distributed Renewable Energy systems (DRE) to reduce resource consumption. A shift in focus for Institutions of Higher Learning traditionally offering product design degrees is imperative for them to produce designers that are responsive and proactive in addressing the global sustainability crisis. This paper explores through a case study, how S.PSS applied to DRE can be taught and learned by students enrolled in a traditional product design degree. The major findings informing pedagogy show that the context can be used as an interactive resource to inform teaching and learning in non-conventional learning spaces. Students now tackle design challenges from a product service systems approach which shows a positive transition towards service-oriented solutions leading to a sustainable culture.

Key Words: sustainable product service systems; service economy; teaching and learning; distributed renewable energy systems.

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1. INTRODUCTION

In order for countries to move to more sustainable societies, a radical redefinition of the current structures of production and consumption requires a system discontinuity (Ceshin, 2013; UNEP, 2002). The focus on product-orientated solutions have not brought any sustainable results and therefore, a new systematic approach need to be considered that seeks to re-orientate the current standards of consumption and production. Energy and materials are the biggest concerns in this global catastrophe. In this quest to re-orient consumption patterns, a shift to renewable and distributed sources of energy is also very important. Distributed renewable sources of energy facilitate less dependence on fossil fuels and local communities can be empowered to produce for themselves. Different scholars (Manzini and Vezzoli, 2003; Valencia et al., 2015; Ceshin, 2013; Baines et al., 2007; Beuren, 2013) have alluded to the fact that to combat the global challenges, a sustainable product service system seems to be a promising alternative. A Product Service System can be defined as an innovation strategy that shifts the business focus from only designing and selling physical products, to designing and selling a competitive system of products and services which are jointly capable of fulfilling specific client demands with lower environmental impacts (Manzini & Vezzoli, 2003; Mont, 2002). Selling the use is more emphasised than selling the product itself (Pergande, 2012). PSS consists of a mix of tangible products and intangible services designed and combined so that they are both capable of fulfilling customer needs (Tischner, Verkuji & Tukker, 2002; Baines et al., 2007). A Product Service System design goal is to be more competitive in an economy, satisfy customers and social demands by reducing consumption of material products through alternative scenarios of providing product service solutions over products ownership, and offering services that have a low environmental impact.

It is against this premise that the University of Botswana seeks to equip design students with the necessary S.PSS knowledge and skills so that they can contribute to the sustainable industrial development of their country. This new generation of designers could assist the country to leapfrog, thus avoiding some of the mistakes that were made by developed countries. The goal is to inculcate the values of S.PSS in equipping a new generation of designers with the necessary knowledge and skills to mitigate economic, environmental and socio-ethical issues differently than the current scenario. It is anticipated that this new generation of designers will contribute towards a sustainable future and assist companies to construct service-oriented strategies that compliment, strengthen, or replace the already existing product-oriented strategies. New ways of developing S.PSS skills as well as strategies of how to address energy issues when exploring DRE within a S.PSS framework are needed. This paper explores how skills of S.PSS applied to DRE can be developed in an innovative teaching and learning environment in undergraduates of a traditional product design degree.

2. THEORETICAL FRAMEWORK

According to Fidler (2013) and Tukker (2004) Product service systems can be categorised into three areas:

a. Product oriented PSS - The ownership rights of the product are transferred to the customer and a service arrangement is provided to ensure the utility of the product over a given period of time. Examples include warranties and maintenance contracts,

b. Use oriented PSS - The ownership rights of the product are retained by the service provider in this configuration and the customer purchases use of the product over a given period of time or units of service,

c. Results oriented PSS - While the ownership rights of the product are retained by the service provider, similar to use oriented PSS, the customer purchases the utility as an outcome and not the use of a product over a given period of time. For example, instead of purchasing a washing machine, the customer purchases the service of clean clothes delivered through a washing service.

A classification of S.PSS applied to DRE has already been developed by Emili, Ceshin and Harrison (2016). This classification explores possibilities of DRE solutions across all the three categories of PSS. An example of a product-oriented archetypal model would be selling individualised energy systems with advice and training services. In this scenario the end users pay for and owns the energy system and the provider offer advice and training on how to use and take care of the system. The benefit of a S.PSS in this arrangement is the opportunity to create environmental awareness on users and the socio-economic benefits of access to better lighting, especially in developing contexts as well as skills from the training services to develop a business. Despite PSS offering a promising alternative to mitigate environmental, socio-ethical and economic issues, there is a slow uptake by academia and manufacturing companies. In a study conducted in the United Kingdom, three important limits to knowledge on PSS that contribute to the slow start of PSS delivery were identified by Cook, Bhamra and Lemon (2006) and UNEP (2002):

- The financial proposition of product services remains unproven.
- The environmental benefits that can be gained from using it have not been sufficiently quantified.
The knowledge set associated with the concept is insufficient to produce the design methodologies that are necessary to help designers and engineers in the design of more environmentally friendly products needed to support services.

Overcoming the customers’ cultural barrier dominated by the norm of ownership to solutions based on sharing and access. To customers, ownership represents status, control as opposed to owner-less solutions. Furthermore, PSS innovation encounter the opposition of the existing socio-technical context, that is, changing dominate daily routine behaviours reproduced by individuals, groups, business communities, and governmental institutions (Ceschin, 2013; Tukker and Tischner, 2006).

According to Qiu (2010) it has been shown, for example, that sustainability concerns have an impact on teaching approaches. Furthermore, what people learn, how they learn, and where they learn will radically change in future. There is a need to make the transition towards a service economy and sustainable culture, and it is imperative to start inculcating the same values in the students because they are the future leaders. This requires a cultural shift to redefine customer needs away from product ownership (Manzini & Vezzoli, 2003). In support of the latter, Ceschin (2013) advances that there is a need to move from a focus on product improvements only, towards a wider systematic approach that takes into consideration new potential ways of satisfying the social demand of well-being. Apart from cultural barriers, there are also corporate and regulative barriers (UNEPI, 2002; Tukker and Tischner, 2006).

There are several advantages that can be gained by implementing S.PSS and applying S.PSS to DRE. The benefits relate to the service providers, consumers, governments, the environment, and society at large since they are the drivers of PSS in their different capacities (Boehm & Thomas, 2013; Emili et al, 2016). The major benefits of the PSS are focused on the continuous improvement of the business, innovation in quality, and the satisfaction of consumer demand, which results in building long lasting relationships and fostering loyalty among consumers. In the case of DRE systems, S.PSS empowers communities and provides affordable clean energy options. Moreover, providers and develop their position in the value chain and increase their innovation potentials by analysing the information obtained from the customers and the vast degree of customisable energy systems to suit different energy needs. These relationships help to develop new systems that improve the product performance. From the providers’ point of view, PSS provides an opportunity to identify strategic new market opportunities, market trends and development, and the potential to stay in the competitive economy driven by environmental limitation (Mont, 2002). The companies that are carrying out the S.PSS can assist to reduce the consumption of scarce resources and environmental problems by producing products and services that reduce waste. From the government and society point of view, the benefits of PSS are in the making of policies that are aimed at promoting sustainable patterns of consumption and sustainable lifestyle (Mont, 2002). Understanding the S.PSS concepts is seen as a means influencing stakeholder relationship and networks. PSS aims to bolster sustainability, thus reducing the environmental problems and society. Increasing the supply of services can create new job opportunities (Beuren et al., 2013). Consumers receive a variety of choices in the market ranging from maintenance and repair service, and various payment schemes (Mont, 2002). Through PSS, consumers can also obtain simply knowledge by educating themselves about the different available environmental features of products.

3. METHODOLOGY

At the University of Botswana some students may not have the opportunity to learn strategic design for sustainability. This is because design for sustainability courses are still offered as optional courses, which hinders development of appropriate sustainable design skills for all design students. In this paper, the authors report on a case study that was conducted with design students at the University of Botswana. A case study approach was adopted because it is a source of ideas about behaviour, offers opportunities for innovation and challenges theoretical assumptions and to help to understand and explain causal links and pathways resulting from a new service development (Yin, 2009; Crowe et al., 2011). Evidence for this case study was collected mainly through a 2-week workshop involving user research, brainstorming to explore possible solutions and a structured presentation to share the outcomes. In order to address the research question posed in this paper, a reflection on this workshop which was part of the LeNSes project was conducted. The research question was in part addressing aim number three of the LeNSes project; “Delivering these curricula through an innovative teaching approach…” (Vezzoli, et al, 2015: 135). This aim was of great interest to the authors from the perspective of teaching and learning of S.PSS and DRE in a product design degree.

The workshop participants consisted of 41 fourth year students from the Bachelor of Design (Design and Technology Education) programme at the University of Botswana. Different experts from research institutions on renewable energy, energy companies, government departments and academic experts on DRE and S.PSS contributed as
facilitators during the workshop. The participants were chosen in consultation with the Departmental Board, to reflect issues of sustainability in their then on-going Minor Project course. This sample was also on the verge of undertaking their Major Design Project course the following semester. The workshop, therefore, came at the right time to equip participants with sustainable PSS and DRE knowledge to further apply into their major Design Project. The experts were chosen for their expertise to the main working hypothesis of the LeNSeS project, which purports that S.PSS could be effectively applied to DRE as a promising opportunity to couple environmental, economic and social benefits (Vezzoli et al, 2015).

The workshop was structured to include lectures, practical activities and field visits. During the introduction of the workshop, the project aims and objectives and a design exercise were launched to enlighten participants what was expected of them. As the first stage of the workshop, the students were given lectures on sustainable development, sustainable design, sustainable product service systems and distributed renewable energy systems. This was followed by a field trip to facilitate user research on the launched design exercise. With a pre-requisite knowledge about sustainability, PSS and distributed renewable energy systems, the students were now able to undertake the design exercise. There were 2 briefs for the design exercise. However, the nature of the tasks were similar and the deliverables were the same. The tasks (briefs) and their breakdown (final expected outcome) are summarised in Table 3.1.

<table>
<thead>
<tr>
<th>Briefs</th>
<th>Final expected outcome</th>
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<tbody>
<tr>
<td>a. Design a Product-Service System to improve safety of townships by</td>
<td>• Summary of problem and user analysis</td>
</tr>
<tr>
<td>providing light and security to public, passages and open spaces</td>
<td>• Offering diagram</td>
</tr>
<tr>
<td>which are not lit at night</td>
<td>• Concept description</td>
</tr>
<tr>
<td>b. Design a Product-Service System to assist students from low-income</td>
<td>• Interaction storyboard</td>
</tr>
<tr>
<td>and rural areas to study at night</td>
<td>• Details on the energy system and 'energy using products'</td>
</tr>
<tr>
<td></td>
<td>• Details on services</td>
</tr>
<tr>
<td></td>
<td>• Details on the payment structure</td>
</tr>
<tr>
<td></td>
<td>• Stakeholder system map</td>
</tr>
<tr>
<td></td>
<td>• Sustainability potential</td>
</tr>
</tbody>
</table>

The ability to develop sustainable product service system solutions for distributed renewable energy systems formed the foundation provided by lectures and user research conducted during the field trip to potential users on the site. User research was conducted in a local low-income community in Gaborone. A summarised structure of the workshop is represented in Table 3.2.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Workshop activity</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduction of the workshop aim</td>
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<td></td>
<td>Launch of the design exercise</td>
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<tr>
<td></td>
<td>Lectures</td>
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<tr>
<td>2</td>
<td>Lectures</td>
</tr>
<tr>
<td></td>
<td>Field visit</td>
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<tr>
<td></td>
<td>User research and problem framing</td>
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<tr>
<td>3</td>
<td>Lectures</td>
</tr>
<tr>
<td></td>
<td>Brainstorming - solution seeking</td>
</tr>
<tr>
<td>4</td>
<td>Solution detailing and presentations</td>
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</tbody>
</table>

Qualitative data generated was handled using thematic analysis (Miles and Huberman, 1994). The main analytical question was: How did students absorb new S.PSS and DRE knowledge and reflect it in their outcomes? Observations during the workshop and student presentations on the expected outcomes formed the basis of the data analysed.
4. RESULTS

The experimentation with teaching and learning of S.PSS applied to DRE has been conducted in a workshop setting. The practical component of the teaching and learning was the design exercise. Results are discussed below under five themes with sample of outcomes to support each theme.

4.1. The context as an interactive resource

An understanding of the local context elicited important information on users and their energy needs. All groups demonstrated this theme either by profiling of users as described personas or a visual representation of the same (Figure 1). These provided useful insights through the emphatic approach adopted during the field trip to the Old Naledi community. An interaction with the environment and the people, who live and work there, uncovered and shaped what should be investigated, how it should be investigated and possible configuration of the outcomes. This is a different approach when compared to the classroom-based approach. In the classroom scenario, the context is not explicitly planned into the learning activities to be a resource, even though students are usually encouraged to conduct user research in the context.

![Persona 1 and Persona 2](image)

FIGURE 1. Detailed character profiles of typical Naledi Community residents in Gaborone

4.2. Non-Conventional New Learning Spaces

Facilitating the acquisition and assimilation of new knowledge meant that the new learning space had to be defined. A framework under which this was made possible was developed as described in the methodology section. Treating both energy issues (DRE) and the business model issues (S.PSS) at the same time were evident in the students’ work. However, the ability to demonstrate this capability was not naturally there among the students. Learning a new concept in a non-conventional learning way prescribed new learning spaces for learning S.PSS and DRE (Figures 2 and 3). A dynamic learning environment was evident where students constantly consulted various experts at the same time, within the same room. Defining parameters of this new learning space was the flexibility to consult academics, industry experts and members of the community within a manageable space of time.
4.3. Integrated Use Of Enabling Tools

The socio-technical rigour of S.PSS and the technical perspective of DRE required that students use tools that can effectively communicate both qualitative and quantitative data. Qualitative tools often allowed for exploring holistic systemic issues, defining actors and their roles, products and possible services, what a DRE-S.PSS offer could look like in various archetypal models, customers and their roles as well as payment modalities and system benefits. Tools such as the idea generation map in Figure 4, allowed students to build narratives and express situations in the local context. Quantitative tools such as the system information tool in Figure 5 provided technical rigour in student solutions. Students were able to work out how much energy the products they were prescribing were going to use in order to work out the system efficiency.
4.4. Learning and Problem Solving through Networking

The diversity of human capital involved in the workshop provided students with opportunities for networking and having access to new knowledge from various people (Figure 6). Various experts from research institutions, energy companies, government departments and members of the Old Naledi community contributing in their various ways meant that this vast knowledge was integrated into a whole made accessible to students. This network was altered daily as new people were brought into the workshop for their different inputs. The disconnect between PSS and DRE was linked through bringing experts on PSS and DRE and energy systems together under one roof. This created a platform for cross-pollination of ideas, thus defining how PSS can be practically applied to DRE in Botswana.
4.5. Process Reflective Outcomes

The outcomes from all the ten groups were a reflection of the integration of principles explored through the design exercise and lecture structures of the workshop. The dynamic engagement with the environment where the design exercise was based, engagement of various experts and members of the community as well as use of various tools, motivated students to come up with comprehensive solutions. Almost all offering diagrams (Figure 7) from the students reflected local community structures such as the Village Development Committee, local manufacturers/providers and payment modalities that are applicable in the local context. With the understanding of who the stakeholders are and what their roles will be, a stakeholder system map (Figure 8) was used to put these together to show how they will relate to each in a system win-win scenario, where the customer meets their needs and the providers make profits at no or minimal cost to the environment.
5. DISCUSSION

For students to develop these solutions, they had to overcome a dominant and established cultural barrier of designing products for ownership as opposed to designing solutions based on sharing and access. The knowledge imparted through a series of lectures and the design exercise regarding S.PSS and DRE assisted students to overcome that cultural barrier and facilitated the design of solutions based on S.PSS in a systemic landscape. This could be argued to be an innovative teaching approach given that it took place outside the conventional lecture room environment, but directly informed the students’ design skills base. Conducting user research and building familiarity with the context during S.PSS and DRE teaching and learning could help develop valuable solutions which are systemic in nature and appropriate for the users in the given context (Rapitsenyane and Bhamra, 2013; Rapitsenyane, 2014).

According to Qiu (2010) it has been shown, for example, that sustainability concerns have an impact on teaching approaches. As a resource into teaching and learning, it is important to build awareness on resources available in the physical environment and how fragile they are, so that social and economic development issues are cautious of a rebound effect. Constant interaction with the community, experts and knowledge of the energy situation in Botswana by students who participated in the workshop is an example of this measure. Furthermore, what people learn, how they learn, and where they learn will radically change in future. There is a need to make the transition towards a service economy and sustainable culture, and it is imperative to start inculcating the same values in the students because they are the future leaders. This requires a cultural shift to redefine customer needs away from product ownership (Manzini & Vezzoli, 2003) to integrated system solutions. The results from the students projects illustrated in Figure 7-9 show a transition from a product-orientated solution to a S.PSS approach. The University of Botswana sees S.PSS knowledge and skills vital to their design students so that they can contribute to addressing issues of national concern in their country. A dynamic teaching and learning environment could also promote self-directed learning especially where students see the practical value of acquiring new knowledge and skills. Through constant networking and direct interaction with real people, real needs and the real environment, values of transfer of academic concepts into the real world are made simpler. The S.PSS approach advances the strategic position of design in sustainability, which requires a retrofit of the teaching and learning environment in universities such that communication of the service component to student designers in a product design undergraduate programme is not an alien abstraction.

6. CONCLUSION

The case study approach offered an opportunity to explore two issues. Firstly, to conduct teaching and learning of sustainable product service systems in a localised context where systemic problems were identified. After identifying the problem, students used a system thinking approach to develop the solutions. That is, using a set of synergistic analytic skills used to improve the capability of identifying common elements and understanding their interconnection, predicting their behaviours, and devising modifications to them in order to produce the desired effects and viewing systems as a whole rather than as parts. Secondly, these activities took place in the usual environment of teaching and learning for these students. The authors conclude that learning sustainable product
service systems in existing structures of product design require a change in pedagogy over a period of time. This process should be supported by local and social settings in terms of learning resources and examples that can demonstrate the practicability of PSS. The findings indicate that there was a trajectory through which student designers developed a mind-set change after being introduced to product service systems and DRE. Though S.PSS is still a new business concept in new emerging economies, it has proved to have the potential to address economic, socio-ethical and environmental challenges facing the society such as exploitation of renewable energy systems in developing contexts. A recommendation for future scaling up of this initiative could be to work closely with education ministries so that the concept is trickled down to lower levels in the education system, as opposed to end of pipe approaches currently being implemented only at university and corporate levels.

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