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How to engage design students to become Problem finders as well as Problem solvers

Due to a changing economic, social, cultural and technological landscape design problems have become more complicated with the role of the designer expanding. Designers are moving from just responding to a brief from a client to also actively engaging with users and stakeholders to become 'problem finders' as well as 'problem solvers'. In order to meet these challenges design education must equip students with the skills to seek out new opportunities for design solutions. This article outlines a methodology adopted and developed to guide Product Design students in carrying out primary research to identify the needs of users and stakeholders in any given context. The methodology was developed in the course of conducting a number of projects at University Limerick (UL) in conjunction with University Limerick Smarter travel over a three year period. Its effectiveness is outlined and the extent to which students were able to develop a mind-set that enabled the uncovering of insights that led to innovative solutions is examined. Furthermore, the challenges faced by the students are also explored.

Background

Many problems addressed now by designers are ill defined and require techniques beyond what is achievable by one discipline (Cross, 2006, Jonassen, 2008, De Vere et al., 2010, Kiernan and Ledwith, 2014). As a result, designers are working on a broader set of design problems involving complex systems and working as part of interdisciplinary teams (Moritz 2005, Wohlfarth 2002, Dym et al. 2006). Meeting such challenges will increasingly require designers to become *'problem finders'* as well as *'problem solvers'* (Fleischmann, K. 2013). There is now a growing emphasis on ethnographic and observational research. Observing people using products and services can lead to the discovery of unmet and unarticulated needs which can lead to a breakthrough in innovation (Cooper and Evans, 2006). By understanding the needs of the user the designers may question established practice and modes of thinking and yield innovation that gives real benefit (Cooper and Evans, 2006). Product design education has typically focused on creating employable *'problem solvers'* rather than *'problem finders'*, therefore, to what extent can design students be educated to uncover the right problems to solve? Design research is increasingly looking to anthropology and psychology to create meaningful and relevant solutions through understanding people´s motivations and expectations. A number of tools and techniques have been developed in this area such as 'The human centred design toolkit' (Ideo, 2009), *'Biodesign: The Process of Innovating Medical Technologies'* (Zenios et al., 2009) and the *'Boot camp Bootleg'* (Plattner, 2010). These methods were adapted by the authors to guide students through the problem finding process. How the students were engaged in the process and responded to the methodology is a focus of this paper.

Implementing a design research process in a product design and technology program.

The product design and technology program at UL is a four year Bachelor of Science degree course. Understanding user needs is central to the course philosophy and this is combined with the knowledge of technology, materials and manufacturing to ensure the design of products that are useful and address real user needs. In the second year of the program, students take a twelve week module which focuses on primary research to identify opportunities or needs that can provide the basis for design solutions. The contact time for the module is one x four hour session a week which is divided equally between two x six week projects. The weekly sessions are run in a workshop format combining lectures and project work. There is a strong emphasis on discussion within the class and students present their work regularly throughout the

References

Anderson, C. (2010) 'Presenting and evaluating qualitative research', American journal of pharmaceutical education, 74(8), 141.

Cooper, R. and Evans, M. (2006) 'Breaking from tradition: Market research, consumer needs, and design futures', DESIGN MANAGEMENT REVIEW, 17(1), 68-74.

Cross, N. (2006) Designerly Ways of Knowing London: Springer.

De Vere, I., Melles, G. and Kapoor, A. (2010) 'Product design engineering–a global education trend in multidisciplinary training for creative product design', European journal of engineering education, 35(1), 33-43.

Dym, C., Agogino, A., Eris, O., Frey, D. and Leifer, L. (2006) 'Engineering design thinking, teaching, and learning', IEEE Engineering Management Review, 34(1), 65-92.

Fossey, E., Harvey, C., McDermott, F. and Davidson, L. (2002) 'Understanding and evaluating qualitative research', Australian and New Zealand journal of psychiatry, 36(6), 717-732.

Gilson, L. L. and Shalley, C. E. (2004) 'A little creativity goes a long way: An examination of teams' engagement in creative processes', Journal of Management, 30(4), 453-470.

Ideo (2009) 'Human Centred Design toolkit', available: https://climateandhealthresearch.files.wordpress.com/2015/04/ideo-org_hcd_toolkit.pdf [accessed 30/1/2017].

Jonassen, D. H. (2008) 'Instructional design as design problem solving: An iterative process', Educational Technology, 48(3), 21.

Kiernan, L. and Ledwith, A. (2014) 'Is Design Education Preparing Product Designers for the Real World? A Study of Product Design Graduates in Ireland', The Design Journal, 17(2), 218-237.

sessions to encourage debate and reflection. The projects at the focus of this article were developed in conjunction with a client University Limerick Smarter Travel (ULST) and have been running for the past three years with slightly different themes each year. One objective of the module was to provide students with the experience of working on *'real world'* projects in order to uncover issues that impact on actual stakeholders. *'Real world'* problems, when sponsored by real stakeholders, can engage students in ways that *'artificial'* projects often do not (Mulder et al., 2012). The topic area was developed between the authors and the ULST co-ordinators. The projects were focused on understanding the barriers to users of the UL campus in using sustainable means of commuting to the university such as cycling and walking. Another objective for the project was to come up with solutions that could be realistically implemented by ULST. The students were put into teams of three and four to conduct the work. The project followed the process as outlined in Figure 1.

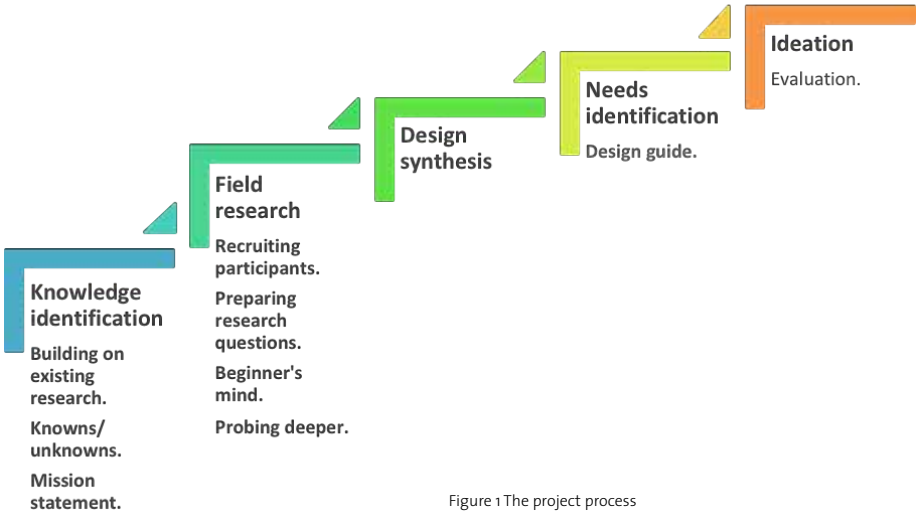

Figure 1 The project process

Knowledge identification

Building on existing research

The first step in the process was to build on existing research. Rather than conducting research from scratch the students were provided by ULST with quantitative data which detailed the numbers and profile of people that did not use a sustainable means of travel. This enabled the students to target their research to a particular demographic. For example, it was revealed that a large number of students who lived within a kilometre of the university drove to the campus while more males than females cycled to the campus.

Knowns/Unknowns

Teams must share their goals and their teamwork strategies in order to be efficient (Gilson and Shalley, 2004). Groups often fail to apply their distributed information due to a failure to exchange and elaborate on distributed information (van Ginkel and van Knippenberg, 2008). To encourage knowledge sharing amongst the teams the next step in the process was to draw on the distributed prior knowledge of the teams. Each team was asked to identify the collective knowledge of the team in terms of the barriers to cycling and walking to be able to then identify the knowledge gaps related to the project in the form of *'knowns' and 'unknowns'* (Figure 2). Conducting a 'What Do We Know?' session helps call forth existing knowledge related to the project. Once documented, it was possible to freely focus on discovering *'what do we need to know?'* The students found it difficult to begin the process and tended to consider concrete well known issues such as the weather or road surfaces. To gather insights that focused on human interactions and behaviours, the teams were encouraged to recount stories from personal experiences. They were also asked to identify the range of stakeholders that would have a vested interest in the outcomes of the project. The purpose of this was to engage the students in recognising the perspectives of different people with the objective of accommodating often conflicting agendas and desires.

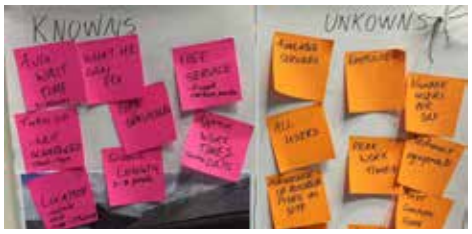

Figure 2 'Knowns' and 'Unknowns'

Mission statement

The next step in the process was the creation of a mission statement to explain the team's aspirations in a concise manner (Figure 3). The use of a mission statement can foster a focus on common objectives, team work, behavioural guidelines and a commitment to the project (Mullane, 2002). The mission statement also captured the desired outcome of the project. The following is an example of one team's mission statement *"Make the transition to a smarter form of travel as easy and as accessible as possible."*

The mission statements also supported the tutors to guide the students. At times the students strayed from the project focus and were therefore repeatedly asked to reflect on what they had done and if this helped them as a team to achieve their mission statement.

References

Kolko, J. (2012) Wicked Problems: Problems Worth Solving: A Handbook & A Call To Action AC4D [online], available: https://www.wickedproblems.com/1_large_scale_distraction.php [accessed 04/11/2013].

Moritz, S. (2005) Service design: practical access to an evolving field, unpublished thesis Köln International School of Design.

Mulder, K. F., Segalas, J. and Ferrer-Balas, D. (2012) 'How to educate engineers for/in sustainable development: Ten years of discussion, remaining challenges', International Journal of Sustainability in Higher Education, 13(3), 211-218.

Mullane, J. V. (2002) 'The mission statement is a strategic tool: when used properly', Management Decision, 40(5), 448-455.

Plattner, H. (2010) 'Bootcamp bootleg', Design School Stanford, Palo Alto [online], available: https://static1.squarespace.com/static/57c6b79629687fde090a0fdd/t/58890239db29d6cc6c3338f7/1485374014340/METHODCARDS-v3-slim.pdf [accessed

Suzuki, S. (2010) Zen mind, beginner's mind, Shambhala Publications.

van Ginkel, W. P. and van Knippenberg, D. (2008) 'Group information elaboration and group decision making: The role of shared task representations', Organizational behavior and human decision processes, 105(1), 82-97.

Van Knippenberg, D. and Schippers, M. C. (2007) 'Work group diversity', Annu. Rev. Psychol., 58, 515-541.

Wohlfarth, J. (2002) 'Making the Grade', International Design, 49, 54-59, available: http://www.ritasue.com/downloads/ID_Mag_092602.pdf [accessed 09/12/2010].

Zenios, S., Makower, J., Yock, P., Brinton, T. J., Kumar, U. N., Denend, L. and Krummel, T. M. (2009) Biodesign: The Process of Innovating Medical Technologies, Cambridge: University Press.


Figure 3 The development of a mission statement

Figure 4 The research participants

Figure 5 Observations

Figure 6 'Try it yourself' technique

Field Research

Recruiting Participants

Qualitative sampling in conducting primary research requires the identification of appropriate participants who can best inform the study (Fossey et al., 2002). Recruiting appropriate participants was therefore critical to the project. However, it was found that students tend to rely on their friends and peers as research participants rather than targeting the right profile of participants. Therefore, identifying a range of participants was stipulated in the brief, including staff, students, visitors and other stakeholders such as the campus bike mechanic and UL Smarter travel personnel (Figure 4). As research is meant to inspire new opportunities, it was also useful to find people who represent *"extremes."*

"Extreme participants help to unearth unarticulated behaviours, desires, and needs of the rest of the population, but are easier to observe and identify because they feel the effects more powerfully than others." (Ideo, 2009)

Preparing research questions

From the unknown information established, the teams were in position to plan and prepare the research approach and choose from a number of methods to carry out the research. The following toolkit of methods was used:

- Individual Interview: Individual interviews are critical to most design research, since they enable a deep and rich view into the behaviours, reasoning and lives of people.
- Group Interview: Group interviews are valuable to learn about a program quickly and are an opportunity for all stakeholders to give their views.
- Expert Interviews: Experts can be called upon to provide in-depth and technical information.
- Observation:
  Fly on the wall (discreet observation): This involves observation without interfering with people's activities (Figure 5).

  In context immersion: This is where the observer is immersed in a community with the aim of collecting more detailed information about a community's habits, opinions and issues. This can include the technique of shadowing someone or asking them to show you how they interact with devices or systems.
- Diary study: A diary study is a research method used to collect qualitative data about users. In a diary study, data is self-reported by participants to collect behaviours, activities and experiences over time.
- Try it yourself: trying the activities and interactions involved can prompt the team to appreciate the experience the users might have (Figure 6).
- Behavioural mapping: This involves tracking the positions and movement of people to define spatial behaviours, inefficiencies and bottlenecks.
- Activity analysis: This involves listing or representing in detail all tasks, actions, objects, performers and interactions involved in a process.

In the first year of the module the students conducted their research once in the field. In developing the program over the course of three years a decision was taken to allow the students to carry out research in the field iteratively with feedback in between field visits. On the initial rounds of field research, the students tended to ask binary questions deferring at times towards quantitative surveys to carry out the research. One team for example found that people did not cycle in the rain, however, they did not find out why people did not cycle in the rain and if there were other barriers to cycling in the rain other than getting wet. Some of the findings therefore did not address the mission statements. By getting the students to present their initial insights from the first round of field research this afforded the tutors to guide the teams back to their mission statements and recognise the limitations of their research approach.

It was also necessary to expand the discussion and debate around some of the insights gathered to challenge conventional thinking. For example, one team found that dog faeces along a pathway from the university to the

city were an issue for path users. During discussion the students suggested the need for 'pooper scooper' bins. However, the students were asked to question the rational in providing this in a rural setting over a distance of four kilometres. They were also reminded to consider other stakeholders like the council who would be tasked with the management of these bins.

Developing the beginner's mindset.
Qualitative research is often criticised for being biased, small scale, anecdotal, and/or lacking rigor; however, when it is carried out properly it is unbiased, in depth, valid, reliable, credible and rigorous (Anderson, 2010). Following initial field visits it was clear that the students were bringing assumptions and biases to bear. For example, some groups stated that the pathway was unsafe as there were *"junkies"* loitering at one end. The assumption here was that anyone loitering was a *"junkie"* and that anyone who was a *"junkie"* was going to be a security threat. In order to remove assumption and bias, the students were provided with a number of techniques to encourage a 'beginner's mind', the kind of mind which can see things as they are. *" In the 'beginner's mind' there are many possibilities, but in the expert's there are few"* (Suzuki ,2010).

To help develop this mind-set, the students were shown a number of photographs and asked to describe what was happening in each one. They were then asked to identify the assumptions that led to their accounts. On examining the assumptions made, the students were then asked to list a series of questions that they would ask if they knew nothing about the context or activity of the people in the photograph. The *'beginner's mind'* set is about questioning and not judging.

Probing deeper
To help students to go beyond surface findings and binary answers they were provided with a number of techniques to provide deeper insights.

Show me: This entails asking participants to show the activities and interactions they go through when engaging with a device or process.

5 whys: Asking "Why?" questions in response to five consecutive answers can determine a root cause of a problem and reveal people's underlying reasons for their behaviour and attitudes.

Think aloud: This involves asking participants to describe aloud what they are thinking as they perform a process or execute a specific task. This can help uncover users' motivations, concerns, perceptions and reasoning.
Find the pain points: This involves asking participants to outline the pain points that they find difficult, frustrating, annoying, awkward or messy when interacting with a system, process or device.

Hacks and workarounds: This involves identifying if participants have developed any workarounds or *"hacks"* to bypass a difficult process.

Design Synthesis
Design Synthesis is a sense-making process of manipulating, organising, pruning and filtering data in an effort to produce information and knowledge (Kolko, 2012). To do this the students were asked to isolate all information into smallest *'chunks'* – single concise and complete sentences on post-it notes. The next step was to identify patterns and themes. Making sense of the research was accomplished by seeing the patterns, themes and larger relationships between the information. This was done by selecting key information to create categories, considering the relationship between categories, grouping and regrouping. The process is highly iterative and required a lot of reworking of categories. Affinity diagrams were used to assist the process as this is a tool that organises data into groupings based on their natural relationships (Figure 7).

Figure 7: The creation of an affinity diagram

Needs identification
In order to translate what was learned through observations into opportunities for innovative solutions, the students were guided to produce need statements. This entailed identifying an observation that was made during the research phase, extracting the problem from the observation and then

Table 1:Need statement development

Observations	Problems	Needs
The bike doctor is only available one day a week.	Some students can't access the service this day.	More flexible bike doctor hours.
The majority of students ignore smarter travel emails.	This leads to a lack of knowledge on smarter travel facilities.	A coherent delivery of information.
Students carry a lot of supplies and equipment to college.	It is difficult to carry things while walking or cycling.	An easier way to walk or cycle to college while carrying supplies.
Bikes are expensive.	The initial investment of a bike is a deterrent.	An incentive for students and faculty to obtain a bike.

Figure 8: Need statement ranking by grouping

Need statement rankings	Score
A system of informing customers how long they will be waiting	5
A way to accommodate people's schedules	5
A way of informing the bike doctors of repairs needed to provide better planning	4
A way for customers to limit their time in the queue	4
An easier way to walk or cycle to college while carrying supplies	3

Based on a 1-5 Likert Scale (1 = no importance, 2 = not very important, 3 = moderately important, 4 = important, 5 = extremely important)

Table 2: Need statement ranking using a Likert scale

Must Haves	Nice to Haves	Discarded
A way for Eoin to have a reliable means of transport.	An informative way of showing students the ideal way of carrying items to college	A way for Ciara to accurately predict her journey time.
A way of preventing theft.	Adequate facilities for students to leave bikes nearby.	A way of reducing the amount of time spent in transition.
A better delivery of information.	A means for cyclists within UL to communicate with each other.	An adequate deterrent to people breaking glass on routes.
A way of informing people of the nearest bike rack.	A way for students to repair their bikes anytime of the day.	A practical way of shopping for students without the use of cars.
A way of keeping cyclists safe, that takes into account social pressures.		A way to maintain all paths in UL.

Table 3: Design guide

converting this to a desirable state in the form of a need statement. Observations statements were statements that recorded what was observed without judgements or interpretations. This ensured that the research phase did not bring assumption and biases to bear. Once observations were defined it was then possible to interpret the observation to extract the problem embedded within it. The need statement entailed defining the desired outcome if this problem was to be solved. This part of the process is nuanced and took several iterations. It was important to get the correct scope of need, if too narrow it could limit innovation, if too broad it could lead to unfocused design later on in the process. It was also important that the final need statement did not have a solution embedded within it. This includes references to current solutions, as well as emerging possibilities. Any reference to a specific solution can introduce artificial constraints into future thinking (Zenios et al., 2009) (Table 1).

Design guide

The next step was to select the needs that could best bring about effective solutions (Figure 10). The teams were asked to apply scoring criteria to the needs. Though not limited to this, the criteria had to include the following:

- What is the level of benefit to the stakeholders involved if this need is addressed?
- Has your client ULST the resources and budget to implement a solution to this need?
- Have you as a team the capacity to solve this need through a design solution?

The students were given freedom in how they approached the filtering criteria. Many of the students did not opt to apply a decision matrix which would involve scoring each need against each criterion as this was found to be extremely time consuming. It also involved applying a scientific approach to needs filtering that was found to require a certain level of intuition to evaluate. Therefore, the students evaluated each need once loosely keeping in mind all of the criteria together. This involved either simply grouping needs on post-it notes (Figure 8) or applying a Likert scale (Table 2).

Once the needs were ranked the teams selected their top needs to form the design guide. The teams had to make a decision themselves as to the number of needs they

would take to the ideation phase. Needs were therefore divided into 'must haves', 'nice to haves' and 'discarded' (Table 3).

Ideation

The teams used a variety of techniques such as brainstorming, sketching and prototyping to develop solutions. The next step was to then evaluate the effectiveness of the solutions against the user needs defined.

Evaluation of solutions

Where feasible the students prototyped and tested solutions, see Figure 9, which depicts the testing of a new workstation layout for the bike mechanic and Figure 10 which shows the testing of wet gear storage. On completion of the projects, the teams presented to their client ULST and users including the bike mechanic. While most of the solutions were received positively there were some solutions that were considered not worth implementing. For example, while many of the teams were able to show the bike mechanic that some of his work practices were inefficient and could potentially cause him repetitive strain injury he did not want to rearrange his work station or change his practices. While the wet gear storage solution in Figures 10 and 11 was received positively there were concerns that the wet gear would not fully dry out over the course of the day as it would still be tightly packed into the proposed solution. A number of apps were developed in the area of booking repairs with the bike mechanic and helping individuals to carry out their own bike maintenance (Figure 12). These are solutions that ULST plan to implement.

In summary, the students conducted projects for ULST to identify the barriers to sustainable travel to and from the university. From their research they identified a series of needs which acted as a design guide to develop solutions which were evaluated and then presented to the client and users. Overall, the projects were of enormous benefit to the learning outcomes of the students. Working for a client on a *'real'* project engaged the students more than a prescribed project as they had opportunities to see their work have an impact. While the students found conducting primary research difficult in the course of the project they began to understand the benefits to capturing deep insights in order to create innovative solutions that responded to actual needs. The process also highlighted the need to keep users and stakeholders involved throughout the design phase in order to get their buy in to final solutions.

Discussion around the challenges encountered

Overall the projects conducted impacted positively to the learning experience of the teams. However, conducting such projects also presents many challenges. The challenges encountered were in the area of ensuring cohesion within the team and optimising the knowledge of each team member. Carrying out research in the field, capturing meaningful data, translating this data into needs and developing solutions that address those needs also presented challenges.

Team work can be challenging due to the diverse perspectives and knowledge of each team member (Van Knippenberg and Schippers, 2007). In ensuring alignment and cohesion, it was necessary to begin the project with the process of identifying known and unknown information and the creation of a mission statement. This ensured that the knowledge available within the team was shared and that the team had established a united goal towards the project. As the project briefs were very open the mission statements helped each team to focus on an area. It also supported the tutors to keep the students on track by drawing them back to the mission statement when they drifted from its objectives. The students initial contributions to the knowns and unknowns tended to focus less on human interactions and behaviours and more on concrete issues such as the weather or road surfaces. They needed facilitation to share their knowledge and experiences and were therefore encouraged to recount stories from personal experiences. They were also asked to consider the range of stakeholders that would have a vested interest in the outcomes of the project to recognise potential conflicting agendas and desires.

During the research phase the students found it difficult to separate their assumptions and biases. Emphasising a beginner's mind-set and going through the techniques for this helped them to maintain an open mind during this phase. Students had a tendency to stay within their comfort zones and only recruit participants to research within their immediate peer groups and families. It was a condition of the project that they selected a variety of participants to carry out the

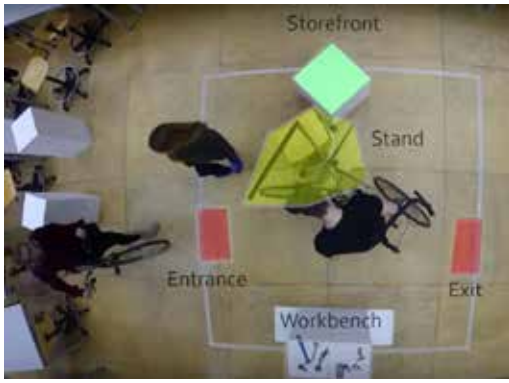

Figure 9: Testing of work station layout for the bike mechanic

research, from staff and students to visitors and extreme users. As staff can have a wider access to contacts from other peer groups it can be helpful to make initial connections to make this engagement easier for students.

One of the biggest challenges for the students was to gather deep insights that could lead to innovative solutions. Many of the research findings that the students presented initially were surface or general findings that were already common knowledge. They tended to ask binary questions and opt more readily to conducting quantitative surveys. It was critical to allow students to present their initial research findings to get direction and feedback from the tutors on the limitations of their research approach. This afforded the students to learn from their mistakes. To maximise the learning opportunity the teams were given a second chance to carry out the research and were supported to probe deeper with techniques such as, *'show me'* and *'5 whys'* along with identifying *'pain points'* and *'workarounds'*. This is where a design mind-set must be engaged with to consider what the solution potential of the research is even at this stage of the process.

The synthesis phase is a phase often neglected and requires much iteration to fully organise and extract the research data. Using post-it notes to create affinity diagrams allowed for the repeated iteration required.

Figure 10 Wet gear storage evaluation

Figure 11 Wet gear storage solution

Forming needs statements was also a challenging aspect of the process. The students found it difficult to see the difference between an observation, problem and a need. It was at this stage it emerged that many of the observations noted were already interpreted and often had either a problem or solution embedded within them. On closer examination it became apparent that in some cases the students had brought assumptions and biases to bear on the process. In these instances the teams were required to re-evaluate the observations or to carry out further primary research until there was an understanding of the mind-set required. In addition, need statements often had solutions imbedded within them and this phase took several iterations. Each successive step in moving from the raw *'observation'*, isolating and defining the *'problem'* and finally, expressing the 'need' for a specific action to be taken became a skill-set that was developed to a high degree of success.

Deciding which needs to carry forward to ideation also took careful consideration. Carrying out a formal decision matrix to score every need against several criteria was found to be laborious and time consuming. The best approach found was to evaluate each need intuitively while also considering all of the criteria together.

While the initial deficits in understanding impeded progress, the subsequent clarification of the methodology and practice paved a way to successfully authoring the design guide document. The design guide gave clarity to the ensuing design process with referenced guiding statements that allowed the designers enough scope to conceptualise design solutions. While many of the outputs met the needs of the stake holders there was also some resistance to some of the solutions proposed. In getting this feedback the teams were able to recognise that while solutions can bring improved benefit, getting users to adopt them or change their behaviours can be extremely difficult pointing to the need for integrating users into the design process in a co-design format, particularly where behaviour change is required.

To conclude, the process was challenging for the students but very effective in meeting the learning objectives of the students which was to gather research and identify needs within a context in order to generate solutions that address those needs. The process is highly nuanced and iterative and requires affording students the opportunity to repeat phases of the process.

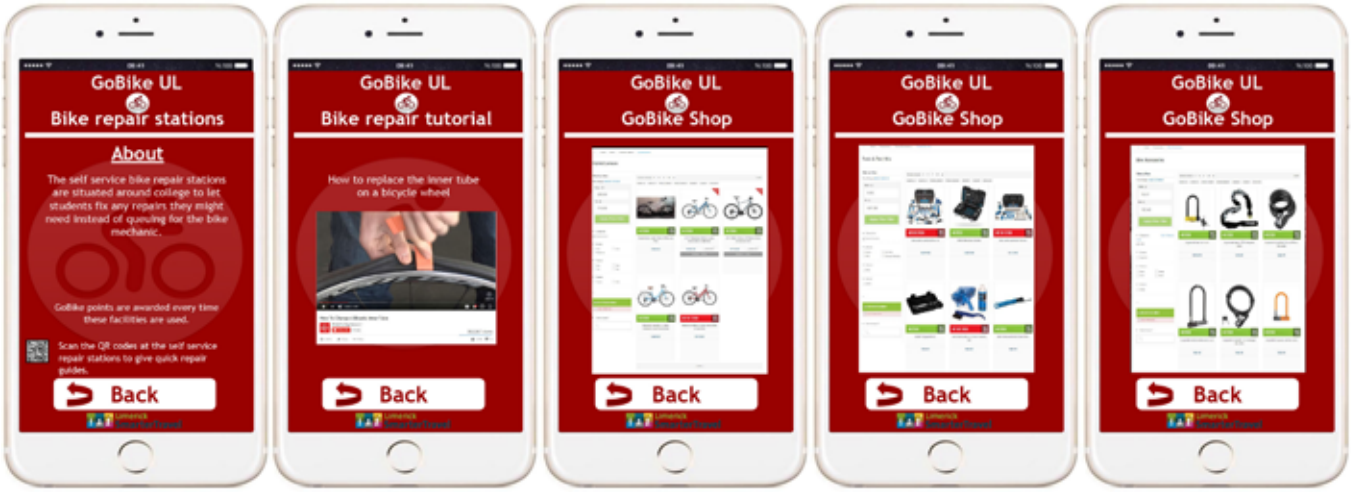

Figure 12 Bike app solution