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Bottom-up ‘grassroots’ innovation in transport: motivations, barriers and enablers.

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Abstract

There is a growing phenomenon of ‘grassroots’ innovation, i.e. that triggered by individual users or communities (physical or virtual) seeking a solution to a personal or societal problem. This has great potential as a new source of sustainable transport innovations, but has been received little attention to date. This study conducted 16 in-depth interviews and a workshop with grassroots innovators in transport. A detailed thematic analysis of the interview data identified: catalysts for the idea and the motivation behind its pursuit; the barriers experienced (those that were overcome and those that were not); and the enablers that permitted the innovations to continue and to flourish. The paper concludes by identifying the conditions that need to exist for such

innovations to be created, developed and exploited in order that their potential for increasing the sustainability of the transport system can be fulfilled.

Keywords

User innovation, social entrepreneurs, sustainable transport, motivations, enablers, barriers.

1 Introduction

The UK government, in line with other developed nations, is committed to delivering a transport policy that delivers economic growth and lower carbon emissions (Department for Transport, 2009). This requires not only innovation to support the development of low carbon technologies but also innovation of products and services to help people make informed sustainable travel and transport choices. In seeking these sustainable solutions, government funding tends to focus on encouraging top-down, traditional research and development (R&D) via large companies and/or already established small to medium sized enterprises (SMEs). Although top-down approaches will continue to make positive contributions to sustainable transport there are increasing opportunities, enabled by recent technological trends (described later), for individuals, small groups and communities to innovate themselves. The term ‘grassroots’ innovation is used in this paper to encompass any such innovation process that originates from outside of organisation-driven R&D (Smith, 2003). The nature of this grassroots (or ‘bottom-up’) innovation has already been studied and reported in the academic literature but, currently, there are very few examples of such innovations relating to transport. The aim of the research reported in this paper was therefore to search for grassroots innovations relating to sustainable transport behaviour and to understand the process by which they are developed; with a particular focus on the motivations, barriers and enablers to bottom-up innovation in this domain. The ultimate aim was to assist policy makers, the transport industry and the innovation community by identifying the characteristics of individuals and environments that provide the conditions for such innovations to be created, developed and exploited. The research mainly focuses on the UK, but raises issues and highlights themes that will also have applicability outside this region.

2 Background

Creative and inventive users are not a new phenomenon, there have always been innovative and skilled individuals who have adapted available products to better meet their needs (NESTA, 2008). However, recent advances in digital technologies and networks, in particular web applications that facilitate information sharing, interoperability and collaboration via the World Wide Web (Web 2.0), have enabled the global connection of like-minded individuals, opened up new possibilities for collaborative development and enabled easy and wide-ranging dissemination of ideas and innovations. Examples of applications enabled by Web 2.0 include Facebook and Twitter (both social networking applications) and the mass collaboration sites Wikipedia (encyclopaedic information), Flickr (photo sharing) and OpenStreetMap (geographic information). Alongside the emergence of collaborative technologies, there has been significant growth in the number of people (not only professional software developers) that are able to exploit these opportunities to develop innovative applications and services. This widening participation has been enabled by advances in software tools including:

- Software Development Kits (SDKs), e.g. the iPhone SDK used to develop applications for the Apple Application Store,
- Application Programme Interfaces (APIs), e.g. the Google API, which enable content such as maps and photos from different sources to be aggregated to create new web services and applications
- The Open Source software movement that promotes free sharing of source code and the collaborative authoring of software which is then freely distributed to others, e.g. the operating system Linux.

The global connectivity enabled by Web 2.0 is of particular relevance when tackling sustainable transport behaviour. A change in one user's behaviour will have negligible benefit but a change, even small, exhibited by a large number of travellers will have a more significant, proportional impact. Hence, the diffusion of new ideas to a potentially global marketplace and the ability of that marketplace to collaborate in order to create, or improve, solutions offers the transport sector potentially large economic, as well as environmental, rewards.

3 Relevant literature

To provide a basis for the study described in this paper, it was necessary to identify the motivations, barriers and enablers to grassroots innovation that have already been reported in the relevant literature. The two main academic areas of relevance were user innovation and social innovation.

3.1 User innovation

User innovation is a much-studied concept within New Product Development research and refers to innovations that originate from consumers or end users rather than from the R & D or market research activities of supplier organisations. User innovators are individuals or organisations who are motivated to innovate because they expect to directly benefit from *using* the resultant product or service (von Hippel, 2005). User innovators will often freely reveal their innovations to manufacturers with no expectation of gaining financially (Luthje et al, 2002). Therefore, the catalyst for innovation is often the desire for something the market cannot yet provide.

User innovators are characterised as: having direct experience of the ‘problem space’ and experiencing needs ahead of the market (von Hippel, 2005); expecting to directly benefit from the innovation through use or from the social capital generated (Leadbeater, 2006); having high emotional ‘involvement’ with the product or service (Gabbot and Hogg, 1999); and likely to gain enjoyment from the innovation process (Hertel et al, 2003; Lakhani and Wolf, 2005). Factors that enable the progression of a user innovation have been identified as: the possession of the necessary technical skills (Luthje, 2004); the ability to minimise costs through ‘local’ information and free testing (Luthje et al, 2002); the provision where feasible of ‘toolkits’ to enable rapid development and easy, iterative trialling of potential solutions (von Hippel, 2001); and the importance of communities for collaboration and diffusion (von Hippel, 2005, Leadbeater, 2006).

3.2 Social innovation (and social entrepreneurship)

Social innovation is the second area of academic research that has relevance to grassroots innovation because it is not driven by traditional R&D or market forces. Phills et al (2008) define social innovation as “a novel solution to a social problem that is more effective, efficient, sustainable, or just, than existing solutions and for which the value created accrues

primarily to society as a whole rather than private individuals”. Social innovation has been a growing phenomena in the last 20 years and has been a result of cross-sector fertilisation between government, business and not for profit organisations which has arisen in order to tackle complex global problems that require sophisticated solutions, for example climate change.

Within the broader concept of social innovation exists the phenomenon of ‘social entrepreneurship’ which has particular relevance to grassroots innovation. Social entrepreneurship focuses on individuals or groups who build new organisations aimed at creating/implementing solutions that produce social value. Social entrepreneurs are motivated by the opportunity to create social value (Peredo and McLean, 2006). They do not anticipate/organise for profit but instead aim for large-scale, transformational benefit to a significant segment of society or to society at large (Martin and Osberg, 2007). The resulting entity can be on a continuum from zero profit, through income for sustainability, to profit for self and/or others (but the latter never as a primary motivation).

Social entrepreneurs are motivated by creating social value for a sub-set of society or for society at large. Some of the personal characteristics that social entrepreneurs possess are: inspiration; creativity; the capacity to exploit opportunity; direct action; acceptance/management of risk; resourcefulness; persistence (even when a lone voice); enjoyment of the process; courage; accountability; ambition and unreasonableness (Martin and Osberg, 2007; Phills et al, 2008).

3.3 Summary

The literature on user innovation and social entrepreneurship provides a useful basis for the investigation of grassroots innovation aimed at sustainable travel behaviour. A key difference exists between the two phenomena in terms of the primary motivation for innovating. User innovation is predominately driven by personal need (through personal experience of the ‘problem’) and has the aim of creating something that will be of personal benefit (in use or in terms of enhanced reputation). Social entrepreneurship is predominately driven by altruism with the aim of creating value for others. Although they are researched and reported as two different phenomena in the literature, there is value, particularly in the sustainable transport context in building on the research findings from both domains. The study reported in this

paper therefore used existing research from both fields as a basis for investigating 'grassroots' innovation within the transport domain and, particularly, innovations that could have the potential to encourage sustainable travel behaviour.

4 Method

4.1 Research design

This study was an exploratory investigation aimed at understanding 'grassroots' innovation in transport, with a particular focus on the motivations, barriers and enablers to the process in this domain.

In-depth interviews were conducted with a sample of 16 innovators (the sample selection process is described below). Each interviewee was asked to set aside at least 60 minutes for the interview but many were longer. Eight open-ended questions were asked which aimed to extract motivations, barriers and enablers to the innovation process. The questions were based on the user innovation and social entrepreneurship literature but were kept broad to maintain the exploratory nature of the study. The questions covered a personal statement of the innovation and its aims, the development timeline, the role of the interviewee and others in the process (including any involvement of end users); the role of technology in the process and the trends that had affected the innovation process. In addition, the interviewer used a series of prompts to expand the discussion. These prompts essentially covered the 'who, what, where, when, why and how' of the responses, to ensure that all the critical data were gathered. Visual materials were at the disposal of the interviewee in order to supplement the prompts given by the interviewer and to allow the interviewee to sketch any aspects of the process or innovation should they find this useful. Where possible, the interview was conducted at the interviewee's work location which was sometimes their home. This helped the researchers gain a greater understanding of the context for innovation.

The population from which the sample was drawn was the 'grassroots' transport innovations documented on the online wiki-based public repository (the 'Innovations Portal') created by the Ideas in Transit research project under which this study was conducted¹. The number of

¹ www.ideasintransit.org

documented innovations was constantly increasing and the sample was recruited over an extended period. To give an indication of size of population (of innovations) from which this sample was drawn; when the first interview was conducted, there were 96 innovations on the repository; at the point of the last interview there were 144. The selection criteria for the innovations studied were that they: showed the potential to have a positive impact on sustainable travel, regardless of whether this was the initial or main motivation; covered a range of travel modes (e.g. cycling, walking, bus, train, car) and transport purposes (e.g. commuting, tourism, freight); were past the idea stage, i.e. were an ‘invention’ or ‘innovation’ according to the definitions of Chayutahakij and Poggenpohl (2002); had a public presence but weren’t necessarily ‘operational’; and involved the use of digital technologies/networks. The selection criteria for the interviewees were that they were the individual(s) who had been involved in the innovation from the initial spark of the idea to the current time. They were invited through a 2 stage process: first, their innovation was featured on the repository and they were emailed to alert them to this fact to make them aware of the research project and to give them an opportunity to improve the wiki entry; then, they were emailed a second time to invite them to take part in the interviews.

Two further sources of research supplemented the interview data. Prior to the interviews, the interviewees researched the innovation through the associated website and press reports. Secondly a workshop was held with 10 of the 16 interviewees to validate the thematic analysis.

4.2 Analysis

All interviews were digitally recorded and transcribed in full. A detailed thematic analysis (Braun and Clarke 2006) was undertaken of the data using NVivo™. Thematic codes were created for all data that related to motivations for innovating and barriers and enablers to the innovation process. The coding structure was created by one researcher and then validated by a second. A workshop was subsequently held with 10 of the innovators to further validate the findings.

5 Findings

5.1 *The innovators and their innovations*

Table 1 describes the innovators interviewed and the nature of their innovations. The term ‘enterprise’ is used loosely as not all of the innovators interviewed had commercial motivations. The size of the enterprise is categorised according to the following definitions: a ‘sole innovator’ is a single person; a ‘micro enterprise’ has a headcount of < 10; a ‘small enterprise’ has a headcount of < 50 (Commission of the European Communities 2003).

Table 1. The innovators interviewed and their innovations

Case	Type & size of ‘enterprise’ at time of interview	Person(s) interviewed	Nature of the innovation	Stage of development at time of interview	Location
A	Sole innovator	Innovator	iPhone transport applications	Late stage (established user base)	UK
B	Micro enterprise	Innovator	Software application for calculating the walkability of a neighbourhood	Late stage (established user base)	US
C	Sole innovators	2 innovators	Cycle journey planner	Late stage (established user base)	UK
D	Sole innovator	Innovator	Web based parcel delivery service	Early stage (increasing public awareness)	UK
E	Micro enterprise	Innovator	Sustainable tourism website	Early stage (increasing public awareness)	UK
F	Small enterprise	Innovator	Freight exchange website	Late stage (established user base)	UK
G	Small enterprise	Innovator Investor	Car club enabled by telematics	Late stage (established user base)	UK
H	Micro enterprise	2 innovators	Facebook lift sharing application	Late stage (established user base)	US
I	Sole innovator	Innovator	Cycle map based on Open Street Map – a wiki style open source map	Early stage (increasing public awareness)	UK
J	Sole innovator	Innovator	Alternative demand responsive travel service	Conceptual (idea-based),	UK
K	Small enterprise	Innovator	Web based lift share service	Late stage (established user base)	UK

Case	Type & size of 'enterprise' at time of interview	Person(s) interviewed	Nature of the innovation	Stage of development at time of interview	Location
L	Sole innovator	Innovator	Web based parking space rental service	Late stage (established user base)	UK
M	Micro enterprise	Innovator	Mobile phone application for calculating personal travel carbon footprint	Early stage (increasing public awareness)	UK
N	Sole innovator	Innovator	Website promoting & facilitating low carbon travel	Early stage (increasing public awareness)	UK
O	Sole innovator	Innovator	Train travel information site	Late stage (established user base)	UK
P	Charity Micro equivalent	Innovator	Isochronic travel time maps	Early stage (increasing public awareness)	UK

Thirteen of the study cases centred upon individuals (or in case C two friends) who had created innovations outside of any formal business context, working in their spare time or as students. Of these, at the time of interviewing, two (G and K) had been established over 10 years and had become small enterprises employing 10-50 people. Five (A, E, H, M and O) had developed to the point where the innovator was able to give up their formal employment to concentrate on developing and promoting the innovation. Of these cases, E, H and M had secured financial backing from investors or grants to enable this to happen; cases A and O were making enough revenue from the innovation itself to support themselves financially. Cases B and P were small software enterprises seeking to develop websites and applications that benefit the community and civic aspects of people's lives. Case F, uniquely within the sample was an innovation targeted at a particular industry rather than the needs of the general public. The innovator was able to continue to work within this industry whilst developing his innovation.

5.1.1 Stage of development

The case studies represent innovators and innovations at a range of development stages. All had some presence in the public domain which had brought them to the researchers' attention, however, for one innovator (Case J), this presence was only a website describing a concept; no working version of the product existed. Case P at the time of interview existed to demonstrate how travel data could be visualised and used to inform individuals and policy makers but was not intended to be a product. Having an 'established user base' does not

necessary mean that the application has been available for a long time. The Apple iPhone application developer (case A) reported that his first travel related application received thousands of downloads over the first weekend after it was released followed by a “flood of requests” for additional functionality. Thousands of downloads does not necessary equate to 1000s of established users, however, use of this definition for stage of development does provide an indication of how far the developer had progressed from idea to innovation.

5.1.2 Catalysts and motivations for innovation

Table 2 summarises the catalysts for innovation elicited from the thematic analysis. In each case the innovators were driven by a range of interrelated motivations some of which emerged after they began to pursue their idea. The interviews sought to uncover what initially triggered their desire to innovate – the ‘catalysts for innovation’.

Table 2 The catalysts and motivations for grassroots innovation

Theme	Case																Total	
	Case	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O		P
Responding to an unmet need		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16
Personal frustration with current products and services		x		x	x	x	x	x	x		x	x	x	x	x	x		13
Seeking to create social value		x	x	x		x		x	x	x	x	x		x	x	x	x	13
Passion for a cause or interest			x	x	x	x	x	x	x	x	x			x			x	12
Financial gain		x		x	x		x	x	x		x	x	x	x			x	11
Enjoyment - learning new skills, exploring capabilities of data or software, problem solving		x	x	x				x		x				x			x	8

In all 16 cases the innovators were responding to identified unmet needs although this was never the sole motivation for innovating. A number of additional often overlapping motivational factors emerged from the thematic analysis: personal frustration with current products and services (13 cases); seeking to create social value (13); a passion for a cause or

interest (12); the opportunity to benefit financially (11); and having fun problem solving or playing around with technology (8).

In all but 3 cases (the exceptions being case I and the civic focussed software companies, cases B and P) the innovator was motivated by *personal* frustration with existing products or services. Frustration related to the lack of convenient and reliable alternatives to private car use (G, H, J and K); lack of information relating to travelling or holidaying sustainably (E, O and N); and lack of up to date readily accessible public transport information. In the remaining 4 cases the innovator was frustrated by current service provision (C, D and F and M). However, although motivated by personal frustration, the majority of these innovators did not align to the conventional definition of user innovators as they had responded to their frustrations by seeking to create products and services that provided value for others rather than primarily for themselves. Although the innovations of cases D, F and L all provide social value (e.g. by reducing traffic on the roads) the innovators motivations were first and foremost commercial.

Another strong theme emerging from the analysis of motivations was passion for a cause or interest. In seven of the 12 cases attributed to this theme the innovator reported that their concern for the environment had encouraged them to pursue their innovation (E, G, H, J, K, M and N). Three others were motivated by their passion for a hobby (C, I and O). The innovators from the civic focussed software companies (D and P) were, not surprisingly, strongly motivated by their desire to create a fairer, more open society. Both were seeking to demonstrate, primarily to policy makers, how well-presented information and data could be used to improve society for both individuals and communities.

Although 11 of the innovators acknowledged that the opportunity to gain financially had motivated them to innovate, in all but 3 of these cases (D, F and L) this was reported to be secondary to their desire to provide social value. Financial success was said to be needed, not only to sustain the innovation and therefore its societal impact, but also to gain commercial credibility. This was viewed as necessary if alternative ways of doing things were to be seriously considered by government and industry:

[Our innovation] is a product to make business more sustainable. But it is also critical that it is a sustainable business in a financial way because that will gain attention. That's why, for us, it's important that we succeed in that manner. [Case M]

All of the innovators reported having to spend long hours developing and promoting their innovations, often in their own free time outside of their regular employment. However, having fun problem solving, learning new skills or exploring the potential of technology was cited in 8 of the 16 cases as a motivating factor. In cases A, C and I the innovators were already expert programmers who were, through the innovation process, exploring the potential of new software tools. In case A the innovator wanted to create an application in order to learn how to program for the Apple iPhone. He chose to develop an application that provided live status updates for the London Underground in response to his frequent commuting problems:

The iPhone SDK was just released and I really wanted to know the tube line statuses on my phone and I thought, well, someone's going to make this...and why can't that someone be me? My first motivations were completely altruistic... I didn't want to charge people to find out the status of the tube. [Case A]

In Case O the innovator was similarly seeking to practice a new skill, in this case creating a website for the first time. He was a passionate train traveller and this led him to create a site showing how to travel within Europe by rail:

It was simply finding a teach-yourself book in <the bookshop> while waiting for the train home that enabled me to actually create a website and give it a go. I didn't actually expect anyone to look at it, but it sort of expanded ... [Case O].

For Case I the innovator's prime motivation for innovating was to prove a point to others within his technical community:

[I wanted to show]...that there was a place for specialist [map] rendering and that there was an outlet for people's frustrations for wanting to show cycle features that didn't mean overloading the central [OpenStreetMap] map [case I].

5.2 Barriers and enablers

Table 3 summarises the main barriers and enablers to innovation that emerged from the thematic analysis. A detailed description of each of these themes follows.

Table 3. The barriers and enablers for grassroots innovation

Theme	Case																Total
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
Immersion in the problem space	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	16 + 0 -
Seeking to meet the needs of end users	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	16 + 0 -
Creating a community of users	+	+	+	+	-	+	+	+	+	-	+	+	+	+	+		13 + 2 -
Networking	+	+	+		+	+	+	+	+	+	+		+	+	+	+	14 + 5 -
Collaboration with others	+	+	+	+	+		+	+	+	+	+	+	+	+			13 + 3 -
Publicity	+	+	+	+	+		+		+		+	+	+	+	+		12 + 0 -
Establish proof of concept	+	+	+	+			+	+		+	+		+	+		+	11 + 1 -
Able to start small	+		+	+			+	+	+	-	+	+	+		+		10 + 1 -
Appropriate technical skills	+		+	-	+		-		+	-	-	-	-		+		5 + 6 -
Appropriate business skills				+	+	+	+			-	-	+	+	+	-		7 + 4 -
Time		-	+	+		+			+	-	+		+		+		7 + 6 -
Awards and competitions				+	+	+				+	+		+	+			7 + 0 -
Investment					+		+	+	+			+	+	+			7 + 0 -
Government policy (local and national)	-			-		-	-				-					-	0 + 6 -
Encouragement from family & friends	+				+						+	+		+			5 + 0 -

+ = enabler present in data from this case

- = barrier present in data from this case

5.2.1 *Immersion in the problem space*

Defining and framing of the problem space is a key aspect of creativity (Dorst and Cross, 2001). Christiaans (1992) found that the more time a designer spent defining and understanding the problem, the more likely they were to achieve a creative result. All of the innovators interviewed showed detailed understanding of their chosen problem space, in the main, because of their own personal experience, but often because of dogged determination to find a solution to a problem fuelled by passion for a cause or interest. However, as already discussed in relation to motivations, personal immersion in the problem space was in most cases accompanied by a real desire to provide value to others:

I have been travelling by train since university days, going on Inter-rail every summer, tootling around, it was just like falling off a log...it is something I know how to do... So, starting with this gap between what I knew how to do and how difficult it was for other people to do it...I have really set out to talk people through it step-by-step in simple, logical steps saying this is how you get there, this is how you get back, this is roughly how much it will cost, and this is how you get the tickets, and this is what it is like [case O].

5.2.2 *Focussed on the needs of others*

All of the innovators were aware of the importance of usability and were actively seeking to meet the needs of other users. For the innovator most closely aligned to the definition of user innovator (case I), their first motivation was to meet their own needs before seeking to consider the needs of other potential users:

It has come about as a consequence of me being an end user. It is the classic open source 'scratch and itch'. I wanted the map personally, and I knew what I wanted the map to show [Case I].

Those more focussed on creating social value did, from the outset, seek to consider the needs of others when specifying features and designing user interfaces. However, none of the innovators carried out a formal user research phase before beginning development, instead relying on their own personal experience and those of their family and friends to determine user needs:

In terms of the user, what they want is basically the fastest or the quietest: this roughly corresponds to confident cyclists who are happy to use fastest routes which tend to be busier and more trafficked, versus less confident cyclists who are much more interested in having a pleasant, quiet route and don't want to deal with traffic. I always think the example is me versus my mum [Case C].

For both lone innovators and small enterprises, compromises needed to be made regarding usability due to the limited time and resources available for development. The majority of the experienced software developers within the sample (A, B, C, and P) had focussed their development process on creating products that were simple and compelling to use, but also technically robust. They then relied on feedback from users (elicited through providing feedback channels within the product itself) to suggest improvements to the product. Because of the innovators' immersion in the problem space and single-minded focus on one project, feedback from users rarely suggested improvements that hadn't already occurred to the innovator. However user feedback was highly valued as a means to prioritise improvements:

It is pretty rare that somebody suggests something, a feature that the team hasn't thought of, since you are living and breathing the stuff. But it definitely helps prioritise which features you should do next. [Case B].

Being small can give a software developer an advantage over larger organisations when seeking to respond to user needs as they can receive feedback directly from users rather than filtered through customer service or marketing departments. The Apple iPhone application developer described how he could easily amend his software and re-release in response to user needs:

So it [the app store] makes it very, very easy for independent developers and in fact, it really favours them because they can move quicker than larger organisations and be more responsive to users' needs [case A]

However, being small could also mean that they couldn't fix or improve everything that others wanted from their product:

I know there are lots of areas where the usability is much poorer than it should be, but it is literally not having enough time to do it [Case C].

5.2.3 Creating a community of users

The emergence of a community of users was a key enabler relating to both the creating and sustaining of an innovation. Five of the innovations (F, H, J, K and L) were essentially exchange services where resources (e.g. lifts, parking spaces, van space) were offered by users to other users via the innovator's website. These services naturally relied on the existence of users with resources to share or trade in order to function. For other innovations (B, C, I and O) the contributions of users enhanced the data provided by the innovator(s) by

providing additional data (e.g. photos or map data) or highlighting inaccuracies within existing data (e.g. timetable changes). Although not always anticipated by the innovator, these contributions from users were an invaluable resource, particularly for sole innovators who singlehandedly would struggle to keep their products up to date or expand their scope without these contributions. It was important that users felt that their contributions provided value for others rather than purely financial gain for the innovator. This was highlighted as a key advantage for innovators developing products outside of commercially-driven organisations. Conversely, it was a barrier for innovators who had initially developed a product or service for altruistic reasons, then sought to commercialise their product in order to provide an income stream to sustain the innovation.

In four cases (B, C, M and N) the innovator was particularly motivated to encourage a community of users around their innovation in order to promote interest in an environmental cause:

So one of the things that intrigued, interested me with this application is that if you end up with a large user base of people, who are using it, getting connected, and getting interested, and they start to want to offset, what you have is the power to create a really high bar [for reducing carbon emissions]. [case M].

Ultimately we want to see users as fully part of the whole process so we have approached a lot of people who have done low carbon travel, we have hosted their blogs and allowed them to document their stories via our site... ultimately we would like the site to help us to have communities of low carbon travellers supporting each other [case N].

The ability to create community was therefore an important enabler for such social entrepreneurs.

5.2.4 Networking

Although networking with others was acknowledged within 14 of the 16 cases as being beneficial to innovation, in five of the cases (E, F, G, J and K) the innovators had experienced problems finding suitable others to network with. When time and resources are already limited, wasting time and money networking with the wrong people was a particular frustration:

I would like to meet up with more innovative people...but everything you ever go to that's supposed to attract innovative people seems to have a lot of accountants hanging around hoping to network [case F].

A particular problem, related to being first to market in a very narrow field, was finding others with common interests. In case E the innovator had found it more beneficial to network with others within the industry that they were seeking to influence rather than with other innovators. Being co-located with other start-ups, and working within a culture that understands start-ups, was considered very helpful. Being in such a culture facilitated informal networking which, when combined with good social skills, led to useful contacts and advice:

I found that I hadn't had long-term mentors but more just kind of conversations that have either consolidated what I already thought or made me have to change tack... Mainly email and phone but also face to face, I have coffees with people [case N].

The value of 'frenemies' – people who are doing similar things and are at a similar stage of development – was highlighted by one innovator [case E]. Such people can keep the innovator focused and competitive. For innovators strongly motivated to achieve societal change, competition from others in the sector was also valued because this meant that, together, their impact within the problem space was more significant.

5.2.5 Collaboration with others

An open, trusting relationship with collaborators was an essential enabler for successful innovation. Only seven of the innovators interviewed (A, B, C, H, I, O and P) had all of the technical skills required to take their innovation from idea to launch without the assistance of others. Sometimes it was also necessary to secure collaboration from others with business, marketing or financial skills (J, K, M and O). In five cases (A, E, K, L and N) informal practical help as well as advice and encouragement from close family and friends was acknowledged to have played a vital part in the development process.

The ability to find suitable collaborators and agree terms of involvement was, particularly for those requiring technical assistance, an essential part of the innovation process. For those with limited resources the first port of call was often family and friends. Case K used a student friend with computing skills to develop the first version of his product. Case E similarly approached her old university in search of students who could provide her with low cost programming expertise. Case N was able to secure technical assistance from work colleagues. In other cases the innovator had to search further afield for suitable collaborators.

For some, this raised concerns about protecting intellectual property, but the need for help drove the innovator(s) to divulge their idea to potential collaborators in order to progress. In the majority of the cases studied, the collaborators were others with a shared interest or passion for the innovator's 'cause'.

5.2.6 Publicity

When an innovation was overtly non-commercial this facilitated publicity (e.g. Case K). All of the innovators were seeking publicity for their innovations. Activities included: leafleting; providing articles for newspapers and online publications; attending trade fairs or conferences related to the problem space; facilitating viral spread via the internet through inclusion of functionality that encourages users to share the product with others; and, most creatively, creating a national day focussed on the problem space. In two cases (B and L) creating newsworthy and press-friendly information (e.g. ranking towns in relation to particular sustainability criteria) was a low cost technique that had led to good publicity. The only reported downside to achieving publicity was when a huge surge in interest led to the innovator being swamped by enquiries from the press and public.

5.2.7 Establish proof of concept

The need to establish proof of concept was an important theme emerging from the interviews. This could mean, at the earliest stages, receiving confirmation from perspective users that they would indeed value and use their product if it was available:

We spent the summer developing a simple website and then we went round fresher's fairs and started promoting it to students. We learnt a lot by talking to the students and it became clear that there was significant demand. As soon as someone said "thank you" for helping them get home I knew more people would want it. [Case K].

For others proof of concept was essential to secure funding from investors. When the concept relates to a radical change in the transport system this can be very difficult for the innovator to achieve and development of the innovation could stall. Proof of concept may also be expensive as it may be necessary to develop much of the service (e.g. coding) even to test it out in a limited fashion.

People who have fed back have said it is too big, just too untested. If you could pilot it somehow in a small geographical area and see that it works to prove the concept then that would do it, and we could do a more

realistic analysis of profit and loss. However the expense is the building the code and by the time you have built it, you could roll it out nationally anyway [case J] .

Therefore being able to test out novel parts of the service on a small scale or using prototypes is a key enabler for innovation within the transport sector:

All of us ...were working on this on a part-time basis and we had a friend that was helping out, kind of proving that we could make thousands of people in one small area carpool.... [we were asked to] just blow them out of the water get, 20% of the population on the system and see what it looks like, and so we did that the first year and then we got some extra funding and investors [case H].

For web-based or distributed software products it is possible to get an early basic version of a product out which can then be refined on the basis of user feedback. As previously discussed, this was the approach favoured by the more experienced software developers:

As soon as [it] was released, it had thousands of downloads in the first weekend it was released and requests just came flooding in for a map and that kind of got me going on the [next] version [case A].

Being first to market in this way also helped counter some of the problems associated with protecting IP. If it wasn't possible to protect IP then 'do it first and do it' well was seen as a way of securing one's place in the market.

For case M it was vital to protect IP in order to later licence the product to mobile phone manufacturers. Restricting access to the software made it difficult to test the concept. The innovators eventually overcame this barrier by taking the software 'off-line' and using the mobile devices as 'data collection' tools only:

We are literally having to rip the engine out and that is not such an easy process but we are getting there and ... now we can then more freely get people to go and play with that. So suddenly all those people I have met over the last year I can actually send them a file and get them to upload it without worrying if they lose their phone. Get feedback from them... [Case M].

Proof of concept was also identified as an important enabler for demonstrating the social value of an innovation:

So we're all about trying to demonstrate and prove what we know and it's already sort of proven anyway but being able to keep building the evidence that car clubs have got a massive benefit in reducing carbon emissions and car use [case G].

5.2.8 *Able to start small*

Closely related to being able to establish proof of concept is the ability to begin innovating on a small scale with little access to resources. The internet as a virtually free resource had been vital to many of the innovators. Some innovations have been developed at almost zero cost, especially where the individual has sufficient technical experience to utilise software tools freely available via the Internet. Software provided by Google including Google Analytics (that provides information on website traffic) and Google maps had been particularly influential.

It is basically because of Google maps. Google maps has been the enabling technology. If Google maps didn't exist, we couldn't do it [case C].

Even those with little software development experience had managed to exploit these resources to support their innovations:

So I went and had a look at Google Analytics, you cut and paste a piece of code onto each of your pages, and Google Analytics then tells you how many visitors you get, how many repeat visitors, where in the world...[case O].

For some innovators, low living costs were crucial to progress the innovation. Here, support of family and friends was often vital.

...moving home and having my office in my sister's bedroom, [parents] cooking for me, housing me, giving me any advice when they could...I spent that whole winter sitting in my sister's bedroom, trying to find a way of making this work, doing more research seeing if anything like this has been done before. Nothing like this had been done online before. [case K].

5.2.9 *Appropriate technical skills*

The importance of collaborating with others in order to access technical knowhow beyond their own skills base has already been discussed. However, lacking a technical background can also lead to innovators underestimating the scale and complexity of the technical development needed, choosing collaborators with inappropriate skills or leading to the generation of custom bespoke solutions which are then costly to update or scale. A key enabler in relation to these potential pitfalls is the ability to devise elegant and simple solutions in response to the identified problem.

5.2.10 Appropriate business and financial skills

The innovators interviewed often lacked the business skills or knowledge needed to get a company up and running. As most had begun to innovate with little commercial motivation, this barrier may only become apparent when the innovation begins to generate enough revenue for the innovator(s) to consider given up their current employment to concentrate on its development. A key enabler in case A was the launch of Apple's Application Store:

Apple have created a clear path to monetisation based on the iTunes store, they've just really just tacked on this whole world of applications that you can develop for the phone. And they take care of everything....they take care of the marketing ...they take care of all the finances, you don't have to worry about whether it's going to scale or not, whether 10,000 people can download it from your server in a day or not. All of that is taken care of for you [case A].

The 'app store' model now being adopted by Google, Nokia and others has therefore provided a revolutionary path for small scale developers to not only provide global access to their innovation but also provides a route for commercial exploitation which requires only low level business skills.

5.2.11 Time

Particularly when the innovator(s) had developed their own technical solution, the availability of time was an important enabler or barrier to innovation. For a number of innovators (C, D, K, L and M) periods of (planned or unplanned) unemployment, or being a student, provided the time necessary to develop their idea into a product. For others (A, I, J and N) their own time, often in the evenings or weekends, was all that was available:

When I got made redundant...I had all my time to develop the idea and have been developing it ever since [case C].

I bought a laptop...which meant I could work on the train to work, that was 2 hours a day as it was an hour each way, plus I would work in the morning when everyone else was still in bed. I would do a bit of research at lunchtimes. [case O].

When, intentionally or unintentionally, a revenue stream emerged from the innovation, the innovator was sometimes able to give up their day job and devote more time to their project:

I discovered the Amazon affiliate scheme... [you] earn a few pence commission if you say 'get this guidebook'. I liked the Lonely Planets and the Rough Guides, so I sent people off, and I think I earned about £20 in a month. I thought, wow, a hobby that buys me a curry.... In 2004, I discovered more affiliate schemes like Eurostar and RailEurope, and that was the point where I thought, hang on, this is a bit more serious. By the time we got to 2007, I realised it could become a full time job [case O].

Conversely, the development can be hindered when the innovator needs to take up paid employment:

I had loads of time, but the sticking points were just a lack of knowledge, no technical skills when it came to going online and not much money either... all I really had then was the idea and time....then gradually it has all kind of flipped...now the problem is time whereas everything else is okay [case L].

5.2.12 Awards and competitions

Competitions are important because they give exposure, credibility and encouragement. Competitions were also seen as a good way of working out whether an idea had really got potential and has been properly thought through. However failing to win awards can also be disheartening:

I remember applying to a competition that was £20,000 and losing out to a piece of chocolate...and they were talking about sustainable design, and I had a non-technical person tell me that this wasn't going to work, and thank God I was too stubborn to listen to stuff like that [case M].

Competitions were also valued for the networking opportunities they provide and the encouragement they can bring from seeing others striving to create social value:

The award ...was all about social change. And I was surrounded by 50 other companies who were all about social change and behavioural change and creating good in the world and whatever. To be there was amazing, to win it was amazing, and have all these people come up to you and say 'this is what I'm doing can you help?' and it was like 'well you can help me too' [case K].

5.2.13 Investment

In 8 of the cases investigated (A, C, D, E, I, K, N, O) the innovator had been able to launch at least a fledging product with no financial investment from others and little in the way of personal resources. All of these products were based on already available software packages. For others (G, J and M) substantial finance was needed to progress the idea to product. In

these cases investment in physical resources - cars and telematics kit (case G) or complex bespoke software development (J and M) was required.

Small amounts of money at the right time can make a huge difference to lone innovators and micros:

This is something I am absolutely passionate about; small amounts of money make a huge amount of difference. When I got that £1000 from the <sponsor>, and I was in college, had been out of work for two years, and you are funding everything, £1000 goes a.. long way [case M].

Even for those who had needed little investment to evolve their idea to innovation, small amounts of money had often played a crucial role in sustaining or expanding the scope of the innovation. For case E a small grant had enabled a complete rework of the website that she had initially developed herself:

So they gave me £5000 and I basically spent the whole lot on the new website [case E].

Being able to show proof of concept, as already discussed, was crucial to securing the interest of investors. Difficulty finding out what funding is available and whether one is eligible to apply was a source of frustration for some innovators. Small independent start ups can be too young and at too early a stage to be able to apply successfully for funding for government funding sources related directly to transport innovation. Finding suitable funding for individuals was portrayed as a very piecemeal hit and miss affair with no 'one stop shop' for those seeking to develop sustainable travel and transport solutions:

When you are looking for funding, you are kind of looking at all sorts of options online and things and I came across a pot of money from the Big Lottery fund called the Big Boost and this funding was for 18 – 25 year olds who had an idea for a project or a business which had a community or environmental benefit...[case E].

Simple application processes (especially for small grants, and for younger applicants) can be very important.

The great thing about it was it was a really very much a straight forward application, it wasn't very complicated, and I was awarded the funding which kind of got the idea off the ground [case E].

5.2.14 Government policy (local and national)

Product development within 6 cases (A, D, F, G, K and M) had been hindered by government policy at either a local or national level. Transport has an impact on, and is impacted by, many other community initiatives (e.g. planning and existing transport solutions) therefore groups within local and national Government need to work together to enable new transport initiatives to flourish.

For case A, a key barrier to development was gaining access (ideally free) to public transport data.

There's a lot of things I want to do with [the application] ...and all my barriers all come back to data and being allowed the permission to use it ...So those are major hurdles for me... it comes down to permission and the quality of data [case A].

When data is available, it can be prohibitively expensive for lone innovators or micros. Data doesn't always come packaged as one data set. The innovator may need to spend a good deal of time linking and merging data sets to support their application.

Another policy aspect was that, when operating in a novel transport area, innovators found it difficult to lobby government and influence policymakers.

It is very frustrating when we have been the only people in this sector lobbying the government and trying to influence policy, we have so many clients and members, the benefits are huge and yet no one else is taking it seriously, it is just really hard work. [case K].

When innovators had secured the support of individuals within local or national government they were often frustrated when the individual moved to another department due to policy change or restructuring. In 3 cases innovators perceived an innate conservatism within the government and the transport industry coupled with a perception of low investment in sustainable transport.

At a local level, innovators found that they had to work with several parts of the local authority (e.g. planners, parking, and transport) to explore adoption of their innovation. They also had to take a long term stance which can be difficult for an individual or small enterprise with limited resources. Local authorities have long standing views about how their transport budgets are allocated and this can prohibit investment in new initiatives. This led one

innovator to suggesting that a change of mindset as well as policy was needed at a local and national level:

You have transport, and you have mobility. Why is there this hierarchy of public transport and private transport? It is just all about shared transport and efficient transport, and mobility for those people who need it...and Europe seems to have got this mobility idea, it is all about mobility, it is about providing sustainable mobility to people. Whereas over here... [anonymous]

6 Conclusions

The interviewees in this study were all creating technology-supported innovations of relevance to sustainable transport and were selected because they were innovating outside of conventional, top-down R&D processes. The study aimed to understand the motivations, barriers and enablers for such non-conventional, grassroots innovation in the transport domain in order to provide insight into how best to foster such innovation in the future.

The innovators exhibited many of the characteristics of user innovators and/or social entrepreneurs as reported in the background literature. For example financial benefit was not a prime motivation, 'involvement' or 'passion' for the area was key, and fun and enjoyment of the process was common. In terms of enablers: keeping costs low, being able to build on existing technology components, networking and building a community of users were all factors that supported the process. New characteristics also emerged (not reported in existing literature). These included the benefits endowed by: being time-rich; gaining free publicity (due to the topical and altruistic nature of the innovation); being able to demonstrate proof of concept; and having a scalable innovation (particularly the ability to start small). Key new barriers emerged that were associated with local and national government policy (e.g. system complexity, multiple (and changing) stakeholders, long time scales and data accessibility)

A key outcome was that none of the innovators completely matched the definitions of either existing phenomenon. The user innovation literature focuses very much on the innovator being totally immersed in the 'problem space', spotting a need not yet satisfied by the market and developing something that will provide them with direct benefit. The interviewees in this study did, indeed, have a deep understanding, from personal experience, of a problem to be solved and an opportunity to provide a sustainable transport or travel solution. However, they were primarily motivated, in line with social entrepreneurship, to provide value for others

rather than particular benefit for themselves. Thus, they exhibited a combination of the two phenomena, particularly in terms of their prime motivation.

The results show that, if the transport sector wishes to find and engage with these innovators, there is no single 'type' of individual that can be identified. However, the findings do point to two potentially rich communities: (i) those developing applications and services employing state-of-the-art digital technologies and networks, e.g. 'Web 2.0' and smart phone applications; (ii) those motivated to create 'social value' by producing sustainable travel solutions. This research has found individuals that bridge these communities to varying degrees. In order to foster and encourage grassroots innovation relating to sustainable transport, initiatives are needed that encourage collaboration between these two groups.

Based on the results from this exploratory study, there are several actions that the transport sector could consider in order to remove barriers and better enable the innovation process.

These are:

- Providing a one-stop shop for advice and funding that covers all categories of innovator (i.e. supporting individuals and small groups innovating at a grassroots level not just those that already exist as business entities).
- Learning from the success of the Apple Application Store which provides a rapid route to exploitation for independent software developers.
- Increasing free access to enabling data (e.g. timetabling, geographic data, pricing) by continuing initiatives that have opened up historical public data to encourage innovation (e.g. www.data.gov.uk in the UK) and extending this access to real-time data.
- Creating and supporting networks of innovators (under tightly-defined topic areas) to support peer-to-peer communication.
- Improving the ability for innovators (as an entity rather than as a lone voice) to engage with policy makers and to ensure continuity of that engagement.

- Supporting free publicity through the popular press and high-profile competitions/awards, plus the provision of a one-stop-shop for public access to emerging innovations.

This study is possibly the first to explore grassroots innovation in transport. Its findings provide an understanding of where such innovations are likely to be found and the conditions which can support it. As such, it offers a first step towards harnessing the potential of such innovations in the transport sector.

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