People's Engagement With Renewable Technologies - Roadblocks and Triggers

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Abstract
This paper discusses early findings on my ongoing constructive grounded theory study looking at people's engagement with mobile communication technologies and remote, sustainable automated systems. Based on qualitative data generated following in-depth semi-structured interviews with 12 people living in Ireland, corroborated with quantitative data generated by the automated system, this papers argues that ownership plays an vital role in people engaging with and adopting new technologies. Also, while people demonstrated having mixed feelings about renewable energy sources, being perceived as expensive and unreliable, the participants expressed their interest in changing their lifestyle and adopting newer energy sources, with the intention of becoming independent from the national grid, which is also being perceived as unreliable. Additional information about this ongoing project can be found at http://eyeduinoproject.online/

Keywords: sustainability; engagement; automation; technology; empowerment; ownership

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Introduction

This mixed methods research aims at developing insights in relation to urban Irish population's interaction with (renewable) technologies, and uncover triggers and roadblocks that are preventing for such interactions to take place. Six automated enclosures, at six different locations in Dublin, Republic of Ireland were built in order to facilitate the qualitative data collection. The enclosures allow the 18 human participants to grow vegetables, each participants having full monitoring and control over the functionality of one of such enclosures. Participants' aim is to ensuring optimal growing conditions for plants to grow inside the enclosures, by means of working physical devices such as windows, ventilation fans, and irrigation. These tasks can be performed remotely, by using a custom developed mobile phone app, in accordance with in-app provided climate information.

Engagement details are recorded on an online server, providing time stamped data in relation to current conditions inside each enclosure, any action taken by the participants, and system's working mode (automatic and manual). The quantitative data will complement the main qualitative data obtained following focus group discussions, semi-structured interviews, observations, and memo analysis, acting at the same time as validation for the ongoing data collection and analysis.

Current literature

We are continuously being warned that the current 'business as usual' economy model can no longer continue. There are signals that the 'cheap food' era is coming to an end, and that more sustainable development policies should be advanced and implemented (Moore, 2010; Morgan, 2016; Räthzel & Uzzell, 2017). Niche innovations might represent an important step towards sustainable development and systemic change (Geels, 2011). They could bring the necessary societal changes in regards to transport, energy, and food, by means and with the help from new legislation, infrastructure, technology and knowledge (Elzen, Geels, & Green, 2004; Geels, 2004; Grin, Rotmans, Schot, Geels, & Loorbach, 2010).

Actor Network Theory asserts that in order for the transition process to be successful, all relationships between humans and non-humans (such as technologies, objects, nature, etc.) should be analysed together, as hybrid 'society-nature' bodies, rather than in isolation, for they are mediating and shaping each other (Latour, 1993; Michael, 2000). Taylor, Clarke, Skelly, & Nevay (2018) recommend that '*further work must*

continue to explore how neighbourhoods can better take ownership not just of the technology, but of the processes that develop them' (Taylor, Clarke, Skelly, & Nevay, 2018:10).

Is simply not enough to providing hardware support, and then expect people to learn the necessary skills to actually using it, without foreseeing any benefit in doing this. It takes more than addressing any 'equipment gap' in order to promote information communication technologies in society. Individual's experience of, and attitudes towards, using technologies plays an important factor as well (Selwyn, 2003; Silverstone, 2005). It has also been suggested that because sustainability brings no individual advantages, but rather contributes to a 'collective good', without meaningful economic changes it implies that innovations will have a low impact when it comes to replacing long, already established technologies (Geels, 2011).

Our planet's 3.8 billion years old natural Research and Development could be used as an inspiration to developing recyclable and biodegradable materials, in a process called 'biomimicry' or 'biomimetics' (Benyus, 2002; Blok & Gremmen, 2016), PV solar panels being compared to leafs for instance. Sandel (1997) suggests that more diverse R&D processes, as well as a creating strong communication channels with society and stakeholders, represent an important step towards acceptance and desire for sustainable innovations as well as for societal change (Sandel, 1997).

Existing knowledge

People which are inclined to test and find new meanings for emerging innovations are also more likely to later adopt them (Ramirez-Portilla, Cagno, & Trianni, 2014). Different views of the same artefact need to be considered as well, images of the same greenhouse having interpreted by various people as change of energy use, or as a means to avoiding waste (Henwood, Shirani, & Groves, 2018).

Senior citizens are less likely to adopt new technologies (Gilly, Celsi, & Schau, 2012), while local communities concerns should be addressed before starting a large scale project (Enevoldsen & Sovacool, 2016). This could be done by implementing similar small scale projects, while providing education, knowledge, and financial support for start-up sustainable businesses (Augustenborg et al., 2012; Qureshi, Ullah, & Arentsen, 2017). This might play an important role in *leapfrogging* – jumping from primitive technologies to sustainable ones (Sarabhai & Vyas, 2017). It is argued however that higher education does not guarantee an increase in regards to renewable adoption rate, and instead the wealthy population are more likely to adopt (Smith & Urpelainen, 2014).

Perceived relative advantage of technology, complexity of the innovation, social influence, and knowledge about grants and costs were advanced as indicators in relation to factors that would influence the adoption of photovoltaic (PV) solar panels (Vasseur & Kemp, 2015). Overall, the financial status was identified as being the main factor when it comes to (non-)adoption of PV panels. (Saka, Olawumi, & Omoboye, 2017). In spite of an initial high interest into adopting solar panels, and after identifying their relative advantage, lack of finance proved to be a huge barrier (Faiers & Neame, 2006).

Methodology and technical considerations

My study adopts a constructivist grounded theory approach, made popular by Katy Charmaz, and the ongoing data collection is based on focus group discussions, in-depth semi-structured interviews, and observations (Alemu, Stevens, Ross, & Chandler, 2015; Mills, Bonner, & Francis, 2006). Detailed analytical memos offer support for current data analysis process, and will serve as a critical framework for building the theory towards the end of the study (Charmaz, 2006). The research process was designed in such a way that each participant is interviewed twice (before and after engaging with the automated system) to allow for collecting and interpreting of different experiences, related to interdisciplinary fields.

Developed in 1967 by Barney Glaser and Anselm Strauss, grounded theory (GT) research is based on reflexive interpretation of qualitative data mainly obtained following interviews, questionnaires, and observations of participants (Birks & Mills, 2011). The emerging theory aims at explaining the phenomenon being studied, through the perspective and interpretation of the researcher (Birks & Mills, 2011; Creswell, 2007; Strauss & Corbin, 1994).

By using a custom developed mobile phone app, participants in this study are using their smart devices in order to operate remote physical devices such as irrigation valves, windows and ventilation fans. Their aim is to ensuring optimal growing conditions for plants inside purpose-built enclosures (greenhouses), by way of monitoring and controlling values related to soil moisture, air temperature and humidity. Although the idea of using a smart phone to controlling remote devices may not be necessarily new to people – such as using it to set the heating, or control lights in their household for instance – by emphasising the fact that it is their responsibility to keep some plants alive may add to participants' emotional impact. Also, because the automation systems are powered solely by means of renewable technologies (photovoltaic panels), the participants are expected to be aware of the amount of available electricity when operating devices, and avoid draining the battery.

In constructivist GT, the data is interpreted following an induction process of the researcher, and therefore the phenomenon described may not be an exact representation of reality, but an interpreted portrayal (N. Denzin & Lincoln, 2005; Kennedy & Thornberg, 2018). During the course of this study, reflexivity, using mixed methods of data collection, and triangulation of data are employed during data collection and analysis, in an attempt to capture truthful representation of complexities, views and actions of lived reality, without making false claims that they are offering and explanation of the 'whole picture' (Charmaz, 2006). Following final data analysis, details will emerge in relation to peoples' engagement with specific communication technologies, i.e. their familiar mobile phones, in order to control remote devices aimed at achieving tasks which may be new to them.

Considering the limited amount of research locations (six), and also for practical purposes, both theoretical and purposeful samplings were used for recruitment of participants. This maximised the opportunities to developing of concepts (ongoing) and their relationship, as well as discovering and comparing variation of information rich data. Participants were mainly recruited from amongst members of community

gardens, with the view that they would already be familiar with the location, and would have at least some gardening experience, so that they are not potentially distracted by the newness of such activities. A few negative/deviant cases were chosen, and they will prove crucial for testing the theory towards the end of the research (N. K. Denzin & Strauss, 2003; Flick, 2011; Maxwell, 1996; Pickering, 2008).

Having theoretical and methodological triangulation applied to collected data (via focus group discussions, individual interviews and on going observations), early findings, patterns and themes emerged, allowing for discussion and intermediate conclusions to be drawn (Flick, 2018). This paper discusses findings related to peoples' recycling practices, sustainable lifestyles, and engagement with technology, based on partial data collected by way of qualitative interviews conducted between March – June 2019.

By sacrificing scope for detail, smaller sample sizes allow for better in-depth analysis of social, cultural and economic factors of each participant, as the data resulting from just one interview can be quite extensive. The recommended average sample size for qualitative research is anywhere from 1 to 20 participants (Birks & Mills, 2011; Brinkmann, 2013; Davies, 2007; Maxwell, 1996; Schreier, 2018). The recruitment of participants was initiated by individual emails being sent to a list of 47 community gardens in Dublin, of which seven replies were received. Subsequently four more potential locations were found, and finally six were chosen in total to take part in the research.

Focus group discussions took place at five location sites during February 2019. Local views and opinions emerged at each location, which allowed for recruiting of a total of 15 participants to participate in the study; three more participants were purposively recruited. Each participant is to interact with one of the six enclosures located at different location across Dublin, for a continuous period of three months. The total time frame allocated for data collection following all participants' interaction is between March – November 2019.

From late February until early March 2019, in-depth semi-structured interviews were conducted with the first six participants due to start their engagement March 2019. Similarly, the first set of interview questions were discussed with the second batch of the six participants, from late May until early June 2019. All interviews were audio recorded, and they are intended to reveal participants' stance in relation to various subjects, including available recycling facilities and behaviour; attitude towards sustainable practices; and upgrading to new technologies.

The first batch of six participants were interviewed for the second time, at the end of the timeframe of their participation. This took place early June 2019, and their interpretations and experiences following the three month engagement were audio recorded. Technical aspects, attitude towards technology, and psychological traits were discovered. Data collection and analysis is taking place simultaneously, and for open coding purposes gerund verbs were used in NVivo, implying action and later turning into topics (Charmaz, 2006). Alongside with reviewing of extensive analytical memos, the analysis naturally moved on from the open coding stage to focused coding, following a process of differentiation, combining and reflection on data

(Charmaz, 2006; Miles & Huberman, 1994). The qualitative data collected following focus group discussions, interviews, and observations are corroborated with the quantitative data collected following participants' interaction.

For the purpose data collection, a total of six enclosures (Figure 1) were purposely built between September 2018 – March 2019, and automation features were added – irrigation valves, windows, and ventilation fans. The enclosures are located at six different sites around Dublin as follows:

- three community gardens, free access for volunteers;
- two up-skilling centres, free, mainly for teenagers from disadvantaged backgrounds;
- one public allotment, paid-for annual membership.

Figure 1 – Enclosure located at one of the research sites. Source: Hamilton V. Niculescu

An Arduino Mega 2560 programmable board, with required accessories, represents the central controlling, processing and remote communication point at each location (Figure 2). Apart from reading the battery voltage level, air humidity, temperature, and soil moisture values and acting upon it, the Arduino board ensures outside communication with an online server through which communication with participants' mobile phone app takes place. Any changes happening from either side – the system in Automatic mode, or the participant in Manual mode – are being recorded on the online server, and can be downloaded for triangulation purposes along with the qualitative data, during the analysis process.

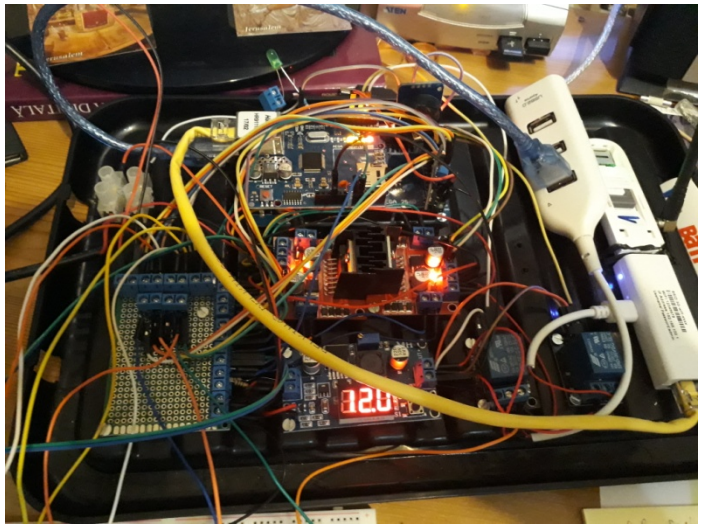

Figure 2 – Arduino Mega 2560 and electronic accessories used for communication and control. Source: Hamilton V. Niculescu

The quantitative data provides time-stamped blocks of data (Figure 3) about system's status as follows:

- system working mode (automatic/manual);
- soil moisture (percentage);
- air humidity (percentage);
- air temperature (Centigrade);
- irrigation status (on/off);
- ventilation fans status (on/off);
- windows status (open/closed).

Figure 3 – Online server acting as data depository, as well as the communication link between the phone app and automated system. Source: https://thingspeak.com

By using a custom developed mobile phone app (Figure 4) participants have control over the functionality of the enclosures. As such, according to sensor values provided, the users can:

- open/close the windows;
- start/stop the air circulating fan;
- start/stop the irrigation;
- send a log, which is paramount in qualitative research.

When the current climate conditions inside the enclosure do not match the optimal values set by the participant, colour-coded bars and in-app notifications are displayed on the phone's screen, prompting the user to take corrective measures. Apart from the need of implementing custom functionalities and settings in the app, required to connecting and controlling a particular enclosure, having developed the mobile app myself also guarantees the anonymity and privacy of participants.

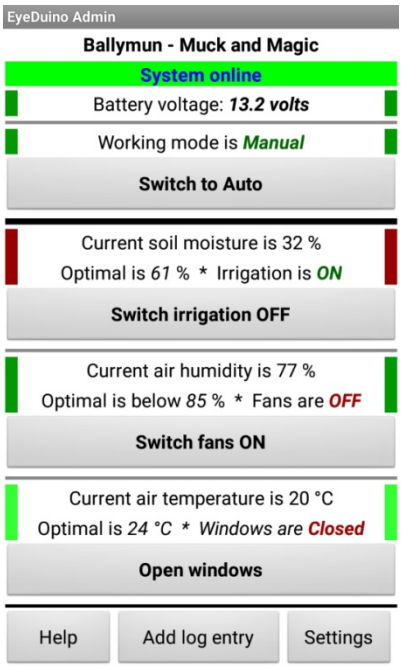

Figure 4 – The main screen of the custom developed mobile phone app. Source: Hamilton V. Niculescu

Findings

During the first interviews it became clear that all participants are aware of the fact that many materials can be recycled in order to save or produce energy. As all those involved in the study have access to community gardens, composting of organic waste does not represent a huge problem.

Mixed feelings in relation to renewable energy sources have emerged, many expressing their concerns related to reliability, price, and their negative impact on the environment. However, it became clear that participants are aware that innovative, more sustainable solutions must be developed in order to ensure their required energy for survival.

Following participants' three months interaction with the automated system, a set of thematic barriers acting against adoption of more sustainable practices surfaced during the interviews, and these will be analysed in detail in the discussion section.

Recycling of packaging and of non-organic waste

In many instances, the location of the household (urban environment) means not having access to proper recycling facilities, due to space restrictions or long distance required to travel to such recycling centres. While shopping, many are forced to carefully select products that have least packaging. In fact many participants expressed their concern in terms of the unnecessary amount of plastic packaging of the goods they are buying, being aware of the amount of money and energy being wasted both during the production and for recycling it.

'*you're actually paying for packaging, and then that goes out and... the tax payers money goes into getting rid of that packaging. Like the people who are producing it and selling it aren't paying as much as they should be to get rid of.*'
Participant #3

Some participants mentioned the problems created by plastic waste in agriculture: pots and trays, polythene covering the greenhouses, irrigation pipes – all being very difficult to recycle when in need of replacement. This is because only specific types of plastic can actually be recycled, and those types need to be sorted, and properly washed of any residues. Participants felt that more education is needed in order to make the general public more aware of energy waste and recycling.

The participants also demonstrated having knowledge about the running out fossil fuels being burned in order to produce electricity and heat. They are trying to reduce the amount of energy being wasted by setting the central heating thermostat to lower values, or by using mobile phone apps that monitor and control the heating or electricity in their household.

Experience with renewable technologies

An interesting topic that emerged during the interview was that of renewable technologies. Although many participants admitted that they are not up to date with the latest technology developments, the general consent is that renewables are expensive, not very reliable, and adding to the amount of already existing electrical waste. In the past, some participants attempted at having some combinations of such technologies installed in their household, but the high price acted as a deterrent. They have done no further investigations more recently, yet believe that these technologies are not financially worthy.

Although people would like to become more independent from the national grid, seen as unreliable, there are also mixed feelings about the reliability of the renewable energy sources, which represent another major barrier into adopting renewable technologies. People believe that they will not be able to produce as much energy as currently needed within their households. However, all participants showed an interest into switching to renewable sources, should money not be a concern, and they would see no problem to consequently changing their lifestyle. It is particularly interesting to note the extensive knowledge that one participant demonstrated in relation to renewable technologies:

'*solar isn't efficient enough, wind turbines also use heavy metals that environmentally are a disaster [...] they don't last, they take huge resources, and cost a fortune*'
Participant #4

Engaging with the mobile phone app

The ease of using the phone app allowed to confidently plant more vegetables than usual, believing that the automation features would assist them, something they would have not done before, due to lack of time required for caring for the plants during their growth cycle.

'*If it was an ordinary polytunnel, without this automation in it, I would have to physically go and check it, have a look at soil, or open the windows or the doors... it's amazing, it does it all for you.*'
Participant #2

'*I would have never had the amount of plants I have now, if it hadn't been for the fact that I knew I wouldn't have the time and I would neglect them.*'
Participant #4

However, the participants showed no remarkable signs of being aware of the fact that the automated systems were powered by PV solar panels and a battery pack, and that they should be wary of actions they take in terms of switching devices on or off. Many admitted of having no knowledge of how electricity actually works.

'*I assumed it was a new battery. And I know nothing about charging values and these things. And I assumed that you put in some fail safe measures. It says now that the voltage is 13.5V, but I don't know what it means, and whether it would take me thru the night. So is this value good?*'
Participant #4

Many participants preferred to initially set some (what they though would be) optimal values in the app, then switch the system to Automatic mode, allowing it to care for the plants by itself. During the interview many acknowledged the fact that they preferred to rely on the system to sustain itself, rather than assuming control and taking suggested actions. These decisions were also reflected in the logs that participants sent during their engagement, mostly referring to problems they have noticed with the (sometimes) non-optimal values they set in the phone app (Figure 5), without actually taking corrective measures by adjusting the related values.

'*I was more interested to see what actually the system was saying, and if it agreed with me. I know the polytunnel for seven years now, so I was looking at it and I was going like 'yeah, yeah, yeah'.*'
Participant #3

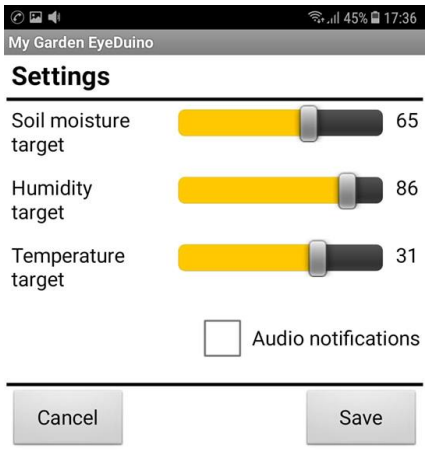

Figure 5 – Settings screen in the mobile app. Source: Hamilton V. Niculescu

However, after comparing this information against the quantitative data, it was concluded that they did not in fact use the app as often as they mentioned they did. As some participants admitted:

'*I think there should be more persons looking after it, for I kept forgetting about it.*'
Participant #6

'*I think sometimes I went into manual mode. And sometimes I forgot about it and left it like this.*'
Participant #5

Most participants manifested a big interest at the start of their engagement timeframe, showed both during their initial training and by the quantitative data, but this was played down by adverse weather conditions, which eventually led them to forgetting about the enclosure and the phone app.

'*At the start I checked it every second day. But it depends on the weather as well. If it's raining, it would be ok, for it's not too hot, the windows don't need to be open*.'
Participant #1

'*The weather was not great, which meant to leave the polytunnel on its own, because it has its own microclimate, so there wasn't much interaction [...] And I forgot the interface. If you don't use it all the time, you forget about it*.'
Participant #3

A direct connection to these statements would be lack of time being invoked for their low engagement. All six automated systems are located within 'working class' areas, and as such the demographics are characterised by participants with generally low income, and as Participant #9 mentioned, '*when people are working really hard and don't have a lot of money and that, they say 'I don't have time', they feel that they are under a lot of pressure*'. This confirms my suspicions that when participants were claiming lack of time as a reason for low interaction, in fact there are some other more subtle, underlying aspects that participants may not have been willing to reveal. During the interviews with the two deviant cases it became more clear that lack of time was not the real issue.

'*the app is interesting as a matter of fact, but I did not feel motivated to go there* [...] *If I knew that at the end of the three months I would make some money by selling the products, I would have been more motivated.*'
Participant #1

Therefore while initially some participants might have interpreted the automated system as a great tool to helping them with growing their vegetables, the prospect that this will only be available to them for a relatively short period of time could have had led them to reassessing their involvement and effort they need to put in.

'*That's why I'm amazed by it, and I'm actually in control of it. Not only that I see it working, I'm actually in control of it. Everybody is fascinated*. [...] *I'm not in control anymore, I will feel that I lost something, I got used to it. I lost control over it, and it's not nice.*'

Participant #2

Discussion

For the first two months (March and April 2019) participants' engagement was generally very low, confirmed during the interviews, as well as by quantitative data, with bad weather having a negative effect on their initial excitement. Cold weather, high winds and high air moisture meant that there was not much they could have done using the phone app in order to improve the conditions inside the enclosures. This fact may have eventually made them getting bored of seeing the same information being displayed on their phone screens, and eventually they started to 'switch off' and forget about it completely.

During initial training delivered to participants, before starting their period of interaction with the automated system, a need for 'instant gratification' was noted on peoples' part. Although they were informed that a certain amount of time has to pass between sending a command using the mobile phone app and the system actually responding to it, all participants were still expecting the system to react instantly upon using the app. This could in effect also have had acted as a deterrent towards engaging in remote communication with some physical system that was not physically in sight.

As most participants involved in this study are volunteers in the community gardens, the allocated time for their gardening tasks may not be tightly scheduled. Creating additional activities, such as engaging with the available automation technology, might act as a push in the other direction, i.e. people taking more time off from the garden and allowing the technology to look after the plants instead. Corroborating these findings with the data collected during interviews with the deviant cases, it became more clear that lack of time is in fact used as an excuse for a more subtle reason, as explained below.

During participants' recruitment process, bad weather acting as a deterrent was also mentioned by the administrator of the paid-for allotment site. An invitation email, sent by the administrator, was circulated amongst members of that place, with only one person making contact with me by email and showing an interest to participate in the study. This prompted me to find an alternative, and purposively pick two more participants of which I knew that they do not have much experience, interest and knowledge in gardening. They would represent the two negative cases in my study. Although I repeatedly emphasised the fact that they are not required to travel to the actual location, but only control it remotely using their smart phones, both of them indicated that they would not have time '*to deal with gardening stuff*' (Participant #1).

While financial revenue was mentioned as one potential motivation factor, this directly links to traits of control and ownership. Going back to data gathered from other participants, I noticed that although not directly acknowledged, knowing that their short engagement period of only three months would eventually mean losing control of the automation features, it might have had an impact in regards to their motivation to engage with the app and the system. Ownership surfaced as being a critical factor influencing engagement with sustainable automated systems, even in community gardens where one would expect people to show a better developed community spirit. Similar behaviour traits were noticed by studies looking at people

adopting technologies aimed at producing renewable energy (Chapman & Itaoka, 2018; Smith & Urpelainen, 2014; Szarka, 2007). People feeling empowered while being involved in a project, at the end of their participation may experience as losing something that allowed them to 'showing off' to their community members. In effect, arguments that technology could both bring benefits, as well as enlarging the knowledge gap for individuals and local communities, are further strengthened by these findings (Cowan R.S., 1989; Csikszentmihalyi & Rochberg-Halton, 1981; Selwyn, 2003; Silverstone, 2003; Silverstone & Hirsch, 1994).

Participants' involvement in technology development and the sense of ownership was also noticed as playing an important role in adoption of technology, by a study that was conducted in Scotland: '*being involved in the project was about enjoyment and personal achievement*' (Taylor et al., 2018). Again, referring back to the negative cases in my study, the Participant #1 has asked me to build a similar automated system for his own greenhouse. That system became functional during the last month of the participant's timeframe of engagement in my study. The sudden change in behaviour in relation to interaction with his own system strengthened my suspicion that ownership plays a vital role in people accepting new innovations.

'*with my greenhouse... it's not like yours. With yours I had no... motivation. [...] Mine. This is what motivates me. That is mine. And yours was not handy to get to.*'
Participant #1

Conclusions

As it became clear from analysing of interviews conducted during this study, recycling became naturally embedded in Irish people's behaviour. Similarly, adoption of sustainable energy sources and changes that these will bring to their lifestyles might only become successful following a long, not necessarily easy process of communication and shared development. As confirmed by similar studies, education represents an important step in the process of diffusion and adoption of innovations by local communities.

After a period of three months, and during a period of relatively low engagement of participants with the enclosures, with bad weather being blamed by most participants, some small changes in peoples' behaviour are observed in regards to their attitude towards and engagement with communication technologies involved in the study. It was learned that ownership, relative advantage and trialability are factors playing a critical role in the process of adoption of innovations, augmenting existing theory and previous studies' findings (Almlund, Jespersen, & Riis, 2012; Claudy, Garcia, & O'Driscoll, 2015; Faiers & Neame, 2006; Gobin, Cadersaib, Sahib-Kaudeer, & Khan, 2017; Nuñez Jimenez, 2015; Ozaki, 2011; Reinhardt, Hietschold, & Gurtner, 2017; Rogers, 1995; Wolske, Stern, & Dietz, 2017)

The ongoing collection of data (due to finish November 2019) may strengthen these arguments, while other themes may potentially be developed. Studies to include people from other social classes may bring new details in relation to adoption of technologies.

Limitations of this research

The inductive methods used for data interpretation, and also by using a small sample of Irish, working class population living in an urban environment, means that this study's findings may not apply for larger populations, and/or under different settings or locations, and/or under the influence of different social, economic, and cultural factors.

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