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Open E-Learning Platforms and the Design-Reality Gap: Exploring the Impact of User-Perceived Functional Affordances

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OPEN E-LEARNING PLATFORMS AND THE DESIGN-REALITY GAP: EXPLORING THE IMPACT OF USER-PERCEIVED FUNCTIONAL AFFORDANCES

Research Paper

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Abstract

Recorded usage rates of open e-learning platforms are often low, with many users discontinuing their use after initial acceptance. One often cited reason for this acceptance-discontinuance anomaly is the design-reality gap between users' diverse needs and the designed features of an open e-learning platform. To explore the challenges of user continuance behaviour we adopt the lens of 'functional affordances', the possibilities for action that an open IT artefact provides users for achieving individual and collective goals. We investigate the design implications of user-perceived affordances based on findings from an EU sustainability project which developed an open e-learning platform for citizens to improve household energy efficiency. Findings showcase how open e-learning users and designers perceive seven interrelated affordances differently: Informing, Assessment, Synthesis, Emphasis, Accessibility, Navigation, and Goal-planning. We put forward recommendations on how designers of open IT artefacts can bridge design-reality gaps by exploring affordance personalisation for diverse user groups.

Keywords: Open eLearning; Functional Affordances; Sustainable Energy Use; User Perception.

1 Introduction

Open e-learning refers to the delivery of educational content to students through open access platforms made freely available online (Daniel, 2012; Gregori, Zhang, Galván-Fernández, & de Asís Fernández-Navarro, 2018; Labarthe, Bouchet, Bachelet, & Yacef, 2016). In contrast to 'closed' e-learning platforms where access is contingent on the student satisfying eligibility criteria and paying registration fees, open e-learning platforms are typically available to anyone with an interest in the topic, on a voluntary and cost-free basis. Open e-learning platforms such as Massive Open Online Courses (MOOCs) are an increasingly prevalent medium of education and training delivery in which information, knowledge, and instruction are openly disseminated through online media to diverse user groups (Cidral, Oliveira, Di Felice, & Aparicio, 2018; Daniel, 2012; Gregori et al., 2018; Labarthe et al., 2016; W.-S. Lin & Wang, 2012).

However, evidence suggests that open e-learning users often disengage and do not progress to completion, with drop-out rates cited as high as 97% (Hew & Cheung, 2014). One explanation for this centres on the diversity of user profiles where individuals from different educational, geographic, and socio-economic backgrounds are attracted to open e-learning by the low barriers to registration (Cidral et al., 2018; Daniel, 2012; Gregori et al., 2018; Labarthe et al., 2016; W.-S. Lin & Wang, 2012). This results in numerous design challenges centred on the creation of an open e-learning platform which caters to the diverse learning goals of numerous user groups. To better understand the acceptance-discontinuance anomaly we adopt the lens of 'functional affordances' which explores the possibilities for action that an open IT artefact provides different user groups (Strong et al., 2014; Tuunanen & Peffers, 2018). Functional affordances affect users' feelings or attitudes toward a system by shaping whether it assists or constrains their ability to realise individual and collective goals (Lanamäki, Thapa, & Stendal, 2016; Parchoma, 2014; Volkoff & Strong, 2013). This in turn can affect the perceived usefulness of an open e-learning platform and its continued usage.

While a significant body of research has focused on the critical success factors of implemented e-learning platforms (Choudhury & Pattnaik, 2020), less attention has been directed towards the design practices of open e-learning platforms where functional affordances are appropriated and tested with diverse user groups (Gregori et al., 2018; Tuunanen & Peffers, 2018). Given the potentially significant relationship between user perspectives and system success (Choudhury & Pattnaik, 2020), our ability to understand different users and designers' perceptions of open e-learning affordances may be crucial for addressing the acceptance-discontinuance anomaly going forward (Strong et al., 2014). However, literature has traditionally discussed affordances as a theoretical construct (Balci, Rosenkranz, & Schuhen, 2014; Markus & Silver, 2008) with empirical research on its relevance to open e-learning platform design only now emerging. In addition, our study is motivated by recent calls for research to understand e-learning platform engagement and value particularly, following the Covid-19 pandemic and pivot to online learning in higher education (Bhagat et al., 2020; Singh et al., 2021).

Against the background presented above, our study seeks to answer the following research question: *How do users perceive the functional affordances of open e-learning platforms?* In order to address this research question, we draw on findings from the ECO2 (Energy Conscious Consumers) project which developed an open e-learning platform (ACT4ECO) to help European citizens implement concrete actions for saving energy in the household. As part of this case study, we sought diverse user feedback, focusing on perceived functional affordances of the open e-learning platform in question.

This study makes two primary contributions. Firstly, we draw on Affordance Theory to gain a better understanding of the relationship between an open e-learning system's designed features, different user perceptions of these features, and the affordances these features provide (Evans, Pearce, Vitak, & Treem, 2017; Markus & Silver, 2008; Parchoma, 2014). Building on this understanding, we suggest that open e-learning platforms should be designed to better support possibilities for action that are relevant, interesting, and possible for different user groups. In particular, we assert that open IT artefacts must cater to the contextual constraints of diverse users (Tuunanen & Peffers, 2018). We discuss open IT platform development from an iterative and collaborative perspective (Gregori et al., 2018), and assert the importance of inviting diverse users to participate in the early stages of development. We also contribute practical recommendations for designers to address the design-reality gap by exploring

affordance personalisation. This can help ensure that the open platform better meets the reality of diverse user groups, avoiding a 'one size fits all' approach to open e-learning design (Greenhalgh, Hinder, Stramer, Bratan, & Russell, 2010; Tuunanen & Peffers, 2018).

The paper is structured as follows: Section 2 reviews relevant literature on user perceptions, the design-reality gap, and Affordance Theory. Section 3 then introduces our case study which adopted piloting for gathering user perspectives on affordances. Section 4 presents case study findings followed by a discussion in Section 5. Section 6 summarises contributions and avenues for future research.

2 Background

Open e-learning tends to attract users across a wide spectrum of learning profiles and backgrounds (Cidral et al., 2018; Daniel, 2012; Gregori et al., 2018; Labarthe et al., 2016; W.-S. Lin & Wang, 2012). As a consequence, designers are faced with the sizable challenge of developing open e-learning platforms that respond to diverse user needs (Walji, Deacon, Small, & Czerniewicz, 2016). Features of e-learning platforms must stimulate interest and improve user retention by delivering information that is relevant to their individual and collective goals which cannot be found elsewhere (Conole, 2013; Torres-Ramírez, García-Domingo, Aguilera, & De La Casa, 2014). For users to accomplish their goals, certain "possibilities for action" (as postulated in Affordance Theory) need to be featured in an open e-learning platform. Understanding the perceptions of users and their level of engagement is crucial to ensure that features are aligned with these user goals (Walji et al., 2016).

2.1 User Perceptions of IT

User perception describes individuals' response to an IT artefact, which is derived from their interaction with IT features and goal expectations (Deng, Turner, Gehling, & Prince, 2010; Pallud & Monod, 2010). Literature suggests that task-technology fit is paramount in open e-learning to ensure that the e-learning platform supports users' requirements during learning activities (W.-S. Lin & Wang, 2012). The related concepts of perceived usefulness and perceived ease of use may similarly contribute towards positive user perceptions (Sun, Tsai, Finger, Chen, & Yeh, 2008) as well as variety in the form of multimedia instruction, diversity of assessment, and user interaction through the e-learning platform (Cidral et al., 2018; K.-M. Lin, 2011; Sun et al., 2008). Information / instructional quality have also been identified as significant contributing factors towards user satisfaction in e-learning (Esteban-Millat, Martínez-López, Huertas-García, Meseguer, & Rodríguez-Ardura, 2014; Liaw, 2008; Mohammadi, 2015).

Beyond task-oriented concerns, user experience then looks at users' emotive response to the open e-learning platform (Pallud & Monod, 2010). From an experiential perspective, user perceptions can go beyond task-technology fit alone to consider how the open e-learning platform's capabilities generate pleasure, enjoyment, and empowerment for users (Deng et al., 2010) and potentially support positive emotions such as happiness and cheerfulness (Esteban-Millat et al., 2014). Research suggests that this in turn can improve student learning, lengthen online sessions, increase perceived usefulness, and promote self-regulation (Liaw, 2008; Liaw & Huang, 2013; Mohammadi, 2015).

However, user perceptions are also shaped by negative critical incidents such as the disconfirmation of performance expectations where an e-learning system does not proceed normally, or challenges users' expectations (Deng et al., 2010; K.-M. Lin, 2011). This includes users' expectations around the length of the learning unit, assessment issues, and insufficient system-level feedback (Cappel & Hayen, 2004) which in turn causes the users to experience frustration with the e-learning platform (Saariluoma & Jokinen, 2014). User capabilities may moderate the relationship between negative incidents and perceived ease of use, with inexperienced users encountering greater challenges than experienced users (K.-M. Lin, 2011). For instance, user's perception of their skills to overcome such challenges as self-efficacy and computer anxiety affect user satisfaction as inexperienced users who are unfamiliar with e-learning need more time to develop the competencies to effectively exploit the technology (Esteban-Millat et al., 2014; Liaw & Huang, 2013). To further explore negative critical incidents and user expectations, the next section focuses on the notion of the 'design-reality gap'.

2.2 The Design-Reality Gap

The design-reality gap describes differences between the assumptions built into an IT artefact by designers and the real-life needs of users (Greenhalgh, Hinder, Stramer, Bratan, & Russell, 2010). Gaps emerge when designers develop features that do not match the goals of user groups, and therefore create 'dissonance' between user expectations and systems delivery. To address the design-reality gap, literature suggests that designers must engage in continuous dialogue with users to understand their needs, and bridge any perceived gaps which may arise (Damodaran, 1996; N. Iivari, 2009; Kautz, 2011). Design practice begins by utilising a collaborative approach to exploring, understanding, and defining user needs by generating feedback on the system and perceptions of value (Goldkuhl & Lind, 2010; Gregor & Hevner, 2013; Hevner, March, Park, & Ram, 2004; Parchoma, 2014). This can be achieved through techniques such as user piloting which aims to understand user perceptions of a system through a combination of research methods e.g. focus groups, surveys, interviews (Liedtka, 2014).

Once user needs have been explored, defined and understood, design practice then shifts focus to develop and redevelop systems using an iterative approach (Dodgson, Salter, & Gann, 2005). Prototyping is used to bridge the design-reality gap through 'bold experimentation', developing offerings that are empathetic and responsive to the users' needs (McCarthy, O'Raghallaigh, Woodworth, Lim, Kenny & Adam, 2020; Rosenkranz, Vranesic, & Holten, 2014). Several iterations of a system may be designed, built, and evaluated to see how well each addresses the problem under investigation, and meets / exceeds user expectations (Goldkuhl & Lind, 2010; Gregor & Hevner, 2013). Design principles can be identified to describe the qualities or attributes most valued by users when adopting a solution i.e. physical, cognitive, aesthetical, and emotional parameters and constraints (Gregor et al. 2020).

Existing literature has typically focused on instances where designers work with a limited sample of 'representative user' to explore a finite scope of features to be designed (J. Iivari & Iivari, 2006; N. Iivari, 2009; Mumford, 1983). Yet, openness as a concept intrinsic to open e-learning platforms brings additional challenges to the design process as the diverse user-base means that the platform must continually evolve over time to cater to user needs – especially for needs which could not be anticipated by designers (Tuunanen & Peffers, 2018). The emergent nature of open platforms suggests that exploring and validating user needs can extend well beyond the product launch stage (Feller, Finnegan, Fitzgerald, & Hayes, 2008; Feller & Fitzgerald, 2000; Wynn & Eckert, 2017). It is also suggested that aside from user needs, open platform design requires a context-specific approach whereby societal issues are considered during development to meet citizen needs (Ruijer et al., 2017).

2.3 Affordance Theory

One way of understanding the design-reality gap is through the lens of functional affordances, the 'possibilities for action' offered by a system feature which allows users to accomplish individual or collective goals (Gibson, 1986; Hausvik & Thapa, 2017; Markus & Silver, 2008; Strong et al., 2014; Volkoff & Strong, 2013). Functional affordances consider both the materiality of technical objects (e.g. features of an open e-learning platform) and their relationship with users as agents of change (Leonardi, 2013; Zammuto, Griffith, Majchrzak, Dougherty, & Faraj, 2007). Examples of functional affordances might include the comment feature of a decision support system which users perceive as offering possibilities for action in the form of an 'idea recording' affordance (Markus & Silver, 2008), or the online check-in feature of an airline system which users perceive as allowing them to save time before their flight ('checking in 24 hours in advance' affordance) (Balci et al., 2014). Functional affordances are embedded in a technical object and their existence does not rest on actualisation by a user, nor does perception of an affordance automatically result in actualisation (Du, Pan, Leidner, & Ying, 2019). Instead, actualisation rests on the completion of actions made possible by the technical object (Hausvik & Thapa, 2017; Strong et al., 2014). When designing IT systems, functional affordances are best understood as potential for actions which have some durability.

Possibilities for action are finite and functional affordances can both enable and constrain user actions (Gibson, 1986; Hausvik & Thapa, 2017; Strong et al., 2014; Volkoff & Strong, 2013). Users may ignore certain functional affordances or create workarounds in order to achieve individual goals (Balci et al., 2014; Parchoma, 2014; Robey, Anderson, & Raymond, 2013). Capabilities of the user /

user groups and their prior experience of using IT can also impact this (Balci et al., 2014; K.-M. Lin, 2011; Parchoma, 2014). Similarly, prior research suggests that users' interactions with affordances may depend on their age, and education profile. Nevertheless, functional affordances offer a useful construct for understanding how the different features of an IT system dynamically shape usage, and the effects these features have on individual and collective action.

Users may perceive functional affordances in unique ways, and in turn derive different symbolic expressions which they attach to a technical object (Markus & Silver, 2008). For instance, functional affordances may create feelings of freedom for some users, efficiency or equality of participation for others, which users then begin to associate with the technical object (Balci et al., 2014). This can vary across individuals and collective user groups (e.g. experts vs. less experienced users). Moreover, functional affordances may be interpreted differently by designers and users; while functional affordances offer potential for action, they are not necessary or sufficient conditions for IT use (Balci et al., 2014; Markus & Silver, 2008). Indeed, the designers' intended affordance may often differ, or potentially even conflict with the goal-oriented actions of users (Norman, 1988). Affordance Theory can provide insights into how designers appropriate a system by changing the features to match user goals over time (Leonardi, 2013). It can also elucidate how the interrelated functional affordances which make up a technical object are perceived across contexts of use (Strong et al., 2014). Functional affordances can allow us to examine how users interpret open e-learning material to climb a "ladder of change" e.g. eventually engaging in more sustainable energy practices (Seidel, Recker, & Vom Brocke, 2013).

3 Research Design

The authors adopted an interpretive case study approach to investigate the aforementioned research question (Darke, Shanks, & Broadbent, 1998; Walsham, 1995). Our case study centres on ECO2, a large-scale open e-learning project funded by the EU Commission's Horizon 2020 programme. The aim of the ECO2 project is to increase citizens' awareness of their energy consumption and improve energy efficiency in households through open e-learning. This is achieved by developing an open e-learning platform called ACT4ECO (http://act4eco.eu/) to help European citizens implement concrete actions for saving energy (see Figure 1). In total, the project seeks to reach 10,000 citizens across Europe who will sign up to the platform and learn how to complete actions that will increase their energy efficiency. By following the learning paths proposed by the open e-learning platform, each user will climb the "ladder of change" from 'Motivation' to 'Exploration' and finally to 'Action' where they make more environmentally sustainable choices (Kahma, Ertiö, McCarthy, & Fitzgerald, 2021).

The case study was focused on the piloting stage of the project when usability tests were run to provide in-depth insights into how users perceived an initial prototype of the platform and its e-learning content. The researchers were also involved in drafting contents / information blocks for the e-learning platform, working alongside designers of the prototype and user interface. The project consortium consists of private and public organisations from Denmark, Finland, Ireland, Italy, Belgium, Lithuania, Bulgaria, Portugal, and Greece who are responsible for recruitment in their respective countries.

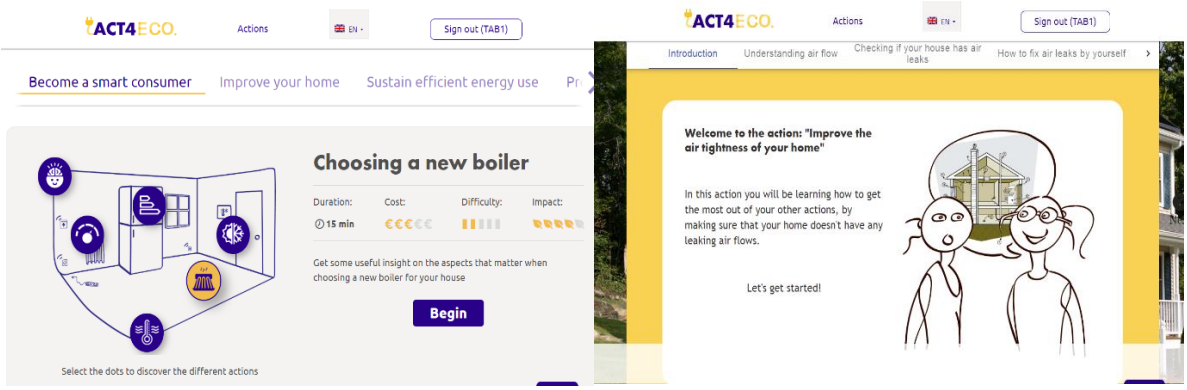

Figure 1. Screenshots of ACT4ECO Platform.

Table 1 describes the themes used to structure users' learning experience on ACT4ECO. The content was validated through a three-step process: 1) internal evaluation within the project team, 2) individual test runs with stakeholders, and 3) pilots with user groups. In this paper, we will focus on step 3.

e-Learning Theme	Description
'Become a smart consumer'	Informs users on how to consume energy efficiently.
'Improve your home'	Educates users on how to create an energy efficient home.
'Sustain efficient energy use'	Ensures that users maintain energy efficiency measures.
'Produce your own energy'	Explores how users can generate energy at home.
'Manage your energy consumption'	Increases users' awareness of energy consumption over time.

Table 1. Themes of ACT4ECO.

3.1 Data Collection and Analysis

Data collection took place during the piloting phase between February and May 2020. Piloting was completed in all nine countries. However, for the purposes of this paper, we will draw on findings from two countries in particular: The Republic of Ireland, and Finland.

28 participants took part in these pilots: 15 participants from Ireland and 13 participants from Finland. These countries were chosen as they provided insights into diverse user groups: while the level of energy awareness is quite high among citizens in Finland, Ireland comes from a lower base of understanding (Kahma et al., 2021). According to the subjective evaluations, the Finnish pilot participants were more energy aware (76.9% compared to Ireland 46.6%), and more knowledgeable about energy (69.3% compared to Ireland 33.3%). In contrast, Irish pilot participants were more tech savvy (66.7% compared to Finland 46.2%). The digital divide however, created challenges in recruiting users with 'very poor' levels of technology savviness as some communities suffer from a lack of internet access and IT skills. There was a relatively even split between the genders and age groups taking part in the pilot (Appendix 1). Table 2 provides an overview of diverse pilot user groups in Ireland and Finland.

During the pilot, participants accessed the ACT4ECO platform, and then reviewed and discussed its design features and e-learning content with the research team. A combination of semi-structured focus groups and individual surveys were used for piloting the open e-learning platform. Focus groups lasted for approximately 1.5 - 2 hours, and a summary of the accompanying online survey is included in Appendix 2. Focus groups in Finland were conducted in Finnish and English. In Ireland, due to the introduction of COVID-19 restrictions (March 2020), participants engaged with data creation online.

Level	Energy Awareness		Knowledge about Energy		Technology Savviness	
	Ireland	Finland	Ireland	Finland	Ireland	Finland
Very Good	2 (13.3)	8 (61.5)	0 (0.0)	3 (23.1)	3 (20.0)	5 (38.5)
Good	5 (33.3)	2 (15.4)	5 (33.3)	6 (46.2)	7 (46.7)	1 (7.7)
Neutral	2 (13.3)	1 (7.7)	3 (20.0)	0 (0.0)	2 (13.3)	5 (38.5)
Poor	5 (33.3)	2 (15.4)	5 (33.3)	2 (15.4)	2 (13.3)	2 (15.4)
Very Poor	1 (6.7)	0 (0.0)	2 (13.3)	2 (15.4)	1 (6.7)	0 (0.0)
Total	15 (100.0)	13 (100.0)	15 (100.0)	13 (100.0)	15 (100.0)	13 (100.0)

Table 2. Pilot Users' Energy Awareness, Knowledge, and Technology Savviness; n (%).

Recent studies have underlined the similarities of individual surveys and focus group interviews as sources of data collection, emphasising how they both generate data on experiences, beliefs, and opinions. Nevertheless, there may be variation in the level of 'depth' in terms of comparability and the

frequency of themes (Guest, Namey, Taylor, Eley, & McKenna, 2017). The data collection methods are therefore, not interchangeable. Morgan (1996) suggests that the main difference between individual and group data collection methods is that whereas the former produces deeper knowledge, the latter offers a broader perspective on the theme studied (Crabtree, Yanoshik, Miller, & O'Connor, 1993; Morgan, 1996). Focus groups also allow for more speculation, as the group members encourage each other to elaborate on the discussed themes and consider a wide range of viewpoints beyond what is obvious (Heikkilä & Kahma, 2008; Kaplowitz & Hoehn, 2001). Combining the two techniques allows not only a comparison between two data sets, it may also be that in individual surveys there is more space for reflection than in a social group setting. The level of specificity also differs between the two types of data which can help gain a richer picture of functional affordances.

Qualitative thematic analysis (Patton, 2002) and descriptive statistics were used by the authors to analyse participants' responses. Four authors coded the data with their findings compared and reconciled where necessary. The authors began by continuously rereading the transcribed content from both consultations to generate a set of codes which were judged as meaningful and important to the research question. Data analysis centred on ACT4ECO's features and the possibilities of actions (i.e. affordances) provided. These codes were then grouped together to form overarching categories of codes which helped organise the content according to similar types of affordances. We allowed for new affordances emerging from the data over time, with new categories created as necessary to help further analyse the content. The authors continued this process of thematic analysis until a point of saturation was reached and further analysis did not contribute new interpretations, but rather supported existing ones (Patton, 2002). The authors also drew on the work of Bower (2008) to provide initial seed affordance categories.

4 Findings

As previously discussed, open e-learning platforms are typically aimed at large-scale diverse user groups. In this respect, the measurement of e-learning success shifts from traditional completion rates and certification, to assessing levels of goal relevance. Table 3 present a matrix of features and the affordances perceived by users, as inductively revealed from our thematic analysis of pilot data. Overall, we find that results across other countries were largely consistent with those from Ireland and Finland, despite differences in the socio-economic backgrounds and skill levels of participants.

Affordance	Description of ACT4ECO Feature(s)
Informing	Instructional content relates to the following themes: 1) Become a smart consumer; 2) Improve your home; 3) Sustain efficient energy use; 4) Produce your own energy and 5) Manage your energy consumption.
Assessment	Quizzes test user knowledge on the delivered instructional content related to each ACT4ECO theme.
Emphasis	Module information is provided on the estimated duration, financial cost, difficulty, and 'green' impact associated with each ACT4ECO theme.
Synthesis	Graphics explain instructional content visually and aim to represent knowledge in different ways.
Accessibility	The login feature allows users to undertake self-paced study by saving progress across content sections (i.e. themes). Users can return to previous pages of instructional content as required within the selected theme.
Navigation	'Next' and 'back' buttons allow the user to navigate through the different sections of the themes. "Small circles" denote the users progress through a section.
Goal-planning	At different points, users are asked: "*what do you plan to do next?*" This prompts users to reflect on their motivation for engaging with the module and helps them develop a plan for goal-oriented action in the future.

Table 3. Functional Affordances and the Associated Features of ACT4ECO.

4.1 Informing and Assessment Affordances

The informing affordance was central to participants' open e-learning experience. Participants with limited prior knowledge of energy commented on the importance of well-organised instructional content to learn about possible actions and appreciated when "*information was given in manageable blocks*". These participants also noted the need for brevity when delivering instructional content, observing that sections which were "*too wordy*" impeded their learning. They suggested that shorter bullet points could be useful for maintaining their attention and understanding of possible actions. Similarly, comments were made by participants with limited knowledge of energy that some technical content needed to be reworded as it did not make sense. For instance, one survey participant noted "*The issue/energy efficiency confuses me; I'm looking for plain language advice*." Designers faced considerable challenges in crafting an accessible form of language for all users, as they also risked losing users with more advanced knowledge of energy.

Creating assessments that were sufficiently challenging for all participants was also difficult for designers. It was highlighted that some felt assessments were not challenging enough, while others thought it sufficiently tested the knowledge, they had gained from the instructional content provided on the open e-learning platform. Some survey participants stated that quizzes "*were the most engaging part*" for learning; however, others recommended that designers "*make sure there's a clear purpose for quizzes (not just self-reflection) and ensure they're sufficiently challenging for all*." Participants with a good knowledge of energy were also unsure about the purpose of assessments and felt "*a bit confused about 'what brought you here?'*". For instance, one focus group participant felt that the quizzes seemed pointless without a certificate for completion and expected to "*get a diploma on the next slide*". Focus group participants also noted the need for clear feedback on their progress: "*it would be nice… when I choose one of them, that I would get feedback on my choice. I mean 'right!' or 'wrong!'*".

Finally, a key challenge faced by designers was making the topic of energy awareness attractive for all learners. For instance, one participant with low energy awareness felt that some content can be "*a little boring*" and there is "*nothing (that) drags you in*". Others observed that the use of guilt or shaming tactics to build user motivation for action was ineffective for changing their energy consumption practices. It was recommended that designers should rewrite sections with a more positive tone using a "*feel good mantra to tell your friends and neighbours*". The following quote illustrates the feelings of one survey participant on the tone on the platform: "*people are being made to feel guilty for using appliances they always have… you want people to change their behaviour, not necessarily make them feel bad for their current behaviours*". The unintended consequence of guilt tactics according to participants, was that then they may give up entirely and decide it's not worth acting. Nevertheless, other users noted that the information provided was interesting and offered them "*Common sense ideas*" about energy efficiency actions. They also liked sections where the tone of the content was more conversational and observed that "*The pictures and short text descriptions kept my attention*".

4.2 Emphasis and Synthesis Affordances

At the start of each learning theme, key information was offered to shape user expectations on what instructional content would be delivered and the potential impacts they could realise from their engagement. When asked about how this emphasis affordances offered by ACT4ECO shaped their expectations, pilot participants suggested that action-oriented phrases such as "*energy saving*", "*saving money*" and "*reducing my (carbon) footprint*" drew them in and kept their attention. However, there were different perspectives on the meaning of some emphasised words, with one survey participant assuming that 'Cost' refers to the expense of completing the course rather than the proposed actions. Suggestions were also made to include additional emphasis affordances such as "*a checklist or step–by-step approach to start the action 'journey'*". Participants with low levels of energy awareness described the need for more objectives to increase motivation for action, and for the purpose of each theme to be made clear. New features were suggested as means of achieving this: "*I'd be motivated to use it if there was some purpose - a certification at the end, some reward for being involved like a leader board*."

In relation to the synthesis affordance, both groups suggested that the summative graphics provided by open e-learning platforms were useful for summarising learnings, and aided user's sense-making of

possible actions. One participant with limited prior knowledge of energy noted that: "*The graphics are great… Once you start into actual pieces of advice it is actually really good*". A few participants also observed the importance of graphics for conveying messages, supporting learning, and enhancing motivation. However, a shared comment was that some content was "*overly convoluted in places*" and "*over complicated"* so graphics proved useful for summarising *"a lot of information in one go [and helping] to spread it out*." Participants with limited prior knowledge felt that graphics were useful for summarising messages: '*once you make your way through the [language] used, I found pieces of useful information*'. Participants with good prior knowledge noted that graphics could also convey more detail than text content alone and satisfy their desire for further knowledge: "*everyone understands that electricity just doesn't come from the wall outlet whenever you plug something in, but there are the stages. You could maybe open up a little how that actually happens… Explaining it really fast [with] a stock photo*". However, some graphics conflicted with knowledgeable participants' understanding of the content, pointing to the importance of cohesiveness in content delivery: "*most of energy goes keeping your warm, but then there's a picture of a fridge… and an air-conditioner?*"

4.3 Accessibility Affordance

Feedback on the accessibility affordance related to the designed layout of the open e-learning platform and its sign-in process. Comments on the colour scheme (white, blue, and yellow) and website layout were generally positive with the majority saying that the design of the open e-learning platform was important to ensure good use of colour, and images and text were easy to read. However, the colour scheme sometimes clashed with other knowledgeable participants' expectation: "*there is the eco theme, so in terms of colours you could have something pointing to that direction, I mean people expect ecological colours, green and such?*". One survey participant also suggested the need for increased guidance for less tech savvy users.

A streamlined sign-in process was crucial by designers for the successful recruitment of 10,000 users, given the voluntary nature of the open e-learning platform. However, both tech savvy and less tech savvy participants had mixed opinions on the sign-in process of ACT4ECO, with some saying it was 'easy', and others saying it was 'difficult' or 'very difficult'. The main issue was that most participants did not like the 'self-paced learning' feature which required users to enable local storage in order to save progress. In particular, less tech-savvy participants felt there "*shouldn't be a sign-in process*", as it compromises the platform's attractiveness relative to other sites: "*There are a number of sites you can find from Google instead of [using] this platform. So that personally I would not register unless the sign-in has some real advantages to me*". More basic accessibility concerns related to the registration link, and lack of system feedback when users would be redirected to the open e-learning platform's back-end content management system in order to enter login details. Participants also noted that the need for users "*to return to the site and refresh the page*" during login was "*very off putting*". To improve accessibility, both tech savvy and non-tech savvy participants asserted the need to: "*Make sign-in easier*", "*Make it seamless*", and "*Provide more feedback*." It was also recommended that a chat portal be provided if less tech savvy users had queries around the platform.

4.4 Navigation Affordance

Navigation turned out to be another crucial design challenge for effectively guiding users through the learning path or "ladder of change" from 'Motivation' to 'Exploration' and finally to 'Action'. When discussing the navigation process, less knowledgeable participants felt it was sometimes difficult to click through a lot of sections and they would welcome a clear indication of "*what is going on*" relative to the learning path. In order to aid learning, participants recommended that the e-learning sections should flow from one into another and avoid the default navigation of returning to the homepage once users finish a theme's sub-action. They asserted that this would help participants maintain their sense of orientation in the platform using a clear breadcrumb trail to remind users of the learning pathway.

Overall, design choices around page navigation posed issues for different participants as the learning path was harder to follow than the designers had expected, and participants felt navigation wasn't intuitive. In particular, energy aware participants called for a search function to overcome this issue.

The importance of system feedback for navigation was again noted by participants with limited prior knowledge, who desired clearer indications on the "*need to click/scroll through the headings in the 'act now' section for further content*". A scrolling slideshow was designed to capture users' attention but link mapping issues meant "*some of the links to the action do not take you to the same start point every time*" with one survey participant noting "*the scrolling slideshow (top of page) should direct down to… 'Explore the actions you can take' instead of 'Action Themes Archive'*".

4.5 Goals Planning Affordance

At the end of certain sections in the e-learning platform, users were provided with a goal-planning affordance when asked the following question: '*what did you learn from ACTO4ECO today?*' Participants with low levels of energy awareness indicated several possibilities for action based on the learning path provided. Over half of the survey participants said that they 'would make changes at home' to save energy. Participants described the energy saving actions they had learned and how these could be maintained, with one participant with limited prior knowledge detailing how the platform enabled them to become "*more aware of my own behaviour and how I select and use more energy efficient appliances*" whereas another participant realised "*I'm not using my appliances correctly*".

Still some indicated that they did not see possibilities for action based on their engagement with the platform. The design challenge centred on gaps between suggested goals and the resources available to different user groups. While questions of home ownership and income were outside the scope of our questionnaire, some participants noted that the suggested possibilities for action were not feasible for them as they lived in rented accommodation and faced financial constraints. More energy aware participants also asserted the importance of options being framed in a real-world context: "*I personally [liked] the last page, select the ones you're willing to do... I wish there could be some sort of story about someone and their daily habits… I have no idea what's going on in my electric bill. What is the actual impact, if it's like one euro per month, two euros per month, or is it bigger, what is the impact?*". More knowledgeable participants also stated that while the information provided was useful, it would be beneficial for the platform to note when help should be sought from professional tradespeople.

5 Discussion

The following section provides a discussion of case study findings in relation to our research question: *How do users perceive the functional affordances of open e-learning platforms?*

In contrast to traditional face-to-face learning environments, open e-learning is characterised by low barriers to registration, and self-paced independent study which allows diverse user groups to engage with open instructional material (e.g. teaching-materials, assignments, and quizzes) at their own convenience (Cappel & Hayen, 2004). However, the diversity of user profiles can make designing e-learning platform a challenge, particularly in light of the high drop-out rates recorded in practice. To better understand this acceptance-discontinuance anomaly, we sought to elucidate differences in how users perceived the designed affordances of an open e-learning platform in order to better understand the 'design-reality gap' (Greenhalgh et al., 2010; Tuunanen & Peffers, 2018). Based on our findings, we contribute insights into seven affordances provided by open e-learning platforms: *Informing*, *Assessment*, *Synthesis*, *Emphasis*, *Accessibility*, *Navigation*, and *Goal-planning*. In the following section we discuss each of these affordances in turn and provide recommendations on how to bridge gaps between user-perceived affordances and an open e-learning platform's design going forward.

The *informing* affordance calls on users' cognitive abilities to comprehend content, solve problems and make sense of possible actions (Bower, 2008; Cidral et al., 2018; K.-M. Lin, 2011; Sun et al., 2008). We find that effectively designing for this affordance requires that designers cater to users with different levels of prior knowledge so they can comprehend content and deep dive into selected sections. Our findings suggest that avoiding wordy formulations is key to organising information, especially as literacy skills differ in adult populations. For instance, 17.9% (1 in 5) of adults in Ireland have a literacy levels at or below Level 1, considered to be 'very poor literacy skills' (OECD, 2015). Effectively designing for this affordance is necessary to provide gradated challenges in open e-learning and

accommodate the diversity of users' backgrounds, learning profiles, and tech savviness, so they can undertake the actions they may wish to pursue (Walji et al., 2016). Findings suggest that the *assessment* affordance can help here by strengthening users' comprehension of possible actions through quizzes, and their reflections on different action outcomes (Cidral et al., 2018; K.-M. Lin, 2011; Sun et al., 2008). Less knowledgeable participants noted it was essential for instructional content to be supplemented by quizzes to provide feedback on learning, with errors explained to assist in user self-reflection (Cappel & Hayen, 2004). Given the emergent nature of open e-learning design, informing and assessment affordances need to be re-structured each time new features are added or removed.

We also find that the *synthesis* and *emphasis* affordances both supported learning through the internalisation of knowledge and management of expectations (Bower, 2008; Deng et al., 2010; K.-M. Lin, 2011). These affordances may in turn facilitate improved information quality for both knowledgeable and less knowledgeable users, a key antecedent of user satisfaction in e-learning (Cidral et al., 2018; Esteban-Millat et al., 2014; Mohammadi, 2015; Sun et al., 2008). Pilot results also show how the related design affordances of *navigation* and *accessibility* support ease of use. This is important for allowing users to achieve "flow" by concentrating on what they are doing, to the exclusion of other stimuli (Deng et al., 2010; Esteban-Millat et al., 2014; Pallud & Monod, 2010). Lastly, we see how the *goal-planning affordance* transforms user learnings into possibilities for action, once cognisant of the resources available to them (Strong et al., 2014). User perceptions are tightly bound to the interaction between IT features and their goal expectations (Deng et al., 2010; Pallud & Monod, 2010). Through goal-planning, users may also derive symbolic expressions which they attach to an open e-learning platform (Markus & Silver, 2008; Pallud & Monod, 2010). This goes beyond technical considerations, and requires equal concern for users' positive and negative emotive responses (Pallud & Monod, 2010).

Table 4 provides recommendations on how to close the design-reality gap in open e-learning by delivering affordances which are interesting, relevant, and possible for diverse user groups.

Affordance	**Recommendations for bridging the Design-reality Gap**
Informing	The informing affordance must cater to the diversity of users' backgrounds, learning profiles, and the different goals and actions they may wish to pursue. This is achieved by calling on users' cognitive abilities to comprehend content, solve problems and make sense of possible actions. Open e-learning must offer gradated levels of difficulty and complexity to appeal to a wide range of user abilities.
Assessment	The assessment affordance must strengthen both knowledgeable and less knowledgeable users' comprehension of possible actions through tailored quizzes. This provides a space for user reflection on different action outcomes and helps in bridging the gap with the informing affordance of open e-learning.
Synthesis and Emphasis	The synthesis and emphasis affordances must support different user groups' internalisation of knowledge and management of expectations. These affordances may in turn facilitate improved information quality as a key antecedent of user satisfaction in open e-learning.
Accessibility and Navigation	Accessibility and navigation affordances must cater to users with different levels of tech savviness. Designing affordances for these different user groups can allow them to better achieve "flow" by concentrating on what they are doing, to the exclusion of other stimuli.
Goal-planning	The goal-planning affordance must transform the learnings of different users into possibilities for action, while being cognisant of the resources available to them. This fosters symbolic expressions (e.g. 'helpful', 'useful') which users then attach to an open e-learning platform.

Table 4. Implications of Affordances for the Design-reality Gap in Open e-Learning.

Building on Affordance Theory, we develop insights into how designers might appropriate an open IT artefact to ensure *affordance personalisation*. This can ensure features are changed to match user expectations and contextual constraints (Leonardi, 2013). Designers of open IT artefacts must therefore seek to deliver clear action-oriented content aligned with user needs. We propose that the inclusion of personalised content for knowledgeable, and less knowledgeable users may support continuance behaviour in open e-learning by helping different user groups to recognise how the system is facilitating the achievement of goals (Strong et al., 2014; Volkoff & Strong, 2013). In addition, our findings suggest that functional affordances may play a mediating role between the features of an open e-learning platform and users' satisfaction. Findings suggest that well-designed affordances may combine to improve user satisfaction by driving them towards the achievement of individual and collective goals i.e. more environmentally sustainable choices. This can also promote better user experiences through cognitive absorption in relevant content (Esteban-Millat et al., 2014).

In open e-learning, we therefore recommend that affordances should be designed with personalisation in mind, supporting enhanced alignment between diverse actions, user goals, and tasks (W.-S. Lin & Wang, 2012). To that end, the openness of e-learning must be complemented with ongoing collaborative and iterative revision to ensure the needs of new users are embedded in the existing platform, in turn delivering an emergent and continuously realigned platform. We recommend that differing piloting techniques also be adopted to offer complementary insights from different user groups. Focus groups can be used both as a self-contained method or as a complementary method to other ways of generating data such as individual surveys. As stated by one focus group from Finland: "*it's good to discuss it in a group… it brings more in the end than just individual work... I only look at [it] from my perspective, but I don't know the other, so it's good to hear*". Summary information from survey instruments also provide supportive comparative data on a quantitative scale.

Lastly, we suggest the need for cross-national studies to support open IT artefact design for diverse groups. As suggested by Affordance Theory, the interrelated functional affordances which make up a technical object may be perceived differently across context of use (Strong et al., 2014). Although methodological challenges exist when conducting cross-country studies, the involvement of diverse user groups is crucial for informing the development of open e-learning platforms going forward.

6 Conclusion

In this paper, we investigated the role of functional affordances for bridging the design-reality gap in open e-learning. Open e-learning platforms offer several unique advantages to users and instructors alike such as location flexibility, knowledge archival / storage, and the sharing of digital content made freely available online (K.-M. Lin, 2011; Zhang, Zhao, Zhou, & Nunamaker Jr, 2004). Nevertheless, there are often differences between the intentions of designers and the affordances as perceived by diverse user groups (cf. Design-Reality Gap) (Greenhalgh et al., 2010; Norman, 1988). For instance, design-reality gaps often emerge between the features of an open e-learning platform, and users' perceptions of its affordances as sufficiently interesting, relevant, and possible. This can impede the primary objective of open e-learning platforms to direct diverse users towards different possibilities for action through diverse learning paths or "Ladders of Change" e.g. Motivation, Exploration, and Action.

In order to better understand design-reality gaps in open e-learning, our research draws on case study findings from 'ACT4ECO', an open e-learning platform which aimed at educating consumers on how to make small changes in the home to increase their energy efficiency. Based on our findings, we present two primary contributions which will be of interest to academia and practice. Firstly, we inductively developed a taxonomy of seven functional affordances which can help designers understand the possibilities for action provided by open e-learning platforms: *Informing, Assessment, Synthesis, Emphasis, Accessibility, Navigation,* and *Goal-planning*. We contribute recommendations for supporting the design of more user-centred open e-learning platforms through iterative and collaborative piloting with diverse user groups. The insights gained from this can help designers, developers, and instructors to enhance the delivery of open e-learning, and ultimately deliver more positive user experiences (Leonardi, 2013). Secondly, we suggest the personalization of open e-learning affordances may be pivotal for bridging gaps and accommodating different learning profiles (e.g. experts vs. less

experienced users), demographics, and contextual factors (Esteban-Millat et al., 2014; Sun et al., 2008). Our research contributes practical insights into the importance of user engagement in open e-learning, not only for identifying the affordance gaps in technical development, but also in gauging user satisfaction and continuance behaviour.

In terms of future research, we suggest that the recommendations presented in Table 4 for closing the design-reality gap could form the basis of design requirements or principles in open e-learning development going forward (cf. Gregor et al. 2020). While it was outside the scope of this paper to evaluate design principles for e-learning, the insights provided can act as a springboard for further research. We recognise that generalisability cannot be claimed due to limitations inherent in the current sample size; therefore, future research efforts will seek to collect large-scale feedback from diverse user groups across different national contexts as well as other open e-learning platforms. This may involve measuring the usage statistics of open e-learning platforms such as the number of actions recorded, and quizzes attempted to further understand the impact of functional affordances. One limitation of the paper is that the case study was primarily focused on the initial stages of designing the open e-learning platform. Future studies can seek to provide a longitudinal analysis of the impact of functional affordances from design to the implementation stages of IS development.

7 Appendices

Demographics		**Ireland**	**Finland**
Age range:	18-24 years	0% (0)	38% (5)
	25-34	40% (6)	38% (5)
	35-44	20% (3)	8% (1)
	45-54	7% (1)	8% (1)
	55-64	26% (4)	8% (1)
	65+	7% (1)	0% (0)
Gender:	Female	53% (8)	76% (10)
	Male	47% (7)	24% (3)

Appendix 1. Demographics for the Irish and Finnish Participants.

Topics	**Scales**
Location & Living: 1. Where do you live? 2. What type of home do you live in? 3. Who owns the property? 4. How is your home heated?	1. Town/City/Countryside/Coast. 2. Flat/Shared Accommodation/ Terraced House/Semi-Detached/Detached/Other. 3. Private Landlord/Company/Me or Spouse/Relative/Other. 4. Electric/Gas/Oil/Other.
Prior Knowledge: 5. I am energy-aware e.g. I am interested in energy use in the home, I read my energy bills. 6. I'm knowledgeable about energy issues e.g. I read documents or other material on this topic. 7. I rate my skills in technology as?	5. Very Good – Very Poor 6. Ver Good – Very Poor 7. Very Good – Very Poor
eLearning & Act4Eco evaluation: 8. Evaluation on the look and design of Act4Eco 9. Evaluation on the Act4Eco homepage 10. Evaluation of sign-in for Act4Eco 11. Evaluation of Action sections	8. Strongly Agree – Strongly Disagree 9. Strongly Agree – Strongly Disagree 10. Strongly Agree – Strongly Disagree 11. Very Easy – Very Difficult

Appendix 2. Sample of other Act4Eco survey instrument categories.

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