
Blurred Lines: How Does Cross-Disciplinary Research Work In Practice

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Abstract

This paper describes how cross-disciplinary research works in practice, illustrated through examples and experience from two large cross-disciplinary domestic energy research projects. The paper discusses the challenges of working across disciplines in this context and suggests a framework which helps to bridge the gap between technology developers or engineers and householders.

Author Keywords

Cross-disciplinary; User Centred Design; Domestic energy demand reduction

ACM Classification Keywords

C.4 [Performance of systems]: Design Studies
D.2 [Software engineering]: Design tools and techniques, User interfaces
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H.5.2 [Information interfaces and presentation]: User Interface--- Ergonomics, User-centred design, Theory and methods, evaluation/methodology

General terms: Design, Human Factors

Introduction

Historically, there have been distinct boundaries between academic subject areas and even specialities within those subject areas. However, more recently it has been acknowledged that for work in complex areas to be most effective, research between and across disciplines is necessary [1] and recent funding calls

have reflected this need for cross-disciplinary working [2]. This blurring of the lines between disciplines provides new perspectives to big research challenges, such as the reduction in energy demand [3,4], particularly in domestic properties, however, this collaboration can also result in more challenging working relationships [5].

The specific challenges associated with cross-disciplinary working, combined with the documented challenges of working within the home [6,7], present further complexities. By considering the home as a holistic system, the tension of exploring an engineering solution within a social environment must be managed. This can raise interesting questions of how engineering problems are researched, when those with the expertise to do so may not have the appropriate social research skills. Carrying out research within the home requires an interface with the lives of participants. Disruption to daily life should be minimal, whilst still enabling the collection of useful data. This requires maintaining a balance between meeting the engineering and monitoring needs of a research project whilst keeping the householders happy and disturbance to a minimum. In addition, there are particular challenges when designing innovative or future technologies for the home, where user wants and needs relating to specific technological solutions must be gathered. This paper focuses on the cross-disciplinary role which bridges this gap between the technology developer and the householder.

The research

This paper draws upon the work of the CALEBRE project (October 2008 - April 2013), funded by the Research Councils UK (RCUK) Energy Programme and E.ON, and

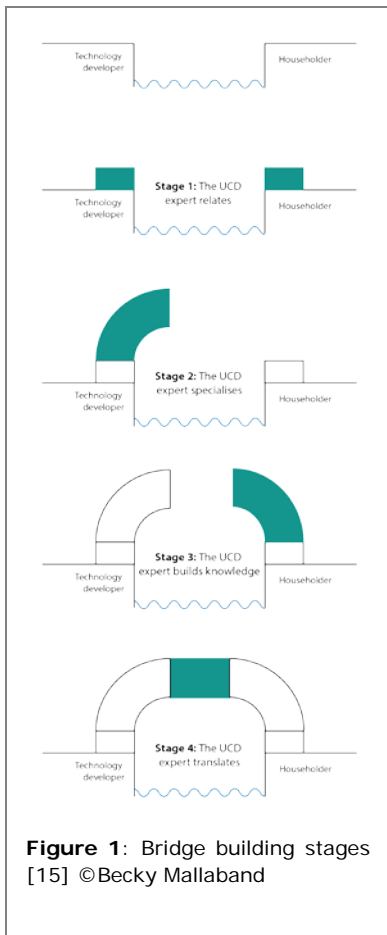
the DEFACTO project (October 2012 - October 2017) also funded by the RCUK's Energy Programme.

The CALEBRE project aimed to establish a comprehensive refurbishment package for reducing domestic carbon levels that was specifically acceptable and appealing to householders and through this central focus on users, brought together technology developers, User Centred Design (UCD) experts and specialists from other disciplines. Through the successful completion of the CALEBRE project, many lessons were learnt in relation to cross-disciplinary working. Some of these have since been applied within DEFACTO, another cross-disciplinary project involving engineers & UCD experts, which aims to investigate how the use of digital control and feedback technologies in the home enable reduction and management of heating energy use.

Whilst the multi-disciplinary work conducted on the CALEBRE project was effective and resulted in significant advances in understanding (demonstrated by a range of published multidisciplinary papers [e.g. 8, 9, 10]), the DEFACTO project seeks a greater level of integration and collaboration in order for researchers to work together to investigate the research questions with a shared methodological approach [11].

Methods

The CALEBRE project included a householder study conducted in the home, to provide information for the user centred design experts and the technology developers. It became clear that there were specific challenges with this type of collaboration and therefore certain skills and activities were identified which could help to build bridges between the disciplines. To



explore these further, semi-structured interviews with three UCD practitioners and four engineers were used to investigate past experience of academic researchers working on cross-disciplinary research across engineering and UCD domains. This particularly related to research in the home, to see if the experiences of researchers on the CALEBRE project were typical. Questions focused on any issues researchers had experienced as well as ways they had found which improved working with those from other disciplines. All participants had more than 10 years' experience in their area of expertise, had participated in cross-disciplinary research projects and had commercial or consultancy experience, which ensured they had a broad range of collaboration experiences to draw upon. All participants had experience as a principal or co-investigator of a research project, meaning that they had an overview of a collaborative research project in addition to their own cross-disciplinary research experience. The information gathered from these interviews, along with evidence from the CALEBRE project, enabled reflection on the nature of cross-disciplinary research and role of the UCD expert, which led to the conceptualisation of four key stages to support cross-disciplinary working. In addition, six principles for effective cross-disciplinary working were identified and then evaluated using an online survey with 52 academic respondents. Both the stages in cross-disciplinary working and the finalised principles are presented in this paper.

Learnings from the CALEBRE project

As already mentioned, monitoring energy use within the home has particular challenges due to the use of an engineering approach within a social environment. Through the CALEBRE project, this tension was

managed by the UCD experts who had good social and communication skills [12] and who were able to liaise across disciplines [13], effectively building bridges. The framework developed (see Figure 1) sets out four ways in which the UCD expert intermediates between the end user (or householder) and technology developer at different stages through the project: the UCD expert relates, the UCD expert specialises, the UCD expert builds knowledge, the UCD expert translates.

In order to demonstrate this process and illustrate the stages, the physical act of building a bridge has been used. This is intended to help those involved in cross-disciplinary working, particularly when relating to the home, to visualise and understand the different stages which need to occur in order to develop strong and effective working relationships and valuable collaborative results.

Stage one: The UCD expert relates

The first stage in the process of building a bridge between the householder and the technology developer begins with laying foundations on both sides. This is a relational foundation, enabling the building of trust and rapport. This is done through communication and contact with both the householders and the technology developers, predominantly through face to face meetings, but also through emails and other remote forms of contact. This builds an understanding of the householders' or technology developer's point of view, priorities and level of understanding, which further enhances communication.

Failure to complete this stage successfully or a breakdown in relational foundations can prove detrimental to the research. If relations with the

Examples:

CALEBRE: Interactive timeline activity used to gather information and build relationship with householders [13]



Figure 2: CALEBRE timeline exercise ©Loughborough University

DEFACTO: Project branding ensured a professional approach and uniformed contact



Figure 3: DEFACTO project branding ©Loughborough University

householder are damaged, this can make it difficult to acquire knowledge and information from them, due to a lack of trust and engagement in the research. This is why it is so important to ensure care and time is taken to establish a relationship with the householder early, from recruitment onwards. Likewise, if relations with the technology developer are damaged, then this may prevent them receiving appropriate information, or not appreciating the value of the information being provided, meaning they are not able to include the user research within their product development.

Whilst every effort may be made to build these relational foundations early on in the research process, the collaborative nature of cross-disciplinary research means that there are likely to be tensions along the way. Those from different disciplines may be compared to those of diverse nationalities with different languages and cultures, which can understandably lead to misinterpretation and confusion. Coupled with the multi-cultural nature of research teams, it is clear to see how simple relational breakdowns can occur.

In practice: In the CALEBRE project, this relational foundation was built with the technology developers through regular meetings and a series of more formal interviews, exploring the development of their technologies, the problems they were trying to resolve and the information they needed from end users. With the householders, relational foundations were established through activities at the beginning of the data collection process, planned to help put the householder at ease and build a trusting relationship. These included discussing how long they had lived in their home and what work they had done to improve it, using a magnetic timeline tool, see Figure 2 [7, 14 & 15

describe these methods in more detail]. All methods and investigations then built upon these initial relational ties.

In the DEFACTO project, much of the initial interaction with householders was conducted from a distance, due to the nature of the recruitment process. This provides additional complexity to building a relationship with the householder. Project branding was developed so that all literature and communication from the project team was recognisable and consistent (see Figure 3). This was intended to provide a professional appearance, to help increase the level of trust participants placed in the project. Information sheets were provided to all interested participants which included photographs and names of the research team. This was intended to prompt some level of familiarity from the outset, in order to reduce some of the barriers which may be experienced when communicating with a stranger. In addition, one member of the research team held the '*cohort interaction*' role and managed communication with householders, and therefore most of the contact came directly from them or had been approved by them. Part of this role was also as a '*gate keeper*' to the householders, protecting them from unnecessary hassle and contact. Although necessary for the participants, this role has the potential to cause tension within a project team, particularly where requests to contact the householder are overruled.

All emails were sent from a project email address (to ensure continuity) but were signed from the cohort interaction researcher, to give the feel of personal contact and continuity. Any interviews with householders were then attended by this researcher (and a chaperone) which meant that the householders

had already experienced a level of contact and relationship which could then be built upon during the interview.

Stage two: The UCD expert specialises

Following the establishment of relational foundations with the technology developer and the householder, the UCD expert is then able to provide specific user information. The engineer or technology developer is likely to have very specific questions which need answering, whether that be in relation to users' preferences and habits or specific data and monitoring of appliances and energy usage. Due to the difficulties of cross-disciplinary working discussed previously and a difference in the skill sets of experts, a specialist is needed to effectively extract and obtain this information from users. This first requires the relational building with the engineer, in order to understand what they need from the process and why. This requires '*immersion*' so that there is a level of understanding by the UCD expert and often '*translation*' to understand how the needs of the technology developer can be transformed into a methodological approach that gathers the appropriate information.

In practice: In the CALEBRE project, this included activities such as householder interviews, carried out within the home, which investigated particular aspects of habitual practices relating specifically to technology design and a study into domestic hot water use, which provided specific information on the householders' practices and needs. This information was gathered with a range of tools [7], all of which were enabled through the prior relationship established with the householder.

In the DEFACTO project, engineers required particular information from the householders in relation to their house structure, heating system and energy use. Whilst some of this information was collected from the householders themselves, there were certain issues encountered when they did not have or know the particular information required. This raises the issue of relying on householders for more technical information and presumes a certain level of knowledge that may be missing. Part of this specialising stage is ensuring that the technology developer or engineer understands the nature and format of the information they will receive and, importantly, the practical challenges associated with research in homes, which may mean they will not necessarily receive full sets of the desired information.

Stage three: The UCD expert builds knowledge

As discussed, not only does the UCD expert collect information for the technology developer and aid collaboration between the disciplines, they also build knowledge relating to users and the process of investigating their needs in order to advance their own field.

When conducting this kind of socio-technical, collaborative research, it would be easy for the UCD expert to merely collect the necessary information in their role as the specialist; however, in order to ensure their knowledge base is extended, they must use the opportunity to gather specific information about users and the effectiveness of research approaches in this context. If not, it is likely that the UCD expert becomes a vehicle by which others conduct their research, limiting their own potential. However, much of this responsibility lies with the UCD expert to include the

set of principles to be considered during cross-disciplinary working were developed, evaluated and refined. The principles were intended to aid those conducting this bridging role when working in a cross-disciplinary context, particularly with technology developers, but are applicable for use by any member of a cross-disciplinary project team. Whilst they should be of particular use within the relationship building stage, they can also be applied through all stages of a research project. These six principles are:

Value: It is important to both respect and value those working within other disciplines. This includes both the individual, their work and their opinions. Their input should be valued and trusted and you should be open to having your own ideas challenged. This in turn will help to facilitate good working relationships.

Immerse: In order to communicate successfully with someone from another discipline, it is important to spend time immersing yourself in their work and the wider context. Whether this be a particular product or an area of expertise, having a basic level of understanding will enable successful personal interaction.

Communicate: Findings and data should be communicated clearly, in a format that is easy to understand and requires little explanation. Care should be taken to present results in an appropriate format for the audience. Communication of findings should occur throughout the process, not merely at the end.

Translate: In order to encourage understanding between disciplines, it is important to translate information into a format that others can easily

understand. This should not include discipline-specific vocabulary and where relevant, acronyms should be expanded and explained. Where possible, time should be taken to understand the preferred methods of communication used by others.

Rapport: It is necessary to establish a good rapport through regular contact with the people you are working with across disciplines. Frequent face-to-face contact is ideal where possible and time should be devoted to building relationships through contact in the early stages of the project. This may be through project meetings, informal discussions, email exchanges or by other means.

Iterate: Both the working relationship and the research carried out should be developed in an iterative nature. The product, project, system etc. should be developed through teamwork and regular contact, returning to previous stages to evaluate and expand.

Conclusion

This paper has highlighted the ways that blurred lines both between disciplines and between experts and users can be bridged through four distinct stages: relating, specialising, building knowledge and translating. This highlights the importance of strong relational foundations and how these should form the basis of cross-disciplinary work. The set of six principles to aid cross-disciplinary working, particularly in the relationship building stages, further expand on how researchers from different disciplines can work together to improve the quality of the cross-disciplinary research, essential in domestic energy demand reduction.

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