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Factors Influencing Adoption And Non-Adoption Of Cyberinfrastructure By The Research Community

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FACTORS INFLUENCING ADOPTION AND NON-ADOPTION OF CYBERINFRASTRUCTURE BY THE RESEARCH COMMUNITY

Research-In-Progress

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Abstract

Technology adoption has received a great deal of research attention in information systems. While the results are quite consistent in workplace settings, only limited attention has been paid to assessing the conditions – e.g., adopters, context – that influence relationships in existing models. Cyberinfrastructure -- integrated computing, storage, and collaborative infrastructure – represents an underexplored technology. Likewise, the adopters of this technology, i.e., researchers, represent an underexplored audience for technology adoption. In order to understand the factors influencing adoption of this technology by these users, we employ an open-ended interview among members of a scientific research community. The goal of the interview is to elicit researchers' beliefs in order to understand the reasons they do and do not choose to participate in cyberinfrastructure projects. The focus of this research is one particular cyberinfrastructure known as the iPlant Collaborative. The results of this research-in-progress will contribute to the literature on technology adoption and provide valuable guidance for research institutes and governments that fund large-scale cyberinfrastructure projects to support multi-disciplinary collaborative research.

Keywords: Technology Adoption, Theory of Planned Behaviour, Cyberinfrastructure, Interview

1 INTRODUCTION

Technology adoption has received a great deal of research attention in information systems (IS). While most studies focus on workplace adoption (e.g., Venkatesh et al. 2003), some researchers have explored adoption in other contexts, such as the household (e.g., Brown & Venkatesh 2005; Venkatesh & Brown 2001). Additional research has examined specific types of systems, such as electronic medical records (e.g., Kohli & Kettinger 2004; Venkatesh et al. 2011) and e-government (Chan et al. 2010; Hu et al. 2009). The varying findings associated with different contexts and different IT artefacts, highlight the importance of a continued examination of the nuances that are important in distinguishing various technology adoption models.

One particular IT artefact that has received only limited attention in the research literature is cyberinfrastructure. According to the United States' National Science Foundation (NSF), cyberinfrastructure integrates hardware, data, networking capabilities, software, and other tools needed to support advanced scientific computation (Atkins et al. 2003). The goal is to provide support for research that extends beyond traditional thinking and tools, and enables scientists to answer grand challenge or moon shot questions. In these environments, researchers are asked to adopt tools that can enhance their research productivity and can contribute to answering larger research questions. Participating in these activities requires a time commitment and a commitment to sharing. The time commitment is tantamount to volunteering and results in a reduction of time available to engage in one's personal research. The commitment to sharing requires a participant to provide (e.g., donate) data or tools to other researchers, potentially giving up some competitive research advantage. Further, adoption in this context can mean more than simply using a new tool, particularly for the earliest adopters. For these individuals, adoption means participating in development of and beta testing new tools. This combination of factors is quite different from the conditions under which workplace and household adoption occur, suggesting that existing models of technology adoption may need to be altered for this context.

Understanding adoption of cyberinfrastructure has direct implications for funding institutions and government agencies. NSF's rationale for initiating cyberinfrastructure projects has been to help researchers ask new and different questions and to provide the computational infrastructure needed to answer those questions (Atkins et al. 2003). The European Union is initiating similar projects (see European Commission 2011). But, the success of these initiatives is directly dependent on adoption of the tools by a wide swath of the community. Thus, understanding the factors influencing this community to adopt these tools is important, and understanding why researchers do not adopt them may be even more important.

This research in progress describes a study that is currently underway to collect data regarding the factors influencing research scientists' adoption and non-adoption of cyberinfrastructure. The objectives of this study are to: (1) identify the factors that determine cyberinfrastructure adoption among research scientists; (2) identify the factors inhibiting cyberinfrastructure adoption; and (3) develop a model of cyberinfrastructure adoption.

2 LITERATURE REVIEW

2.1 Technology acceptance

There is a long and rich history of adoption research in the IS field (e.g., Compeau & Higgins 1995; Davis et al. 1989; Karahanna et al. 1999; Taylor & Todd 1995; Thompson et al. 1995; Venkatesh et al. 2003). This body of work has identified a variety of characteristics that influence the adoption of technology in the workplace. These characteristics include usefulness, ease of use, the influence of peers and superiors, as well as conditions that facilitate adoption. The majority of this research has been conducted in or for the workplace, with a fairly utilitarian focus (Brown & Venkatesh 2005; Venkatesh & Brown 2001).

Venkatesh and Brown (2001) argued that the workplace may represent an important boundary condition for adoption models. Under this view, they set out to identify the factors that influenced adoption and non-adoption of PCs in households. They found that workplace models did not account for some important components of household adoption, such as rapidly changing technology (i.e., fear of obsolescence) and declining technology costs. Their results uncovered several dimensions within each of the constructs contained in the Theory of Planned Behavior (TPB:Ajzen 1985; 1991), and demonstrated that the specific factors influencing household adoption, and more importantly non-adoption, are different from those influencing workplace adoption.

Research in healthcare technology adoption has also helped to identify important boundary conditions of existing models (e.g., Hu et al. 1999; Sykes et al. Forthcoming; Venkatesh et al. 2011). In the healthcare setting, multiple constituents, such as administrators, physicians, nurses, and staff members, are involved in the technology adoption process. The nature of the relationship between physicians and the hospitals adopting electronic medical records, for example, can have an impact on adoption (Kohli & Kettinger 2004). In a study of telemedicine adoption, Gagnon et al. (2003) found that factors such as professional and social responsibility, as well as a physician's self identity, contributed to adoption. These differences can be, at least partially, attributed to the nature of the positions these individuals hold and the professional culture associated with them (Kohli & Kettinger 2004). In general, this research demonstrates that there is a relationship between professional roles or career characteristics and the adoption and non-adoption of technology, at least in some fields.

The examples from the household and healthcare environments highlight two very important issues. First, context matters with respect to technology adoption. Second, the nature of the 'work' being done by individuals in the different contexts also matters. In the case of the household, some of the work was actually fun (i.e., hedonic outcomes), depending on who the target user was. Likewise, in the healthcare setting, individuals in different roles had differing expectations of the system, which led to different attitudes and outcomes with respect to adoption. These same elements are expected to matter when researchers are asked to adopt cyberinfrastructure.

2.2 What is Cyberinfrastructure?

Cyberinfrastructure refers to infrastructure based upon distributed computer, information and communication technology (Atkins et al. 2003). It is typically thought of as a 3-tier architecture comprising data storage and networking, software applications and algorithms, and user-friendly interfaces to access the applications and data. Interoperability is important in cyberinfrastructure for facilitating multidisciplinary projects. It is important to note that cyberinfrastructure is much more than high-performance computing and connectivity. Its purpose is to enable sharing, efficiency, and the availability of greater research capabilities across research communities. It is also focused on providing new applications and mechanisms for storing massive amounts of data that have been acquired over time, quite often decades. Ultimately, cyberinfrastructure offers the potential to conduct new and different types of research in new and different ways (Atkins et al. 2003). As a result, cyberinfrastructure projects are being initiated and/or considered in a variety of locations, including the United States (e.g., Atkins et al. 2003), the European Union (e.g., ELIXIR) and Australia (see NRIC 2010).

Examples of cyberinfrastructure projects include:

- NCEAS (National Center for Ecological Analysis and Synthesis; http://www.nceas.ucsb.edu/) supports cross-disciplinary research that uses existing data to address major fundamental issues in ecology and related fields, and their application to management and policy. NCEAS was established in 1995 and has a record of successful collaborations.
- The iPlant Collaborative (http://www.iplantcollaborative.org) is a multi-institutional effort to develop cyberinfrastructure to advance plant science research. It began in 2008 and includes cross-disciplinary teams working with iPlant staff to design and develop Discovery Environments -- "software platforms custom designed to help the team address a grand challenge question." Two grand challenge development projects are currently underway.

- ELIXIR (European Life Sciences Infrastructure for Biological Information; http://www.elixir-europe.org/page.php) aims to develop an "infrastructure for biological information in Europe to support life science research and its translation to medicine and the environment, the bio-industries and society." ELIXIR was initiated in 2008, and went through an extensive preparatory phase of inviting input and recommendations from the broader scientific community. The construction phase began in December of 2010.
- Project Bamboo (http://projectbamboo.org/) is a multi-institutional, interdisciplinary, and inter-organizational effort to bring together arts and humanities researchers, computer and information scientists, librarians, and information technologists. Project Bamboo in an emerging cyberinfrastructure project that aims to develop shared technology services. The goal of these services is to enable this diverse group of scientists to collectively engage in the enhancement of arts and humanities research.

These cyberinfrastructure initiatives have a number of things in common. First, they all rely on a core technology infrastructure that enables data sharing and collaboration. Second, the projects aim to build and sustain connections among individuals from different institutions and diverse disciplinary backgrounds, and in some cases different countries. While the ultimate outcomes are to share existing knowledge and generate new knowledge, cyberinfrastructure fundamentally changes the way knowledge is created and shared (Bottum et al. 2008; Dirks & Hey 2007; Wilbanks 2010). Finally, the success of these projects relies on their acceptance by a large swath of the communities impacted. The changes to the process of creating and sharing knowledge can be a significant factor influencing adoption in this environment, thus impacting the ultimate success of the projects.

2.3 The Adopters

In the case of cyberinfrastructure, the adopters are typically academic researchers[1]. Academic research careers represent a sort of hybrid where individuals simultaneously work for themselves and another entity (Enders & Kaulisch 2006). The individual is able to develop an identity and re-invent that identity over time, while still maintaining a relationship with the organization that employs him or her. The academic career can also be characterized as boundaryless (e.g., Baruch & Hall 2004; DeFellipi & Arthur 1994) because organizational (and disciplinary) boundaries matter less in an academic and professional career than in more traditional careers. With all of this flexibility in mind, it is still important to acknowledge that academic careers are embedded within a fairly well-defined hierarchical structure with established ranks and corresponding privileges (Enders & Kaulisch 2006).

An academic research career is built on an individual's ability to create new knowledge and thus obtain tenure and advance in rank within the hierarchy. The ability for an individual to advance is largely determined by their research productivity, even in situations where teaching is important (Huber 2002). Being part of a cyberinfrastructure project can potentially enhance an individual's research output. At the same time, however, participation can actually reduce any one individual's impact, due to the number of people involved in a project. This tradeoff between the potential for increased productivity and reduced reputation makes the decision to participate in a cyberinfrastructure project a difficult one to make, particularly for pre-tenure researchers.

In order for participation in a cyberinfrastructure project to be valuable to an individual, it must be seen as valuable in the larger research domain. Within the hierarchical structure of academia, this typically means that senior researchers, journal editors, and university administrators need to embrace the project and reward participation in it. However, this can also be a challenge as it requires more advanced scholars, typically older and having less exposure to technology than their more junior peers, to embrace something very new and different from what they know. The influence that these senior scholars have on a field's direction can be significant with respect to any change, particularly the introduction of cyberinfrastructure.

[1] Note that non-academics do participate in these projects, but since the overwhelming majority of participants are academics, that is our focus here.

In addition to career-related challenges associated with adopting cyberinfrastructure, there are also technical challenges, particularly associated with usability. In many ways, this group of users is not dissimilar from household and workplace users who prefer that technologies are easy to use (e.g., Brown and Venkatesh 2005; Venkatesh et al. 2003). It may, however, be more important with respect to cyberinfrastructure, for two important reasons. First, technology knowledge within a particular domain can vary greatly. While we would expect computer scientists to be comfortable with computing tools, we might also expect that those who study English literature or history would rely less on technology as part of their academic careers. Integrating these different groups into a cyberinfrastructure project, as Project Bamboo does, requires that significant attention be paid to usability issues. Second, ease of use may even be a pre-condition to obtaining the buy-in needed from senior scholars in a field. If, as stated above, senior people have less technology experience but a great deal of influence over what matters in a field, it becomes imperative to attend to ease of use issues in order to gain their acceptance.

3 MODEL DEVELOPMENT

Given our discussion of cyberinfrastructure and the academic research profession above, we aim to develop a model that identifies the specific elements associated with this context and this IT artefact. Consistent with the work of Venkatesh and Brown (2001), we frame our study within the TPB (Ajzen 1985; 1991). While TPB represents an overarching model, we expect that the specific factors within each dimension will be different when compared to other settings and contexts. Figure 1 presents our overarching research model, with some of the possible determinants that we describe below. Given our qualitative approach to the research, it is possible to identify constructs that may have stronger connections to other theories. We remain open in our approach, but use TPB as a starting point.

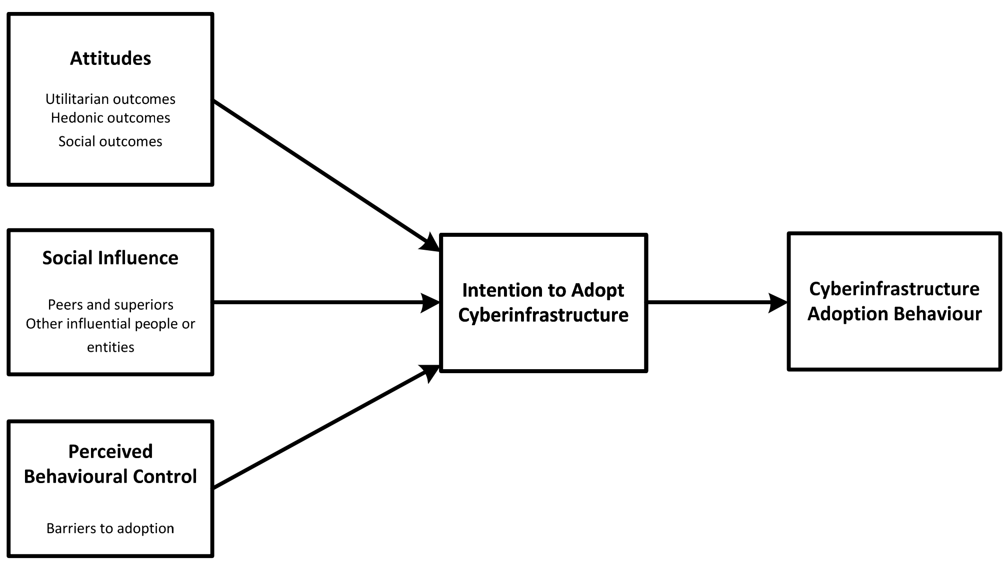

Figure 1. Overarching Research Model

We use Venkatesh and Brown's (2001) categorization of attitudes as consisting of utilitarian, hedonic, and social outcomes as a starting point. In the context of cyberinfrastructure, utilitarian outcomes may potentially equate with research productivity, while hedonic and social outcomes may or may not be important in this context. While social outcomes include 'status effects' in the household, we believe a new category, professional outcomes, may emerge and include reputation effects of participating in cyberinfrastructure projects. We do not expect to find hedonic outcomes, though we may find other attitudinal factors not previously identified.

The role played by the community with respect to accepting and appreciating cyberinfrastructure involvement represents an important aspect of social influence. Workplace models identify peers and superiors as having an influence on behavioural intention and household models identify friends and family members as important influencers. In the academic research environment, we expect there to be other important people and entities, such as editors and reviewers, that have significant social influence. We expect that friends and family members will not exert influence in this environment. Again, we may find additional social influence factors not previously identified.

Finally, Venkatesh and Brown identified a number of barriers to adoption in the household, classified within perceived behavioural control. Issues associated with pressure for tenure, fear of being 'scooped', and the time it takes to realize an impact from cyberinfrastructure research are likely to be identified in this context. It is unlikely that fear of obsolescence will be a factor here, as most cyberinfrastructure initiatives are targeted at leveraging new technologies to enable large-scale collaboration.

4 RESEARCH METHOD

4.1 Research Site

Our research population consists of Plant Science researchers. We chose this population for three important reasons. First, the iPlant Collaborative (www.iplantcollaborative.org) is a three-year old cyberinfrastructure project funded by NSF. iPlant's objective is to enable diverse groups of scientists to solve grand challenge questions in plant science through the development of a cyberinfrastructure. It is focused on providing a mechanism for sharing data and tools among plant scientists. iPlant's goal is to build CI to advance plant science research. The project was founded on the belief that CI is 'by, for, and of the community,' leading to an 'if they come, we will build it' approach. During the first year of the project, scientists came together to identify grand challenge questions and the cyberinfrastructure needed to answer them. Today, two of those projects are underway.

Second, participation in iPlant is open to researchers from a broad range of disciplines, including biology, ecology, statistics, bio-informatics, and computer and information science. This diversity of research interests makes iPlant a particularly interesting context for the current study. Third, iPlant is still early enough in its development, that the individuals participating in the project today would represent innovators and early adopters (Rogers 1995). Thus, we should be able to obtain a fairly accurate picture of the differences across these groups and the chasms (e.g., Brown & Venkatesh 2003; Moore 1999) that must be crossed in order to attract a broader range of participants.

4.2 Data Collection and Analysis

Our research method includes an open-ended interview that elicits the factors that influence both the adoption and non-adoption of cyberinfrastructure. The interview questions are presented in the Appendix. Two different interview scripts have been developed. One script is focused on current adopters, those individuals who are participating in the design, development, and beta testing of the cyberinfrastructure today. The second script focuses on plant science researchers who have not yet engaged with the project, but certainly could if they had the knowledge and interest to do so. Each interview takes approximately 30 minutes to complete. A pilot test of the interview process invited participants to participate in a telephone interview or type their responses to the script questions. We found the typed responses did not provide sufficient detail when compared to the telephone interviews, thus this option was discontinued for the full study. Data collection for the full study is currently underway.

All interviews will be transcribed after completion. After the interviews are transcribed, two research assistants will code the responses according to a "start list" (Miles and Huberman 1994, p. 58). This list includes definitions of key adoption determinants from prior technology adoption research. The start list for this project includes definitions from Venkatesh and Brown (2001) and Venkatesh et al. (2003). Following Venkatesh and Brown (2001), any responses that the coders are unable to match to a pre-existing definition, will be tagged. All tagged responses will subsequently be grouped into categories based on similarity. These responses will then be used to derive additional constructs, as needed. A card sorting technique will be used for this portion of the process.

5 EXPECTED CONTRIBUTIONS

The results of this research will contribute to the literature on technology adoption. By considering the specific characteristics of the adopter group and the IT artefact they are adopting, we will provide additional refinement to current technology adoption models. In addition, given the global nature of cyberinfrastructure initiatives, this research promises to provide guidance to scientists, governments and funding agencies regarding how to successfully reap the benefits of these investments.

6 CONCLUSION

This research-in-progress describes the motivation for and the design of a study to investigate the adoption of cyberinfrastructure by research scientists. Researchers' motivations for adopting and not adopting technology are expected to differ from those of employees in a traditional workplace, and from individuals in homes, two important contexts for prior research. The very nature of cyberinfrastructure, as a large-scale, shared resource, is expected to have a significant influence on adoption motivations in this context. The results of this research are expected to contribute to the broad body of research on technology adoption. In addition, the results should offer guidance to governments and funding agencies that are pursuing these initiatives.

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8 APPENDIX: INTERVIEW SCRIPTS

Interview for adopters: <*focus area of the questions*>

1. When did you join the iPlant Collaborative? <*adopter category*>
2. What are the reasons that led you to participate in the project? <*attitudes, social influence*>
    a. Note to interviewer: list each reason individually and ask them to rate their importance:
       Please rate <reason> on a five-point scale where 1 is not at all important, and 5 is extremely important.
3. About how fast are you at adopting new technology: Would you say you are among the first people to adopt a new technology? Do you prefer to let a few others test it first? Do you wait until a lot of other people are adopting it? Do you prefer to make sure it's generally accepted first? Do you wait until you have no choice but to adopt it? <*innovativeness*>
4. Do you participate in MyPlant? <*adopter category for MyPlant*>
    a. If yes, describe your participation (and why you participate) <*attitudes, social influence, barriers*>
    b. If no, why not? <*barriers*>
5. Of the people whose opinions matter to you, about what percentage of them are participating in iPlant? <*importance of social influence*>
6. To what degree does participating in iPlant help or hinder your professional status and reputation? Please explain. <*potential barrier*>
7. What, if anything, made or makes it difficult for you to participate in iPlant? <*barriers*>

Interview questions for community members:

1. Are you familiar with NSF's cyberinfrastructure initiatives? <*adopter category*>

If no, explain what they are and describe iPlant. And skip to ***(A)***
If yes: If you were to describe CI to someone, how would you do it?

2. Are you familiar with any specific cyberinfrastructure (CI) projects? If so, which specific one(s)? <*adopter category*>
   [if they do not list iPlant, ask – have you heard of iPlant?if they haven't, describe it and give them the web page: www.iplantcollaborative.org]
3. Are you currently participating in a CI project? <*adopter category; behavior*>
   If yes: which specific one(s)?
   What are the reasons that you decided to participate in the project? <*attitudes, social influence, barriers*>
   Please rate each of the factors you gave on a five-point scale where 1 is not at all important, and 5 is extremely important.

   If no: are you considering participating in a CI project in the next 6 months? <*intention*>
   If yes: which one?
   What are the reasons that you to want to participate in the project? <*attitudes, social influence, barriers*>
   Please rate each of the factors you gave on a five-point scale where 1 is not at all important, and 5 is extremely important.
   (*If no, see next if no)*

(A) *If they were not familiar with CI: "Given what I just described to you, would you consider participating in a CI project in the next 6 months?"*
If yes: What are the things that lead you to want to participate in the project? <*attitudes, social influence, barriers*>
Please rate each of the factors you gave on a five-point scale where 1 is not at all important, and 5 is extremely important.
If no: why not? <*barriers*>
What things stand in the way of your participating in a CI project?
Please rate each of the factors you gave on a five-point scale where 1 is not at all important, and 5 is extremely important.
What, if anything, would change your mind?

4. Do you think CI projects can provide effective ways to collaborate with others? <*attitudes*>

If yes, what makes it effective?
If no, why not?

5. Do you believe that social networking tools, like FaceBook, can help in the research process? <*attitudes*>

If yes, how?
If no, why not?

8. Do you use social networking tools in your research?
   Have you heard of MyPlant? <*adopter category*>
   (if they haven't, please describe; if they have, please ask if they are participating in it – how they are participating and what led them to participate)
9. About how fast are you at adopting new technology: Would you say you are among the first people to adopt a new technology? Do you prefer to let a few others test it first? Do you wait until a lot of other people are adopting it? Do you prefer to make sure it's generally accepted first? Do you wait until you have no choice but to adopt it? <*innovativeness*>
10. Would you be interested in learning to use technologies that would aid in your research? <*intention*>
    If yes, how do you believe they would help?
    If no, why not?

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