



Accelerating Cyberinfrastructure: Understanding Innovation Attributes and Adopter Categories of the Diffusion of Innovations Theory in the Context of e-Science

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Spring 2016, Chapman University; Orange, California



Introduction

The big data, e-science, and cyberinfrastructure (CI) movement is gaining increasing attention and momentum in the research community. CI can be considered as a complex system, involving a diverse network of interdependent technologies, remote instruments, big datasets, dispersed experts, diverse institutions, etc. (Kee et al., 2011). In order to understand the big data, e-science, and CI movement, it is essential to comprehend the complexity of the innovation itself (e.g., CI), and also the organizations through which it spreads.

Literature Review

Everett Rogers (2003) developed the diffusion of innovations theory (here after referred to simply as diffusion theory), a framework commonly used to understand innovation adoption. The theory, which is the most cited communication theory to date (Kee, forthcoming; Rice, 2009), describes a complex model of innovation attributes, adopter categories, diffusion networks, and opinion leadership which enable the adoption and diffusion of innovations.

Specifically, Rogers' (2003) diffusion theory discusses five main innovation attributes that influence the adoption of an innovation: relative advantage, compatibility, complexity, trialability, and observability. His theory also distinguishes five adopter categories based on the timing of adoption: innovators, early adopters, early majority, late majority, and laggards. These innovation attributes and adopter categories can be used to describe the objects and the people that collectively constitute CI.

Although the diffusion theory lends a model that predicts the spread of innovations, such as CI, it fails to address certain macro conditions that could affect the diffusion process. One such condition to consider is organizational capacity. Organizational capacity can be defined as "the processes, practices, and people that the organization has at its disposal that enable it to produce, perform, or deploy resources to achieve its mission" (Shumate, in press). Therefore, some e-science projects lack the organizational capacity needed to adopt CI and fail to embrace the technology.

Combining diffusion theory with the principles of organizational capacity allows for the potential to most optimally understand the diffusion of CI within the scientific community. Therefore, this study seeks to answer the question: "What are the relationships between organizational capacity and (1) innovation attributes and (2) adopter categories in the process of CI adoption?"

Methodology

This poster employed the grounded theory approach (Corbin & Strauss, 1990) and analyzed 15 interviews conducted with members in the e-science community, such as directors, domain scientists, and PIs. Participants were from a diverse range of institutions and states across the U.S. Following a semi-structured protocol, interviews were conducted by telephone. Guided by the stated research question, the co-authors performed multiple iterations of data analysis and literature integration, yielding preliminary findings presented in this poster.

Findings

Innovation Attributes and Organizational Capacity

Perceived Relative Advantage

An organization must have the capacity in order to recognize the advantage of an innovation over the idea it supersedes. When an organization has the capacity, it is able to progress and take on new innovations that are more beneficial for their projects. In the context of CI, integrating computational resources must be perceived as relatively advantageous.

- "You may not have something at your home institution or have direct access to something you can grow, but by working with places that do have the infrastructure, you are able to do bigger and better things" (Technologist, AZ, 4/29/16)

Perceived Simplicity

In order to make an innovation simpler, e-scientists must have the organizational capacity to lower the barrier of entry when integrating CI.

- "If the person using the technology feels like if they run into a problem, that there is some sort of issue, that it will get solved easily, then that will help out" (Developer, AL, 3/23/16)

Perceived Compatibility

In order for a tool to be perceived as compatible with the existing workflow, the organization must have a certain degree of organizational capacity. In other words, the capacity of an organization dictates what is considered compatible.

- "[Cyberinfrastructure] was new. It was a little-sized company, but a year later most of the companies were at the same level of network infrastructures and distributed computing. Maybe the bigger companies were earlier than we were because they had more money and more people to do it" (Administrator/Scientist Developer, IN, 3/23/16)

Observability

CI must be visible in the scientific community before it can spread. However, organizations must also have the capacity to (1) share their experiences about CI and (2) have the capacity to stay up-to-date with the climate of the community.

- "Conferences, better training to show students 'hey, if you adopt some of those tools or use it, you can get more of your research done or you can ask bigger questions'" (Administrator/technologist, CO, 3/21/16)

Trialability

Organizations must have infrastructure and policies in place that are conducive to experimenting with an innovation; such organizational capacity would remove barriers to entry and potential users will be more likely to try an innovation.

- "If universities see the benefits of services on campus and provide the financial means, they give researchers the opportunity to test out the technology" (Administrator/Scientist Developer, IN, 3/23/16)

Adopter Categories and Organizational Capacity

Organizational Capacity → Adopter Category

Organizational capacity dictates where an individual falls on the adopter categories bell curve (See Figure 1). According to Shumate (in press), organizations must have a certain degree of capacity which will in turn enable stakeholders to produce, perform, or deploy resources. In the context of CI, this means that the infrastructure of an organization influences when an individual will adopt an innovation.

- "We are a research intensity institution and while we have to provide a stable platform for ongoing research, we always want to be on the leading edge of exploring what's new and fascinating out there in order to introduce appropriate technologies to our user base and bring them into the fold" (Administrator, UT, 4/6/2016)
- "I think my company is more aggressive than me and it has to do with the fact that I build production systems but the core business of NCSA [National Center for Supercomputing Applications] is machines, like Blue Waters" (Administrator, IL, 4/5/16)

Adopter Category → Organizational Capacity

Conversely, characteristics of an individual (e.g., innovator, laggard) can influence the capacity of their organization. For example, an innovator may carry their organization forward, however, a certain degree of organizational capacity must be in place in order for this progression to occur.

- "One of the organizations, one of the factors was they were not willing or open to change. Here, they let me run with ideas. The trouble is finding resources to do it, but I have the freedom to explore new ideas" (Administrator/technologist, CO, 3/21/16)
- "I guess I'm always looking at better ways to do things. I research it and if I think this will solve the problem better, then I might make the pitch whether to go with it or not" (Developer, AL, 3/23/16)



Figure 1. Adopter Categories

Conclusion

In answering the research question, "What are the relationships between organizational capacity and (1) innovation attributes and (2) adopter categories in the process of CI adoption?", we can conclude there are existing relationships between organizational capacity and elements of diffusion theory (i.e., innovation attributes and adopter categories). Specifically, this poster sets forth that organizational capacity affects the (1) attributes of a tool, in that a certain degree of organizational capacity must be in place in order for tools to have desirable attributes. Furthermore, organizational capacity has a complicated relationship with (2) adopter categories. At times, the capacity of an organization will affect a stakeholder's ability to adopt; conversely, there are times when the characteristics of the adopter will affect an organization's capacity.

When discussing organizational capacity in relation to the diffusion of innovations, one must consider the complexities of an innovation. In other words, each innovation is composed of a range of components and requires different amounts of coordination. A cooking-related analogy could be: if you are making chocolate covered strawberries, you simply dip a strawberry in a bowl of melted chocolate; but, if you are baking chocolate chip cookies from scratch, you need a long list of ingredients and certain appliances. When deciding on which dessert to serve, you must consider what you *have* available and what you will *need*; this assessment also stands true in the context of CI. Adopting an innovation, such as CI, requires a larger level of organizational capacity, as compared to less complex innovation. In order to more fully understand the relationship between organizational capacity and (1) innovation attributes and (2) adopter categories in the process of CI adoption, future research should consider another critical component of diffusion theory: opinion leadership. Such future investigations will lend to examining diffusion theory as a whole, as it relates to organizational capacity. Ultimately, findings will reveal strategies to more effectively facilitate organizational capacity and increase diffusion of CI.

References

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