Bridging the Gap: Training Strategies to Advance the Adoption of Cyberinfrastructure by Researchers

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Introduction

Innovations and technologies go hand in hand, and almost seem inseparable. However, what exactly is it that makes a new piece of technology able to diffuse amongst the general public? Facebook and Twitter are popular social media platforms that reaches roughly 2.27 billion people worldwide and 335 million people worldwide, respectively (Zephoria, 2018; Statista, 2019). Facebook, for example, is a platform that is user friendly, and simple; which makes it easier to adopt. In essence, in order to use Facebook, all an individual has to do is point and click, leaving much of the complex coding and engineering to the developers. The nature of cyberinfrastructure is inherently complex and not highly compatible with traditional methods of conducting research in individual labs with desktop equipment. Including its multiple characteristics, layers, processes, and outcomes to define cyberinfrastructure yielded this precise, but hefty description of cyberinfrastructure as "…data-intensive, computationally powerful, distributed, hierarchical, interoperable, and with second-order growth…" (Kee, Cradduck, Blodgett, & Olwan, 2011, p. 159). Its definition is not simple to apprehend, or even conceive. As an innovation, cyberinfrastructure has some difficult barriers to overcome due to its complexity, which have slowed its adoption. Cyberinfrastructure is as much idea as it is hardware.

Literature Review

The nature of cyberinfrastructure is inherently complex and not highly compatible with traditional methods of conducting research in individual labs with desktop equipment. Hundreds of millions of dollars have been invested in CI projects such as XSEDE and its successor XSEDE2 (Kee, 2017), but a gap remains in connecting researchers to the appropriate CI tools. Including its multiple characteristics, layers, processes, and outcomes to define cyberinfrastructure yielded this precise, but hefty description of cyberinfrastructure as "…data-intensive, computationally powerful, distributed, hierarchical, interoperable, and with second-order growth…" (Kee, Cradduck, Blodgett, & Olwan, 2011, p. 159). Its definition is not simple to apprehend, or even conceive. As an innovation, cyberinfrastructure has some difficult barriers to overcome due to its complexity, which have slowed its adoption. Cyberinfrastructure is as much idea as it is hardware.

- Complexity and compatibility are key innovation attributes (along with relative advantage, observability, and trialability) in Rogers' theory of the diffusion of innovations (2003).
- For cyberinfrastructure (CI) to become more widely adopted, its relative advantages must significantly outweigh the complexity and incompatibility costs incurred in adopting it.
- Many words have been used to describe the activities and the roles of change agents in the diffusion of CI-related knowledge: outreach, education, facilitators, consulting, advising, champions, workshops, and training.

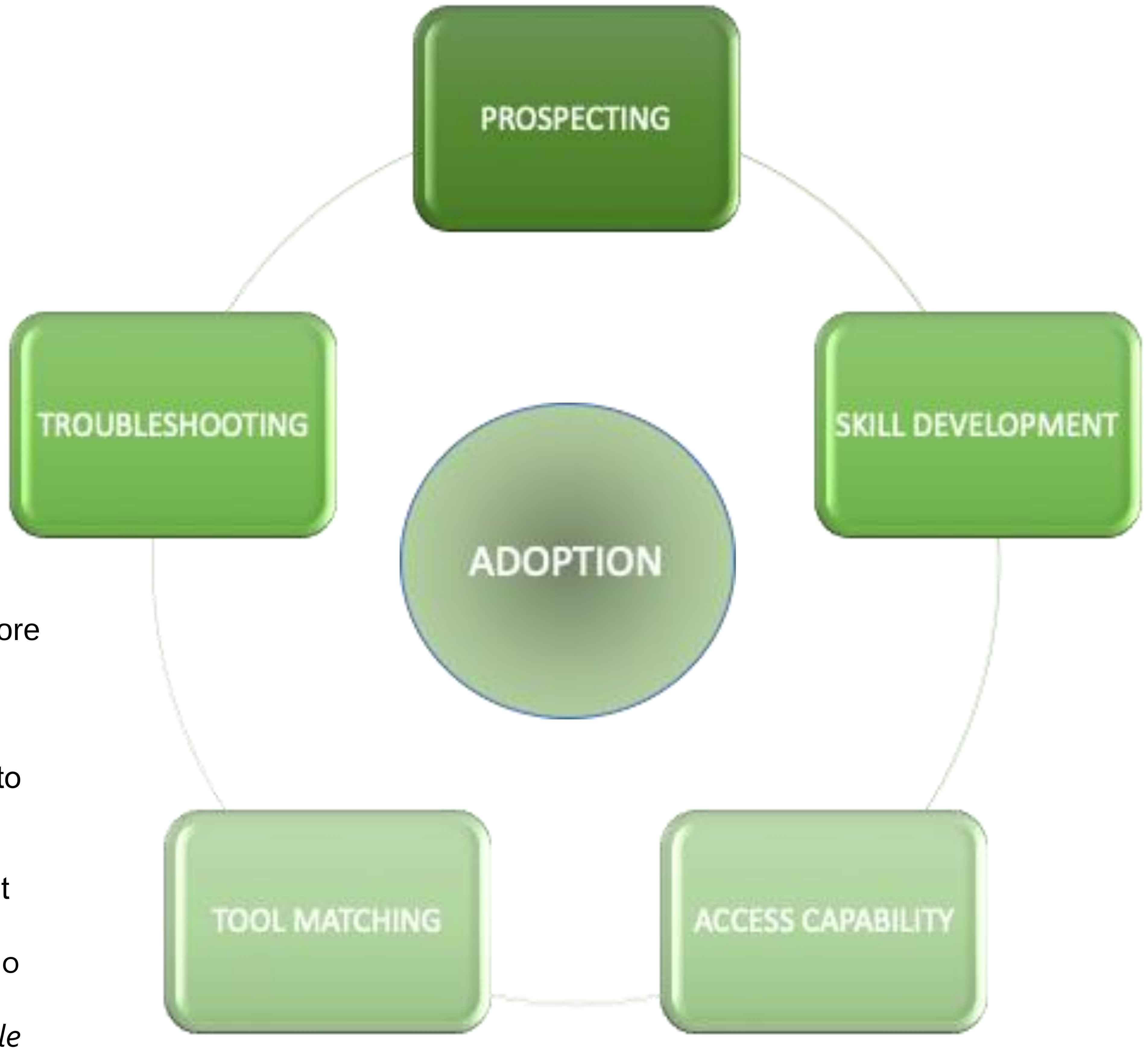
Efforts to increase adoption among researchers have not yet led to widespread use among most research communities. It is not because the advantages are not significant, nor that the complexity and compatibility barriers are necessarily prohibitive. The big questions about humanity that remain unasked and their answers which remain undiscovered are the driving reasons this paper's central *research question* is

"How can CI professionals optimize their training strategies to bridge the gap and allow for greater CI adoption by researchers?"

Methodology

The data for this paper is a subset of a larger data set collected for a larger project, which included 123 semi-structured interviews with 124 individuals (one interview involved two participants) between March 2016 and July 2018. Gender representation is almost four times more men (*n*= 97) than women (*n*= 26), partly because there are more men than women in the e-science community. Furthermore, their professional roles are represented by a diverse range of stakeholders, including scientists as users (*n*=6), technologists as developers (*n*=9), center administrators as facilitators (*n*=27), liaisons as outreach educators (*n*=5), and also informants who play a combination of the aforementioned roles (*n*=69). The bulk of informants who play multiple roles gives this data set a unique holistic perspective. Most informants had earned a graduate degree, and many had received a Ph.D. **In the subset of the data for this particular paper, we have more men (n=25) than women (n=4), which was anticipated based on the overall gender representation**.

TRAINING



Illustrative Quotes:

1. **Prospecting: "**As that possibility became increasingly realizable with more and more sophisticated computers and software tools…I [could run] computational laboratory experiments on dynamic systems and the interactions between people and the environment."
2. **Skill Development:** "…[Researchers] don't understand and are unable to grasp the complexities of the technology properly…but most of the impediments that we see are a lack of know-how and time.
3. **Access Capability:** "…it's not as simple as giving everybody an account and saying, 'Have at it.'"
4. **Tool Matching:** *"Here's what we can provide.", and then asking, "*What do you need?*" and then figuring out how to make those two come together."*
5. **Troubleshooting:** *"We do training and consultation and support so people that need help, get stuck– when you call office hours, we come in consultation…"*

Conclusion

Many innovations are able to diffuse rapidly and broadly among populations because they are relatively easy to understand and incorporate into people's lives. Cyberinfrastructure is unique in its scope and scale, which makes it an interesting context for the study of diffusion of innovations. The interviews revealed through redundancy and repetition that training (and similar terms) was critical for adoption. The purpose was to explore generalizable themes of training that could be used to guide facilitators, advisors, champions, and administrators in advocating for the adoption of CI. Prospecting, skill building, accessibility training, tool matching, and troubleshooting all emerged as important elements for training researchers. This study's findings also suggest a useful addition to Rogers' theory in that innovations with high complexity and compatibility may require training in addition to promotion by change agents. The training cannot be focused solely on advantages, but must take into account other factors such as skill levels, troubleshooting, and specific use-case scenarios to support and sustain adoption.

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