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Research-in-Progress

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Abstract

Despite decades of technological and organizational change our research in the area of technology adoption continues to use measures for constructs that were developed during the late 1980s and early 1990s. In this research-in-progress paper, we examine one such measure, computer-self-efficacy. We consider the implications of changing technologies and context and propose a new direction for conceptualizing and measuring self-efficacy. We present an updated conceptualization and a definition for a new construct called Technology Self-efficacy. We describe our process for developing the item pool for this new construct and outline our plans for testing the new instrument's validity.

Keywords: computer self-efficacy, measure development

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Research-in-Progress

Introduction

For more than 30 years, information systems (IS) researchers have examined user acceptance of information technologies (IT) in organizations. From the earliest studies (e.g, Robey and Zeller 1978) on, research has focused on variables associated with the technology, the organizational context and with the cognitions (i.e., beliefs and attitudes) of the individual users. Our interest in these concepts has persisted through decades of change in the technologies studied, the organizations in which they are studied, and in the experiences and capabilities of the individual users.

And yet, despite these changes in the context for use, research continues to draw on a relatively unchanged set of measures developed during the 1980s and 1990s. For example, Fred Davis developed popular measures of perceived usefulness (PU) and perceived ease of use (PEOU) for his doctoral dissertation at MIT, which he completed in 1986 and have not substantially changed since then. Similarly, the most commonly used measure of computer self-efficacy (CSE) was developed by Deborah Compeau in her dissertation, completed in 1992. These constructs remain central to our understanding of user acceptance, being frequently used to predict key outcomes such as use, innovation, exploration, and trust in technology. In particular, CSE has emerged as a recurring control variable in models of technology use (Johnson et al., under review)

While new theoretical lenses, such as the Elaboration Likelihood Model (ELM) or Expectation Confirmation Theory (ECT) have been applied to understand changes in the interplay among technology, organization and people, we have not seen corresponding changes in the operationalization of key concepts. We must not forget the need to consider the implications of such changes in substantive theories that explain and predict technology use for our theories of measurement, since substantive theory and measurement theory are intimately connected (Bagozzi 1984).

To that end, we have undertaken to critically evaluate the conceptualization and measurement of a core construct in the technology acceptance literature: computer self-efficacy. Based on our review of technological changes in the personal and work environment, we propose a new measure that reflects the contemporary context for technology use and that incorporates the findings of the past 25 years of CSE research. In this paper, we present our initial findings regarding the conceptualization of CSE, and outline our proposed measure. In the coming months, we will undertake to validate this measure and assess the implications of using or not using an updated construct in the face of substantial contextual change.

The Changing Landscape of Technology and Technology Use

Over the past three decades, technology has changed in many ways. Since the 1980s, the human-computer interface has moved from a command line interface, to one using touch, voice and even sometimes, with context-aware systems (Yoo 2010) that act without our knowledge. Since the 1990s, the hardware has evolved from a mainframe, to the PC, to client-server networked computers, and now to mobile devices operating in a complex ecosystem (Tiwana et al. 2010) with other types of computers. Since the early 2000s, although our initial devices were multi-purpose by nature (word processing, spreadsheets etc.), the number of applications embedded in our devices, and the domains to which they are relevant, have increased exponentially. This evolution of ubiquitous, cross-domain technology platforms enables individuals to seamlessly transition between work, social, entertainment and daily operations platforms.

As the platforms have evolved, individuals not only use technology differently but interact with it in more areas of the technology lifecycle. In the 1980s, users often depended on technicians for acquisition, implementation and the support of technology. Today, most users research, acquire, and maintain their personal technology without assistance from technicians. For example, slipstreaming updates in cloud infrastructure have almost eliminated the need for technicians who support to users updating their software. Thin clients and apps have minimized the need for maintaining large local applications to the point where applications are increasingly managed and maintained in the cloud without much user intervention. Rather than trained technicians, we have turned to YouTube videos, from manuals to online forums, from face to face support to remote access and from physical disks with software updates to cloud auto updates.

The Paradox

It is curious that in a field focusing on technologies which change frequently and often radically, we find ourselves using – largely without question – measures that were developed in a vastly different technology, user and organizational environment. How have we come to rely on such measures, and what negative consequences might such a reliance produce?

A review of some key historical touchpoints in the field perhaps illuminates this paradox. The first touchpoint is the conference presentation by Peter Keen at the first ICIS meeting in 1980 (Keen 1980), in which he offered an analysis of the forces that were challenging to the legitimacy of the IS field. An emphasis of his presentation was the importance of establishing a cumulative tradition. Keen argues that "unless we build on each other's work, a field can never emerge, however good individual fragments may be" (p. 9). This argument, then, set out the idea of building on one another's work (our definitions, topics and concept as he later notes (p.13)) was essential to our very existence as a legitimate academic field. The second touchpoint is a paper by Detmar Straub, which examined the state of validation of research instruments in IS (Straub 1989). A key recommendation following from his analysis was that "researchers should use previously validated instruments wherever possible, being careful not to make significant alterations without revalidating instrument content, constructs and reliability" (p. 161).

This historical exposition is offered not just as a way of understanding the time during which our measures were developed, though that is important. It is also offered as a means of understanding IS as a field today, and why we find ourselves, paradoxically, in a world of constantly changing technologies and yet with theories - and especially theories of measurement - that have not changed substantially since the late 1980s. The language of the cumulative tradition is an important part of our identification with the field of IS itself (Grover et al. 2006), and the importance of validation of research instruments is perhaps equally ingrained in our identities (at least in those of quantitative and positivist scholars) through our training as researchers and the practices of our journals. And thus, even as technology, people and organizational contexts have been transformed, our field continues to examine them using the lens that has become so much a part of our identification as a field.

In order to shed light on this paradox, we re-examine computer self-efficacy's conceptualization and measurement. CSE represents an interesting and instructive case study of measurement and technology acceptance, for several reasons:

- The mostly widely used measure of computer self-efficacy (CSE) was published by Compeau and Higgins in 1995, based on research conducted between 1989 and 1991, thus reflecting one of the older and more enduring instruments in the field.
- Computer self-efficacy has been shown to have robust effects on a variety of dependent variables, including outcome expectations (Compeau and Higgins 1995a), PEOU/PU (Agarwal and Karahanna 2000), perceived behavior control (Pavlou and Fygenson 2006), internet anxiety (Thatcher et al. 2007), and performance (Compeau and 1995b; Johnson and Marakas 2000)
- Self-efficacy theory (Bandura 1997) is based on a highly generalized concept (self-efficacy is thought to play a role in all (or almost all) domains of human functioning). But a key dimension of conceptualizing and measuring self-efficacy is an understanding of the behavioral domain, and this is where the changing nature of technologies may play a role.
- The measurement of self-efficacy has also seen a degree of controversy over the years (Claggett and Goodhue 2011; Marakas et al. 2007, 1998) which while separate from the discussion of "currency" or "updating" has implications for how we think through the problem. This addresses another of Boudreau et al's (2001) additions to the guidelines for validating research instruments.

The Evolution of Computer Self-efficacy

The concept of self-efficacy derives from the work of Albert Bandura. The earliest papers on the subject date back to the late 1970's, when Bandura proposed self-efficacy as "the conviction that one can successfully execute [a] behavior required to produce [an] outcome…" (p. 193). The introduction of self-efficacy was important because it added to the then dominant view that behavior was driven by beliefs that executing a behavior would result in desirable outcomes: outcome expectations in Bandura's terms, or behavioral beliefs in the language of the Theory of Reasoned Action (Fishbein and Ajzen 1975). As Bandura noted, "individuals can believe that a particular course of action will produce certain outcomes, but if they entertain serious doubts about whether they can perform the necessary activities such information does not influence their behavior" (Bandura 1977, p. 193).

Several studies in the mid 1980's applied self-efficacy to the domain of computing. Hill et al (1987) examined the influence of self-efficacy on the decisions of individuals to enroll in computer classes. They developed a 4 item measure of CSE to conduct their research (e.g., I will never understand how to use a computer). Gist et al (1989) examined the role of CSE and software specific self-efficacy (SSE) in training performance, using self-developed measured focused on different specific computer / software operations such as operating a micro-computer / writing a formula for addition. Compeau and Higgins developed a 10-item scale, adapting and extending the levels of support for completing a task from the instrument developed by Gist et al (1989). They focused their instrument on the completion of a hypothetical task using a novel piece of software

Although reviews of the literature demonstrate that Compeau and Higgins' measure has predominated (Johnson et al, under review), it has not been unchallenged. Marakas and his colleagues (Marakas et al. 1998, 2007) challenged the Compeau and Higgins conceptualization, arguing for measures that were closer to those developed by Gist et al (1989) which were more tightly tied to the domain for which self-efficacy was being considered. They viewed the Compeau and Higgins measure as too general, and thus not following Bandura's recommendation for tying self-efficacy judgments to the behavioral domain under study.

Claggett and Goodhue(2011) reviewed the two directions of self-efficacy measurement in IS and argued that the Marakas et al approach to measurement relates more to the underlying knowledge or skills of the user while the Compeau and Higgins approach relates more to the sense of psychological confidence. Moreover, they suggest that self-efficacy is most interesting when it relates to judgments that are not focused just on perceived skills but rather incorporate the individual's sense of psychological confidence. While the skills oriented measures may correlate more strongly with dependent variables such as task performance, they do not tell us much about the self-reflective process that the individual is engaging in, or how such beliefs might affect other outcomes such as choice behaviors, effort and persistence, or emotional arousal. These other outcomes, all of which are argued as important consequences of self-efficacy judgements, are more naturally linked to the psychological confidence.

Our review of the literature on computer self-efficacy demonstrates a number of reasons why updating of the measure might be necessary. In addition to changes in the technologies available, discussed earlier, we identified changes in the nature of users and the use experience. Technology users in the late 1980s were mostly digital immigrants (Prensky 2001) so the idea of dealing with never-before-seen applications was central to the experience. That level of novelty does not have the same resonance today as it did before. Certainly we are confronted with new applications, but the extent of novelty is lower and perhaps less relevant. On the other hand, technology today is more embedded in a wide range of our daily activities including both work and leisure activities. In essence, we argue that the meaning of the construct may have changed over time, and that for this reason the construct requires re-visiting.

A New Direction: Technology Self-efficacy

In order to develop a new conceptualization of self-efficacy that better reflects the world of 2016, we followed the recommendations of Mackenzie et al (2011). Their 10 step process begins with conceptualization and development of a definition, and continues through development of items, specification of the model (formative vs. reflective) and through scale validation and norm development. To date, we have completed our conceptualization, and we have developed a set of tentative items. Our development of the construct was also sensitive to the demands of contextualization (Hong et al. 2014), as our main goal in updating the measure of computer self-efficacy remains one of adapting to a new context (a new technology environment).

Defining the Construct

We began by reviewing the definitions of self-efficacy and computer-self-efficacy in 53 articles published in the basket of eight top IS journals, as well as articles published in management journals that had specifically measured self-efficacy. We compared these definitions to the definition of self-efficacy provided by Bandura (1997), along with key conceptual writings in the area of self-efficacy.

There is strong agreement on a number of factors important to defining the construct. First, CSE applies to the entity of a person. While some research in management has looked at collective efficacy (and such a construct is possible in the domain of IT) the emphasis of all of the IS literature has been on CSE as a property of an individual. Second, CSE is widely understood to reflect an individual's cognition. Most definitions mention terms like belief or perception. Moreover, the definitions reflect that self-efficacy is a belief *in one's ability or capability*. It is a state variable rather than a trait because it is expected to change based on experience (enactive mastery, vicarious experience, social persuasion and physiological states). Finally, it is defined with regard to a particular domain of functioning (Bandura 2006), though Bandura also notes that efficacy beliefs may co-vary across domains, especially when the "spheres of activity are governed by similar sub-skills" (p. 308).

We identified 2 key difference in the definitions with regard to the domain of functioning. The first relates to the use of technology as a means versus an end. Some definitions emphasize using the computer as the domain of functioning (or the goal). For example, Compeau and Higgins (1995) define CSE as "a judgment of one's capability to use a computer" where using the computer is the goal. Marakas et al (2007) is similar: "general computer self-efficacy (GCSE) refers to an individual's judgment of his or her ability to perform across multiple computer application domains". Other definitions, however, emphasize using the computer as the courses of action necessary to achieve some other goal, the accomplishment of the task. For example, Brown et al (2010) define CSE as an individual's "belief in his/her ability to use a technology to accomplish a task." Other definitions (e.g., Munro, Huff, Marcolin, & Compeau, 1997; Venkatesh, Morris, Davis, & Davis, 2003) are similar. In these definitions, the use of a computer as a task in itself is subordinated to the performance of a task for which a computer might be used. The device thus becomes a means to an end.

We view this distinction as important. Is the use of the technology the means to an end, or is it the end in itself. Is it an attainment, or is it part of the courses of action that must be orchestrated to realize the attainment? We believe that for the construct of technology self-efficacy, it is important to treat use of technology as an end in itself. It is certainly possible to conceptualize self-efficacy for tasks such as 'completing organizational budget forecasts' that might involve organizing and executing various behaviors such as estimating revenues and costs, predicting rates of inflation, and using a spreadsheet to compile the results, but if we are to understand how people react to technology across a range of situations in their lives, then we believe it is important to focus on the goal of using a computer.

The second main difference in CSE measurement relates to the level of specificity of the domain. The relative utility of a general "computer" self-efficacy vs. a more focused (e.g., application specific) self-efficacy is debated. The literature seems to find value in both, though the application-specific self-efficacy measures are expected to more strongly predict the performance of individuals as it relates to that domain. This debate within the IS literature is sometimes linked to the broader self-efficacy literature, where there is a discussion of the problem of "general self-efficacy". Bandura argues that there can be no universal self-efficacy that applies to all spheres of human existence. This begs the question of whether general technology self-efficacy is too broad a domain. We argue that technology use represents a reasonably tractable *domain of functioning*. Bandura (2006) reports on domains of functioning such as parenting, management, and self-regulation that are equally broad. We accept that more specifically defined self-efficacy (e.g., the ability to use a particular technology) will be more strongly related to some of these behaviors but we argue that there is value in being able to assess individuals' confidence in their technology abilities as a whole.

Before constructing our revised definition, we need to speak further about what it means to use information technology in today's environment. When Compeau and Higgins developed their measure of computer self-efficacy, they focused on use within the work environment of the 1990s, where computers and software were purchased and installed for users at work. But today, using an information technology requires more than just the interaction with a tool at work. Consider the use of a smartphone app. A person must be able to find the app, install it, complete the initial setup, interact with it, troubleshoot any problems, and keep it updated. He or she may also need to link it to other apps to share data. In the case of a device like a fitness tracker or a smart thermostat, similar selection, installation, operation and maintenance activities are necessary. Thus, when we refer to "using a technology", we refer to use in this broad sense, encompassing all of the activities of using a technology across its life cycle.

Based on this analysis, then, we define technology self-efficacy as *a person's belief in his or her capabilities to organize and execute the courses of action required to use information technology across its lifecycle.*

Item Generation

In developing items for our revised measure, we considered three possible directions: a simple updating of the Compeau and Higgins measure, following the measurement direction advocated by Marakas et al. (2007) and the development of a new measure, based on a variety of existing current measures. For the reasons stated above, we chose to the lattermost option.

Thus, we followed the process advocated by Bandura (2006) to identify new items. To assure content validity, we focused on individuals' judgments of what they can do (self-efficacy) as opposed to what they will do (intention) and we differentiated the construct from related constructs such as outcome expectations, emotion, and self-esteem. We sought to develop items that represented different gradations of challenge, as judgments about both simple and complex tasks are important to reflect an individual's confidence in their ability overall.

We drew in part of the work of Howard (2014). Howard proposed a 12 item scale that included items related to solving computer problems, dealing with unexpected events, and completing computer-related tasks. The importance of problem-solving as a reflection of CSE is important in 2016, and perhaps better reflects the context of use than does Compeau and Higgins' dealing with novel technologies. However, our measure focuses more broadly than just solving problems to reflect the idea that using a technology today requires more than just interacting with a piece of software installed on a device. Rather, we view use as requiring the marshalling of resources throughout the lifecycle of a technology – from initial acquisition to learning and using, to sharing and extending and to dealing with problems. In this sense, our measure of TSE corresponds to self-efficacy measures such as parenting or teaching which involve the engagement of broad repertoires of specific behaviors (Bandura 2006).

At this point, we have constructed a preliminary item pool, with 15 items as outlined in **Error! Reference source not found.**. The items are organized using the technology lifecycle, and can be applied to different types of technologies (single or multi-purpose devices, traditional software packages and apps).

We argue that our instrument is best modelled as a reflective measure of the construct. Four key questions (Jarvis et al. 2003; Petter et al. 2007) determine whether a measure is formative or reflective:

1. Direction of causality from construct to measure
2. Interchangeability of indicators
3. Covariation among indicators
4. Nomological net of indicators

In looking at our proposed measures of self-efficacy it is tempting to focus on question 3 above and suggest that the construct is formative because the items do not necessarily covary. A person who believes they can use the simple features of a technology does not necessarily think they can troubleshoot problems. However, we maintain that this conclusion would be inconsistent with the conceptual definition of self-efficacy. Bandura (1997) notes that "perceived self-efficacy is not a measure of the skills one has but a belief about what one can do under different sets of conditions with whatever skills one possesses" (p.37). Thus, skills and self-efficacy are differentiated. People with the same level of skill may exhibit different levels of psychological confidence, based on their experiences and attributions.

Thus, while it is empirically possible that someone would make different judgments about these two tasks, it is important to understand why someone would feel they could do one and not the other. We argue that modelling the construct as formative emphasizes the differences (the non-overlapping variance) in the items and thus more closely represents the individual's skills. Modelling the construct as reflective, by contrast, emphasizes the shared variance between the items and this is what we argue is the meaning of self-efficacy (Q1). Modelling the construct as reflective, in essence, treats differences in skills as part of the error term for each of the items. We believe this is precisely what Bandura meant by the statement that self-efficacy is what you can do regardless of the skills one possesses. Thus, while the individual items we have generated do represent slightly different tasks, we believe that the commonality between them best reflects the individual's self-efficacy judgment and thus that reflective measurement is the correct approach.

Table 1. Proposed Measure of Technology Self-efficacy

Technology is all around us, and every day we encounter technologies that we might be able to use in our lives. Using technology involves a range of different activities, from purchasing to learning to using to sharing. In the following questions, we will ask you about your confidence in dealing with the technologies that you encounter in your life. Please rate how certain you are that you can do each of the things described below by selecting the appropriate number on the scale.

Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

0	10	20	30	40	50	60	70	80	90	100
Cannot do it at all					Moderately certain I can do it					Highly certain I can do it

I can:

1. Scan my environment for useful new technologies
2. Purchase technologies that will help me.
3. Install / set up technologies
4. Integrate a technology with other technologies related to it
5. Adapt to new features and updates
6. Learn to use unfamiliar technologies
7. Use technologies for simple tasks
8. Use technologies for advanced tasks
9. Use technologies for new unintended tasks
10. Become skillful using my technologies
11. Troubleshoot problems
12. Keep it updated
13. Find support for problems that are beyond my abilities to solve.
14. Show people around me how to use it
15. Help others fix problems

To the extent that they represent different types of technology activities, one can also argue that the items are not interchangeable (Q2) but again, we emphasize that the aim of the construct is to identify the parts of the items that "share a common theme" (Stacie Petter et al. 2007, p635) related to confidence. Any differences in the responses that relate to differences in underlying skill should, according to the conceptual definition of self-efficacy, be removed from the meaning of the construct, leaving the psychological confidence (Claggett and Goodhue 2011) as the core of our measure.

Testing the Measure

Our next steps in the research are to test the new measure empirically, and assess its validity and utility in comparison to the original measure. Our intention is to conduct multiple studies, using a wide range of users including students and working professionals, and an array of technologies to assist in the assessment of generalizability.

Our first study (in progress now) will focus on validating the general version of the new TSE scale. We will conduct a large-scale survey measuring technology self-efficacy as well as key constructs for which discriminant validity must be established (e.g., outcome expectations, locus of control) and for which TSE should be a predictor e.g., technostress (Tarafdar et al. 2007), IT identity (Carter 2013), cognitive absorption (Agarwal and Karahanna 2000), perceived innovativeness with information technology (Agarwal and Prasad 1998), and technology use.

Additional studies will assess the predictive validity of the new TSE measure in comparison to the original Compeau and Higgins CSE measure, and will compare the general TSE measure to adaptations designed for particular technology contexts (such as smart phones).

Conclusion

The time has come for the IS community to re-assess the validity of some of its core measures in the face of changing technology and technology use conditions. We have demonstrated the first steps in this activity for a key IS construct: computer self-efficacy. We have made the case for change and have provided a preliminary measure that we believe better reflects the technology use experience in 2016. We hope our analysis spurs a greater discussion of the need to update our constructs as well as our theories, and provides guidance on the process of undertaking this sort of reconsideration.

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