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# Effective ICT use for Digital Innovation: An Actualized Affordance Perspective through ICT enabled Design Thinking

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## Abstract

Available technologies in organizations can be exploited for creating useful innovative solutions in a rather quick, efficient and economical way. Despite the huge benefits that can be derived by proactively exploiting available technologies and systems for innovation, there is relatively less academic research devoted to the subject. Motivated by this perceptible gap in the digital innovation literature, we theorize and examine the role of one possible structured creative mechanism (design thinking approach) for exploiting existing digital technologies to facilitate innovation. Grounding our arguments in the ‘effective use of IS’ and ‘technology affordance’ literature, we conceptualize *innovation agent attributes* and *actualized innovation affordance* achieved through the use of ICT, as the two salient facilitators for digital innovation. Innovation agent attributes are operationalized via domain generic and domain specific attributes of ‘creative self-efficacy’ and ‘affect towards ICT use’ and actualized innovation affordance is operationalized as the effective use of available technologies through an ‘ICT enabled design-thinking approach’. The hypothesized model is empirically tested via a quasi-experimental method comprising data from a two-wave temporally separated survey. Results establish the significant influence of both —*innovation agent attributes* and *actualized innovation affordance* for facilitating digital innovation. Moreover, actualized innovation affordance, operationalized through ICT-DT, has a stronger association with digital innovation compared to the innovation agent attributes. This result underlines the need for organizations to proactively focus on using ICT effectively through structured creativity approaches (such as DT) for facilitating innovative outcomes. The study also offers several implications for research and practice.

## Keywords

Design thinking, digital innovation, creative self-efficacy, affect towards ICT use, microfoundations, actualized affordances, effective use.

# Utilisation efficace des TIC pour l'innovation digitale: Une perspective actualisée d'affordance à travers le Design Thinking supporté par les TIC

## Résumé

Les technologies de l'information (TIC) disponibles dans les organisations peuvent être utilisées pour créer des solutions innovantes d'une manière rapide, efficace et économique. Malgré la nécessité de mieux comprendre les modalités permettant d'utiliser les TIC dans les organisations pour favoriser l'innovation, la littérature sur l'innovation numérique/digitale se concentre principalement sur l'étude de la mise en œuvre de TIC existantes dans de nouveaux contextes ou sur la conception et le développement de nouvelles technologies de l'information. Cet article enrichit ces travaux de recherche en étudiant un mécanisme créatif alternatif mobilisant les technologies digitales existantes pour l'innovation. En ancrant nos arguments dans la littérature sur l'usage efficace des SI et « l'affordance de la technologie », nous conceptualisons les caractéristiques des agents d'innovation et l'affordance actualisée de l'innovation basée sur l'utilisation des TIC, comme les deux principaux facilitateurs de l'innovation digitale. Les caractéristiques des agents d'innovation sont opérationnalisées par le biais de caractéristiques génériques et spécifiques au domaine de « l'auto-efficacité créative » et de « l'affect envers l'utilisation des TIC ». L'affordance de l'innovation actualisée est opérationnalisée comme l'utilisation efficace des technologies disponibles grâce à une approche de conception basée sur les TIC ou encore « *ICT enabled design-thinking* » (ICT-DT). Le modèle proposé est testé empiriquement via une méthode quasi-expérimentale comprenant des données provenant d'une enquête en deux temps de collecte. Les résultats montrent une influence significative à la fois des caractéristiques de l'agent d'innovation et de l'affordance actualisée de l'innovation pour faciliter l'innovation digitale. Cependant, l'affordance actualisée de l'innovation, opérationnalisée par l'approche ICT-DT, a une relation plus forte avec l'innovation digitale par rapport aux caractéristiques de l'agent d'innovation. Cela souligne la nécessité pour les organisations d'intégrer l'utilisation des TIC pour permettre des approches de créativité structurées (telles que le DT) et encourager les productions innovantes. L'étude offre également plusieurs implications pour la recherche et pour la pratique.

## Mots clés

Design thinking, Innovation numérique, auto-efficacité créative, affect envers l'usage des TIC, micro fondations, affordance actualisée, usage efficace

## 1. Introduction

Digital innovation, which pertains to the use of digital technologies for renewing and transforming business models, has been conceptualized in different ways in IS literature (Kohli and Melville, 2019). The three broad conceptualizations of digital innovation relate to – (1) adoption and diffusion of an *existing IT artifact to a new context or organization* (e.g. Fichman, 2004; Jeyaraj *et al.*, 2006; Rahrovani *et al.*, 2014), (2) design and development of *new IT artifacts* by combining physical and digital products (e.g. Lee and Berente, 2012; Yoo *et al.*, 2010), and (3) *creative application of existing IT artifacts within the organization* by combining technological and organizational dimensions to create value (e.g. Fichman *et al.*, 2014; Chatterjee, *et al.*, 2020, Srivastava *et al.*, 2015). Hence, digital innovation includes activities related to either the 'initiation, development, and implementation' of new systems, or the 'exploitation' of existing systems for innovative purposes.

Prior IS innovation literature has laid emphasis on the need for effectively using available resources for designing innovative solutions (Srivastava *et al.*, 2013; Srivastava, *et al.*, 2021, Srivastava and Shainesh, 2015). Evidently, to provide quick, efficient and economically viable

innovative solutions, there is a need to examine how available technologies in organizations can be exploited and effectively used for creating such solutions. Kohli and Melville (2019) in their comprehensive literature review article on digital innovation have emphasized the need to examine the exploitation aspect of digital innovation i.e., reuse and recombination of technology and data for digital innovation orchestration. However, Kohli and Melville (2019) note that 91% of the reviewed digital innovation articles examine the development and implementation aspects of digital innovation, while only 9% of the articles study aspects related to initiation and exploitation of existing technologies for innovative outcomes. Given the importance of understanding the mechanisms for effectively using existing organizational technologies for innovation and the relatively less research attention given to the subject thus far, presents a glaring gap in the digital innovation literature. Moreover, the link between the strategic and pivotal role of available information technology within an organization in fostering digital innovation outcomes is inconsistently addressed in literature, with only one recent research leveraging the technology affordance lens addressing this crucial gap at the organizational level (Chatterjee, *et al.*, 2020). Motivated by this perceptible void in the digital innovation and affordance literature, we theorize and examine one possible mechanism for *exploiting* existing digital technologies in the organization for innovation.

Exploitation of technologies for digital innovation implies leveraging existing IS for maximal value, such as reusing prevailing systems in new ways and for new purposes. Similar to recent study by Chatterjee *et al.*, (2020), we view the exploitation of existing organizational technologies through the lens of ‘effective use’ and ‘actualized affordance’, which together offer a parsimonious framework for conceptualizing and examining digital innovation (Burton-Jones and Grange 2013; Burton-Jones and Volkoff, 2017). Actualized affordance is the affordance enacted by the human agents through ICT tools as informational objects for the digital innovation (Livingston *et al.*, 1997; Withagena & Kampb, 2018; Ciriello *et al.*, 2017; 2019), We posit that orchestrating ‘effective use’ of existing technologies in the organizations can help achieve innovation goals. Effective use of IS refers to the “use of systems for attaining the desired goals” (Burton-Jones and Grange 2013, p. 633) or “intelligent effort by direct users . . . [such that] the effort facilitates desired outcomes” (LeRouge *et al.*, 2007, p. 1291). In the context of our research, the term orchestration of digital innovation signifies the modalities for facilitating an effective use of IS for innovation. It refers to the problem–solution matching as a micro foundation of digital innovation and includes the instrumental role of digital technologies in enabling or supporting such orchestration, pursued by an innovation agent or by a collective (Nambisan *et al.*, 2017, p227). For theorizing the mechanisms facilitating such a digital innovation, we need to build on the three basic elements of ‘effective use’ namely, characteristics of the *task*, the nature of *systems* and competencies and motivations of *users* (Burton-Jones and Straub 2006). In our study context, the ‘task’ relates to achieving innovation outcomes by exploiting the existing organizational digital ‘systems’ and leveraging the competencies of the ‘users’ or the organizational innovation agents. Thus, from the effective use perspective, the two elements for facilitating ‘digital innovation outcomes’ using technology are competent technology users or *innovation agents* and an *actualized innovation affordance* achieved through the effective use of available technologies (Burton-Jones and Volkoff 2017; Chatterjee *et al.*, 2020). Appendix 1 provides a framework that shows how the concept of effective use and actualized information affordances are fused to enable us to effectively understand the role of technology exploitation for digital innovation orchestration in the context of this study.

Clearly, exploitation of existing systems presupposes two prerequisites: a goal directed agent with creative potential and an enactment of effective use of existing IS by the agent for fulfilling

the desired goals, also termed as actualized affordance (Burton and Grange 2013). This is similar to the two factors of digital innovation described by prior literature –one that leans towards recruiting and building ‘technology users with appropriate innovative capabilities and motivations’, and the other, that focuses on implementing the ‘right methods for orchestrating innovation’ (Amabile and Pratt, 2016; Drazin *et al.*, 1999; Srivastava *et al.*, 2013; Srivastava, 2015). Recent practitioner reports also reiterate the key roles of employee competency and structured innovation methods for effectuating digital innovation (Forrester, 2019, Gartner, 2019). Though, digital innovation literature has examined each of these elements in different contexts, efforts to understand their relative importance for the enactment of digital innovation, especially at the individual level of analysis is largely missing (Ciriello and Richter, 2015; Chatterjee *et al.*, 2020; Fichman *et al.*, 2014; Micheli *et al.*, 2019), which we try to address through our study.

In a recent study, organizational courage is conceptualized as a collective and primordial attribute of human agency that percolates into how creativity and innovation goals are approached in a digital innovation context (Chatterjee *et al.*, 2020). The article found that organizational courage and harmonized IT affordance in an organization (HITA) offered a matching fit enabling actualization of the technology affordances for digital innovation outcomes (Chatterjee *et al.*, 2020). HITA is reflected as a co-alignment of the three major IT affordances in an organization—collaborative affordance, organizational memory affordance, and process management affordance. Extending this line of enquiry, in our study, we conceptualize the innovation agent competencies and motivations, as the agent attributes that are expected to assist in the task of innovation. Because we are examining the context of digital innovation at the micro level, we consider two proximal attributes: ‘innovation agent attributes’, one that relates to the ability to innovate (domain generic) and the other that relates to the use of ICT itself (domain specific). The domain generic competency that we consider in our study is the innovation agent’s *creative self-efficacy*, which is related to the human agent’s cognitive creative competency, and the domain specific attribute for digital innovation that we examine in our study is the innovation agent’s *affect towards ICT use*, which describes the human agent’s affective disposition towards the use of ICT for digital innovation. These two factors are intrapersonal in nature and reside within the cognitive and affective spheres of the innovative agent—waiting to be appropriated (Amabile, 1996). Both these agent attributes have been identified as significant attributes in the creativity and innovation (*creative self-efficacy*) (Amabile, 1996) and information systems (IS) – (*affect towards ICT use*) (Thompson *et al.*, 1991) literature, but have not yet been examined in the context of digital innovation.

The actualized innovation affordance, is conceptualized in our study through one specific method, namely—ICT enabled design-thinking (DT) approach. Past management research provides consistent evidence that DT approach helps in fostering innovation and is beneficial for firms adopting it (e.g., Brown & Martin, 2015; Cooper *et al.*, 2009; Gruber *et al.*, 2015; Rauth *et al.*, 2014). Currently, design-thinking approach is considered as one of the effective structured creative methods (Johansson-Sköldberg *et al.*, 2013; Glenn *et al.*, 2014; Pope-Ruark *et al.*, 2019) and we posit that it is equally applicable to the context of digital innovation (Elsbach and Stigliani, 2018; Micheli *et al.*, 2019). A design index conceived as early as 2015 showed that for a period of 10 years in a row, design-led companies have maintained significant stock market advantage, outperforming its competitors by a whopping 211%, making design as an important creative process to instill for organizational success (DDM, 2020). However, the basis of DT largely continues to be a human-process-centric activity, which may or may not use ICTs. Digital innovation researchers have stressed the key-role of ICTs for effectuating a structured creative innovation method (Ciriello & Richter, 2015; Srivastava & Shainesh, 2015;

Mithas *et al.*, 2016). Though it is generally recognized that ICT use enhances the creative processes (e.g., Couger *et al.*, 1993; Pacauskas & Rajala, 2017), technology enabled design thinking has thus far has neither been operationalized nor empirically validated in academic research. We address this void by conceptualizing *ICT enabled design-thinking* (ICT-DT) approach to operationalize the ‘actualized innovation affordance’ for facilitating digital innovation. More details on why we look at ICT-DT in this research is also elaborated in subsequent section (see, section 2.2 below). Building on the discussion above, the research question that we seek to address in our study is:

*RQ: Do ‘innovation agent attributes’ and ‘actualized innovation affordance’ help in exploiting existing IS to facilitate digital innovation? And what is their relative importance?*

The answer to this question is germane to understanding how digital innovation can be facilitated in an organizational setting by orchestrating the effective use of existing IS. Theoretically, we aim to integrate digital innovation and effective use of IS literature to examine the rather unexplored ‘exploitation’ of available technologies perspective for digital innovation. For theoretical coherence and parsimony, in the context of this paper, we use the term-actualized affordance to signify the enactment of effective use of available generic ICT that are easily accessible for creative process by a goal directed innovation agent for facilitating innovation. Rooted in the logic of technology affordances (Majchrzak and Markus, 2012; Pozzi *et al.*, 2014; Godé *et al.*, 2020; Boukef and Charki, 2019), our study leverages information systems (IS) and creativity literature to theorize the distinct influence of the two contextual dimensions on digital innovation (Nambisan *et al.*, 2017).

To answer our research question, we employ a quasi-experimental method. The research data is collected through a two-wave temporally separated survey in a natural academic setting, where the respondents were expected to produce an innovative outcome by using the available ICT tools for collaboration and working. The academic context encouraged the study participants to exploit the existing IS through the use of the design thinking approach for solving an unstructured societal problem, which provided them with the opportunity to creatively undertake individual level digital innovation initiatives (Unsworth 2011; Kohli and Melville, 2019).

The rest of the paper is organized as follows. First, we provide background literature on the key concepts used in our study. Next, we elaborate on the theoretical arguments leading to the research model and hypotheses. Subsequently, we describe the details of the quasi-experimental method designed for validating the hypothesized model. Finally, after discussing the obtained results, we conclude with the theoretical and practical implications emerging from our study.

## **2. Background Literature**

### **2.1 Digital Innovation and Effective ICT Use**

Digital innovation is at the heart of today’s economy. Organizations, nations, and societies are leveraging digital capabilities and technologies to stimulate and create value for different stakeholder groups through innovation either in underlying processes or the resulting products (Nambisan *et al.*, 2017). Though, businesses and societies have realized the importance of digital innovations (Fichman *et al.*, 2014; Yoo *et al.*, 2012), theoretical deliberations devoted to understanding the modalities for ‘proactively’ fostering such innovations are limited (Livingston *et al.*, 1997; Nambisan *et al.*, 2017; Ciriello & Richter, 2015). Research that focuses

on theorizing and examining the mechanisms facilitating digital innovation will be of value to both theory and practice.

Although digital innovation has been described in the literature in different ways, in our research we examine how organizations can achieve digital innovation by exploiting existing organizational resources and technologies (Kohli and Melville, 2019). Specifically, taking an “effective use” of technology perspective, we posit that for achieving the *task* of digital innovation, organizations need to leverage the motivations and competencies of the *users* and orchestrate the use of organizational *systems* and technologies through a structured innovation approach (Burton-Jones and Grange 2013; Burton-Jones and Volkoff, 2017). We classify these two elements for facilitating digital innovation as ‘innovation agent attributes’ and ‘actualized innovation affordance’ (Livingston *et al.*, 1997; Withagena and Kampb, 2018; Ciriello *et al.*, 2017).

Traditionally, innovation has been linked to the creative ability of the individuals involved in the innovative process. Such innovation agent abilities have been shown to transcend their general attributes such as intelligence or personality traits to include domain and task specific attributes, which have been shown to influence innovation outcomes (Lubart, 2008; Lubart and Guignard, 2004). Recent literature on individual level creativity support systems also calls for further studies to tease out the relevant individual level attributes in the context of technology mediated creative process enactments (Wang and Nickerson, 2017). Thus, creative competencies and motivation to use technologies can be considered as important attributes to facilitate digital innovation.

In addition to recognizing the key role of ‘innovation agent attributes’, digital innovation researchers have also pointed to the key role of structured creativity innovation methods enabled by ICTs (Ciriello *et al.*, 2017). For example, studies have investigated the role of creativity support systems in enhancing the level of innovation by stimulating and documenting creative processes (Masseti, 1996; Wierenga and van Bruggen, 1998; Wang and Nickerson, 2017; Couger *et al.*, 1993; Pacauskas and Rajala 2017; Gabriel *et al.*, 2016). Creativity, a quintessential concept related to innovation is defined as the process of forming novel, useful, and appropriate ideas (Amabile, 1983; Woodman *et al.*, 1993). The terms creativity and innovation are often viewed as a single competency, but creativity is at the heart of all digital innovation research (Fichman *et al.*, 2014). Consequently, in our study, we view creativity and digital innovation together as a sociotechnical phenomenon (Ciriello *et al.*, 2015).

Prior studies focusing on the use of technologies for digital innovation have examined different technological aspects, for example — specific technology design features that can contribute to accidental innovation (Austin *et al.*, 2012), the role of digital infrastructure in fostering innovation networks within organizations (Lyytinen *et al.*, 2016; Ciriello & Richard, 2015), or the competing concerns related to implementation of digital innovations (Svahn *et al.*, 2017). As highlighted earlier, the bulk of the digital innovation literature focuses on the “development and implementation” aspects of digital innovation. Studies related to the “initiation and exploitation” of existing technologies for innovative outcomes are very limited (Kohli and Melville, 2019). By focusing on ways to *exploit* existing organizational technologies by using them more effectively we address a noteworthy gap in literature. Moreover, most digital innovation studies are in the form of conceptual frameworks, essays and reviews without empirical validation (Yoo *et al.*, 2012; Fichman *et al.*, 2014; Lusch and Nambisan, 2015; Kohli and Melville, 2019). There have also been calls in this domain to deliberate on the socio-materiality perspective for examining micro-foundations to digital innovation orchestration

(Barrett *et al.*, 2012; Nambisan *et al.*, 2017) by adopting an affordance perspective for examining digital innovation (Chan *et al.*, 2019). Few studies such as Ciriello *et al.* (2017), have followed this line of enquiry to conceptualize four interrelated collective digital innovation practices in corporate settings, namely making sense of an idea, aligning mental models, negotiating solution paths, and crafting an idea. We build on such prior studies by taking into account the use of specific innovation processes and affordances offered by the digital artefacts (Chatterjee *et al.*, 2020). In our study, by leveraging the effective use and affordance perspective we clearly delineate the role of user attributes (innovation agent attributes) and a structured innovation approach through effective technology use (actualized innovation affordance) in the form of ICT enabled design thinking (ICT-DT) for facilitating digital innovation. We describe the conceptualization of actualized affordance of existing organizational technologies through ICT-DT in the next section.

## **2.2 ICT enabled Design Thinking – An Actualized Innovation Affordance Approach**

Among the various structured innovation processes, the design-thinking (DT) approach has recently gained wide popularity amongst innovation practitioners and is considered to be one of the effective innovation and creativity methods (Johansson-Sköldberg *et al.*, 2013; Glen *et al.*, 2014; Elsbach and Stigliani, 2018). DT is a human-centric approach widely used to stimulate creativity relevant processes during innovation management (Gartner, 2019; Von Stamm, 2008; Mahmoud-Jouini *et al.*, 2019). Recent research on the subject has demonstrated the positive impact of the DT approach on innovation (Carlgren *et al.*, 2016; Elsbach and Stigliani, 2018; Liedtka, 2017; Nagaraj *et al.*, 2020) and the consequent financial outcomes (Forrester, 2019, Gartner, 2019). Following digital innovation researchers who have stressed on the key role of ICTs for effectuating a structured creative innovation process (Ciriello and Richter, 2015; Srivastava and Shainesh, 2015; Mithas *et al.*, 2016) we conceptualize actualized innovation affordance through “ICT enabled design thinking process” (ICT-DT). Please note that ICT-DT is one of the possible approaches that can be leveraged for actualized innovation affordance, there can also be other methods, which future research can explore and examine.

Specifically, given the embedded nature of the DT approach, we conceptualize ICT-DT as an actualized innovation affordance for effective use of technology by the human agents trying to use existing IS for their desired innovation goals (Burton and Volkoff, 2018). DT approach is particularly interesting from the standpoint of this research for two specific reasons. First, for its popularity and relevance to the innovation management discipline. Second, the context of the specific study, which was undertaken in a natural field setting that recommended the use of DT for enacting the creativity processes through technology –which is consistent with our objective of using ICT for DT. In other words, the desired structured creativity process (DT) was infused into the context of the study *a priori* (Dumas and Mintzberg, 1989, 1991). Hence, in our study we contextualize the DT approach to the digital innovation context through the use of existing ICT tools for effectuating DT approach. We term this contextualized DT approach as ICT enabled DT creative method (ICT-DT). Our conceptualization of ICT-DT is depicted through the use of ICT for the sequence of five activities or phases crucial to the design thinking approach –(1) *empathize* - data collection about the problem, (2) *define* - data synthesis to gain a refined understanding of the problem, (3) *ideate* - suggest ideas for solving the problem, (4) *prototype* - develop tangible representations of the ideas for solving the problem, and (5) *test* - the problem solution with the potential users (see Plattner *et al.*, 2009).

Although in our research we examine the use of general ICTs for effectuating DT method, prior research has also identified specific tools that might be suitable for each of the DT phases (Alves



et al. 2013; Chasanidou et al. 2015). For example, Smaply, a web service that hosts and presents personas and other tools, such as stakeholder maps are useful for the *empathize phase* in the DT approach. Similarly, for the *define phase* in the DT approach, customer journey maps can be produced by tools such as Touchpoint Dashboard or Creately which generates service blueprints. For the *ideate phase* Strategyzer is a tool that can possibly be used. For the *prototype phase* Axure RP can perhaps be leveraged as it allows for rapid prototyping and helps get feedback through easy website creation techniques using a graphical user interface (Chasanidou et al. 2015). Several commercial firms are promoting all-purpose crowd thinking tools to practice design thinking. For example, some firms in France use a collaborative platform called Foreseeds for practicing the design thinking creative approach. Apart from the aforementioned specific tools, we know that existing IS can also be used during ideation and developmental phases of design thinking, such as PLM web conferencing is known to help in managing real-time problem-solving situations when developing new products by enhancing knowledge transfer amongst diverse participants (Merminod and Rowe, 2012). Technology innovation projects that combine design thinking and other agile methods are now commonly taught in business schools and students are encouraged to rely on *generic ICT tools at their disposal* for such projects (Freitas da Silva, 2020), which is similar to the approach followed in our research.

### 3. Theory and Hypotheses

#### 3.1 Linking innovation agent attributes with digital innovation

In our research, we conceptualize the innovation agent competencies and motivations, as the agent attributes that are expected to assist in the task of innovation. Because we are examining the context of digital innovation, we consider two ‘innovation agent attributes’, one related to the ability to innovate (domain generic) and the other related to the use of ICT itself (domain specific). The domain generic competency that we consider in our study is the innovation agent’s *creative self-efficacy* (Amabile, 1996), which is related to the human agent’s cognitive creative competency, and the domain specific attribute for digital innovation that we consider in our study is the innovation agent’s *affect towards ICT use* (Thompson *et al.*, 1991), which describes the human agent’s affective disposition towards the use of ICT for digital innovation.

Creativity theorists have flagged the importance of examining agent’s self-perceptions about their own creative behaviors and capabilities (e.g., Tierney and Farmer 2011; Zhang, 2013). Past literature on creativity has emphasized the need to examine the individual’s capabilities in orchestrating creative processes and behaviors (Bandura, 1977). It has also indicated the key role of self-efficacy in processes involving self-regulation (Bandura 1977; Bandura 1982). Moreover, domain specific self-efficacy has been found to have a stronger influence on the outcomes as opposed to a general self-efficacy measure (Choi, 2004; Malik *et al.*, 2015). Consequently, in our research we theorize the key role of ‘creative self-efficacy’. Tierney & Farmer (2002; 1999) observed that creative self-efficacy is a significant predictor of an individual’s creative performance. Creative self-efficacy is the belief in one-self that the individual has the requisite knowledge and skills to produce creative outcomes. Prior research has found it to be a key driver for individual creativity (Gong *et al.*, 2009; Lim & Choi, 2009) and creativity is an essential component of digital innovation (Fichman *et al.*, 2014; Micheli *et al.*, 2019).

In our research, we focus on the exploitation of available ICT tools for achieving the desired innovation goals. We posit that when individuals are faced with a task, they will be motivated to use the available technologies to achieve their goals. However, this is contingent on the

individuals having the efficacy to execute the assigned task. Past research shows that new idea generation leads to uncertainties, such uncertainties can be overcome when the individual has self-efficacy perceptions as these lead to safety perceptions which then are translated to innovation outcomes (Farr and Ford, 1990, Frese, *et al.*, 1999). Individuals with past experience and motivation combine knowledge diversity more effectively which makes their task output more innovative in terms of both novelty and usefulness (Taylor and Greve, 2006). Creative self-efficacy has also been linked to development and implantation of ideas in organizational settings. (Hammond, *et al.*, 2011). Because we are focusing on creative tasks, we argue that the individual's creative self-efficacy will play a salient role for the enactment of digital innovation through the effective use of available technologies (Burton and Volkoff, 2018; Kohli and Melville, 2019). Hence, grounding our arguments in prior creativity and effective IS use literature we posit that the individual's creative self-efficacy should be positively related to the facilitation of digital innovation. Hence, we hypothesize:

**H1a:** Innovation agent's 'creative self-efficacy' is positively associated with digital innovation.

Affect towards technology use has been identified as one of the ICT domain specific attributes of the individuals and is expected to positively impact digital innovations (Lubart & Guignard, 2004). Prior studies have found that affect, in general, guides congruent behavioral responses (Koenig-Lewis & Palmer, 2014; Kubicek *et al.*, 2013; Richard *et al.*, 1996). Behavioral affective association model predicts that affective associations influence not only the cognitive beliefs and behavioral responses of the individuals, but also impact an individual's final decisions and outcomes (Kiviniemi and Duangdao, 2009). Prior IS research views affect as one of the key dimensions responsible for shaping an individual's attitude towards technology use (Srivastava and Teo, 2021; Shirish, 2020). Moreover, 'affect towards ICT use' has been found to be a significant individual-level attribute that determines the extent of technology use (Thompson *et al.*, 1991).

Notwithstanding the positive association of affect towards ICT use with task oriented digital outcomes, prior creativity research has shown a mixed impact of positive and negative moods on creative outcomes. For example, George and Zhou (2002) and George and Zhou (2007) demonstrate that negative mood, under certain circumstances, can lead to an increased creative performance. Another study from Bledow *et al.* (2011) shows that when there is an affective shift from a negative mood to positive mood, the creative performance increases. Hence, the relationship of an individual's mood with creativity is not conclusive. Moreover, mood and affect reflect different aspects of the emotional dimension. While affect is associated with a specific stimulus and usually determines an individual's attitude towards that stimulus (Thompson *et al.*, 2001), mood is a superficial and transient emotional aspect of an individual and is not associated with a specific stimulus. Mood can manifest as a general affective state of an individual. Moreover, in our study we are examining the affect towards using technology.

Although, our task context depends on creativity, we argue that there is a positive relationship between positive affect towards ICTs with digital innovation. Our reasoning derives from the fact that ICT use in our context is contingent on effective mobilization of technological resources, which is similar to the instrumental use of technology. Hence, consistent with prior IS research a net positive affect towards ICT use should result in better mobilization of technological resources for the specific task situation of digital innovation (Shirish, 2020). We take the originally conceived view in IS research that 'affect towards ICT use' is more of a stable disposition of an individual towards technology use, accounting for the net of the positive

and negative affect that individuals have towards technology (Thompson *et al.*, 2001). Moreover, we are examining the specific context of effective technology use for digital innovation orchestration by goal directed innovative agents (Burton and Grange 2008; Diliello *et al.*, 2011). Thus, based on prior studies, we argue that an innovation agent's affective disposition towards technology use is related to his/her task related motivational mechanisms, which in turn should facilitate digital innovation (Costa *et al.*, 2017; Ashkanasy and Dorris, 2017; Ford, 1996; George and Zhou, 2002; George and Zhou, 2007). Hence, we hypothesize:

**H1b:** Innovation agent's 'affect towards ICT use' is positively associated with digital innovation.

### 3.2 Linking actualized innovation affordance with digital innovation

Technology affordance refers to “an action potential, that is, to what an individual or organization with a particular purpose can do with a technology or information system” (Majchrzak & Markus 2012, pp. 832). However, it is through the effective use of the technology that one can explicate in a contextual manner the usefulness of technology affordance (Burton and Grange 2008). Prior research has shown that the mangling of creatively structured processes with technology through reciprocal and emergent intertwining of human and technical practices can influence digital innovation (Pickering, 2010). Because innovation affordance has been proposed as a useful lens for examining digital innovations in action (Orlikowski, 2007; Barrett *et al.*, 2012; Nambisan *et al.*, 2017; Ciriello *et al.*, 2017; Burton and Volkoff, 2018), we argue that the actualized affordance offered by structured ICT-enabled innovation methods should facilitate digital innovation. However, we elaborate on the notion of actualized innovation affordance at the individual level in the context of our research.

In our study, innovation affordance is operationalized through the affordance of informational objects by innovative agents. It can also be the use of innovation practices enacted through technology use (Ciriello *et al.*, 2017). Particularly, ‘actualized innovation affordance’ is a relational concept that links specific creativity approach, goal-oriented users, and ICTs as informational objects (Andriani and Cattani, 2016; Burton and Grange 2008). Thus, information objects (systems) interact with the goal-oriented user (innovation agent) to contribute to the enactment of affordance in the digital innovation context (Chan *et al.*, 2019). This is similar to conception of business process model as an informational object in recent IS affordance studies (Bernhard *et al.*, 2013). Use of ICT during the creativity process can extend the conceptual creative space for the innovation agents by enabling enhanced perspective taking and improved creative learning, which can facilitate enhanced digital innovation (Glăveanu *et al.*, 2019). Hence, in the context of our research, ICT-DT that measures the actualized affordance is linked to digital innovation (Liedtka, 2017; Pope-Ruark *et al.*, 2019) through the concept of effective IS use (Burton and Grange 2008).

We further tease out how ICTs could be used for creativity process engagement and why imbrication of user and systems is key for digital innovation (Bhurkhardt and Lubart, 2010; Livingstone *et al.*, 1997). ICT serves as an institutional support mechanism for creative process engagement (Lubart, 2005). However, according to the ecological account of creativity, it is the actualized affordance that leads to materialization of creativity as well as technology induced creative process engagements (Pozzi *et al.*, 2014). The exploitation of *technology-enabled support for creative process* available in the environment by an innovating agent thus becomes desirable (Livingstone *et al.*, 1997; Isaksen *et al.*, 1993).

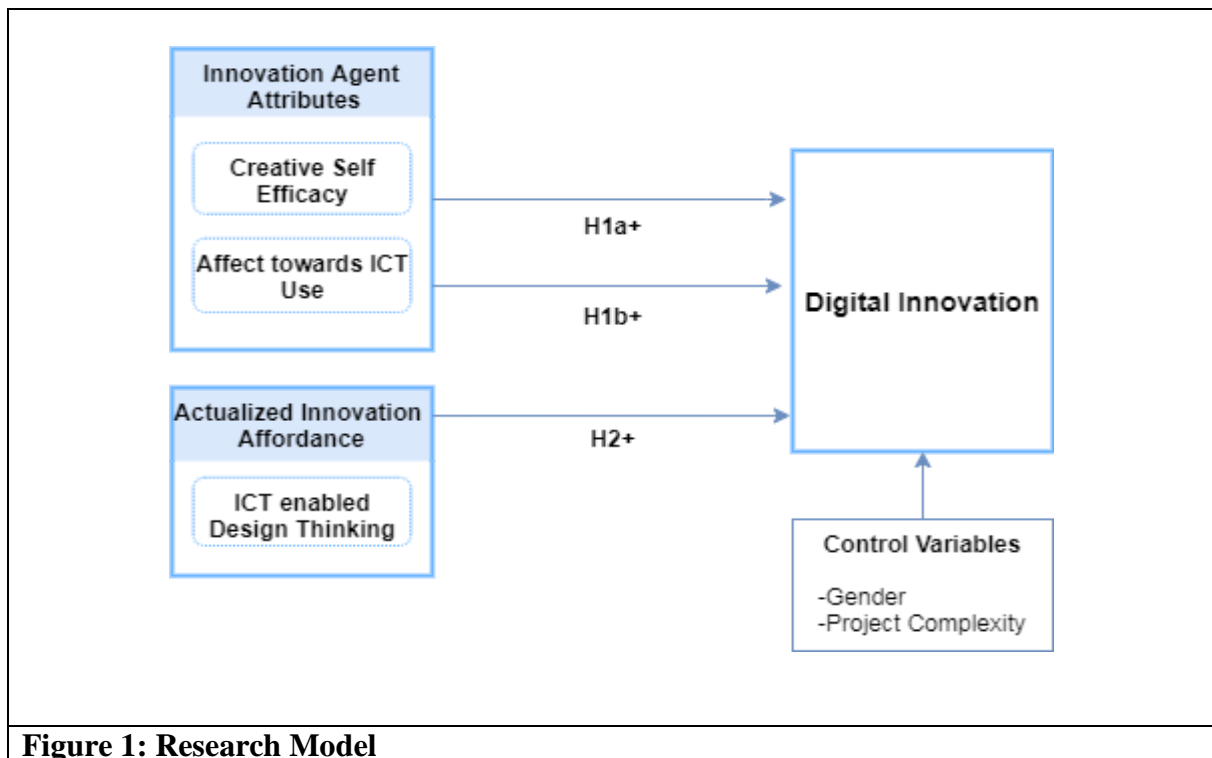
However, we must not ignore the possibility that ICTs can also constrain an innovation agent's activity (Leonardi, 2011). Prior research has shown the deleterious effects of *rigid* structured processes on creativity and exploration (Lenfle, 2008; Lenfle and Loch, 2010). Nevertheless, from the effective use perspective, we posit that the *flexible and iterative nature* of the ICT-DT method would provide individuals with an enabling environment for a goal directed innovation task (Burton and Volkoff, 2018). Prior research such as Lubart (2005) describes the key role of digital technologies in facilitating creative work through various mechanisms such as enhancing the communication between individuals, collaborating on creative projects, using creativity enhancement techniques, and integrating human-computer interactions during the idea production stage. The presence of and encouragement for unrestricted use of ICTs should lead to open and flexible innovation affordances by supporting the convergence of ideas and allowing for generative experimentation. Consistent with the findings of Lubart (2005), we posit that available ICTs, when effectively used through the DT approach, would facilitate innovation by providing the required structural support during the different phases of the DT method.

ICTs can also afford a viable foundation to understand the potential problems of users in depth by permitting easy collection of user data. Moreover, ICTs can also facilitate efficient data synthesis and analysis, which is clearly superior to the manual processes. Thus, ICTs can help innovation agents to better *empathize* and *define* the problem that requires an innovative solution. In a similar vein, ICTs can also be useful during the *testing* phase of design thinking for obtaining user feedback and also for capturing the digital usage footprints of the innovation agents. This information can be used to tweak the innovative process for better results. ICTs also afford better creative communication management amongst the innovation agents involved in the project (Lubart, 2005), which we believe is crucial for *defining* and *ideating* about the intended digital innovation. Defining and ideating stages of the design thinking process require close collaboration, wherein ICTs can complement face-to-face communication. Moreover, in the case of digital innovation, the innovation agents may also see affordances while using ICTs to express their creative acts through integrated human-computer cooperation during idea production (Lubart, 2005). In addition, available ICTs will also allow for implicitly representing and manipulating ideas; such an affordance is useful during the *ideation* and *prototyping* phases of design thinking. The use of ICTs for creative process would allow the innovation agent to appropriate both the convergent and generative affordances for digital innovation enactment (Yoo *et al.*, 2012; Glăveanu *et al.*, 2019). In summary, structured creative approach can positively influence innovation as it aids in the planning and the execution of innovations (see Osburn and Mumford 2006; Amabile 1983; Parnes and Noller, 1972; Sternberg, 1986).

Efficacious innovative agents would seek out opportunities and resources available in the social context/space to further their goals and aspirations (Bandura, 2001; Overmyer and Carlsen, 2019). Therefore, ICT use in the structured method of DT should clearly increase innovation agent's control over the execution of the creative process, which in turn will facilitate digital innovations. Hence, we contend that actualized innovation affordance enacted through ICT-DT by a goal directed motivated innovation agent in the context of a creative task should be positively related to digital innovation affordance (Burton and Grange 2008). We hypothesize:

**H2:** Actualized innovation affordance orchestrated through 'ICT enabled design-thinking' approach (ICT-DT) is positively associated with digital innovation.

The hypothesized relationships are represented in Figure 1



**Figure 1: Research Model**

## 4. Method

### 4.1 Research Setting

Quasi-experimental method was adopted for our study. A two-wave temporally separated survey was used to collect data from respondents in a natural academic setting. The participants in the study were graduate students majoring either in engineering or management disciplines. All participants had enrolled in a joint collaborative academic program between a business school and an engineering school that share the same campus in France. The participants from both the schools, signed up for a weeklong graded collaborative academic program where the objective was to work on a collaborative digital social innovation project focused on alleviating societal problems. The participants were grouped into teams ensuring that there is a balanced mix of management and engineering students in all the teams. All the teams were introduced to the concept of design thinking as part of their creativity-training program on the first day of the program. The participants were encouraged to use design thinking innovation process for their projects. They had at their disposal the digital technology infrastructure including Internet access through Wi-Fi, engineering simulation tools, ICT communication tools, software and physical labs equipped with ICT and multimedia facilities that could be used for video production etc. Other proprietary or personal digital technologies were also allowed to be used for the purpose of the project. Thus, connected objects, personal PCs and laptops, mobile phones, smart phones, and social media technology tools were all used during the project. Two of the researchers had acted as a coach in a similar innovation training conducted earlier and were aware that students used digital tools at their disposal for such innovation projects. Participants worked as a team for a week in a flexible manner with minimum requirements on their physical presence. On the last day of the project, each team had to present their proof-of-concept (POC) through a 3-minute video teaser and create a website describing their new venture detailing the elements of their digital social innovation. The teams were also asked to provide a 2-page synthesis of their innovation as a part of their grading process on the last day of the program. A total of 452 innovation agents participated in the week-long program.

## 4.2 Data Collection

After obtaining the express permission from the program coordinators, the research data was collected from each of the team members in two temporally separated study waves in the form of surveys –first, at the start of the week-long program and second, at the end of the study project. The participants were informed about the nature of their voluntary participation in the study. 178 students responded to both the waves of the survey indicating a response rate of 39.4 percent, which is satisfactory for such an elaborate kind of a research design. Among the 178 respondents, the age of the majority of respondents ranged from 22 to 26 years. There were 105 male participants and 73 female participants who answered all the questions for the two surveys comprising this study.

Data on creative self-efficacy, affect towards ICT use and demographic variables were collected during the first wave of the survey. Data on ICT enabled design thinking creative process and ICT enabled digital innovation were collected during the second wave. Most of the constructs used in the study were adapted from validated construct scales from prior studies where psychometric properties have already been established. For example, we used the 3-item scale for ‘affect towards ICT use’ from Thompson *et al.*, (1991), which has items such as “using ICTs makes work more interesting”. We adapted 6-item scales for measuring creativity self-efficacy from Oldham & Cummings (1996). Example items include; “I am confident about my ability to solve problems creatively”; “I feel that I am good at generating novel ideas”. Project complexity construct was measured using scale from Baccardini (1996), where we asked questions on general complexity levels of the project, use of non-routine methodology and use of complex development processes in their projects. Digital innovation was measured using 3-item scale adapted from (Tarafdar *et al.*, 2010) – for example, “ICTs help me to try out innovative ideas”; “ICTs help me to come up with new ideas relating to my team tasks”; “ICTs help me to identify innovative ways of doing my team tasks”. All constructs except, ICT enabled design thinking creative method have been modeled using reflective indicators. The newly conceptualized construct called ICT enabled design thinking creative method (ICT-DT) was developed as a formative construct during the study. We followed all the rigorous methodological procedures for the development and validation of the new ‘ICT enabled design thinking’ (ICT-DT) scale, the details of which are provided in Appendix B. Because the dependent variables may be influenced by factors other than those in the hypothesized model, we incorporated suitable control variables in our analysis to better understand the variance explained by the predictor variables. Specifically, “gender” and “project complexity” were used as controls because prior studies have found them to be significant factors. In addition, the study was conducted in a natural academic setting, hence the innovation reward-recognition objective climate is the same and can be assumed to be controlled for all the study participants.

## 5. Data Analysis

For the purpose of the data analysis, we used Partial Least Squares (PLS), a latent structural equation modeling technique, as implemented in Smart PLS 3.0, which utilizes a component-based path modeling application (Ringle *et al.*, 2005). PLS avoids the two major problems of inadmissible solutions and factor indeterminacy and is thus appropriate for analyzing complex models with latent variables (Fornell and Lacker, 1981; Wold, 1985). Many prior IS studies have found PLS to be a useful analytical tool (Setia *et al.*, 2013; Srivastava and Chandra, 2018; Srivastava and Teo, 2010). We followed the recommended two-stage analytical procedure (Hair *et al.*, 1998), where the first stage of data analysis evaluates the measurement properties of the constructs, and the second stage examines the structural relationships. Because our

research model has both “reflective” and “formative” constructs, we need to undertake the measurement model assessment for both types of constructs.

### 5.1 Evaluating Measurement Model for Reflective Constructs

We tested three types of validity: content validity, convergent validity, and discriminant validity. Content validity assesses whether the chosen measures appropriately capture the full domain of the construct (Straub *et al.*, 2004). We examined content validity by checking for consistency between the measurement items and the existing literature. This was done at the questionnaire design stage.

Convergent validity checks that the indicators for a construct are more correlated with one another than with the indicators of another construct (Petter *et al.*, 2008). For this, we tested the measurement model with digital innovation as the dependent variable. Confirmatory factor analysis shows strong correlation between each of the items and their corresponding constructs (Table 1). This demonstrates convergent validity. We further tested convergent validity by examining the composite reliability (Craig, et al.) and average variance extracted (AVE: the ratio of the construct variance to the total variance among indicators) for the indicators (Hair *et al.*, 1998). 0.70 is the suggested CR threshold for reliable measurement (Chin, 1998). As can be seen in Table 2, the CR values ranged from 0.85 to 0.90. For the AVE, against the recommended threshold of 0.50 (Fornell & Lacker, 1981), values ranged from 0.55 to 0.76. In addition, the high Cronbach alpha values, ranging from 0.74 to 0.84, confirm the reliability of the scales for all the constructs.

We verified the discriminant validity of the various constructs by checking the square root of the average variance extracted, as recommended by (Fornell & Lacker, 1981). The values of the square root of the AVE (shown on the diagonal in Table 3) are all greater than the corresponding inter-construct correlations (the off-diagonal entries below the square root of AVE in Table 3), exhibiting satisfactory discriminant validity. We also checked the cross-loadings of the items on other constructs, which are quite low, indicating satisfactory discriminant validity (Table 1).

	Affect towards technology	Creative Self efficacy	Gender	ICT enabled innovation	Project Complexity
Affect towards ICT use					
ATU1	<b>0.87</b>	0.15	-0.01	0.31	0.20
ATU2	<b>0.88</b>	0.20	-0.03	0.28	0.19
ATU3	<b>0.79</b>	0.16	-0.08	0.27	0.11
Creative Self Efficacy					
CSEFF1	0.23	<b>0.71</b>	0.22	0.18	0.05
CSEFF2	0.09	<b>0.79</b>	0.20	0.16	0.14
CSEFF3	0.05	<b>0.69</b>	0.02	0.17	0.08
CSEFF4	0.07	<b>0.79</b>	0.17	0.11	0.16
CSEFF5	0.20	<b>0.75</b>	0.05	0.25	0.14
CSEFF6	0.17	<b>0.69</b>	0.16	0.13	-0.06
Gender	-0.04	0.17	<b>1.00</b>	-0.05	0.01
Digital innovation					
DINOV1	0.26	0.26	-0.03	<b>0.86</b>	0.23
DINOV2	0.30	0.21	-0.06	<b>0.89</b>	0.21
DINOV3	0.34	0.17	-0.04	<b>0.88</b>	0.21

Project Complexity					
PCOM1	0.06	0.13	0.08	0.13	<b>0.76</b>
PCOM2	0.19	0.10	-0.02	0.21	<b>0.78</b>
PCOM3	0.13	0.08	-0.02	0.23	<b>0.88</b>

**Table 1: Factor Loadings and Cross-Loadings**

	Cronbach's Alpha	rho_A	Composite Reliability (Craig, et al.)	Average Variance Extracted (AVE)
Affect towards ICT use	0.81	0.81	0.89	0.72
Creative Self efficacy	0.84	0.86	0.88	0.55
Digital innovation	0.85	0.85	0.91	0.77
Project Complexity	0.74	0.78	0.85	0.65

**Table 2: Measurement model for the assessment of reflective constructs**

	Affect towards ICT use	Creative Self efficacy	ICT enabled innovation	Gender	Project Complexity
Affect towards ICT use	<b>0.85</b>				
Creative Self efficacy	0.20	<b>0.74</b>			
Digital innovation	0.34	0.24	<b>0.88</b>		
Gender	-0.04	0.17	-0.05	<b>1.00</b>	
Project Complexity	0.17	0.12	0.25	0.01	<b>0.81</b>

**Table 3: Construct correlations and the Fornell-Larcker criterion**

## 5.2 ICT enabled Design Thinking: Evaluation of Formative Measurement Construct

We followed the recommended three-stage approach for evaluating the measurement properties of the sole formative construct – ICT enabled design thinking creative process (ICT-DT) (Hair *et al.*, 2017). First, to establish the content validity of this construct, a thorough literature review was conducted with respect to different aspects and stages of the design thinking process. Based on the prior academic literature and industry practices, initial construct indicators were developed according to the five stages in the design thinking (DT) process namely– *empathize*, *define*, *ideate*, *prototype*, and *test* (Brown, 2010, Financial Brand, 2018). The measures for ICT-DT were developed based on the extent to which different ICT tools were used for each of the five stages in the DT process. *Empathize*, is the first stage, where the individuals collect data about the real need or the problem that requires a creative solution. The second stage is to *define* the problem clearly with a view to solve it. In this stage, the individual needs to synthesize the gathered views to gain a refined understanding of the problem. The third phase is to *ideate* the meaning where individuals need to suggest or invent ideas for solving the problem. The fourth stage is to *prototype* tangible representations of the ideas. The last stage is to *test* the prototype with the potential users to check if the identified creative solutions are relevant to the needs of the intended users. For a good overview of the literature on design thinking please refer to Carlgren *et al.*, (2016).

In this study, we examined the process of DT enabled by ICT. We posit that the described five phases of the human-centered design thinking approach are pertinent for any innovative process. Thus, the concept of DT is multifaceted and is formed together by all the phases and not a mere reflection of these five phases. Theoretically, these five components are enriched by ICT to comprise the full content of ICT-DT creative process. We first generated 12 items that



represented the five stages and then refined the list of measures using a structured process with the help of 9 innovation experts who were either academics or heads of different innovation hubs (incubators). Table 4 provides more information on the background of the innovation experts who validated the newly constructed scale of ICT-DT. After finalizing the indicators for the ICT-DT scale, to make the measure parsimonious, we used one item to represent each of the five stages of design thinking process in the conceptualized formative construct for “ICT enabled design thinking” (ICT-DT) scale (Appendix B).

S.No.	Title	Expertise
1.	Associate Professor at Information Systems Department of an European Business School	Researcher in technology and innovation
2.	Full-Professor at Information Systems Department of an European Business School	Teacher, researcher and consultant on design thinking and technology
3.	Director of Innovation Center from Columbia	Innovation Industry Expert
4.	An Incubator Co-Director from Mexico	Innovation Industry Expert
5.	An Incubator Director from Uruguay	Innovation Industry Expert
6.	Vice-President of Entrepreneurship Center from Peru	Innovation Industry Expert
7.	Director of Institutional Innovation Center in Paris, France	Innovation Industry Expert
8.	Academic Director of International Relations from leading university in America	Academic coordinator responsible for ensuring student collaboration on innovative projects
9.	Academic Coordinator of International Relations from leading university in Argentina.	Academic coordinator responsible for ensuring student collaboration on innovative projects

**Table 4: Profiles of experts consulted for validation of the newly formed scale of ICT-DT**

Following the guidelines (Hair *et al.*, 2017), we proceeded to evaluate the convergent validity of the formative construct. The convergent validity of the formative construct is measured by examining its correlation with an alternative measure of the construct, using reflective measures or a global single item measure (Hair *et al.*, 2017). If the correlation between the formative construct and the reflective construct is above 0.70 then the construct is said to have convergent validity (Hair *et al.*, 2017). Because there was no prior construct in the literature that represented DT or ICT-DT we had to use a new set of indicators that reflected each of the five stages of design thinking from the original pool of items generated using literature review. We then ran the redundancy test using the procedure prescribed by Hair *et al.*, (2017). The correlation between the formative ICT-DT construct and the reflective ICT-DT construct was 0.97, which is higher than the prescribed threshold of 0.70. Thus, we conclude that the construct has a good convergent validity.

The next stage in establishing the measurement model for a formative construct is to examine the collinearity of the indicators comprising the formative construct. It is recommended that the VIF value for each indicator be lower than 5. The VIF value for all the formative indicators ranged between 1.34 and 1.53. We therefore concluded there is no significant multicollinearity between the indicators comprising the formative construct.

The third stage of evaluation for the formative construct involves assessing the significance and relevance of the formative construct. The significance of the outer weights is assessed to determine if all the chosen five indicators are relevant for explaining the proposed formative construct. After running the bootstrapping procedure, we found that the outer weights for the five items comprising ICT-DT were not significant. Therefore, we proceeded to check the outer loadings as per the decision process prescribed for such analysis (Hair *et al.*, 2017) to assess their significance. All the outer loadings of the indicators for the ICT-DT construct were greater than or equal to 0.50 and were significant at  $p < 0.05$ . Thus, we concluded that all items of the

newly formed construct should be retained, and all are useful for explaining the focal formative construct. Moreover, to further tease out the discriminant validity of the ICT-DT construct and digital innovation construct in particular, we undertook a mediation method proposed by Wang *et al.*, (2015) to gather evidence for the discriminant validity for the formative measurement. The results from this method supported discriminant validity of the ICT-DT construct (see Appendix C).

### **5.3 Common Method Bias**

Common method bias can either inflate or deflate observed relationships between the constructs. Variance occurring due to the measurement method may cause systematic measurement error and further bias the true relationship among the theoretical constructs (Chandra, *et al.*, 2012). In a critical review of common method bias in behavioral research (Podsakoff, *et al.*, 2003) provide recommendations to alleviate common method bias by (1) using procedural remedies during study design, and (2) performing statistical checks. Similar to Srivastava *et al.*, (2015b), we used a mix of procedural and statistical checks to ensure that common method bias did not confound our results. During the research design stage, the study was designed as a two-wave survey with a temporal separation of one week between the data collection on different sets of variables. By employing this procedure, we were able to temporally detach some of the independent variables from the dependent variable. However, the time period of one week might be too short for avoiding a recall bias. Hence, we employed two further tests to ensure that common method bias did not confound our results.

First, to assess the severity of common method bias in the data we used Harman's one factor test (Podsakoff and Organ, 1986). Exploratory factor analysis revealed that the maximum variance explained by a single factor was 22.7%, which was much lesser than the prescribed limit of 50%. Hence, we can conclude that common method bias was not a significant problem with the data in our study (Podsakoff *et al.*, 2003).

Second, for data analysis we are using partial least squares- structural equation modelling (PLS-SEM) and our research model has both formative and reflective constructs. For such a situation, Kock (2015) has recommended the use of a "full collinearity variance inflation test" for checking if common method bias is confounding the results. Per Kock (2015) for identifying common method bias using PLS, the inner VIF values for both reflective and formative constructs can be utilized - "the occurrence of a VIF greater than 3.3 is proposed as an indication of pathological collinearity, and also as an indication that a model may be contaminated by common method bias. Therefore, if all VIFs resulting from a full collinearity test are equal to or lower than 3.3, the model can be considered free of common method bias" (Kock 2015, pp. 7). Our results presented in Appendix D allow us to conclude that there is no common method bias confounding our results as all the full collinearity variance inflation tests are lower than 3.3.

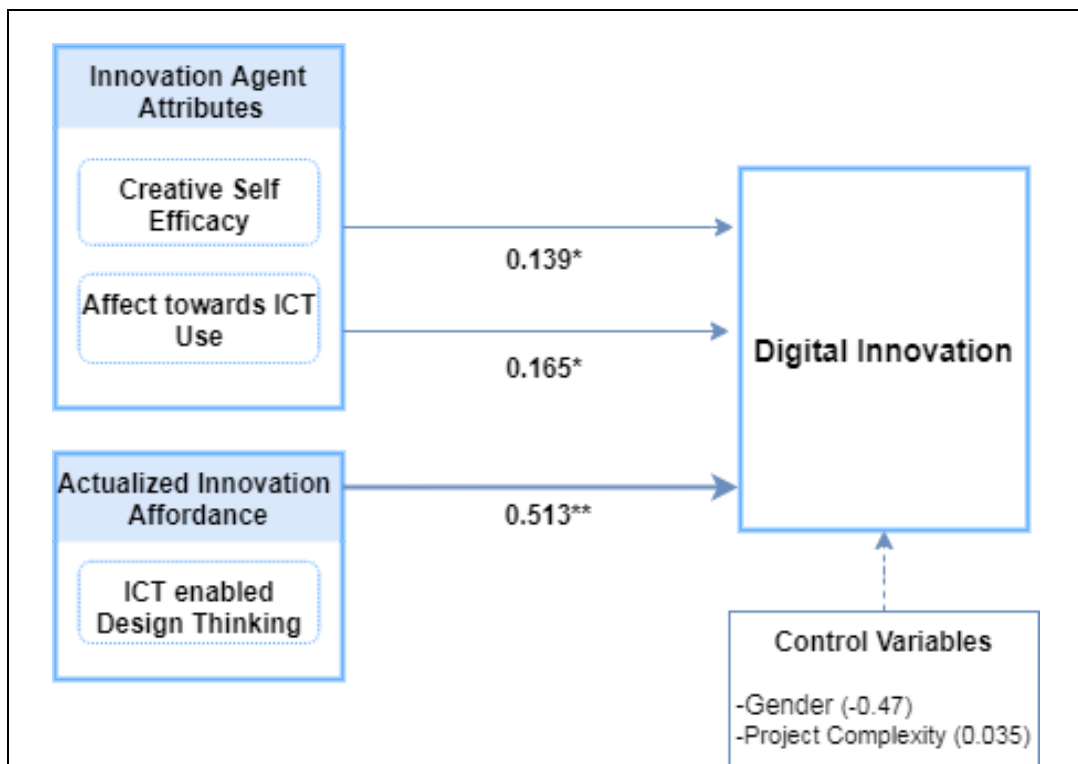
Based on the design procedures and statistical checks described in this section, we can conclusively allay the possibility of common method bias confounding our data and results. In the next section, we take up the structural model assessment to check the hypothesized relationships.

## **6. Results: Structural Model Assessment**

The results from the structural model are indicated in Table 5 and Figure 2.

Control Variables	Digital Innovation		
	Model 1	Model 2	Model 3
	$\beta$	$\beta$	$\beta$
Gender	-0.05	-0.07	-0.05
Project Complexity Perception	0.25**	0.18**	0.04
<b>Innovation Agent Variables</b>			
Creative Self Efficacy		<b>0.18*</b>	<b>0.14*</b>
Affect towards ICT use		<b>0.27**</b>	<b>0.17*</b>
<b>Innovation Affordance Variable</b>			
ICT enabled Design Thinking Creative Process			<b>0.51**</b>
R <sup>2</sup>	0.063	0.182	0.404
$\Delta R^2$		<b>0.119**</b>	<b>0.222**</b>
N=178; * p <0.05 **p <0.01; $\beta$ -Path coefficient			
<b>Table 5: Hierarchical Stepwise Structural Model Results</b>			

The stepwise reporting of results using PLS is similar to other notable prior IS studies, such as Setia *et al.*, (2013), Srivastava & Chandra (2018), and Ann Sykes (2015). The results are presented in Table 5 as a stepwise hierarchical structural model, where in the step 1 only control variables are introduced, in step 2 we introduce innovation agent attributes (creative self-efficacy and affect towards ICT use) in addition to the control variables and in step 3, we add the actualized innovation affordance (ICT-DT). We observe that among the control variables entered in model 1, gender is not significant ( $\beta=-0.05$ ,  $p >0.05$ ) but the perception of project complexity is significantly related to digital innovation ( $\beta=-0.25$ ,  $p <0.01$ ). In the model 2, we note that innovation agent's 'creative self-efficacy' is significantly related to digital innovation ( $\beta=0.18$ ,  $p <0.05$ ), supporting H1a. Similarly, 'affect towards ICT use' has a significant relationship with digital innovation ( $\beta=0.27$ ,  $p <0.01$ ), thereby providing support to H1b. Model 3 provides us insights on actualized innovation affordance where ICT enabled design thinking (ICT-DT) is found be significantly related to digital innovation ( $\beta=0.57$ ,  $p <0.01$ ), supporting H2.



N=178; \*\* indicates p value <0.01; \* indicates a p value <0.05; Other paths are non-significant

**Figure 2: Structural model – Relationships of controls variables, innovation agent attributes and actualized innovation affordance with digital innovation**

For the evaluation of the predictive relevance of the structural model, the Stone and Geisser  $Q^2$  test was performed using the blindfolding procedure (Geisser, 1974, Stone, 1974). The blindfolding test, which was conducted with omission distance equals to 7 (the recommended number), revealed that all  $Q^2$  values of endogenous variable was greater than zero (digital innovation) —0.33 for model 1 and 0.12 for model 2 and 0.27 for model 3. Positive  $Q^2$  values provide evidence of the predictive relevance from the research sample size.

The  $R^2$  or variance explained from each model further elaborates that the control variables only explained 6.3% of the variance in digital innovation (Model 1). However, ‘innovation agent attributes’ together with control variables explains 18.2% of the variance in digital innovation (Model 2). Whereas ‘actualized innovation affordance’ (ICT-DT) together with control variables and innovation agent attributes explain 40.4% of variance in digital innovation (Model 3). Further, the change in variance ( $\Delta R^2$ ) from Model 2 to Model 3 is significant to the extent of 22.2% in contrast to only 11.9% change from Model 1 to Model 2. This clearly highlights the relatively greater importance of ‘actualized innovation affordance’ (in the form of ICT enabled design thinking) in comparison to ‘innovation agent attributes’ (creative self-efficacy and affect towards ICT use).

## 7. Discussion

In this section, we first deliberate on the obtained results, followed by a discussion on the theoretical and practical implications stemming from our study. Concurrently, we also point out to the study’s limitations and identify several interesting avenues for future research that can complement and expand our work.

Based on the results presented in the prior section, we observe that all the hypotheses in this study are generally supported. The results for H1a and H1b show that “‘innovation agent attributes” of ‘creative-self efficacy’ and ‘affect towards ICT use’ together explain about 18 percent of the variance in digital innovation. Hence, it is important for digital innovation research to bring together context specific variables from the two disciplines of creativity and IS research. Although ‘creative self-efficacy’ is a well-established concept in the field of creativity research (Amabile, 1996), it has not been previously examined in the context of digital innovation. In a similar vein, ‘affect towards ICT use’ has been found to be a useful variable for explaining different IS contexts (Thompson *et al.*, 1991), it had not yet been used to understand digital innovation. Clearly, digital innovation needs to be viewed from an interdisciplinary perspective to have a holistic understanding on the subject. In addition, results show that both domain generic and domain specific intrapersonal innovation agent attributes influence digital innovation, which we believe is a novel addition to the current understanding on digital innovation (Amabile, 1996).

The results for H2 show that actualized innovation affordance orchestrated through ICT-DT is positively associated with digital innovation, which establishes the salient role of ICT-DT for facilitating digital innovations at the individual level of analysis (Pozzi *et al.*, 2014; Burton and Volkoff, 2018). Our study answers to calls for integrating creativity and digital innovation

literature (Fichman *et al.*, 2014) and also offers a contextual explanatory theory of ‘effective use of existing IS’ for facilitating digital innovation (Burton and Volkoff, 2018; Unsworth, 2001). At lower levels of abstraction, our study provides validation for the efficacy of ICT-DT approach for creative innovation process, thereby contributing to the growing ecological perspective on understanding the micro-foundations to creativity and digital innovation (Isaksen *et al.*, 1993).

Actualized innovation affordance explains about 22 percent of variance in ‘digital innovation’ at the individual level. The study at a more generic level allows us to empirically discern the role of ICT-enabled design thinking creativity process in digital innovation context which has been missing from literature thus far (Burton and Volkoff, 2018). Developing creativity support tools specifically for design thinking process in a holistic manner is a fruitful area for future research. Further, we show that, similar to other innovative processes, both the “innovation agent attributes and the “actualized innovation affordances” enacted by the innovation agent are important for facilitating digital innovation. In fact, their additive influence explains 40 percent of variance in ‘digital innovation’. However, we observe that the role of actualized innovation affordance is more salient for facilitating digital innovation. Our research validates the need for facilitating the imbrication of human and material agencies to support the goal of innovation agent (Lubart *et al.*, 2005; Glăveanu *et al.*, 2019; Ciriello *et al.*, 2017). Our results also align well with recent research that examines how digital innovation and technology use are linked at the organizational level. Generic technologies can offer actualized affordance for facilitating digital innovation provided collective human agency attributes match well with the task specific goals (Chatterjee *et al.*, 2020).

The control variable of project complexity has positive influence on digital innovation. It may be interesting to consider project complexity as a novel boundary condition to ‘effective use of IS’ in the context of digital innovation. Lenfle and Loch (2010) have highlighted that project complexity can lead to emergent learnings and ‘learning by doing’ as a process outcome. This resonates with the use of design thinking approach for digital innovation enactment, as iterations and learning are integral to such an innovation management approach. Therefore, one may envision that project complexity may moderate the relationship between actualized innovation affordance and digital innovation. We did not theorize for such a relationship; however, future research can examine the role of project complexity in facilitating digital innovation outcomes through a structured innovation method. Such an enquiry can help further contextualize the ‘effective use of IS theory’ to the digital innovation milieu (Burton and Volkoff, 2018).

Our study has been conducted using a student sample, which may limit its generalizability to the real-world scenario. Future research can examine the findings of the study in the context of organizations and real-world professionals. The competence and motivation levels of an innovation agent may differ across student and professional samples. Our study did not check for any counter-factual hypotheses, future research can add such notions to their studies to uncover any potential limitations, such as team-level biases or other contextual factors in non-digital innovation settings that can limit the applicability of the proposed model. Although in our study, we have examined the role of affect towards ICT use as a facilitator for digital innovation, it is possible that negative affect towards use can have a different influence. Negative affect towards ICT might impel the innovation agents to not use (or use less) ICT for innovation. It could be interesting to theorize and examine how *negative affect* towards ICT use influences the enactment and the outcome of digital innovation. Our study investigates individuals embedded in teams; future empirical studies can investigate this research model

purely at team levels after validating the new scale on ICT-DT, similar to recent studies looking at DT's impact on team creativity outcomes (Nagaraj et al., 2020). Future studies can also theorize the influence of digital affordance factors on process outcomes and team effectiveness outcomes separately to offer a nuanced evaluation. For example, the notions of team climate and team psychological empowerment perceptions may interact with team level innovation affordance to influence team process and effectiveness outcomes. A multilevel study can also be undertaken to examine if any of the team level factors influence the individual perceptions of innovation affordance and consequent individual-level digital innovation outcomes. Further, a qualitative study on the subject can help tease out the roles of different technologies in increasing or decreasing innovation affordance. In addition to providing several directions for future research, our study has several theoretical and practical implications, which we discuss in the following section.

### 7.1 Theoretical Implications

Our research makes three key theoretical contributions. First, we contribute to affordance and effective use literatures at the broad level. We demonstrate the value of the 'effective IS use' perspective in conceptualizing the *task* of achieving digital innovation as an outcome of effectively leveraging the right *user* competencies and using a structured method for orchestrating the available technological *systems* in an organization (Burton-Jones and Grange 2013; Burton-Jones and Volkoff 2017). Our results clearly show the salience of *innovation agent attributes* and an *actualized innovation affordance* through the effective use of available technologies for facilitating digital innovation. Specifically, we contextualize the undertheorized aspect of socio-materiality of digital innovation orchestration at innovation agent level in a nontraditional natural field setting using effective use lens (Yoo *et al.*, 2012; Nambisan *et al.*, 2017). We demonstrate that both —domain specific innovation agent attributes and domain specific actualized innovation affordances, act as a micro-foundation (resources) for individual level digital innovation. This finding extends other recent research that holistically tries to understand how generic organizational technology use is linked to digital innovation through the affordance lens (Chatterjee *et al.*, 2020)

Second, in addition to the broad level contributions described above, we offer nuanced contributions to technology affordance and digital innovation literature. We theorize and show the extent to which specific resource mobilization potential embedded in *innovation agent attributes* and *actualized innovation affordance* can facilitate digital innovation. At the micro level, our study argues for the co-alignment of human attributes and technology affordance perceptions for actualization of technology creativity affordance in the context of digital innovation. This extends recent study that look at the co-alignment of collective human agency (values) and technology affordance perceptions for orchestrating digital innovation at the organizational level (Chatterjee *et al.*, 2020). By teasing out "creativity self-efficacy" as domain specific human agent attribute and "affect towards ICT use" as technology specific human agent attribute, we demarcate the two unique type of individual level resources for digital innovation at the micro level. The study, thus extends the emerging literature around digital innovation by providing contextual and nuanced understanding that incorporates domain specific innovation agent attributes and actualized innovation affordances perceived by agents as they enact structured digital innovation practices (Ciriello *et al.*, 2017). The findings from our study can help organizations appreciate the importance of specific innovation agent attributes to better staff innovation projects.

Third, we demonstrate the significant role of using ICT for implementing a structured creative approach such as ICT-DT for facilitating innovation. The results highlight the salience of design thinking creative process for digital innovation and the need to look for other similar structured approaches to exploit the digital technologies for innovation in terms of an actualized innovation affordance. We believe that the current study is one of the first to theorize the role of actualized innovation affordance in facilitating digital innovations at the individual level. Specifically, the study demonstrates the greater importance of innovation affordance—in the form of ‘ICT enabled design thinking creative method’ (ICT-DT), in comparison to innovation agent attributes, for facilitating digital innovation. Thus, we contribute to both—digital innovation literature that has called for more research in “exploitation” of digital technology for digital innovation, and the interactional ecological perspective on creativity and digital innovation by conceptualizing innovation affordance as an actual mangling of practices between technology and human creative process (Barrett *et al.*, 2012; Livingstone *et al.*, 1997; Nambisan *et al.*, 2017). Moreover, our work enriches the rather sparse literature that links individual-level creativity engagement with digital innovation (Fichman *et al.*, 2014). The study also integrates the creativity literature with the digital innovation literature by examining the influence of expected creativity on digital innovation (Unsworth, 2001).

## **7.2 Methodological Contribution**

Our research conceptualizes and empirically establishes the importance of having a structured innovation approach, specifically, ICT-DT for digital innovation. Our study contributes to the literature by operationalizing ICT-DT measured as a five-item formative construct. The conceptualized construct can be used by future research to examine the salience of ICT-DT in different contexts. The validated scale can also contribute to the stream of literature that investigates the performative aspects of design thinking (see Carlgren *et al.*, 2016).

## **7.3 Practical Implications**

First, the results from our study encourages innovation practitioners to provide digital infrastructure to innovation agents for actively leveraging its use for innovation. The study demonstrates that the imbrication of human and material technologies can contribute to an affordance perception and enactment for creativity related tasks.

Second, our study informs human resource practitioners that care should be taken while relying only on multivariate and cognitive determinants of creativity for the selection of employees for innovative digital projects. The results from our study demonstrate that an ecological perspective is more effective in facilitating digital innovation. Hence, the managerial focus should be on providing a supportive method-based environment that offers a framework to the workers for enabling a creative output. ICT-DT, conceptualized and proposed in this study, can be one of the structured approaches that can be effective in facilitating digital innovation.

Third, human resource practitioners should take into consideration the role of domain specific and task specific innovation agent attributes such as “creativity self-efficacy beliefs” and “technology specific positive affect” for facilitating digital innovations, rather than relying solely on general traits and capabilities. In this context, it may be prudent to evaluate aspects of individual’s cognitive biases such as the technological frames and the influence of these biases

on innovation affordance (Shirish, 2020). However, more research on this aspect is warranted and can be a potential extension of our work.

Fourth, the results from this study are practically useful in understanding the extent to which DT creative process can facilitate social and digital innovation amongst young adults. The pervasive use of technologies by digital natives provides evidence that even without the structured use of a specific enterprise level creative support system there could be an emergence of innovation affordance (e.g., Shirish *et al.*, 2016; Chandra *et al.*, 2019). Therefore, design-thinking approach can be a useful creative process that can be applied to all types of innovation contexts including those that are distributed or rely on open innovation, such as —social media, mobile applications, analytics, cloud computing and internet of things (Chan *et al.*, 2019). However, it remains to be seen, if the relevance of the ICT-DT as an actualized innovation affordance will be applicable to all areas of innovation beyond the context of ‘digital’ innovation because many new product development teams are focused on creative output but not necessarily digital innovation (Nagaraj *et al.* 2020). It is also possible for future research to examine how ICTs may constrain a specific innovation process (Ciriello *et al.*, 2019).

Another related implication for practitioners and future researchers is to develop a configurational approach to the digital innovation process (see Isaksen *et al.*, 1993). A configurational perspective to digital innovation will allow experimentation on different user profiles in conjunction with appropriate environmental factors for a specific type of innovation problem. Such a nuanced understanding is currently lacking in literature and can be a useful avenue for future research. Configuration can comprise a combination of factors such as innovation agent capabilities, suitable technological infrastructure, a supportive environment, and a congruent problem-solving situation. Research on the influence of specific typologies of such configurations for facilitating digital innovation will help design proactive innovation strategies. In the present study, the problem that required a creative solution was open ended and unstructured. This is different from most actual situations in organizations that may warrant a responsive creativity to a specific problem, which is based on close-ended creative solutions (Srivastava *et al.*, 2013; Unsworth, 2001). Future research can explore responsive creativity and the role of ICT-DT in facilitating planned innovation.

## **8. Conclusion**

With the growth in the availability of digital resources, it is necessary for organizations to understand and implement the modalities for leveraging the available ICTs for their innovation endeavors. Grounding our work in the theory of *effective IS use* and taking a *technology affordance* perspective, we posit that for facilitating digital innovations organizations need to focus on two key elements, namely ‘innovation agent attributes’ and an ‘actualized innovation affordance’. We conceptualize the domain generic and domain specific innovation agent attributes of ‘creative self-efficacy’ and ‘affect towards ICT use’ and an actualized innovation affordance through ‘ICT enabled design-thinking approach’ (ICT-DT). We contend that ICT-DT offers one possible structured approach to effectively use digital resources within an organization for innovation. By integrating creativity and digital innovation literature, our theorization delineates the mechanisms through which the goal-directed ‘problem-solving-potential’ of the innovation agent and the ‘problem-solution-matching’ through actualized innovation affordance, can facilitate digital innovation (Nambisan *et al.*, 2017). Findings highlight the significant role of innovation agent attributes and innovation affordance as micro-foundations for digital innovation. In particular, both the hypothesized innovation agent attributes of ‘creative self-efficacy’ and ‘affect towards ICT use’ are significant facilitators of



digital innovation. In addition, the actualized innovation affordance operationalized through ICT-DT is a significant determinant of digital innovation. However, results demonstrate the stronger association of ICT-DT with digital innovation, highlighting the need for organizations to integrate the use of technologies for enabling structured creativity approaches (such as DT) for facilitating innovative outcomes. Based on our study we also suggest several avenues for future research that can serve to enrich the field of digital innovation and creativity.

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## Appendices

### Appendix A: Contextual integration of digital innovation affordance and effective use of IS literature

Theoretical Perspective	Context	Innovation Agent Attributes	Technology	Affordance Potential	Actualized Innovation Affordance	Outcomes
Digital Innovation - Exploitation of existing information systems	Need to develop a rough prototype of a digital innovation using design thinking creative process	Problem solving potential of innovative agent	Access and freedom to use any existing generic institutional and/or personal ICT tools for digital innovation process or product.	ICT enabled Creative Process Facilitation	Actualized Affordance	Digital Innovation
Effective Use of IS	A challenge to propose a solution to any wicked problem (undefined)	Context specific responsible goal directed IT user attributes	Access and freedom to use any existing generic institutional	ICT enabled Creative Process Facilitation	Effective Use Enactment - The extent of ICT enabled design	Direct Outcome (Measured): <b>Novel and useful solution</b>



	faced by the local community using ICTs and design thinking creativity method	<b><i>-Creative Self efficacy</i></b> <b><i>-Affect Towards ICT use</i></b>	and/or personal ICT tools for goal achievement.		thinking creative process perceived by specific goal directed IS users.	<b><i>proposed to solve wicked societal problem using ICTs.</i></b>  Indirect Outcome (not measured): Learning by doing and reflection on digital innovation orchestration
<p>We situate the current research in digital innovation affordance and effective use of IS literature. The interaction and the use of existing IT by a goal directed potential innovative agent for new purposes leads to enactment of actualized affordance. Thus, both the agent attributes and the sociomaterial dimension constitute resources for innovation orchestration.</p> <p>Note: Those italics and bold lines are measured in this study in relation to digital innovation outcome.</p>						

## Appendix B: ICT Enabled Design Thinking (ICT-DT) creative process construct

### ICT enabled Design Thinking (ICT-DT) construct

To what extent did you use ICTs for your innovation project activities (on a scale of 1 to 5; where 1 denotes “none at all” and 5 denotes “a great deal”).

1. To observe the behaviors and perceptions of the problem impacted user group (DT1)
2. To define potential solutions to the problem (DT2)
3. To enable brainstorming of the creative solutions with others (DT3)
4. To develop a prototype in order to get quick reaction and user feedback (DT4)
5. To iterate and devise a final solution, service or product for the identified problem (DT5)

Please note the term ‘user’ denotes any human/virtual entity e.g. customers, consumer, stakeholders, society as may be relevant to the problem-solving setting.

## Appendix C: Discriminant Validity Check for Formative Construct (ICT-DT)

The methodological procedure for demonstrating discriminant validity for formative constructs is not the same as for models that have only reflective indicators. We followed a specific method proposed for structural equation models undertaken via SmartPLS. Per Wang *et al.*, (2015) discriminant validity between formative causal constructs and reflective constructs can be established using the mediation method approach. In this case, each indicator of the ICT-DT construct was used as an independent variable and the ‘digital innovation’ construct was used as the dependent variable. If the path between the independent variables and the dependent variable is mediated by the formative causal construct ICT-DT then one can conclude that there is sufficient discriminant validity between the formative construct (ICT-DT) and digital innovation. In our analysis, Path A refers to path coefficients of DT1-DT5 to ICT-DT formative causal construct, Path B refers to the path coefficient of between ICT-DT to ‘digital innovation’ and Path C refers to the path coefficient between individual indicators DT1-DT5 to ‘digital innovation’. The below table proves the discriminant validity of the construct DT with regards to ICT enabled digital innovation, hence also ruling out any endogeneity issues that may arise.

	Path A	Path B	Path C without controlling for path A and B	Path C controlling for path A and B	Discriminant Validity through mediation (Partial or full) Established
DT1	.552*	.558*	.486*	.313*	Yes
DT2	.497*	.585*	.277*	-.028	Yes
DT3	.524*	.544*	.476*	.261*	Yes
DT4	.558*	.579*	.307*	-0.22	Yes
DT5	.565*	.545*	.404*	.138	Yes

#### Appendix D: Full Collinearity Variance Inflation Test for Common Method Bias in SEM-PLS

In addition to other procedures described in the manuscript, we conducted common method bias analysis in the context of PLS-SEM by employing “full collinearity variance inflation test”. According to Kock (2015) for identifying common method bias using PLS, the inner VIF values for reflective and formative constructs can be utilized. Kock (2015, p7) stated that “the occurrence of a VIF greater than 3.3 is proposed as an indication of pathological collinearity, and also as an indication that a model may be contaminated by common method bias. Therefore, if all VIFs resulting from a full collinearity test are equal to or lower than 3.3, the model can be considered free of common method bias.” As per Kock 2015, a higher tolerance level of 5.0 is suggested for general collinearity tests, but the more stringent threshold of 3.3 is applied to test for common method bias.

Accordingly, we undertook the prescribed common method bias analysis and the VIF values for all the paths leading to the dependent variable were below 3.3. We also undertook the same test on all the main constructs used in the study in order to provide a full multicollinearity test, namely, with DT, CSEFF and AFFICT variables as well (Tables A to D). The results of the inner VIF values in all the cases were below 3.3 allaying the possibility of common method bias confounding our research results. See tables A to D below that provide the results of our analysis.

Table A. DINNOV Path

	AFFICT	CSEFF	DINNOV	DT	GEN	PCOMP
AFFICT			1.166			
CSEFF			1.122			
DINNOV						
DT			1.235			
GEN			1.045			
PCOMP			1.177			

Note: ATU- Affect towards Technology Use; CSEFF- Creative Self efficacy; DINV- Digital Innovation; DT- ICT enabled Design Thinking; GEN- Gender; PCOMP- Project Complexity

Table B: DT path

	AFFICT	CSEFF	DINNOV	DT	GEN	PCOMP
AFFICT				1.231		

<b>CSEFF</b>				1.188		
<b>DINNOV</b>				1.321		
<b>DT</b>						
<b>GEN</b>				1.068		
<b>PCOMP</b>				1.126		
Note: ATU- Affect towards Technology Use; CSEFF- Creative Self efficacy; DINV- Digital Innovation; DT- ICT enabled Design Thinking; GEN- Gender; PCOMP- Project Complexity						

Table C: CSEFF path

	<b>AFFICT</b>	<b>CSEFF</b>	<b>DINNOV</b>	<b>DT</b>	<b>GEN</b>	<b>PCOMP</b>
<b>AFFICT</b>		1.186				
<b>CSEFF</b>						
<b>DINNOV</b>		1.344				
<b>DT</b>		1.163				
<b>GEN</b>		1.006				
<b>PCOMP</b>		1.114				
Note: ATU- Affect towards Technology Use; CSEFF- Creative Self efficacy; DINV- Digital Innovation; DT- ICT enabled Design Thinking; GEN- Gender; PCOMP- Project Complexity						

Table D: AFFICT path

	<b>AFFICT</b>	<b>CSEFF</b>	<b>DINNOV</b>	<b>DT</b>	<b>GEN</b>	<b>PCOMP</b>
<b>AFFICT</b>						
<b>CSEFF</b>	1.146					
<b>DINNOV</b>	1.747					
<b>DT</b>	1.682					
<b>GEN</b>	1.059					
<b>PCOMP</b>	1.143					