Determinants of users' acceptance of a computer-based system

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Abstract

Sweden has an ambitious target to attain 50% more efficient energy use by 2030. Improving the energy performance of buildings provides a great opportunity to achieve the above-mentioned target. At this point, windows play a substantial role in improving indoor environmental quality and reducing energy consumption and cost. A computer-based system was therefore developed, which allows selecting a suitable window design. The computer-based system was intended to be used in a large-sized window and door manufacturing company in Sweden. However, the benefits of implementing the computer-based system cannot be realized until users accept using it. Former literature employed the technology acceptance model to investigate the influence of external variables on cognitive beliefs and trace their effects on users' intention and actual system use. A successful application of TAM relies on the specification of the external variable. Accordingly, this paper conducted a systematic literature review to determine the external variable, affecting users' acceptance, thereby extended TAM. The analyses of results showed that organizational, individual, technological and environmental characteristics were the most influential external variables when investigating determinants of users' acceptance toward a computer-based system. Organizational characteristics contained mainly top management support, training, organizational culture, and organizational size, while individual characteristics embraced users' previous knowledge and experience. Technological characteristics comprised information quality and system quality, meanwhile environmental characteristics included fulfillment of regulations and competitiveness. The extended TAM overcomes limitations attributed to the unified theory of acceptance and use of technology model since it considers attitude as direct determinants of intentions. In addition, the extended TAM is advantageous when compared with technology, organization, environment framework, because it has clear constructs, which allows tracing the influence of external variables on cognitive beliefs, and thereby their effects on users' intention and actual system use. The extended TAM will be used to investigate determinants of users' acceptance of the computer-based system in the manufacturing company in Sweden and compare the effect of external variables on users' acceptance.

Keywords: Technology acceptance model, computer-based system, perceived usefulness, perceived ease of use

1. Introduction

The Paris agreement commits parties to the United Nations Framework Convention on Climate Change to advance actions required for cutting greenhouse gas emissions, thereby mitigating climate changes (United Nations, 2019). In addition, the European Performance of Building Directive obliged European countries to ensure zero energy codes and minimum indoor comfort thresholds when constructing new buildings (EPBD 2010). An ambitious target was therefore set in Sweden, which binds the country to attain 50% more efficient energy use by 2030 (Goverment Officies of Sweden, 2019). Although several efforts have undertaken to fulfill the abovementioned target, the total energy

consumption within the building and service sector has mainly remained unchanged (Swedish Energy Agency, 2019). This occurs due to the existence of a strategic conflict: whether to enhance the efficiency of supply-side technologies and exploit renewable energy resources or improve the efficiency of demand-side services and technologies (Lundström, 2016). The abovementioned conflict is more illustrated in countries such as Sweden, where the biomass-based district heating system makes up the greatest share in supporting the heating demand in building and service sector (Swedish Energy Agency, 2019). Substituting the biomass-based district heating system is a complex matter due to a high share of secondary energy resources such as waste materials and forestry residuals and cogeneration of electricity and heat in several power plants (Lundström, 2016). The complexity of substituting district heating system shifts focuses on improving the efficiency of demand-side services and technologies for reducing the total energy demand (Hee et al., 2015). According to Hee et al. (2015) and Jalilzadehazhari, Johansson, Johansson, and Mahapatra (2018), the energy performance of buildings and the state of indoor environmental quality depend on building envelopes particularly windows. However, selecting a suitable window is a complex task due to three main difficulties: i) existence of conflicts between visual comfort, thermal comfort, energy consumption and life-cycle cost, ii) availability of various window designs with different sizes, positions, glazing systems, and forms, and iii) the need for considering all criteria which have effect on visual comfort, thermal comfort, energy consumption, and life-cycle cost when selecting windows (Jalilzadehazhari, Johansson, & Mahapatra, 2018).

To overcome the abovementioned difficulties, Jalilzadehazhari, Johansson, Johansson, et al. (2018) introduced a decision-making framework, which allows selecting a window design based on the trade-off between visual comfort, thermal comfort, energy consumption, and life-cycle cost. The decision-making framework is an interactive computer-based system, which utilizes a simulation tool and an optimization platform to select a trade-off window design (Jalilzadehazhari, Johansson, Johansson, et al., 2018). The computer-based system was intended to be used in a large-sized window and door manufacturing company[1] in Sweden to help either private clients or architects and designer in selecting a trade-off window design. Although, the strength of the decision-making framework in solving complex and conflicting tasks was tested and found appreciated (Jalilzadehazhari, Johansson, & Mahapatra, 2018) the complexity of the computer-based system can perceive as a barrier for its implementation in design practices (Lu et al., 2014). Accordingly, benefits expected from implementing the computer-based system cannot be realized unless users[2] accept using it in design practices (Saadé & Kira, 2007). According to Park, Son, and Kim (2012), the reason for failure in the deployment of computer-based systems is not that they failed to fulfill as expected, but rather that users refused to use them.

Former studies investigate the determinants of user acceptance of a computer-based system using the technology acceptance (TAM) model. TAM allows tracing the influence of external variables on cognitive beliefs, and thereby their effects on users' intention and actual system use (Venkatesh, Morris, Davis, & Davis, 2003). Although TAM has been widely applied in different fields (Acquah & Oteng, 2018; Lee, Yu, & Jeong, 2013; Son, Lee, Hwang, & Kim, 2014; Usman & Said, 2012), it received criticisms due to confusion over external variables (Gangwar, Date, & Raoot, 2014). Thus, investigating the determinants of users' acceptance of computer-based systems requires exploration of external variables, which affects their actual use. This study conducts a systematic literature review and summarized external variables, affecting users' acceptance towards computer-based systems, thereby extends TAM. The extended version of TAM in this paper will be later used to investigate determinants of users' acceptance of the computer-based system in the manufacturing company in Sweden and compare the effect of external variables on users' acceptance.

[1] The manufacturing company has more than 1000 employees, thereby is considered as a large-sized company (Arnold, 2012)

[2] Shih and Venkatesh (2004) discussed about four typologies of users: intense users, specialized users, non-specialized users, and limited users. Intense users utilize a computer-based system for a significant amount of time to perform a variety of tasks, while specialized users spend much time using the system but for doing limited tasks (Shih & Venkatesh, 2004). Non-specialized users exploit the computer-based system to perform different tasks but for a limited amount of time, but limited users apply the system for a limited variety of use and for a short period of time (Shih & Venkatesh, 2004).

2. Technology acceptance model

The TAM, originally derived from the theory of Reasoned Action and theory of planned behavior, aims to discover users' acceptance related to a board variety of ICT technologies (Lee et al., 2013; Venkatesh et al., 2003). Application of TAM allows one to investigate the influence of external variables on cognitive beliefs and trace their effects on users' intention and actual system use (Figure 1) (Venkatesh & Davis, 1996). Cognitive beliefs within the TAM comprise users' perceived usefulness and perceived ease of use (Venkatesh & Davis, 1996). Perceived usefulness refers to users' beliefs regarding the usefulness of a computer-based system in enhancing their job performance (Venkatesh & Davis, 1996), while perceived ease of use is defined as the degree to which users believe that using the computer-based system is free of effort (Venkatesh & Davis, 1996). One of the main advantages of TAM is its simplicity (To, Lee, & Lam, 2018), accordingly, it allows researchers to extend TAM and test several hypotheses, drawing upon TAM to explain users' acceptance of ICT technologies.

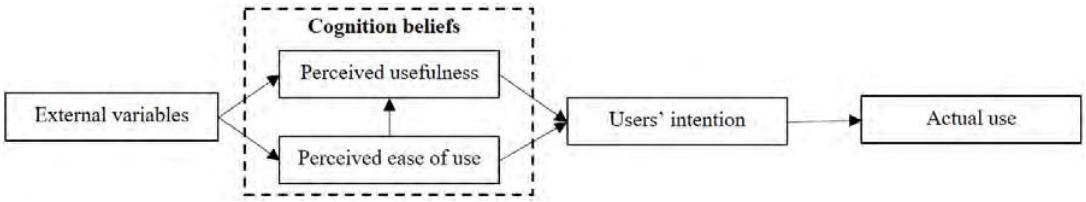

Figure 1: The TAM, proposed by Venkatesh and Davis (1996)

3. Methodology

The search for relevant literature was accomplished in the Scopus database, using six main keywords, including "technology acceptance model", "manufacturing", "architecture", "construction", "ICT" and "computer-based system". The subject area was limited to "business, management and accounting", "engineering", "computer science", "decision science", "energy", "mathematics", "economics, econometrics and finance", "environmental science" and "social sciences". Furthermore, each search term was limited to English language literature, published from 2000 until 2019. The primary search resulted in 146 literature. The abstract of found literature was read and the eligible 49 literature were selected for further review. In addition, relevant literature cited by 49 eligible literature were reviewed to gain in-depth knowledge.

4. Results

Investigated literature considered multiple external variables and analyzed their effects on actual system use. Figure 2 summarized the most influential external variables when investigating determinants of users' acceptance towards computer-based systems, that includes organizational, individual, technological and environmental characteristics. Technological characteristics with a share of 33% were the most studied external variables; following by organizational characteristics with a share of 20%, then individual and environmental characteristics with a similar weight of 12%.

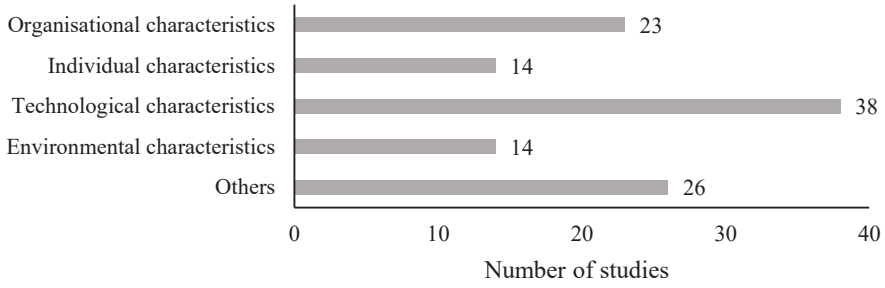

Figure 2: The most influential external variables

4.1. Extended TAM and hypotheses

Organizational characteristics [3] comprised mainly top management support, training, organizational culture, and organizational size (Park et al., 2012; Peansupap & Walker, 2004). Top management support refers to the degree to which the top management comprehend the value of a computer-based system and the domain to which it is exploited in the activities of an organization (Al Haderi, Fareen Abdul Rahim, & Mohammed Bamahros, 2018). Top management support can be considered as one of the most essential factors influencing actual system use (Tatari, Castro-Lacouture, & Skibniewski, 2007) because it is attributed to users' appraisal about top management commitment in allocating resources to support the adoption of a computer-based system (Kamel, 2010). According to Peansupap and Walker (2006), the lack of top management support can evince user resistance to use a new computer-based system. On the contrary, top management commitment in designing a suitable strategy for supporting the acquisition of a computer-based system can reduce users' anxiety and boosts their self-efficacy (Al Haderi et al., 2018). Former literature discussed that top management support is strongly correlated to perceived usefulness and perceived ease of use (Lewis, Agarwal, & Sambamurthy, 2003). The following hypotheses were therefore posited:

Hypothesis 1. Top management support has a significant positive effect on perceived usefulness.
Hypothesis 2. Top management support has a significant positive effect on perceived ease of use.

The training was also concluded as an important factor, which affects perceived usefulness and perceived ease of use (Peansupap & Walker, 2005). Training is an effective way to simplify a computer-based system use in practice, furthermore, it can help users in realizing the usefulness of a computer-based system (Peansupap & Walker, 2005). Training is often influenced by top management support (Tahilramani, 2013) and organizational social context (Tahilramani, 2013). Top management commitment to the training can ensure users' active participation in training, thereby streamlining the use of a computer-based system (Tahilramani, 2013) and improves the effectiveness of the system (Kamel, 2010). Furthermore, the social context within an organization influences the encouragement of training to knowledge acquisition, because it can promote personal developments. Accordingly, the following hypotheses were adopted:

Hypothesis 3. Training has a significant positive effect on perceived usefulness.
Hypothesis 4. Training has a significant positive effect on perceived ease of use.
Organizational culture is mainly defined as an intricate set of assumptions and values (Jones,

[3] Former studies included strategic ICT planning as a significant organizational characteristic, which affects the adoption of a computer-based system in organizations. Strategic ICT planning aligns a computer-based system to organizational objectives (Peansupap & Walker, 2004). Existing of a long-term strategic ICT plan, such as cost reduction strategy and differentiate strategy, can provide competitive advantages to organizations (Peansupap & Walker, 2004). The cost reduction strategy stresses using computer-based systems to improve users' performance and productivity, thereby cutting time and cost, while the differentiated strategy concentrates on using computer-based systems for developing new products, which provides possibilities for new business delivery (Peansupap & Walker, 2004). However, the strategic ICT planning affects organizational decision-making in using computer-based systems (Peansupap & Walker, 2004) rather than users' acceptance, accordingly, it was excluded when extending TAM.

Jimmieson, & Griffiths, 2005), which shape the manner in which organizations carry on their businesses (Mansor, Tayib, & Science, 2010). Values, which are considered as central elements of organizational culture, are employees shared rules and beliefs, that distinguishes an organization from other organizations (Mansor et al., 2010). Hofstede, Neuijen, Ohayv, and Sanders (1990) specified six dimensions to characterize organizational culture, from which three of them were used often when studying users' acceptance of a computer-based system (Ciganke, Mao, & Srite, 2008; Mahomed et al., 2017): Results-oriented vs process-oriented culture, Employee-oriented vs job-oriented culture, and Open-system vs close-system culture. Result-oriented culture concentrates mainly on exploring new ideas and achieving desired results to fulfill organizational objectives, while process-oriented culture promotes risk-avoidance culture among employees with less creativity. According to Ruppel and Harrington (2001), an organization with result-oriented culture improves users' perceived usefulness and perceived ease of use. The following hypotheses were therefore posited:

Hypothesis 5. Result-oriented culture has a significant positive effect on perceived usefulness.
Hypothesis 6. Result-oriented culture has a significant positive effect on perceived ease of use.

An organization with employee-oriented culture shows a great concern about employees' personal needs, in contrast, an organization with job-oriented culture focuses on outputs rather than employees' need. Mahomed et al. (2017) discussed that organizations with employee-oriented culture are more likely to embrace a new computer-based system and give employees opportunities to realize its benefits, thereby improves users' perceived usefulness and perceived ease of use. Accordingly, two further hypotheses were adopted:

Hypothesis 7. Employee-oriented culture has a significant positive effect on perceived usefulness.
Hypothesis 8. Employee-oriented culture has a significant positive effect on perceived ease of use.

Furthermore, an organization with open-system culture welcomes newcomers, where employees have a sense of belonging to the organization, while an organization with closed-system culture is secretive even to its employees (Mahomed et al., 2017). Employees of an organization with open-system culture are willing to share their experiences and aid each other when using a new computer-based system, which can enhance users' perceived usefulness and perceived ease of use (Ciganke et al., 2008). Therefore, the following hypotheses were considered:

Hypothesis 9. Open-system culture has a significant positive effect on perceived usefulness.
Hypothesis 10. Open-system culture has a significant positive effect on perceived ease of use.

Former studies have mainly contradictory attitudes regarding relationships between organizational size and users' acceptance of a computer-based system. For instance, Cho (2007) and Nikas, Poulymenakou, and Kriaris (2007) stated that larger organizations spend additional effort on the effectiveness of a computer-based system, thereby affect perceived usefulness and perceived ease of use. Because larger organizations deal with greater business and operational complexity, furthermore they have more organizational and economic resources (Cho, 2007; Nikas et al., 2007). While Hua (2007) discussed that small and medium-sized organizations have more flexibility, accordingly they more likely to support a new computer-based system and thereby improve users' perceived usefulness and perceived ease of use. The following hypotheses were therefore considered:

Hypothesis 11. Organizational size has a significant positive effect on perceived usefulness.
Hypothesis 12. Organizational size has a significant positive effect on perceived ease of use.

Individual characteristic comprises users' previous knowledge and experience, which refers to the degree whether or not users know how to use a new computer-based system (Lu et al., 2014; Xu & Quaddus, 2005). Lack of knowledge and skill can negatively impact perceived usefulness and perceived ease of use; accordingly, it makes the actual use of a computer-based system a sophisticated matter. The latest statement is more illustrated in small and medium-sized companies since they can be incapable to afford a high-salary position to expert personnel (Lu et al., 2014). Thus, the following hypotheses

were posited:

Hypothesis 13 users' previous knowledge and experience have a significant positive effect on perceived usefulness.

Hypothesis 14. Users' previous knowledge and experience have a significant positive effect on perceived ease of use.

Technological characteristics in terms of computer-based system usage include mainly different attributes of information quality and system quality (DeLone, McLean, & out of mind, 1999; Park et al., 2012). Information quality refers mainly to accuracy, reliability, and compatibility of a computer-based system. Former literature has a controversial view when investigating the importance of information quality. Some literature propounded information quality as being important from users' perspective (Mohd, Syed-Mohamad, & Zaini, 2005), while others considered it as being important from vendor's view (Chismar & Wiley-Patton, 2003). The results of previous literature have shown that information quality is significantly correlated to perceived usefulness and perceive ease of use (Chismar & Wiley-Patton, 2003; Lin, 2007; Mohd et al., 2005; Wang, Wang, & Education, 2009). Accordingly, the following hypotheses were considered:

Hypothesis 15. Information quality has a significant positive effect on perceived usefulness.

Hypothesis 16. Information quality has a significant positive effect on perceived ease of use.

System quality stresses simplicity and responsiveness of a computer-based system (Lu et al., 2014; Park et al., 2012; Son et al., 2014). Users' experience in terms of system quality has a significant influence on their perceived usefulness and perceived ease of use (Lin, 2007; Wang et al., 2009), thereby it shapes their intentions in accepting a computer-based system and affects actual use. The following hypotheses were therefore added:

Hypothesis 17. System quality has a significant positive effect on perceived usefulness.

Hypothesis 18. System quality has a significant positive effect on perceived ease of use

Environmental characteristics include mainly governmental regulations, competitiveness (Al-Fahim, Jusoh, & Abideen, 2014; Hameed & Arachchilage, 2017) and market demands (Nikas et al., 2007). The fulfillment of environmental characteristics can positively influence the output quality and results' demonstrability. Output quality refers to the degree to which users believe that a new computer-based system can accomplish required tasks, while result demonstrability is about the tangibility of the results (Gupta, Singh, & Bhaskar, 2016). The results of previous literature have shown environmental characteristics are significantly related to perceived usefulness and perceived ease of use (Akça & Özer, 2016). Thus, the following hypothesis was included:

Hypothesis 19. Governmental regulations and competitive forces have a significant positive effect on perceived usefulness.

Hypothesis 20. Governmental regulations and competitive forces have a significant positive effect on perceived usefulness.

Further hypotheses were posited to explain the relationship between perceived usefulness and perceived ease of use. According to Legris, Ingham, Collerette, and management (2003) and Venkatesh and Davis (2000), a computer-based system is perceived more useful when it is easy for users to utilize it in practice, that explains the effect of perceived ease of use on perceived usefulness. Enhanced perceived usefulness and perceived ease of use can improve user's intention in using a computer-based system, which can later lead to actual system use (Liao et al., 2018; Venkatesh & Davis, 1996). Thus, the following hypotheses were considered:

Hypothesis 21. Perceived usefulness has a significant positive effect on users' intention.

Hypothesis 22. Perceived ease of use has a significant positive effect on users' intention.

Hypothesis 23. Perceived ease of use has a significant positive effect on perceived usefulness.

Hypothesis 24. Users' intention has a significant positive effect on actual use.

Figure 2 illustrates the extended version of TAM, developed to investigate determinants of users' acceptance of a computer-based system. It includes the organizational, technological, individuals and environmental characteristics, and presents how they affect users' perceived usefulness and perceived ease of use, thereby shape the actual use. The arrows show hypothesized relationships in the direction of arrows.

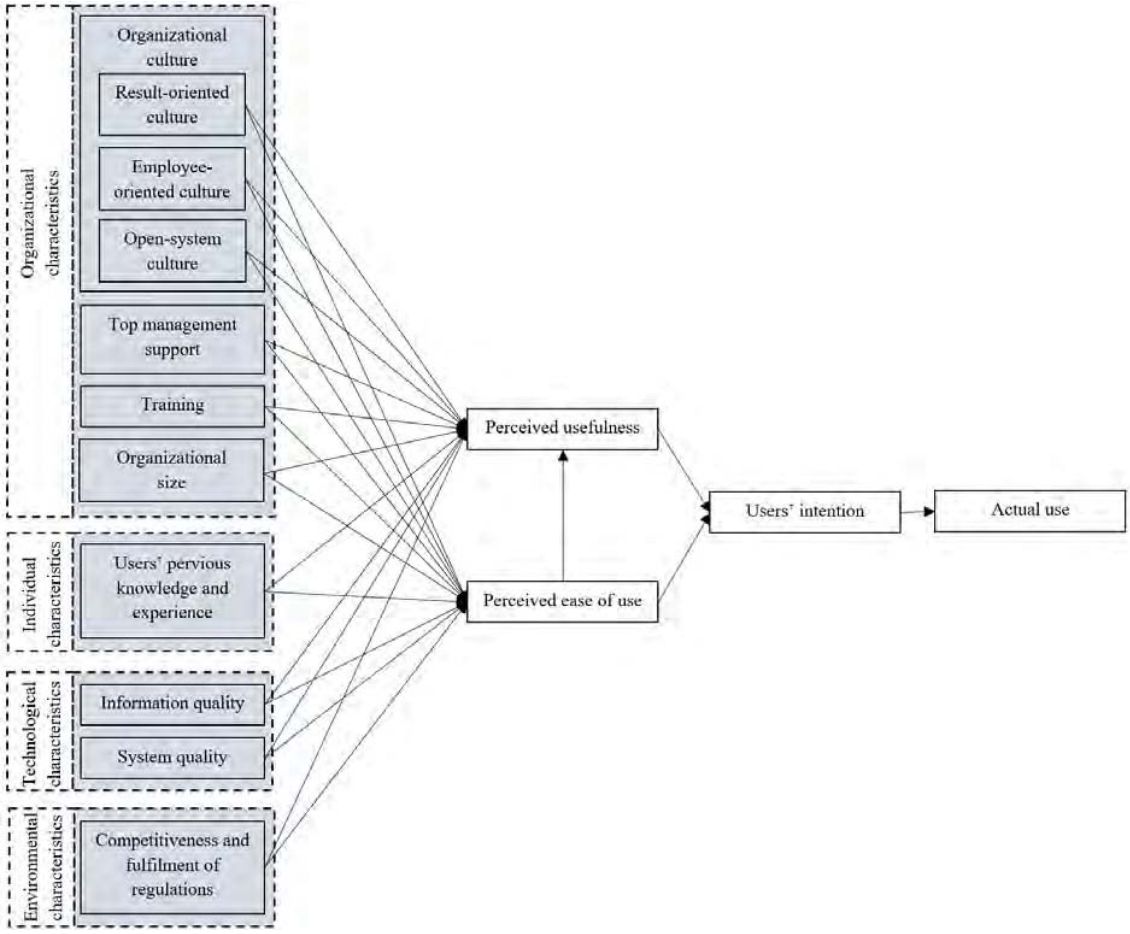

Figure 2: The extended version of TAM

5. Conclusion

Ambitious targets were set in Sweden, which binds the country to achieve 50% more efficient energy use by 2030. Although several attempts were made to achieve the abovementioned target, the energy consumption within the building and service sector in Sweden remained unchanged. At this point, selecting a suitable window design can reduce the energy performance of buildings, in addition, it contributes to improved indoor environmental quality and reduced cost. For this purpose, a computer-based system was previously developed, which allows selecting a suitable window design. The computer-based system was intended to be used in a large-size window and door manufacturing company in Sweden. Although, the strength of the computer-based system in selecting a suitable window design was tested and found appreciated, benefits expected from its implementation cannot be realized unless users accept using it in design practices. Former literature has mainly employed the technology acceptance model (TAM) to investigate the determinants of users' acceptance of a computer-based model. The TAM allows analyzing the effect of external variables on users' intention and actual system use. Successful application of TAM is highly dependent on the specification of external variables. Accordingly, this study conducted a literature review to determine external variables,

influencing users' acceptance of a computer-based system, thereby it extended TAM. Former literature considered multiple external variables and analyzed their effect on users' acceptance. However, the most influential variables can be categorized into organizational, individual, technological and environmental characteristics. Organizational characteristics comprised mainly top management support, training, organizational culture, and organizational size, while individual characteristics included users' previous knowledge and experience. Technological characteristics contained information quality and system quality, meanwhile environmental characteristics included fulfillment of regulations and competitiveness.

The extended TAM differs from other available theories and models, used when investigating users' acceptance: "media richness", "social presence", "unified theory of acceptance and use of technology (UTAUT)", and "technology, organization, environment framework" (TOE). The media richness theory concentrates on abilities of communication mediums as computer-based systems in delivering rich information (Oliver, 2019; Watjatrakul & Barikdar, 2007), while social presence theory addresses the degree of salience (i.e., state of being connected) between users of the communication medium (Oliver, 2019; Watjatrakul & Barikdar, 2007). The abovementioned theories have mainly analyzed how communication mediums as computer-based systems facilitates sending rich information and how they improve the quality of human-to-human communications and interactions (Sallnäs, 2004). But TAM concentrates mainly on human-to-computer interactions and provides insight about external variables, which determine users' acceptance. The UTAUT and TOE were commonly used when investigating users' acceptance, but they were criticized due to some limitations. The UTAUT considers only the indirect effect of users' intention on actual system use (Moghavvemi, Salleh, & Abessi, 2013). Furthermore, UTAUT is limited due to its inflexibility to be adapted to different contexts (Al-Gahtani, Hubona, & Wang, 2007). The TOE is only a taxonomy of drivers with no clear constructs, hence it should be further developed to represent an integrated conceptual framework (Dedrick & West, 2003). But the extended TAM considers intention as direct determinants of actual system use (Dedrick & West, 2003), furthermore it functions fully across cross-cultural boundaries (McCoy, Everard, & Jones, 2005), thereby the extended TAM overcomes limitations with the application of UTAUT. In addition, the extended TAM has explicit constructs, which allows one to trace the influence of external variables on cognitive beliefs, and thereby their effects on users' intention and actual system use.

The extended TAM was developed by reviewing literature from manufacturing, architecture, and construction disciplines; accordingly, it can be employed to investigate users' acceptance of a computer-based system within these disciplines. However, the extended TAM can be criticized due to its inherent limitations (Salovaara & Tamminen, 2009). When using the extended TAM, one should conduct questionnaire research method to gather and analyze users' acceptance toward a computer-based system. However, users may have different understandings about the questions (Salovaara & Tamminen, 2009). For instance, a user may concentrate on utility of a computer-based system, while another user may focus on enjoyment, when answering questions. To overcome the abovementioned limitation, one should design the questionnaire in a way to include users' possible understandings. Furthermore, users may have different perceptions in different situations and timeframes (Liu, Lu, & Niu, 2018). Conducting longitudinal studies can help to include variations in users' perception and thereby overcome the latest limitation in using extended TAM. The future work of this literature review includes the application of the extended TAM when investigating determinants of users' acceptance of the computer-based system in the manufacturing company in Sweden.

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