This is the Pre-Published Version.
This is an Accepted Manuscript of an article published by Taylor & Francis in Behaviour & Information Technology on 27 Feb 2019 (Published online), available online: http://www.tandfonline.com/10.1080/0144929X.2019.1585476

A double-edged sword? Exploring the impact of students' academic usage of mobile devices on technostress and academic performance

Word count: 12,968

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Abstract

The proliferation of mobile technology provides not only myriads of opportunities to support teaching and learning, but also challenges or even stress to the mobile device users in higher education. On the basis of the Person-Technology fit model (P-T fit model), this study developed a theoretical framework to investigate the double-edged effect of students' academic usage of mobile devices. Specifically, we compared the positive effect (boost academic performance) with the negative effect (bring technostress) of mobile device usage among university students. We further investigated a moderating role of mobile technology self-efficacy toward technostress. Data were collected among 208 university students. Results corroborated that students' academic usage of mobile devices does not lead to technostress; however, it helps in enhancing academic performance. Moreover, students' individual differences, e.g., mobile technology self-efficacy and extent of usage significantly influence the technostress.

Keywords: mobile device, mobile learning, technostress, academic performance

1. Introduction

Mobile technologies such as smartphones, tablet devices, and laptops have become an increasing presence in higher education learning environment (Melhuish & Falloon, 2010). On the basis of a sample of 3132 Dutch university students, Kobus, Rietveld and Ommeren (2013) affirmed that 96% of students own at least one of these mobile devices. With respect to smartphone users, EDUCAUSE Center for Analysis and Research revealed that 86% of US undergraduate students had smartphones in 2014; out of which

15% were heavy users who "could not live without" the device (Dahlstrom & Bichsel, 2014; Smith, 2015). The surge in mobile device ownership among university students triggered an interest in investigating the effect of mobile device usage in enhancing students' academic performance (Karpinski, Kirschner, Ozer, Mellott & Ochwo, 2013). There are also corresponding new terms describing the new learning environment under the mobile context, e.g., mobile learning (Wu, Wu, Chen, Kao, Lin & Huang, 2012), ubiquitous learning (Chen, Chang & Wang, 2008), here-and-now mobile learning (Martin & Ertzberger, 2013) and flexible learning (Bere & Rambe, 2016).

Substantial literature on the benefits and problems mobile technologies or mobile devices bring to the students has emerged. Some of them even described the phenomenon as the "double-edged problem" (Kuznekoff & Titsworth, 2013), this is because despite the convenience and effectiveness of using mobile devices, the distraction possibilities of multiple-tasking, over attachment and poor time control also emerge (Olufadi, 2015). Compared with general studies on mobile device usage among university students, the present study sets its scope with the students' academic usage of mobile devices (regardless of the context in which mobile learning takes place, e.g., in-class, out-of-class), which may involve: accessing course information and materials, communicating with teachers or peers, collaborating on group projects and taking a test or quiz (Cheon, Lee, Crooks & Song, 2012). In other words, the present research focuses more on the use of mobile devices in the mobile-based learning environment, instead of broad usage in students' daily lives, e.g., for hedonic or entertainment purposes. By doing so, the definition of "double-edged problem" is also different from past research on mobile-based learning that treats "distraction" as the major concern. The "dark-side" (Tarafdar, Tu, Ragu-nathan & Ragu-nathan, 2011) of technology usage in this study is manifested as the "technostress" students tend to carry when they frequently use mobile devices for the increasing demands of mobile-based learning. From the perspective of educational practice, when mobile-based learning happens in a class, the study on mobile technostress is directly related to university policy toward Bring Your Own Devices (BYOD) (Kobus, et al., 2013), where students are allowed to bring their personal mobile devices to university for learning purposes. Meanwhile, if the use of the mobile device takes place outside class, it could have an impact on students' work-life balance (Dén-Nagy, 2014). Accordingly, the results of the present study would have significant theoretical and pedagogical implications for educational practices.

In the present study, the "dark-side" of mobile technology usage (technostress) is defined as the "negative impact on attitudes, thoughts, behaviors, or body physiology that is caused either directly or indirectly by technology" (Weil & Rosen, 1977). It is the stress experienced by individuals due to use of Information and Communication Technologies (ICTs) and a "modern disease of adaptation caused by an inability to cope with new computer technologies in a healthy manner" (Brod, 1984). Many studies in the Information Systems (IS) literature have explored the antecedents, consequences, and components of technostress among general ICTs users (e.g., Tarafdar, et al., 2011; Salanova, Liorens, & Cifre, 2012; and Fuglseth & Sørebø, 2014). There are also recent studies examining the technostress with mobile communication technology in particular (e.g., Lee, Lee & Suh, 2016; Oh & Park, 2016; and Lee, Chang, Cheng & Lin, 2016). However, relatively few efforts were made to investigate technostress in the educational field. Even for research conducted in the educational field, most focused on teachers' (Joo, Lim & Kim, 2016), educators' (Burke, 2009) or academicians' (Jena, 2015) stress toward technology use instead of students' perception of technostress. Only a few conceptual papers discussed the technological difficulties of using computerized library resource (Ennis, 2005). The possibility that university students' technostress is not extensively studied is because university students born during the computer technology explosion usually have adequate computer skills to adapt to changes in technology (Burke, 2009). We would argue that this might apply more in the context where students are using these technologies for personal interest or entertainment, and technostress may still exist when students use ICTs intensively for teaching and learning purposes.

Mobile technology usage has a direct impact on technostress (Leung and Zhang, 2017); however, this study also aims to explore the possible moderating effect of mobile technology self-efficacy in the path. Mobile technology self-efficacy refers to an individual's judgement about his or her ability to use mobile technologies in accomplishing a learning-related task (Compeau & Higgins, 1995a). Given the individual differences, students may have various levels of confidence in technology usage. Past research has confirmed that a higher level of self-efficacy is associated with a lower level of computer-related anxiety (Compeau & Higgins, 1995b) and a lower level of computer-related technostress (Shu, et al., 2016). In this study, it could possibly mean that when students' mobile usage increases, the rise in technostress creators will be slower due to the presence of a higher-level of self-efficacy. We therefore believe that students' technology self-efficacy may have a significant moderating effect on mobile technostress in the mobile learning context.

In sum, the present study intends to contribute to the evolving stream of research by examining the influences of students' academic usage of mobile devices on both academic performance and possible technostress creators. It also explores the moderating effect of mobile technology self-efficacy. Specifically, this study aims to address the following research questions:

(1) What is the relationship between students' academic usage of mobile devices and students' academic performance?

(2) What is the relationship between students' academic usage of mobile devices and students' mobile technostress?

(3) Does technostress perceived by the students negatively influence students' academic performance?

(4) Does students' self-efficacy toward mobile technology usage moderate the relationship between students' academic mobile device usage and technostress creators?

The rest of this paper is organized as follows: first, we introduce the literature of concepts relevant to the present study; second, we present the hypotheses development processes and the research model; third, the data collection and data analysis processes are introduced. Section 7 discusses the findings of the present study. The last several sections conclude the contributions to theory and pedagogic practice, highlight the limitations and identify directions for future research.

2. Literature Review

2.1 Technostress and mobile device usage

Technostress has its roots in the IS literature when exploring the organizational effects of ICTs. On the one hand, the ubiquity of ICTs is beneficial for the efficiency of organizations; on the other hand, the surge of technology use also promotes employee technostress (Srivastava, Chandra & Shirish, 2015), which is depicted as the dual nature or dark effect of the implementation and use of ICTs (Tarafdar, et al., 2007; Shu, Tu & Wang, 2011). According to Tarafdar et al. (2011), stress is a cognitive state experienced by an individual when an environmental situation is perceived as presenting a demand that threatens to exceed the person's capabilities and resources for meeting it. Meanwhile, stressors (or stress creators) represent factors or conditions that create stress. Stress may come from the role (role stressor), the task (task stressor) or the technology due to the use of ICTs (technology stressor). Together with other studies, the present study only focuses on the stress technology brings to individuals. Given the importance of technostress, research in past decades has extensively discussed the components/conditions, antecedents, and consequences of technostress creators in organizations. For instance, as to the antecedents or influencers of the technostress creator, research has examined technology characteristics (Ayyagari, et al., 2011; Yan, Guo & Vogel, 2013), innovative support and involvement facilitation (Tarafdar, et al., 2011), computer self-efficacy and technology dependence (Shu, et al., 2011), personality traits (Srivastava, et al., 2015), and user demographics (Tarafdar, et al., 2011). With respect to consequences, most studies manifested negative effects on psychological strains (satisfaction, commitment, role stress, and intention to use ICTs) and behavioral strains (performance and productivity) (Tarafdar, et al., 2011; Fuglseth & Sørebø, 2014).

Mobile communication technologies are part of the larger concept of ICTs. Similar to ICTs in general, mobile device usage has also generated a double-edged effect or "helpful-stressful cycle" effect (Lee, et al., 2016) on users. For instance, Tremblay (2002) contended that flexibility in scheduling individual tasks led to increased productivity, improved job satisfaction, and work-family balance. However, despite these conveniences, excess usage and habitual checking of mobile devices can cause significant stress for users as well. Heavy usage has been confirmed to increase fatigue, sleep problems, and depression (Thomee, Harenstam & Hagberg, 2011). The frequent usage of mobile devices for work-related purposes could induce technostress. In Leung and Zhang (2017)'s work, technostress caused by mobile device usage was measured via two dimensions: techno-overload (situations where technology compels users to work faster and longer) and techno-invasion (situations where users can be contacted anywhere and anytime facilitated by the invasive effect of the technology). The two dimensions are designed specifically for the mobile computing context. Similar studies like Ayyagari, et al. (2011) and Yan, et al. (2013) also verified that work overload and role ambiguity (related to techno-invasion) are the dominant stressors when using mobile devices.

Research on technostress in education is relatively rare. Earlier studies have argued the technostress of secondary teachers (Joo, et al., 2016; Al-Fudail & Mellar, 2008), academicians (Jena, 2015), and educators (Burke, 2009). Studies also cover the concept of technostress under the auspices of technology ambivalence - considering technology (social media) usage as a distraction in learning (Rambe and Nel, 2014). Nevertheless, little attention was paid to the technostress of students when using mobile devices for learning purposes. We believed that students' perceptions are similar to ordinary employees in the workplace. They benefit from the ubiquitous and permeable nature of mobile devices and also face the same challenges (e.g., multi-tasking, work-life imbalance, and overload) when using modern mobile technologies for academic purposes (accomplishment of assignments, project collaboration, interaction with peers and teachers). The above discussion leads to the objectives of the current research.

2.2 Technostress and performance

Performance is categorized as one of the behavioral strains influenced by technostress creators (Tarafdar, et al., 2007; Tarafdar, Pullins & Nathan, 2015). Studies have addressed the negative effect of technostress on individual performance. For instance, Suharti and Susanto (2014) proved that technostress due to work overload has a significant negative impact on employee performance. Tarafdar, et al. (2015) confirmed a negative effect of technostress on salespersons' working performance. Karr-Wisniewski and Lu (2010) further examined the negative relationship between techno-overload and knowledge worker's productivity, and emphasized a moderating role of technology dependence in the path. For the mobile device usage, Tarafdar et al. (2007) and Tarafdar et al. (2011)

explained that mobile and wireless computing devices have capabilities for ubiquitous and continual connectivity, which make users feel compulsive about being connected, forced to respond to work-related information in real time, trapped in almost habitual multitasking and left with little time to spend on sustained thinking and creative analysis. The capabilities further blur the home and work contexts, creating difficulty in maintaining work-life balance, leading to a loss in productivity and performance. Research on computer-related, especially mobile-related stress among university students is rare, yet Balance and Rogers (1991) is one such study. Their research claimed that, if human-computer interactions are associated with stressful experience, the anticipated beneficial effects of using computing technology in educational activities may likely be compromised. However, their study did not find a significant relationship between students' academic achievement and stress.

2.3 Mobile device usage and academic performance

Increasing debate emerges among pedagogical scholars on the relationship between mobile device usage and students' academic performance. When assessing the benefits of mobile devices/technologies/learning, some researchers have studied effects on improving learner motivation, especially in terms of attention and engagement (Chaiprasurt & Esichaikul, 2013; Kuh, 2009); some others have studied influences on learning processes (e.g., interacting with peers, accessing resources, and transferring data) (Chen, et al., 2008). Much of this stream of research has directly examined the positive effect of mobile device usage on students' academic performance. For instance, Rabiu, Muhammed, Umaru, and Ahmed (2016) proved that mobile phone usage significantly influences academic performance among male and female senior secondary school students, and mobile technology significantly improved students' examination performance after engaging with mobile assessment exercises (Morris, 2010). The reasons for the positive effect have been summarized as "enhancing availability and accessibility of information networks, engaging students in learning-related activities in diverse physical locations, and enhancing communication and collaborative learning in the classroom" (Liu, Wang, Liang, Chan & Yang, 2002). Certain studies have examined the impact of specific types of mobile devices or applications. For instance, Powell and Mason (2013) contended that students could gather laboratory information more effectively when it was presented in an on-demand Podcast format. Stowell (2015) discovered that students' overall attitudes toward using clickers and mobile devices were favorable. Bere and Rambe (2016) suggested several contextual determinants (device portability, communication cost, collaborative capabilities of device and learner controls) of flexible learning via mobile instant messaging.

As to the problems of mobile device usage, the major concern of researchers lies on the possibility of the distractions mobile users could bring to the class (which will jeopardize academic performance) (Obringer & Coffey, 2007). Indeed, the usage will distract not only users' own attention to learning, but also other students' and instructors' attention in the class (Burns & Lohenry, 2010). The main reasons were presented as: multi-tasking (e.g., texting and playing games) while learning, over use/over attachment to mobile devices, and too much time committed to device usage (Olufadi, 2015). In addition to distractions, Pimmer and Rambe (2018) also studied dialectical tensions of using mobile instant messaging in supporting teaching and learning activities. They believed that the educational use of instant messaging is not straightforward; it requires users to navigate interdependent tensions from temporal, relationship, and intellectual dimensions. The current research focuses on students' academic use of mobile devices (e.g., downloading mobile-learning software to finish the assigned tasks or collaborate with peers) and will not involve situations when students use mobile devices for hedonic or entertainment purposes (e.g., watching movies, playing games, and generally interacting via social media). Therefore, distractive situations (mentioned above) are irrelevant to the current study. We are, however, in line with research focusing on tensions brought by mobile device usage in the mobile learning environment and investigating one particular type of negative effect (technostress) on students' academic performance.

2.4 Mobile technology self-efficacy

Mobile technology self-efficacy is regarded as a moderator between students' academic mobile device usage and technostress. On the basis of social cognitive theory, self-efficacy, the belief that one has the ability to perform a particular behavior or task, shapes the individual's responses to demands associated with performing that task (Bandura, 1982). Applying this concept, technology self-efficacy refers to a belief in one's capability to use a certain type of technology (in the present study, we specify it as mobile technology self-efficacy) (Compeau & Higgins, 1995a). Past studies have claimed that high technology self-efficacy is associated with a higher level of computer use (Compeau & Higgins, 1995a), lower computer-related anxiety (Compeau & Higgins, 1995b), higher comfort in using computers (Compeau, Higgins & Huff, 1999), and a generally positive attitude towards technology usage (Venkatesh & Davis, 1996). Technology self-efficacy has also been proved to reduce computer-related technostress (Shu, et al., 2016), given that individuals with higher technology self-efficacy could adapt to changes and developments in technologies easily. Accordingly, we believe that students' self-efficacy differs from one to another and that students may have various levels of "fear" toward using mobile devices for learning purposes. Mobile technology self-efficacy, thereupon, could function as a moderator to help mitigate the level of students' technostress.

2.5 Person-Technology fit model

Our study on the antecedent and consequence of students' technostress is based on the theoretical lens of the Person-Technology fit model (P-T fit model) (Ayyagari, et al., 2011). The P-T fit model is the extension and application of the Person-Environment fit model (P-E fit model) (Edwards & Cooper, 1988) in the stress literature. The core concept of the P-E fit model is the degree to which the individual and environmental characteristics match (in terms of individual abilities vs. environment demand and individual values vs. environment supplies) (Kristof-Brown, Zimmerman & Johnson, 2005). It assumes that an equilibrium relationship emerges between people and their environment. When this relationship is out of equilibrium, it results in strain. Ayyagari, et al. (2011) specified the environment in the P-E fit model to the technology environment and developed a situation specific P-T fit model (shown in Figure 1). The P-T fit model is among the first to provide insight into how technology characteristics influence stressors (technostress creators). The three major components of the P-T fit model are as follows: technology characteristics, stressors and strain. Technology characteristics refer to attributes or features of a particular ICT (we specify them as mobile technology features in this research). Stressors represent factors or conditions that create stress (technostress here). Strain refers to the behavioral, psychological and physiological outcomes of stress that are observed in individuals (Cooper, Dewe & O'Driscoll, 2001). Psychological strains are emotional reactions to stressor conditions, which may include exhaustion, depression and negative self-evaluation, whereas behavioral strains involve reduced productivity and poor task performance (Tarafdar, et al., 2011; Ayyagari, et al, 2011). The present study mainly discussed the behavioral strains (reduced academic performance) mobile technology brings to students. In pedagogy, few researchers have applied the P-E fit model in their work, Al-Fudail and Mellar (2008) is one of such study. They built a teacher-technology environment interaction model based on the transactional approach (Lazarus & Folkman, 1984) and the P-E fit model, and adapted it for the specific context of teachers working in a technology rich classroom.

Insert Figure 1 about here

Figure 1. Person-Technology fit model (Ayyagari, et al., 2011)

On the basis of the above discussions in the literature, we identified several gaps in the research. First, although ICTs' usage has been identified as the primary source of technostress (in the IS literature), the mechanism through which ICTs and mobile technologies in particular exert impacts on students' technostress and students' academic performance is largely unknown. Second, the literature extensively discussed the dual effect of mobile device usage in the mobile learning context; however, the examination of one particular type of negative effect (technostress in this study) was rare. Third, in the same area of research, no sufficient examination of personal specialty/individual differences (e.g., technology self-efficacy and gender) when using technology devices to facilitate learning emerges. Fourth, little research has been done to investigate the antecedents of technostress, especially specific technology characteristics leading to technostress (Yan, et al., 2013). Fifth, from the theoretical perspective, there is little attention from educational researchers to use the P-T fit model to understand the causes of students' technostress. The present study intends to fill in the foregoing research gaps. It extends previous literature on students' academic usage of mobile devices in the new "double-edged" context (boosting performance vs. technostress); it also applies the P-T fit model (as a theoretical lens) to explore the antecedents and consequences of technostress when students use mobile devices for academic purposes.

3. Research Model and Hypotheses

On the basis of the aforementioned theoretical streams of research and the P-T fit model, this study explores the relationships between students' academic mobile device usage and technostress creators, and their consequences on students' academic performance. We summarize the proposed relationships to be tested in Figure 2. In Figure 2, students' academic usage of mobile devices is related to the technology characteristics in the P-T fit model (to represent the features and what students could do with mobile devices for learning purposes). It becomes the antecedent of technostress creators (Ayyagari, et al., 2011). Moreover, technostress creators mediate the relationship between students' academic usage of mobile devices (technology characteristics) and academic performance (strain). More practical works in education and IS fields supporting each hypothesis are discussed below.

Insert Figure 2 about here

Figure 2. Research model

Mobile technology usage will cause technostress. According to Ragu-nathan et al. (2008), technostress is caused by an individual's attempts to deal with constantly evolving ICTs and changing physical, social, and cognitive responses demanded by their use. In universities, students will usually bring their own mobile devices to class; they are then either requested to download different mobile applications (e.g., for Blackboard, Clicker, Wiki, and podcasts) for daily learning objectives (Cheon, et al., 2012) or use the existing mobile applications to communicate or collaborate with group members and instructors (e.g., via WeChat, WhatsApp). In most cases, students must constantly or unconsciously check or update their latest messages about learning at school, at home, and even on vacation. Given the technical limitations of the mobile devices themselves (small screens with low resolution displays, inadequate memory, slow network speeds, and lack of standardization and comparability) (Haag, 2011; Park, 2011), students usually find that working efficiently using mobile devices is difficult. Moreover, students are not psychologically ready to use the mobile devices they own for instructional purposes (Park, 2011). These lead to anxiety and stress. For the specific dimension of technostress, Leung and Zhang (2017) clearly elucidated that techno-overload and techno-invasion are the two major reasons leading to technostress among mobile phone users. As for techno-overload, mobile communication tools have made it routine for students to simultaneously handle different streams of information while studying (Ragu-nathan, et al., 2008). They tend to communicate more than needed and receive more information than they can effectively process and use (Tarafdar, et al., 2011). With respect to techno-invasion, the pervasive usage of mobile technology has invaded personal life, leading to work–life conflicts (Yun, Kettinger & Lee, 2012). In the university setting, students could be contacted anywhere and anytime. Capabilities for constant connectivity make students never feel “free” of technology and always “on call” with peers and teachers (Tarafdar, et al., 2007). This blurs the boundaries between home and school, leading to potentially negative effects (stress) associated with their use. With the above discussions, we arrive at the first hypothesis:

H1: Students’ academic usage of mobile devices is positively associated with technostress creators.

Appropriate usage of mobile devices for mobile learning purposes will enhance students’ academic performance. Mobile learning was defined as learning that takes place when the learner is not at a fixed, predetermined location or when the learner takes advantage of the learning opportunities offered by mobile technologies (Vavoula, 2005). Our definition of mobile learning belongs to the second category. Prior research has supported the integration of mobile devices in and out of classrooms to enhance students’ learning and academic performance. For instance, mobile devices enable students to work on assignments and access information in a manner that is not restricted by time and space (Sarkar, 2012). Mobile devices can facilitate students' group collaboration (Lauricella & Kay, 2010), increase interpersonal communication between students and teachers in an informal way (Rau, Gao & Wu, 2008), and better motivate and engage students, which lead to a higher possibility of academic success (Kuh, 2009; Chaiprasurt & Esichaikul, 2013). Moreover, due to their unique features (portability, instant connectivity and context sensitivity), mobile devices are effective in promoting four types of learning – individualized, situated, collaborative, and informal (Cheon, et al, 2012), and across different learning contexts – in the classroom or out of the classroom, on campus, or off campus (Bere & Rambe, 2016). Finally, Rabiu et al. (2016) and Morris (2010) empirically corroborated that mobile device usage significantly influences students' academic performance (e.g., subject results and Grade Point Averages (GPAs)). With the above discussions, we propose H2.

H2: Students' academic usage of mobile devices is positively associated with students' academic performance.

Despite the convenience and benefits mobile devices bring to students, the possible technostress caused by intensive usage could also damage students' productivity and academic performance. This is what Lee et al. (2016) has called "helpful-stressful cycle", in which one purchases a mobile device to help manage the workload only to have it induce stress and become the bane of one's existence. Technostress creators were proven to be inversely and directly related to individual productivity and performance (e.g., Suharti & Susanto, 2014) given that mobile technologies help in multi-tasking and leading individuals to exceed their personal limits, resulting in exhaustion, burnout, and lower levels of productivity (Tarafdar, et al., 2007). When faced with tremendous information, students are forced to work faster to cope with increased and real-time processing requirements from instructors and groupmates. Their performance will be impaired with techno-overload. In view of the techno-invasion, students will perceive a loss of privacy because mobile device usage blurs the boundaries between home and school, leading to a reluctance to use mobile applications to finish school work. Another reason leading to lower levels of performance is that, when working off-site (e.g., at home or on the way home), students tend to access the kinds of information available to them and exclude other information that may have to be accessed on-site. This ineffective use of ICT ignores the deep thinking necessary for innovation and creative decision-making, which contributes to a downgrade of academic performance (Tarafdar, et al., 2011). On the basis of the P-T fit model, technostress creators were manifested to be negatively related to a series of job-related outcomes: e.g., commitment, job satisfaction (Ragu-nathan, et al., 2008), job engagement (Srivastava, et al., 2015), intention to reuse (Fuglseth & Sørebø, 2014), affectivity, and technology-enabled performance of academicians (Jena, 2015). Hence, we propose H3.

H3: Technostress creators are inversely associated with students' academic performance.

According to the social cognitive theory, self-efficacy is the belief that one has the ability to perform a particular behavior or task (Bandura, 1982). It influences the choice of activities, degree of effort expended, and persistence of effort. Mobile technology self-efficacy in the present study refers to a belief of an individual's judgment about his or her ability to use mobile technologies in accomplishing a learning-related task (Compeau & Higgins, 1995a). On the basis of the transactional approach (Lazarus & Folkman, 1984), individual stress is formed by the relationship between the person and the environment appraised by the person; and the ability of self-appraisal (technology self-efficacy in this case) significantly affects perceived stress levels. Past studies have inferred that perceived high technology self-efficacy helps in increasing the use of technology and decreasing an individual's technology anxiety (Fagan, Neill & Wooldridge, 2003). This means when mobile technology self-efficacy increases, students tend to use mobile devices more and freely, which gradually help to decrease the effect of academic usage of mobile device on technostress creators. In other words, students with higher self-efficacy are less sensitive to the increasing demand of using mobile devices for academic purposes, therefore, the effect on technostress creators are minimal. With more confident mobile device usage, individual students with higher mobile technology self-efficacy will also more easily adapt to the changes of mobile applications than those with lower mobile technology self-efficacy (Shu, et al., 2011). We therefore hypothesized that the positive relationship between mobile device usage and technostress creators is negatively moderated by mobile technology self-efficacy so that more mobile technology self-efficacy mitigates the students' anxiety and stress when using mobile devices for learning purposes. The last hypothesis (H4) is given below:

H4: Mobile technology self-efficacy moderates the relationship between students' academic usage of mobile devices and technostress creators, so that a higher level of mobile technology self-efficacy leads to a lower level of technostress creators.

Given that the quality of the dependent variable may be influenced by factors other than those in the hypothesized model, we incorporated suitable controls in the research model. Age, gender, extent of mobile device usage, experience with mobile devices and number of mobile devices owned were used as control variables in the research model. Education was also mentioned as an influence on technostress (Ragu-Nathan, et al., 2008). However we do not involve education as one of the control variables given that data were collected among university students in the same subject classes and that educational level of the students should be the same in the current research context. For age, there could be students taking the same class but having different ages. The effects of age and gender on individual reactions to ICTs vary. However, they became significant influencers toward technostress creators in Ragu-Nathan, et al., (2008)'s work. Tarafdar, et al. (2015) further proved that men experience more technostress than women. The extent of mobile device usage was reported as the number of average hours of mobile device usage each day. It reveals the difference of heavy mobile users and occasional users. Ayyagari et al. (2011) proved that the extent of ICT usage significantly affects the technostress creators. Experience with mobile devices examines the past experience of using mobile devices (for any purpose). We believe that the more experienced the mobile users are, the less stressful they will be when using mobile devices for academic purposes. Finally, we expect that the more mobile devices the students own, the more tasks they will have to handle, and the more technostress they will perceive when using these devices.

4. Research Methods

4.1 Setting and sample

Target students for our survey were year one and year two bachelor students from the School of Business, who took a compulsory course on introduction to Management Information Systems (MIS). Students came from different majors, e.g., Accounting, Finance, Transportation and Logistics, and Management, with various levels of IT understanding. With the progress of teaching and learning in the semester, students gradually built up confidence toward technology usage. At the beginning of the semester, students were required to use any type of mobile devices (e.g., laptops, tablets, and smartphones) available to them to engage in teaching and learning activities, which included downloading teaching notes from the e-learning system (Blackboard), reading case studies in class (via mobile devices), constantly communicating or collaborating with groupmates for group projects (via mobile applications), and receiving teachers' feedback and comments on submitted assignments. At the end of the semester, after 12 weeks' mobile device usage for academic purposes, students were invited to finish a paper-based questionnaire to reflect on their perceptions of mobile technostress.

4.2 Data collection

Data were collected among five classes of students taking the same subject-introduction to MIS, and 250 questionnaires were sent out. Two hundred twenty students responded to the survey, making the response rate 88%. We excluded students who had no mobile devices or who used mobile devices for non-academic purposes. We also eliminated responses with missing data. Finally, two hundred and eight students' responses were used as the final data set for further data analysis. Table 1 shows the profile information of the respondents. Moreover, Table 1 depicts that most of survey participants were female students with an age range of 19 to 21; over 60% of students owned two or three mobile devices, and more than 80% of students used mobile devices for over three hours per day. A total of 74.6% of students were good students with a Weighted GPA (WGPA) of more than 3.0. Over 90% of the students responded that mobile device usage positively influences their academic performance.

Insert Table 1 about here

Table 1. Profile information of the respondents

Notes: WGPA = Weighted Grade Point Average; AP = Academic Performance

4.3 Measures

In the present study, students' academic usage of mobile devices and technostress creators were treated as formative constructs, whereas, mobile technology self-efficacy a reflective construct. According to Chin (1998), reflective measures are caused by the latent construct, whereas, formative measures cause the latent construct. Moreover, reflective construct is measured by repeated indicators with similar meaning, and formative measurement provides a means of modeling a construct from a diverse and potentially disparate set of observable phenomena (Cenfetelli and Bassellier, 2009). Here, students' academic usage of mobile devices involves multiple tasks and academic activities; similarly, technostress creators in the current research context are caused by three major reasons (techno-overload, techno-invasion, and techno-complexity). They are therefore considered as formative constructs. Mobile technology self-efficacy is a reflective construct, since seven roughly repeated items (on facilitating conditions) were used to measure the construct.

4.3.1 Students' academic usage of mobile devices

Students' academic usage of mobile devices is defined as students' usage of any type of mobile devices (smart phones and tablet computers in particular) for teaching and learning purposes. With the installation of certain mobile applications, students could accomplish different course-related tasks in-class and out-of-class. Cheon, et al. (2012) gave a good summary of the occasions students could learn via mobile devices. We adopted their approach and asked students about the frequency of performing each activity in the mobile learning context. Students' academic usage of mobile devices was designed as a formative variable in the present study.

4.3.2 Mobile technology self-efficacy

Technology self-efficacy represents an individual's judgment about his or her ability to use technologies in the accomplishment of a task (Compeau & Higgins, 1995a). In the specific context of this research, "technology" is specified as mobile technology, and "tasks" refers to teaching and learning related tasks. The original set of measures was developed by Compeau and Higgins (1995a). They asked respondents to indicate whether they could use an unfamiliar software package under a variety of confidence levels. Tarafdar et al. (2015) reduced the total number of indicators from 10 to six to measure salespersons' technology self-efficacy. We adapted measures from Compeau and Higgins (1995a) and Tarafdar et al. (2015) and assessed students' mobile technology self-efficacy from seven confidence perspectives.

4.3.3 Technostress creators

Technostress creators are factors or conditions that create technology stress for users. Most of the works examining technostress used Tarafdar et al. (2007)'s instruments to measure technostress creators. Tarafdar et al. (2007) categorized technostress creators into five dimensions: techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty. Techno-overload describes situations where ICTs force users to work faster and longer. Techno-invasion describes the invasive effect of ICTs in terms of creating situations where users can be reached any time and be connected constantly; thus, a blur will emerge between work and personal life. Techno-complexity means that the complexity associated with ICTs makes users feel unconfident with their existing skills and are forced to spend time and effort to learn. Techno-insecurity and uncertainty are related to the worries and fears of users when facing ever-evolving technologies. Specifically, techno-insecurity is related to the job security of employees, and uncertainty refers to the constant changes and upgrades of software and hardware that may impose stress on employees. Research (Leung & Zhang, 2017; Yan, et al., 2013) in the telecommunication field has studied technostress caused by usage of mobile devices in particular. In the present study, the threat to jobs (techno-insecurity) is irrelevant. Furthermore, we believe that university students are "digital natives" and tech-savvy.

Techno-uncertainty facilitated by ever-changing mobile technologies would not be a critical issue for university mobile device users. Instead, increasing workload due to the "convenience" of mobile technology and the invasion into students' personal lives regardless of time and location should be major stress sources for students. The two dimensions were also summarized as related to the "role stress" of telecommuting users in Leung and Zhang (2017)'s work. Last, we believe that techno-complexity is still relevant here given that the functions of teaching and learning tools/applications in universities are always evolving. University students and teachers must spend time and effort to learn, which leads to consideration and measurement of technostress creators in the current research. We measured technostress creators from three sub-dimensions (techno-overload, techno-invasion, and techno-complexity) and the construct itself was treated as a second-order formative construct.

4.3.4 Academic performance

Many prior studies (Hawi & Samaha, 2016; Olufadi, 2015) have assessed students' academic performance facilitated by mobile devices with their cumulative GPAs. There are also studies (e.g., Morris, 2010; Rabiu, et al., 2016) using students' single test results or examination results of a subject to measure students' academic performance. This research collects information from both cumulative GPAs and exam results of the subject (Introduction to MIS) to evaluate students' academic performance. Table 2 summarizes the measures of the three major constructs.

Insert Table 2 about here

Table 2. Constructs and measures

5. Data Analysis

SPSS (v. 20) and SmartPLS (v. 3.2.4) (Ringle, Wende & Becker, 2015) were used as the statistical software to test the current research model. SPSS was used to carry out the reliability test and the primary factor analysis; SmartPLS was applied to examine the measurement model, structural model and the moderating effect of mobile technology self-efficacy.

5.1 Measurement model

In the reliability test, all the reflective variables had Cronbach's alpha ranging from 0.68 (techno-invasion) to 0.86 (self-efficacy). For the exploratory factor analysis, results presented a four-factor pattern for the four reflective variables. The instruments were therefore in good shape. We input them into SmartPLS to test of the measurement and the structural models. Following two-stage analytical procedures (Anderson & Gerbing, 1988), confirmatory factor analysis was first conducted to test the measurement model.

Convergent validity was examined by checking composite reliability and Average Variance Extracted (AVE) from the measures (Hair, Anderson, Tatham & Black, 1998). Table 3 shows that all the composite reliabilities are above the threshold of 0.70 (Chin, 1998), and all the AVEs pass the recommended value of 0.5 (Fornell & Larcker, 1981). To verify the discriminant validity, the squared roots of the AVEs were used to compare with the correlations between constructs (Fornell & Larcker, 1981). Table 4 shows that all the squared roots of the AVEs are greater than the levels of correlations involving the constructs. The factor loadings are also heavily loaded on its own construct than other constructs (Table 5), showing good discriminate validity of the current measures.

Insert Table 3 about here

Table 3. Reliability and AVEs

Insert Table 4 about here

Table 4. Correlation between constructs

Notes：The shaded numbers in the diagonal row are the square roots of the AVEs.

MTSE = Mobile Technology Self-efficacy; T-O = Techno-overload; T-I = Techno-invasion; T-C = Techno-complexity; AP = Academic Performance; No. MD = Number of Mobile Devices owned

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Insert Table 5 about here

Table 5. Results of confirmatory factor analysis

MTSE = Mobile Technology Self-efficacy; T-O = Techno-overload; T-I = Techno-invasion; T-C = Techno-complexity

5.2 Structural model

After the measurement model was confirmed, we began to test the structural model. Given that the structural model contains one second-order construct (technostress creators), we created a superordinate second-order construct using factor scores for the first-order construct (Chin, et al., 2003). Technostress creators were treated as a formative variable measured from three different dimensions (techno-overload, techno-invasion and techno-complexity). Figure 3 and Table 6 show the SmartPLS data analysis results.

As shown in Figure 3 and Table 6, the path coefficient between students' academic usage of mobile devices and academic performance was significant at 0.01 level (H2 supported); similarly, the path coefficient between technostress creators and academic performance was significant at the 0.05 level (H3 supported). However, students' academic usage of mobile devices did not significantly influence technostress creators (H1 not supported). Mobile technology self-efficacy also did not moderate the relationship between students' academic usage of mobile devices and technostress creators (H4 not supported). The R square values of the two dependent variables (technostress creators and academic performance) were 0.12 and 0.07, respectively. Finally, the control variable (the extent of mobile device usage) demonstrated a significant effect on technostress creators (at the 0.1 level); and all other control variables (i.e., age, gender, experience, and number of device) did not have a significant effect on technostress creators. In the post hoc analysis, moderator-mobile technology self-efficacy negatively affected technostress creators.

Insert Figure 3 about here

Figure 3. Structural model results

*Notes: *p < 0.1; ** p < 0.05; ***p <0.01; the solid lines were supported, while the dotted lines were not supported.*

Insert Table 6 about here

Table 6. Summary of path coefficient results

Notes: SAUMD = Students' academic usage of mobile devices; MTSE = Mobile Technology Self-efficacy; AP = Academic Performance; S = Significant; NS = Not Significant

For the formative variable-SAUMD, we examined its outer weights. The SmartPLS results (Table 7) deduced that SAUMD_2 and SAUMD_5 had the highest weights (0.71 and 0.54) among the five items measuring SAUMD. This means that using mobile device to communicate with teachers (SAUMD_2), take quizzes, tests, or exams (SAUMD_5) are the most important factors influencing students' academic performance.

Insert Table 7 about here

Table 7. Outer weights of SAUMD

Note: SAUMD = Students' academic usage of mobile devices

When academic performance was measured by the subject grade of one of the introductory courses of MIS, the data analysis results (Table 8) affirmed a similar pattern:

students' academic usage of mobile devices significantly influenced academic performance as measured by subject grade; the control variable-extent of mobile device usage had a positive impact on technostress creators. The post hoc analysis result was also consistent with the one in Table 6. One major difference was that technostress creators did not significantly influence academic performance as they did in Table 6. We believe that this is mostly due to the nature of the subject. The MIS subject required students to bring their own devices and work on them frequently; in the subject, we also taught ICTs related concepts. Students in classes are very familiar with and skillful toward ICTs; therefore technostress does not necessarily lead to decreased academic performance in the present study context.

Insert Table 8 about here

Table 8. Summary of path coefficient results

Notes: SAUMD = Students' academic usage of mobile devices; MTSE = Mobile Technology Self-efficacy; AP = Academic Performance; S = Significant; NS = Not significant

6. Discussions

This research aims to investigate the double-edged effect of students' academic mobile device usage: it tests the main effect of students' academic mobile device usage on technostress creators and academic performance and examines the relationship between technostress creators and academic performance as well as the moderating effect of mobile technology self-efficacy. Data analysis results support two of the four hypotheses in the research model and reveal some interesting findings.

First, contrary to our prior assumption, students' academic usage of mobile devices does not significantly influence technostress creators (H1), which means that students do not treat new mobile technologies/devices as a burden or a threat when using them for learning purposes. Hence, the techno-overload, techno-invasion, and techno-complexity that workplace employees usually have with general ICTs do not apply to university students in the mobile learning context. This result is somehow inconsistent with the major body of technostress literature (e.g., Tarafdar, et al., 2011; Ayyagari, et al., 2011) and the P-T fit model (technology characteristics would induce technostress). It is also different from studies on educators' or teachers' technostress (e.g., Burke, 2009; Joo, et al., 2016). Several possible explanations for this result are available: (1) Unlike educators or teachers, today's university students are "digital natives" and tech-savvy (Jena, 2015); they usually have adequate ICT skills necessary to deal with daily tasks as well as academic tasks. (2) Confidence with technology usage was gradually built up after the entire semester's training on MIS and students are no longer "afraid" of using technologies, even for learning purposes. (3) Compared with the technologies or devices companies generally provide, the mobile devices under investigation are usually owned by students. Students should be very familiar with these devices and treat mobile learning applications as similar to any other mobile applications they usually use. (4) In terms of the nature of the job, academic tasks such as assessing course information and collaborating with other students may not be as tense as work-related tasks in the business environment. Hence, university students would not feel as stressed as organizational employees if there is a P-T mismatch.

Second, H2 is supported. Students' academic usage of mobile devices is positively associated with students' academic performance. This result is confirmed by statistics in Table 6 and Table 8; it is also consistent with students' answers to one of the subjective questions (Do you think that mobile device usage positively affects your academic performance?), where over 90% of the respondents answered "yes" in Table 1. Through this finding, we reconfirm the positive effect of students' academic usage of mobile devices in pedagogy; we are also in line with much prior educational research (Rabiu, et al., 2016; Morris, 2010) that mobile device usage significantly influences students' WGPA and subject results. In terms of the specific mobile technology features, Table 7 shows that communicating with teachers and taking quizzes, tests, or exams are the most important mobile application functions positively influencing the students' academic performance.

Third, congruent with our prediction in H3, technostress creators impair the students' academic performance. This finding indicating the relationship between stressor and strain is supported by the transactional model of stress (Lazarus & Folkman, 1984) and the P-T fit model in psychology and IS literature, which both believe that stressors caused by person-technology misfit will lead to negative behavioral and psychological consequences. It is also manifested by a series of empirical research focusing on the negative impact or consequences of technostress on individual productivity and job performance (Ayyagari, et al., 2011; Tarafdar, et al., 2011). Regarding the specific type of technostress, Tables 6 and 8 reveal that techno-invasion and techno-complexity are the two most dominant stressors contributing to lower levels of academic performance (GPA and subject grade). It also means that the majority of the stress (leading to lower academic performance) comes from the situation when the mobile device usage blurs the boundary of home and school and when the mobile technology or, for example, mobile-based learning application is too complicated for students to learn.

Fourth, we corroborate that mobile technology self-efficacy did not moderate the relationship between students' academic usage of mobile devices and technostress creators (H4). Together with the result of H1, this means students' mobile device usage does not necessarily lead to technostress with and without the condition of individual self-efficacy on mobile technology. Personal belief in their own mobile technology skills is also not able to help release the pressure of technology when using these devices for multiple learning purposes. Nevertheless, the post hoc analysis in Tables 6 and 8 shows a direct and significant relationship (main effect) between mobile technology self-efficacy and technostress creators. This finding is consistent with past literature taking technology self-efficacy as a predictor (Shu, et al., 2011) or significant control variable (e.g., Ragu-Nathan, et al., 2008) toward technostress creators. In other words, mobile technology self-efficacy is directly associated with perceptions of techno-overload, techno-invasion, and techno-complexity.

Fifth, regarding the components and importance of specific types of technostress, our results reveal a similar pattern with most of the literature on technostress among employees (Shu, et al., 2011; Tarafdar, et al., 2011; Ragu-Nathan, et al., 2008). Among the three technostress creators involved in the current research, techno-complexity is the most important component in forming students' technostress. Students will feel the biggest stress when the mobile technology/application is too complex to use.

With respect to control variables, five control variables are theorized to influence the level of technostress creators. Our data analysis results confirm that only the extent of mobile device usage is marginally significant in explaining technostress creators (in both Tables 6 and 8), while age, gender, experience with mobile devices, and number of mobile devices owned are insignificant. Extent of mobile device usage is the frequency of mobile device usage each day and gives a difference between heavy and occasional mobile users. Results were in line with Ayyagari, et al. (2011), which imply that heavy mobile users tend to experience more technostress when using devices for academic purposes. Differing from several past studies on technostress (Ragu-Nathan, et al., 2008; Tarafdar, et al., 2015), elderly students, male students, and other device owners did not demonstrate a higher level of technostress in the present research.

7. Contributions and limitations

This paper develops an understanding of the double-edged effect of students' mobile device usage on technostress and academic performance. The theoretical contributions, implications for pedagogy and limitations are reflected in the succeeding texts.

7.1 Theoretical contributions

First, the present study is one of original research demonstrating the dual effect of the mobile device usage among university students. We investigated not only the benefits mobile devices bring to students but also the possible negative effect of using mobile technology for educational purposes. Although the negative effect is not proven to be significant, we still verified the existence of the technostress in influencing academic performance. In addition, our study extends the present literature on mobile learning, and provides more insights into students' academic usage of mobile technology.

Second, our study is among the first to introduce the psychological theory of stress (Edwards & Coopers, 1988) and the P-T fit model (Ayyagari, et al., 2011) to the students' mobile learning context. The stress theory, especially the P-T fit model has been largely applied in psychology and IS literature; however, the chain relationship of technology characteristics, stressors and strain -- the antecedents and consequences of technostress creators, has yet to be extensively explored in the educational field. Educators have little idea on whether the mobile device usage will induce technostress, and whether technostress will negatively influence academic performance. Based on the appropriate theoretical lens, this research extends our understanding of technostress (originally arising in the workplace) and provides answers to the above questions to the educators.

Third, this study contributes to the emerging stream of research by introducing the concept of technostress, especially students' technostress, to the field of pedagogical research. Prior studies on technostress focused on technostress of the workplace employees and teachers or educators (e.g., Joo, et al., 2016; Burke, 2009), and little attention was paid to the technostress of university students who are the major and pioneer adopters of mobile devices. In the present study, we specifically examine students' perceptions of technostress and prove the existence of technostress among university mobile users. We further unlock the black box of technostress creators, and prioritize the three technostress creators influential to students' learning.

Fourth, this study echoes the call for continued theoretical and scholarly development in the technostress domain by investigating the technostress phenomenon in particular contexts entailing specific types of technologies, roles, or tasks (Ayyagari et al., 2011; Shu, et al., 2011). In the present research, we specify ICTs as mobile technology, roles as students' roles, and tasks as students' academic activities.

Fifth, this research reveals important functions or mobile technology characteristics in promoting students' academic performance. It is among the first endeavors to compare the importance of different mobile functions for students' learning. We affirm that communicating with teachers and taking quizzes, tests, or exams are the most critical mobile learning functions in the present research.

Last, we discuss personal specialty/individual differences toward students' technostress. We prove that students with higher mobile technology self-efficacy and lower frequency of using devices are likely to have greater control and feel more relaxed toward technology usage. Age, gender, past experience, and number of mobile devices owned do not necessarily lead to increased or decreased levels of technostress. We hope these results could engender more discussions on the implications for pedagogy.

7.2 Implications for pedagogy

First, and most importantly, this research brings inspiring news to educators that students' academic usage of mobile devices may not cause the "double-edged" effect on students:

academic usage will only boost students' academic performance and does not necessarily lead to technostress. Students as digital natives enjoy the convenience of using mobile devices for learning purposes. The benefits of using mobile devices therefore outweigh the problems. University teachers and administrators could relieve the pressure of massively adopting mobile technology for teaching and learning purposes; they would also have a more open gesture toward students' BYOD behavior.

Second, although the frequent usage of multiple mobile application functions does not lead to technostress, the perception of technostress still exists, and this stress will impair students' academic performance. To achieve positive learning outcomes, educators and mobile application developers should work together to design relatively simple functions within learning applications and try to avoid giving too much work and forcing students to use mobile learning applications during their leisure time.

Third, in face of technostress, students should avoid using mobile learning applications too frequently (since it will increase stress levels); universities should provide sufficient training to enhance students' confidence in their beliefs to handle emerging and always-changing mobile applications for learning purposes. Furthermore, elderly students and male students may not have a higher level of technostress. Students with longer usage history and more mobile devices also do not necessary feel more stressed when using devices for academic purposes. Universities and educators should treat these students equally when dealing with the issue of technostress.

7.3 Limitations and future research

Certain limitations are to be considered while interpreting the results. First, the study was conducted within a limited setting of business students from five classes taking the same subject and with students who are currently using mobile devices. Further research can probably show the robustness of the findings across different settings, e.g., students from different age groups, taking different subjects, or from a major other than business, and include students who may consider using mobile devices in the future. Second, the cross-sectional survey could only capture a snapshot of the research issues at a given point, future research should consider using longitudinal studies to measure technostress, and to investigate the relationship between technostress and academic performance. Third, for the measure of students' academic usage of mobile devices, we would expect to explore more features that mobile learning applications could bring to students and thus have a better understanding of their impact on students' psychological and academic outcomes. Moreover, measures of techno-overload should be clearer and more specific to the current teaching and learning context, e.g., "school work" should be used to replace "work" to avoid ambiguity. Fourth, the students' academic usage of mobile devices are also closely related to the total amount of workload expected from the usage of mobile devices. A moderating role of workload via mobile device becomes an area of further investigation. We suggest future research exploring the moderating role of workload in the relationship between students' academic usage of mobile devices and academic performance, and between the usage and technostress creators. Fifth, in the P-T fit model, there are many possible strains technostress brings to users. Decreased academic performance is only one of the behavioral strains (other strains may include burnout, satisfaction, and commitment, etc.) (Tarafdar, et al., 2015). We look forward to future pedagogical research to include other dimensions of the psychological factors (which have been successfully applied in IS literature) to further understand the influence of technostress on university students. Last, we hope other researchers could generalize our results and apply them in a specific research context to further examine the robustness of causal relationships in the research model (e.g., the study of a certain type of mobile learning application or a certain brand of the mobile device).

8. Conclusions

Mobile technology has become progressively more visible within the higher education learning environment. Educators use mobile devices to facilitate teaching and learning which benefits students at large. However, while the benefits of mobile technology are not in doubt, it is also true that the adoption, rapid diffusion and utilization of mobile technology in collaborative teaching and learning might bring several challenges to higher education. If students are not adaptive to new mobile technology, then they may suffer from technostress. Based on the extant literature and the P-T fit model, this study explores the consequences (the double-edged effect) of students' academic usage of mobile devices for learning purposes. Results claim that students' mobile device usage generates a positive effect on students' academic performance; however, usage has no significant relationship with technostress. Meanwhile, the existence of technostress negatively impacts the academic performance. We hope our original research on technostress could bring some insights and further discussions to the body of research on students' mobile device usage in pedagogy.

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Figures

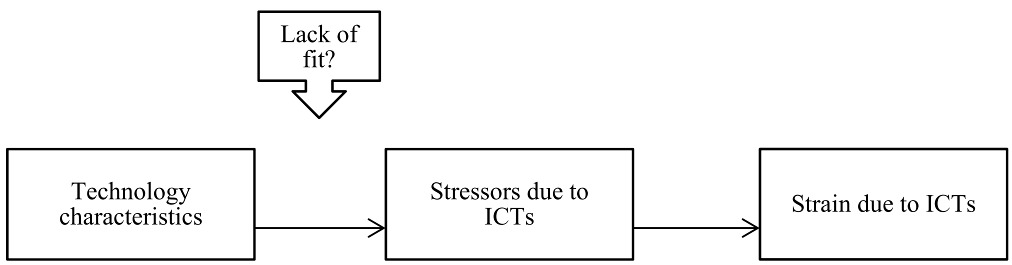

Figure 1. Person-Technology fit model (Ayyagari, et al., 2011)

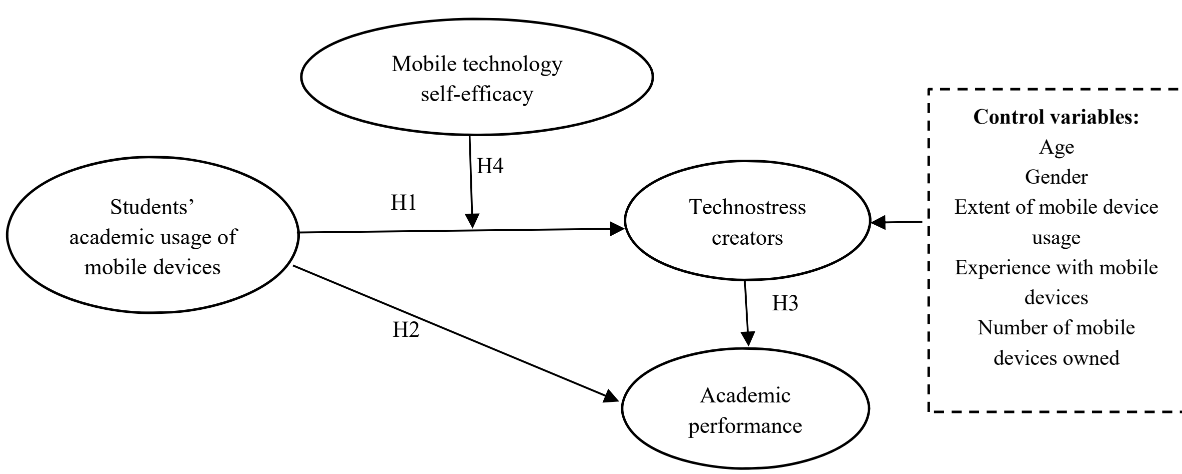

Figure 2. Research model

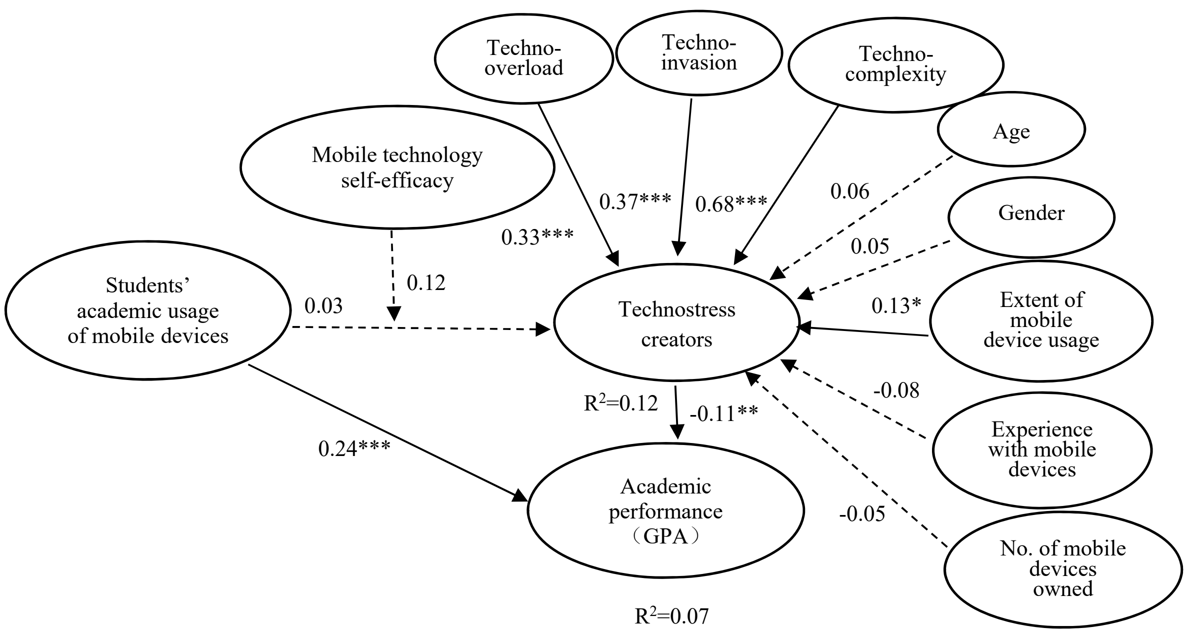

Figure 3. Structural model results

*Notes: *p < 0.1; ** p < 0.05; ***p <0.01; the solid lines were supported, while the dotted lines were not supported.*

**p < 0.1 represents marginally significant*

Tables

	Category	Frequency	Total (%)
Gender	Male	72	34.6
	Female	136	65.4
Age	15 to less than 17	1	0.5
	17 to less than 19	23	11.1
	19 to less than 21	160	76.9
	21 to less than 23	19	9.1
	23 or above	5	2.4
No. of mobile devices owned	0	0	0
	1	46	22.2
	2	90	43.3
	3	59	28.4
	4	10	4.8
	5 or above	3	1.4
Average hours using mobile devices per day	0 to less than 1 hour	0	0
	1 to less than 3 hours	26	12.5
	3 to less than 5 hours	64	30.8
	5 to less than 7 hours	54	26.0
	7 to less than 9 hours	40	19.2
	9 hours or more	24	11.5
History of using mobile devices	0 to less than 1 year	4	1.9
	1 to less than 3 years	24	11.5
	3 to less than 5 years	31	14.9
	5 to less than 8 years	77	37.0
	8 to less than 10 years	39	18.8
	10 years or more	33	15.9
WGPA	0 to less than 2.0	0	0
	2.0 to less than 2.5	11	5.3
	2.5 to less than 3.0	42	20.2
	3.0 to less than 3.5	117	56.3
	3.5 to less than 4.0	38	18.3
Subject grade	F	7	3.4
	D	0	0
	D+	1	0.5
	C	9	4.3
	C+	45	21.6
	B	66	31.7

	B+	50	24.0
	A	22	10.6
	A+	8	3.8
Mobile device positively affect AP?	Yes	189	90.9
	No	19	9.1

Table 1. Profile information of the respondents

Notes: WGPA = Weighted Grade Point Average; AP = Academic Performance

Constructs	Measures	Source
Students' academic usage of mobile devices (Formative) (1=very rarely, 5=very frequently) **-** the students' usage of any type of the mobile devices for the teaching and learning purposes.	How often do you use your mobile device(s) for the following academic activities both in and out of the class? 1) Assessing course information and content (e.g., schedulers, academic results, teaching notes and other course related materials). 2) Communicating with teachers 3) Discussing about course content with other students 4) Collaborating on course projects with other students 5) Taking a quiz, test, or exam	Cheon, et al. (2012)
Mobile technology self-efficacy (Reflective) (1=strongly disagree, 5= strongly agree) - an individual's judgement about his or her ability to use mobile technologies in the accomplishment of a learning and learning related task	I would complete my learning tasks using the mobile technology/application (e.g. Blackboard Mobile App.) 1) if I had seen someone else using it before trying it myself 2) if someone around could show me or tell me how to do it first 3) if I could call someone for help if I got stuck 4) if someone else had helped me get started 5) if I had much time to complete the task for which the mobile application was provided 6) if I had the build-in help facility for assistance 7) if I have used similar applications before to do the same job	Compeau and Higgins (1995a); Tarafdar, et al. (2015)
Technostress creators (Formative) (1=strongly disagree, 5= strongly agree) **-** the factors or conditions that create technology stress for the users of the mobile devices.	**Techno-overload** When working on the learning related tasks, I am forced by the functions and applications in my mobile device(s) (or mobile technologies) …… 1) to work much faster 2) to do more work than I can handle 3) to work with very tight time schedules 4) to change my work habits to adapt to new mobile technologies 5) to handle higher workload due to the increased technological complexity **Techno-invasion** Because of the use of mobile device(s) for the learning purposes…… 1) I spend less time with my family	Tarafdar, et al. (2007)

	2) I have to be in touch with my school work even during my vacation 3) I have to sacrifice my vacation and weekend time to keep current on new mobile learning applications 4) I feel my personal life is being invaded **Techno-complexity** When working on the learning related tasks, 1) I do not know enough about the mobile technology/application to handle my learning tasks satisfactorily 2) I need a long time to understand and use new mobile technology/application 3) I do not find enough time to study and upgrade my mobile technology skills 4) I find other students in this class know more about the mobile technology than I do 5) I often find it too complex for me to understand and use new mobile technology/application	

Table 2. Constructs and measures

Measures		Items	Composite reliability	AVE
Mobile technology self-efficacy		7	0.89	0.54
Technostress creators	Techno-overload	5	0.84	0.52
	Techno-invasion	4	0.81	0.52
	Techno-complexity	5	0.89	0.61

Table 3. Reliability and AVEs

	MTSE	T-O	T-I	T-C	AP	Age	Gender	No.MD	Experience	Extent
MTSE	0.74									
T-O	-0.31	0.72								
T-I	-0.25	0.23	0.72							
T-C	-0.15	0.12	0.36	0.78						
AP	0.02	-0.00	-0.07	-0.11	-					
Age	0.11	0.01	-0.02	0.01	-0.04	-				
Gender	-0.07	0.03	0.09	0.03	-0.05	-0.10	-			
No. MD	-0.07	0.14	0.13	-0.02	0.10	0.07	0.09	-		
Experience	-0.01	-0.01	0.05	-0.10	0.04	0.11	0.11	0.13	-	
Extent	0.08	-0.01	0.19	0.03	-0.04	-0.02	0.08	0.21	0.11	-

Table 4. Correlation between constructs

Notes：The shaded numbers in the diagonal row are the square roots of the AVEs.

MTSE = Mobile Technology Self-efficacy; T-O = Techno-overload; T-I = Techno-invasion; T-C = Techno-complexity; AP = Academic Performance; No. MD = Number of Mobile Device owned

Factor loadings					
Construct	**Items**	**MTSE**	**T-O**	**T-I**	**T-C**
MTSE	MTSE_1	**0.73**	-0.26	-0.17	-0.05
	MTSE_2	**0.83**	-0.24	-0.15	-0.14
	MTSE_3	**0.78**	-0.19	-0.20	-0.15
	MTSE_4	**0.83**	-0.23	-0.23	-0.19
	MTSE_5	**0.61**	-0.13	-0.14	-0.01
	MTSE_6	**0.73**	-0.32	-0.20	-0.09
	MTSE_7	**0.61**	-0.23	-0.16	-0.07
T-O	T-O_1	-0.28	**0.73**	0.11	0.09
	T-O_2	-0.21	**0.81**	0.15	0.16
	T-O_3	-0.15	**0.78**	0.25	0.08
	T-O_4	-0.29	**0.60**	0.14	0.00
	T-O_5	-0.26	**0.67**	0.18	0.05
T-I	T-1_1	-0.15	0.05	**0.64**	0.24
	T-1_2	-0.29	0.29	**0.71**	0.20
	T-1_3	-0.13	0.14	**0.70**	0.25
	T-1_4	-0.14	0.16	**0.82**	0.34
T-C	T-C_1	-0.11	0.09	0.27	**0.76**
	T-C_2	-0.10	0.12	0.19	**0.80**
	T-C_3	-0.14	0.00	0.34	**0.75**
	T-C_4	-0.16	0.17	0.30	**0.76**
	T-C_5	-0.08	0.08	0.30	**0.83**

Table 5. Results of confirmatory factor analysis

MTSE = Mobile Technology Self-efficacy; T-O = Techno-overload; T-I = Techno-invasion; T-C = Techno-complexity

Hypotheses	**Path coefficient**	**T-statistics**	**S/NS**
H1:SAUMD->Technostress creators	0.03	0.37	NS
H2:SAUMD->AP (WGPA)	0.24	3.92	S (at 0.01 level)
H3: Technostress creators->AP (WGPA)	-0.11	1.96	S (at 0.05 level)
H4: Moderating effect of MTSE	0.12	1.54	NS
Higher level paths (weights)			
Techno-overload->Technostress creators	0.33	2.93	S (at 0.01 level)
Techno-invasion->Technostress creators	0.37	8.69	S (at 0.01 level)
Techno-complexity->Technostress creators	0.68	8.25	S (at 0.01 level)
Control variables' paths			
Age	0.06	0.61	NS
Gender	0.05	0.77	NS
Extent of mobile device usage	0.13	1.71	S (at 0.1 level)
Experience	-0.08	1.09	NS
No. of mobile devices owned	-0.05	0.74	NS
Post Hoc analysis			

MTSE->Technostress creators	-0.34	3.85	S (at 0.01 level)

Table 6. Summary of path coefficient results

Notes: SAUMD = Students' academic usage of mobile devices; MTSE = Mobile Technology Self-efficacy; AP = Academic Performance; S = Significant; NS = Not Significant

Outer weights	**Weights**	**T-statistics**	**S/NS**
SAUMD_1	-0.47	1.42	NS
SAUMD_2	0.71	2.41	S (at 0.01 level)
SAUMD_3	-0.08	0.17	NS
SAUMD_4	0.31	0.73	NS
SAUMD_5	0.54	1.98	S (at 0.05 level)

Table 7. Outer weights of SAUMD

Note: SAUMD = Students' academic usage of mobile devices

Hypotheses	**Path coefficient**	**T-statistics**	**S/NS**
H1:SAUMD->Technostress creators	-0.02	0.25	NS
H2:SAUMD->AP (subject grade)	0.26	4.69	S (at 0.01 level)
H3: Technostress creators->AP (subject grade)	-0.01	0.10	NS
H4: Moderating effect of MTSE	-0.07	0.81	NS
Higher level paths			
Techno-overload->Technostress creators	0.34	3.00	S (at 0.01 level)
Techno-invasion->Technostress creators	0.37	8.68	S (at 0.01 level)
Techno-complexity->Technostress creators	0.67	7.97	S (at 0.01 level)
Control variables' paths			
Age	0.05	0.57	NS
Gender	0.05	0.70	NS
Extent of mobile device usage	0.12	1.70	S (at 0.1 level)
Experience	-0.08	1.02	NS
No. of mobile devices owned	-0.04	0.59	NS
Post Hoc analysis			
MTSE->Technostress creators	-0.34	3.83	S (at 0.01 level)

Table 8. Summary of path coefficient results

Notes: SAUMD = Students' academic usage of mobile devices; MTSE = Mobile Technology Self-efficacy; AP = Academic Performance; S = Significant; NS = Not significant