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Learning Complex Technology Online: Effect of Challenge and Hindrance Techno-stressors on Student Satisfaction and Retention

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Abstract:

Despite increasing attention to online learning worldwide, learning complex technologies online has always been challenging and even hindersome to students, who are subjected to elevated levels of technostress. In contrast to most previous studies that focused on the negative side of technostress, this study investigated both the negative and positive sides of technostress. Based on the challenge hindrance framework (CHF), the holistic stress model (HSM), and the person-environment fit (P-E Fit) model, we examined how challenge and hindrance techno-stressors caused distress and eustress in online students and lead to associated outcomes. We empirically validated the research model by analyzing survey data collected from 565 online graduate business students enrolled at a university in the United States. The results revealed that some hindrance and challenge techno-stressors were associated with techno-distress and techno-eustress, which further impacted student satisfaction and student retention. We discussed the contributions and implications and provided future research directions.

Keywords: Technostress, Eustress, Distress, Online Learning, Complex Technology.

[Department statements, if appropriate, will be added by the editors. Teaching cases and panel reports will have a statement, which is also added by the editors.]

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1 Introduction

Online learning has become increasingly popular and influential over the years. The rapid expansion of online programs and "at scale" teaching methods have led to many students enrolling in online programs. Meanwhile, with the rise of science, technology, engineering, and math (STEM)-related jobs in the marketplace, STEM education has become more attractive as it is more likely to provide education with career-oriented training leading to well-paying jobs for graduates. Students in STEM fields, however, often face a steep learning curve in learning complex technologies, and they often find learning even harder in an online environment (Zhao, Bandyopadhyay, & Bandyopadhyay, 2020). Meeting the learning demands frequently results in significant stress levels (Tompkins, Brecht, Tucker, Neander, & Swift, 2016). Despite increasing attention to STEM education worldwide and the importance of online learning, learning complex technologies online has always been challenging and even hindersome to students, who report elevated levels of technostress (Wang, Tan, & Li, 2020).

Technostress refers to the stress individuals experience due to their use of information systems (Tarafdar, Cooper, & Stich, 2019). Technostress issues are becoming prominent with the increased use of digital technology (Chandra, Shirish, & Srivastava, 2019). Although technostress has been studied in the context of employees using technology in organizations, it has not been studied much in an academic setting. In the workplace, technostress has been found to negatively impact job satisfaction and organizational commitment (Kumar et al., 2013). It also leads to adverse employee outcomes, such as absenteeism and turnover (Tarafdar et al., 2011; Salo, Pirkkalainen & Koskelainen, 2019). Zielonka (2022) found that trust in technology reduced the perception of technostress and positively impacted job satisfaction in the workplace. In an academic environment, high levels of stress among students have been found to be related to an increased likelihood of failing to complete the educational program (Tompkins et al., 2016). Psychological researchers have recognized several important academic outcomes of stress that are underscored as vital for investigation, such as student retention and satisfaction (Tompkins et al., 2016; Travis, Kaszycki, Geden, & Bunde, 2020). Student retention refers to staying in school until completing a degree (Hagedorn, 2005). Student retention is critical to institutions as the higher education market has increasingly become competitive, and universities are looking to improve graduation rates and reduce the loss of tuition revenue from students dropping out (Cook & Rushton, 2009). The literature review has recognized that student satisfaction is an essential factor influencing e-learning's effectiveness (Zhao, Bandyopadhyay, & Bandyopadhyay, 2020) and student retention (Schertzer & Schertzer, 2004). Student satisfaction has been defined as "the favorability of a student's subjective evaluation of the various outcomes and experiences associated with education" (Elliott & Shin, 2002, p. 198).

Student satisfaction and retention have become increasingly vital in the post-Covid-19 academic environment. The Covid-19 pandemic practically forced students worldwide into distance learning, often by mandate than by choice (Van Slyke, Clary, & Tazkarji, 2022). After the threat of the pandemic receded, many colleges continued their online course offerings. The presence of stress in online learning, particularly for students who were thrust into it unwittingly during the pandemic, has been acknowledged by several researchers (e.g., Cicha et al., 2021; Dhawan, 2020). Such stress is likely to linger if students have to continue with online education in the post-pandemic period, which can negatively impact student satisfaction and retention.

As little as technostress has been studied in an academic setting, the focus has been primarily on instructors teaching technology-enabled courses and not on students learning complex technologies online. Because of the COVID-19 pandemic, global higher education has experienced a substantial digital transformation to online learning, and the use of online learning platforms will continue after the pandemic (Barber, 2021; Van Slyke, Topi, & Granger, 2021). Thus, it is crucial to bridge the gap by investigating the mechanism of technostress in the context of students learning complex technologies online.

Research indicates that technostress composes two subprocesses: the techno-eustress subprocess and the techno-distress subprocess (Tarafdar et al., 2019). Eustress refers to positive stress, and the eustress subprocess starts with challenge stressors and is associated with positive psychological responses, leading to positive outcomes (Hargrove, Nelson, & Cooper, 2013). Distress refers to negative stress, and the distress subprocess starts with hindrance stressors and is associated with negative psychological responses, leading to negative outcomes (Hargrove et al., 2013). However, technostress is not always bad for learning. The positive technostress, known as techno-eustress, is little mentioned (Tarafdar, Cooper, & Stich, 2017). Until recently, only a few studies have started to examine techno-eustress (Califf, Sarker, & Sarker, 2020). We want to find out if techno-eustress encourages the satisfaction and retention of students. In our study, we specifically wanted to empirically measure both the positive (challenge) and the negative (hindrance) impact of techno-stressors on student satisfaction and retention in an online technology-intensive learning context. It is essential to know the impact of technostress on students so that interventions can be designed to help students succeed if it impedes their academic performance.

Given the pervasiveness of technostress among university students (Wang et al., 2020), it is crucial to understand what factors contribute to technostress and how. An extant literature review about technostress leads to our contextualization of four generally accepted constructs as hindrance techno-stressors and two well-known constructs as challenge techno-stressors related to learning complex technology online. A few studies have investigated the impact of technostress on academic productivity and satisfaction of university students in a technology-enhanced learning (TEL) environment (e.g., Upadhyaya & Vrinda, 2021; Van Slyke et al., 2022). These studies have focused on the TEL environment (e.g., online learning format) rather than the learning content (e.g., complex technologies). To the best of our knowledge, however, no study has empirically investigated challenge and hindrance techno-stressors and their effects in the context of learning complex technology online. Thus, our research question is:

RQ: What are the effects of challenge and hindrance techno-stressors on student satisfaction and retention in the context of learning complex technologies online?

This study bridges the research gap by examining how the challenge and hindrance techno-stressors affect student satisfaction and retention through two subprocesses of technostress in online learning settings. This study is one of the first ones examining the technostress associated with students learning complex technologies online. To instantiate, we use SAP software as an example of a complex technology students learn online in STEM education. We begin with a review of the relevant literature. This is followed by the development of the research model and the description of the research design. Then, we report the results and discuss the findings and their implications. Finally, we comment on the study's limitations and indicate some directions for future research. We believe that by identifying and examining the effect of challenge and hindrance techno-stressors on student satisfaction and retention, this study will contribute to information systems research and provide practical implications to all institutions using online learning.

2 Literature Review and Theoretical Background

2.1 Stress, Technostress, and Associated Theories

This section explains stress, technostress, and the theories relevant to our study. We start with conceptualizing stress and introduce the well-accepted stressor-strain theoretical approach. The stressor-strain theoretical approach is the fundamental theoretical background of this study. Then, we explain the challenge hindrance framework (CHF), the theoretical foundation for us to clarify the differentiation of challenge stressors from hindrance stressors. The CHF extends the stressor-strain theoretical approach by indicating that challenge and hindrance stressors impact performance in two ways: motivation and strain. After that, we present a more comprehensive model: the holistic stress model (HSM), which complements the theoretical foundation of CHF. The HSM offers an overarching view that after stressors are appraised as beneficial or undesirable, a psychological response is manifested either positively or negatively, leading to performance and outcome. In addition, HSM separates the eustress subprocess from the distress subprocess, further enhancing this study's theoretical foundation. We draw on the tenets of these three theoretical perspectives to theorize our research model. Furthermore, we bring the person-environment fit (P-E Fit) theory to indicate that a misfit between personal and environmental factors generates distress. Finally, we identify four techno-stressors commonly recognized as hindrance stressors and review studies examining challenge techno-stressors.

Conceptualizations of stress have varied in form and context. Selye (1987) defined the term stress as “the non-specific response of the body to any demand placed upon it” (Selye, 1987, p. 17). Dewe, O’Driscoll, and Cooper (2012) consider stress as a "stimulus, response, or the interaction between the two" (Dewe et al., 2012, p. 24). It is assumed that employees in organizations experience various workplace stimuli or demands. These demands are also called stressors, which employees appraise. This understanding of stress is in line with the stressor-strain theoretical approach (Califf, Sarker, & Sarker, 2020). According to the stressor-strain-outcome theory, stressors induce strain and eventually affect individual and work outcomes (Koeske & Koeske, 1993). An appraisal is “the process by which an environmental condition is interpreted by an individual as a stress creator" (Stich, Tarafdar, Stacey, & Cooper, 2019, p. 136). Strain refers to an individual's psychological response to stressors (Ayyagari, Grover, & Purvis, 2011). Examples of work outcomes associated with strain include job satisfaction, workplace productivity, organizational commitment, and turnover intention (Califf et al., 2020; Podsakoff, LePine, & LePine, 2007).

The CHF classified stressors into two types: challenge stressors and hindrance stressors (Cavanaugh, Boswell, Roehling, & Boudreau, 2000). Challenge stressors are "stressors that people tend to appraise as potentially promoting their personal growth and achievement," and hindrance stressors are "stressors that people tend to appraise as potentially constraining their personal development and work-related accomplishment" (Podsakoff, LePine, & LePine, 2007, p. 438). A meta-analytic test of the CHF has found that hindrance stressors are negatively associated with performance through strains, and that challenge stressors are positively associated with performance through motivation (LePine, Podsakoff, & LePine, 2005).

Simmons and Nelson (2007) proposed that HSM offered an overarching view of the individual's experience of work stress. It is emphasized that stressors are inherently neutral (Simmons & Nelson, 2007). In other words, a stressor is defined by how an individual appraises the stressor. During the appraisal process, the individual decides whether the stressor is beneficial or undesirable (Hargrove, Nelson, & Cooper, 2013). Once the stressor has been determined as beneficial or undesirable, the individual goes through a decision-making process to determine how to respond to the stressor (McGrath, 1976). The individual may react positively or negatively to the stressors, which is called the psychological response (McGrath, 1976; Califf et al., 2020). A psychological response is manifested in the form of positive or negative emotional states and attitudes (Hargrove et al., 2013). Based on the psychological response, an individual enters the performance process during which a decision on how to act or perform is made (McGrath, 1976; Califf et al., 2020). Finally, the performance process has an outcome as a consequence.

Recent research indicates that there are two subprocesses in the holistic stress process: the eustress subprocess and the distress subprocess (Tarafdar et al., 2019; Califf et al., 2020). The eustress subprocess is associated with positive stress (Selye, 1987). Eustress, a positive psychological response, comes from the appraisal of challenge stressors, which in turn generates positive outcomes (Shirish, Chandra, & Srivastava, 2021). The subprocess of distress is associated with negative stress (Selye, 1987). Distress, a negative psychological response, comes from the appraisal of hindrance stressors, which in turn generates negative outcomes (Califf et al., 2020).

Another common theoretical lens to study stress is the P-E Fit theory. Researchers use the P-E Fit theory to understand how individuals appraise an environmental attribute to be a stressor, depending on whether the environmental demands fit their preference (Ayyagari et al., 2011). When a misfit happens, individuals experience distress (Stich et al., 2019). In the stress literature, there are variations of distress, such as strain, burnout, depression, anxiety, and tension (Califf & Brooks, 2020).

Technostress is the stress experienced by end-users of information and communication technologies (Ragu-Nathan et al., 2008). Most technostress-related studies have focused on investigating the effect of hindrance stressors on distress, which is the distress subprocess of the holistic stress process (Califf et al., 2020). Five techno-stressors are commonly recognized as hindrance stressors. These are techno-overload, techno-invasion, techno-complexity, techno-uncertainty, and techno-insecurity (Ragu-Nathan et al., 2008). Tarafdar et al. 2011) explained each of the techno-stressors in detail in their study. Techno-overload occurs when users of information systems (IS) appraise stressful situations as they are forced to work faster and longer. Techno-invasion describes situations in which IS users are constantly connected to technology and can be reached anywhere and anytime without a clear work-life boundary. Techno-complexity refers to situations in which the complexity of technology associated with IS makes users feel that their skills are insufficient due to the difficulty related to new technologies. As a result, users must spend time and effort learning and understanding how to use the technology. Techno-uncertainty happens when users feel disturbed because of continuing changes and updates to technologies. Techno-insecurity is about the situation where technology users feel threatened that they will lose their job, either being replaced by the technology or by other people who are better at using the technology than them (Ragu-Nathan et al. 2008).

Recent technostress literature has consistently supported a two-dimensional framework positing that hindrance stressors should be distinguished from challenge stressors, because "these two types of stressors have divergent effects on various affective and behavioral responses" (Benlian, 2020, p. 1260).

Maier et al. (2021) found that challenge IS use stressors and hindrance IS use stressors are appraised through challenge IS use appraisal and hindrance IS use appraisal, respectively. While most technostress studies focused on examining the role of hindrance stressors and the dark side of stress, little empirical research attention has been paid to challenge techno-stressors. According to Califf et al. (2020, p. 813), “Challenge techno-stressors are defined in terms of individuals appraising technology associated with ‘challenges that they are motivated to tackle because they expect that doing so is within their wherewithal and would lead to betterment’ (Tarafdar et al. 2019, p. 14)”. Using the challenge–hindrance stressor framework, Benlian (2020, p. 1261) defined challenge techno-stressors as “technology-driven stressors that present opportunities for individual learning and personal growth”. Tarafdar et al. (2019) suggested that challenge techno-stressors could be linked to positive outcomes such as greater effectiveness and innovation. Califf et al. (2020) conceptualized challenge techno-stressors as technology-related stressors appraised by individuals that are linked to promoting task accomplishment. They found that challenge techno-stressors, including usefulness, technical support, and involvement facilitation, were related to positive psychological responses, and that such responses were related to job satisfaction and attrition, which impacted turnover intention (Califf et al., 2020). Despite these advancements, extant research does not explain how technostress develops among students learning complex technologies online and what are the techno-stressors that impact an academic rather than an organizational environment.

2.2 Technostress in Higher Education and SAP Education

Empirical research about technostress has received some attention in higher education but remains scant. Most of the technostress research has focused on organizational employees’ use of technologies (e.g., Califf et al., 2020; Hwang & Cha, 2018). While some studies have examined technostress in an academic setting, they mostly focused on teachers' technostress. For example, Califf and Brooks (2020) conducted an empirical study about technostress on kindergarten through 12th-grade teachers. Özgür (2020) investigated factors that can alleviate the technostress of high school teachers in Turkey and found that both school support and teachers’ technological-pedagogical content knowledge negatively predicted their technostress level. Only a few studies have investigated university students’ technostress in technology-enhanced learning. Booker, Rebman, and Kitchens (2014) tested university students’ technostress in an online learning environment and found technostress influenced course satisfaction and continuance commitment. They, however, did not differentiate distress from eustress and did not examine the two sub-processes of technostress. Wang, Tan, and Li (2020) examined technostress among university students in a technology-enhanced learning environment based on a multidimensional person-environment misfit framework. However, Wang et al. (2020) did not study the relationship between techno-stressors and technostress. While the context of both studies was technology-enhanced learning, neither focused on students who learn complex technologies online in a technology-enhanced learning environment.

Among the relatively few studies that have focused on students’ technostress, Van Slyke et al. (2022) developed a research model that included both distress and eustress to predict distance learning satisfaction and continuance intentions. They found that distress negatively affected satisfaction and continuance, while eustress had positive impacts on both. In an empirical study of university students in India, Upadhaya and Vrinda (2021) found that female students, older students, and graduate students experienced higher levels of technostress compared to male students, younger students, and undergraduate students, respectively. Another study of university students in India (Sethi, Pereira, and Arya, 2022) found that technostress negatively affected academic productivity. Neither study from India addressed distress and eustress, the two sub-processes of technostress.

In our study, SAP software is used as an instantiation of a complex technology that is learned online by graduate students. Next, we will discuss the importance of SAP education in academics, followed by the extent to which SAP education is covered in our graduate program and how it is delivered to the students.

Enterprise Systems are used by almost all Fortune 500 companies, and most of those companies use SAP software. The Enterprise System (ES) learned in our master's degree program is SAP ERP - the world’s leading producer of business software (SAP, 2022). As a member of the SAP University Alliance, we provide students with hands-on experience with SAP, which is the real ES software used in the world. Employers from local, national, and multinational companies consider ES experience to be a significant differentiating factor when reviewing resumes and selecting candidates for job interviews.

Currently, the College of Business at our university offers five graduate-level ES courses in the curriculum. We also have an SAP-enabled elective course. The following modules are covered in the six courses: Materials Management, Sales and Distribution, Production Planning, Financials and Control, SAP BW

(Business Information Warehouse) and Business Objects, SAP Build, SAP Jam, SAP HANA Cloud Platform, SAP SCM, SAP CRM, and SAP Predictive Analytics.

Students pursue online SAP-enabled courses offered in accelerated 8-week terms. At least half of the course content is about students learning to use SAP technology by working on hands-on assignments. Thus, students may feel techno-overload with learning the technology. Besides, SAP technology is complex in nature and, therefore, we expect students to appraise SAP technology in terms of techno-complexity. Moreover, because SAP technology as well as the supported platforms and operating systems are continuously updated, SAP users may appraise the technology as high in techno-uncertainty. From our teaching experience, we have observed the techno-uncertainty caused by the updates associated with SAP technology. Furthermore, techno-invasion is linked to learning SAP technology online for two reasons. First, students may feel their personal life is being invaded by the online learning environment. Second, because of the steep learning curve with complex technology, students spend more time keeping current on learning the technology. Thus, as a result of learning SAP technology online, they spend less time with their family.

3 Research Model and Hypotheses

In this study, our primary objective is to identify and understand challenge and hindrance techno-stressors related to learning a complex technology, which is SAP software that may induce distress and eustress in online graduate students. We apply concepts and perspectives embedded in the CHF (Cavanaugh et al., 2000), HSM (Simmons & Nelson, 2007), and P-E fit (Stich, et al., 2019) models to examine how these techno-stressors cause distress and eustress and associated outcomes, which are student satisfaction and student retention. Specifically, we employed the HSM as the overarching model to develop our research model. We used the P-E fit theory to propose the hypothesized relationships between hindrance techno-stressors and distress. To propose the hypothesized relationships between challenge techno-stressors and eustress, we used the CHF and HSM models. Figure 1 shows our research model. We discuss the hypotheses developed based on the relationships portrayed in the research model.

[Insert Figure 1 here]

3.1 Hindrance Techno-stressors and Distress

Four of the five commonly studied hindrance techno-stressors are associated with learning complex technologies online, including techno-overload, techno-invasion, techno-complexity, and techno-uncertainty (Ragu-Nathan et al. 2008). We do not include techno-insecurity as it has less relevance to the academic learning context. Students neither compete with the technology they learn, nor with their classmates in terms of using the technology. Thus, students do not feel threatened with losing their jobs, either being replaced by technology or by other people who are better at using technology than them. Empirical support for relationships among techno-stressors and distress has accumulated in employment settings. In an earlier study, Arnetz and Wilholm (1997) found that techno-uncertainty, stemming from constant technological changes, leads to negative psychological responses. Later, negative psychological responses, such as unease, sadness, depression, negative attitudes, and lack of self-esteem, were conceptualized as distress by McVicar (2003). In a more recent study of healthcare workers, Califf et al. (2020) found that technology overload was a predictor of negative emotional responses. Zielonka (2022) studied employees from multiple professions and found that all four hindrance techno-stressors were positively related to perceived distress.

Even though we have seen studies relating to techno-stressors and distress in the workplace, the investigation has yet to be adequately extended to higher education. Students who are users of complex technologies are no less notable than professionals in employment settings. Therefore, we posit that the relationship found in workplace settings between hindrance techno-stressors and techno-distress will also extend to academic settings. We propose that students who appraise the technology they learn online to be associated with hindrance stressors will experience techno-distress. Based on the perspective of P-E fit (Ayyagari et al., 2011) and the stressor-strain-outcome theory (Koeske & Koeske, 1993), we expect a misfit between a student's capability and the demand for using a complex technology to induce distress. For example, students may feel that their skills are insufficient due to the difficulty in learning complex technologies. As a result, students are stressed to put in more time and effort to study and understand the various features of the technologies. In this scenario, students experience the techno-stressor named techno-complexity, and that misfit causes distress. This logic applies to each of the techno-stressors. With a tight course schedule, students are forced to learn complex technologies at high speed and for an extended time. This results in techno-overload, which further induces distress. Similarly, students are always connected to educational technologies in an asynchronous online learning environment. They may feel pressured to access the technology anywhere and anytime without an unclear boundary between school-related and personal contexts. When students appraise this techno-invasion as stressful, distress occurs. Likewise, when students feel disturbed because of continuing changes and updates to technologies they learn, techno-uncertainty happens, which triggers distress. Thus, we hypothesize the following:

H1: Appraisal of the technology that students learn online as having high techno-overload will be positively related to techno-distress.

H2: Appraisal of the technology that students learn online as having high techno-invasion will be positively related to techno-distress.

H3: Appraisal of the technology that students learn online as having high techno-complexity will be positively related to techno-distress.

H4: Appraisal of the technology that students learn online as having high techno-uncertainty will be positively related to techno-distress.

3.2 Challenge Techno-stressors and Eustress

Challenge techno-stressors are technology-related stressors appraised by individuals that are linked to promoting task accomplishment (Califf et al., 2020). One of our goals is to take the first step to investigate what academic institutions can do to help achieve the positive impacts of the techno-stressors. Following this logic, we decided to examine two challenge techno-stressors: literacy facilitation and technical support, and their impacts in the context of learning complex technologies online. Literacy facilitation “describes mechanisms that educate through sharing of IS-related knowledge” (Tarafdar et al., 2011, p. 118). Such mechanisms may include providing training and instructions on applications and systems to functional users (Tarafdar et al., 2011). Technical support describes activities related to end-user support such as addressing users’ IS-related problems and queries (Ragu-Nathan et al., 2008). Literacy facilitation and technical support have been defined and empirically investigated in previous technostress studies, and technical support has been contextualized as a challenge techno-stressor (Califf et al., 2020). We recontextualized literacy facilitation and technical support as challenge techno-stressors that are important to students learning complex technology online. Literacy facilitation and technical support are challenge techno-stressors because they matched the conceptual definitions of challenge techno-stressors, in which they promote rather than hinder task achievement.

We propose that students who appraise the technology they learn online as being related to challenge techno-stressors will experience techno-eustress. According to CHF, challenge stressors are positively related to performance through motivation (LePine, Podsakoff, & LePine, 2005). According to HSM, beneficial stressors lead to positive psychological responses (Simmons & Nelson, 2007). Empirical research suggests that users who appraise technology as associated with high literacy facilitation have a positive psychological response (i.e., eustress) because training and guidance help users complete tasks more quickly (Ragu-Nathan et al., 2008). Moreover, it has been indicated that users who appraise technology to be associated with high technical support leads to eustress, because their workloads are reduced due to technical support and a positive support system (Califf et al., 2020). It follows then that when students are provided with literacy facilitation and technical support, eustress would be generated. Thus, we hypothesize the following:

H5: Students who appraise the technology they learn online as related to high literacy facilitation will experience techno-eustress.

H6: Students who appraise the technology they learn online as related to high technical support will experience techno-eustress.

3.3 Outcomes

Outcomes are individuals’ reactions toward stressors based on their distress or eustress experience (Califf et al., 2020). According to CHF (Cavanaugh et al., 2000) and HSM (Simmons & Nelson, 2007), challenge stressors are positively associated with desirable behaviors and outcomes through eustress, while hindrance stressors are negatively associated with desirable behaviors and outcomes through distress. Empirical findings also provided support towards various outcome variables including job satisfaction, organizational commitment, and turnover intention based upon the presence of challenge or hindrance stressors (Hargrove et al., 2013). In organizational stress research, techno-distress has been constantly linked to decreased job satisfaction and reduced organizational commitment (Tarafdar et al., 2011). Although techno-eustress is much less examined, Califf et al. (2020) find techno-eustress leads to higher job satisfaction and increased organizational commitment. We examine two essential academic outcomes of technostress that are extremely important to both students and institutions: student satisfaction and student retention (Tompkins et al., 2016; Travis et al., 2020). Similar to organizational employees, students also experience techno-distress and techno-eustress while learning and using technologies. We expect that techno-distress leads to undesirable academic outcomes while techno-eustress leads to desirable academic outcomes. Thus, we hypothesize the following:

H7: Techno-distress experienced by students will lead to low student satisfaction.

H8: Techno-distress experienced by students will lead to low student retention.

H9: Techno-eustress experienced by students will lead to high student satisfaction.

H10: Techno-eustress experienced by students will lead to high student retention.

4 Method and Results

4.1 Research Design

To empirically test the research model, we conducted a survey in which all measurement items were adapted from previously validated constructs. Table 1 shows the measurement items and their sources. We developed the survey instrument based on existing scales found in a comprehensive literature review. Considering that in our study, the graduate students (our sample) are learning SAP - an instantiation of complex technology online (their circumstances), we identified appropriate measures from a comprehensive literature review and modified the existing scales to an online SAP learning context. We used the approach from Zhao, Bandyopadhyay, and Bandyopadhyay (2020) to contextualize the existing scales into an online technology-intensive learning environment. The content validity of all scales was established through a content validity expert panel composed of four professors skilled in quantitative analysis and quantitative research methods. Some of the original measurement items were dropped because they did not fit into the context. We assessed most of the measures on a seven-point Likert scale anchored at 1 = strongly disagree and 7 = strongly agree. Only for the eustress construct, we measured it on a scale of 1 to 5, where 1= Never, 2=Sometimes, 3=About half the time, 4=Most of the time, 5=Always. In addition, the construct “retention” was measured using reversed scales. To help readers interpret results more efficiently, we have reversed the coding of the measured construct “retention.” Like in previous similar studies, we used gender, age, and previous SAP experience as control variables in our analysis (Shirish et al., 2021). We performed a pilot test on 82 students taking an online SAP-enabled course to determine the reliability of the scales. The lowest Cronbach’s alpha on the pilot test was 0.856 (uncertainty), indicating satisfactory reliability for all study constructs.

In the main study, participants were online graduate business students who were enrolled at a midsized public university located in the southern United States. The students took SAP-enabled online courses and practiced hands-on SAP assignments. To complete the coursework, students needed to use SAP software on their computers. We collected the survey data toward the end of a term in 2020 to ensure all students had the experience of learning SAP online. We received 565 completed responses. In terms of gender, the sample consisted of 268 males, 295 females, one non-binary/third gender, and one “prefer not to say”. In terms of age, 88 participants were between 18 and 24 years of age, 268 participants were between 25 and 34 years, 135 participants were between 35 and 44 years, 55 participants were between 45 and 54 years, 18 participants were between 55 and 64 years, and one participant was more than 64 years old. According to Cohen (1992)’s statistical power analysis, when the maximum number of arrows pointing at a construct is 4, it is recommended to have a minimum sample size of 191 to achieve a statistical power of 80% for detecting R^2 values of at least 0.1 with a 1% probability of error. Our sample size of 565 was adequate enough for analysis.

To reduce the concern of multicollinearity, we assessed the latent variables’ variance inflation factor (VIF). The highest VIF score was 2.268, well below the threshold value of 5 (Hair, Ringle, & Sarstedt, 2011), which indicated that there was no collinearity problem.

To help eliminate common method bias (CMB), we applied procedural remedies during the survey design. The survey questions to measure exogenous constructs were separated from the ones related to endogenous constructs, so that they did not show in linear order (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Then, we followed Harman's single factor test to assess CMB. According to Podsakoff et al. (2003), if a detrimental level of common method bias exists, "(a) a single factor will emerge from the exploratory factor analysis (unrotated) or (b) one general factor will account for the majority of the covariance among the measures (p. 889)". Results indicated that neither situation applied to our study. We conducted an exploratory factor analysis through which multiple factors emerged to explain the variance and no single factor accounted for more than half of the covariance among the measures. Thus, common method bias was not a serious issue in this study.

Another way to identify common method bias is to assess latent variables' VIF. A model can be considered free of common method bias if all VIFs are equal to or lower than 3.3 (Kock, 2015). Since the highest VIF score was 2.268, it indicated that there was neither common method bias nor any collinearity problem.

[Insert Table 1 here]

4.2 Measurement Model

The measurement model was assessed through indicator reliability, internal consistency that was measured by composite reliability and Cronbach's alpha, convergent validity that was measured by average variance extracted (AVE), and discriminant validity. In our research model, all latent variables were measured by reflective constructs. We used structural equation modeling with partial least squares (PLS) to perform the evaluations. Results indicated good reliability and validity.

Table 2 shows the mean, standard deviation, and loading of each measurement item. The outer loadings of most measurement items were higher than the recommended threshold of 0.708 (Hair et al., 2011), except for two measurement items. The values of these two items were 0.70 and 0.64. We decided to keep these two items because 0.70 was considered close enough to 0.708 to be acceptable. We also followed the recommendation that "indicators with outer loadings between 0.40 and 0.70 should be considered for removal from the scale only when deleting the indicator leads to an increase in the composite reliability above the suggested threshold value" (Hair et al., 2011, p. 103). Since deleting these two indicators did not significantly increase their corresponding composite reliabilities, we decided to keep them.

[Insert Table 2 Here]

Table 3 reveals good results from the PLS confirmatory factor analysis, in which each indicator had a higher loading on the construct it was supposed to measure than on any other construct. Table 4 shows the overview results of the measurement model. The composite reliability and Cronbach's alpha were all higher than 0.708, indicating good internal consistency reliability. The values of AVE were all higher than 0.5, indicating good convergent validity. The square root of the AVE of each construct was higher than its highest correlation with any other construct, indicating good discriminant validity. Besides the assessment of cross-loadings, we checked the heterotrait-monotrait ratio (HTMT) of the correlations to further assess discriminant validity. The HTMT is "the mean of all correlations of indicators across constructs measuring different constructs (i.e., the heterotrait-heteromethod correlations) relative to the (geometric) mean of the average correlations of indicators measuring the same construct (i.e., the monotrait-heteromethod correlations)" (Hair, Hult, Ringle, & Sarstedt, 2022, p. 122). Henseler, Ringle, & Sarstedt (2015) suggest that an HTMT value should be less than 0.9 (ideally less than 0.85) to discriminate between two factors. As indicated in Table 5, HTMT ratios for all pairs of factors in this study were less than 0.85. Thus, our results indicate a satisfactory measurement model in terms of the HTMT criterion. Together, we applied rules of thumb to evaluate the measurement model and found that all criteria were met.

[Insert Table 3 Here]

[Insert Table 4 Here]

[Insert Table 5 Here]

4.3 The Structural Model

To evaluate the structural model, we measured the sizes and significance of path coefficients, which represented the hypothesized relationships among the constructs. Moreover, we assessed the most used measure, which is the coefficient of determination (R^2 value). Additionally, we calculated f^2 effect sizes of the exogenous constructs on the endogenous constructs.

We ran the PLS-SEM algorithm and received the estimated values of path coefficients and R^2. The R^2 value is a measure of the model's predictive accuracy and represents the amount of explained variance of endogenous constructs in the structural model (Hair et al., 2011). After running the bootstrapping method, we got the estimated t values and determined the corresponding significance of the relationships.

According to the widely accepted guidelines about effect size f^2, threshold values of 0.02, 0.15, and 0.35, represent small, medium, and large effects respectively (Cohen, 1992). The effect size f^2 is calculated by the difference of the R^2 values before and after a specific exogenous construct is omitted from the model (Hair et al., 2011). The model explained 44.8 percent of the variance of distress (R^2 = 0.403), 14.7 percent of the variance of eustress (R^2 = 0.147), 24.1 percent of the variance of student satisfaction (R^2 = 0.241), and 24.6 percent of the variance of student retention (R^2 = 0.246). All but two of the hypotheses were well supported by the empirical results and were significant at the 0.01 level. Table 6 shows the parameters assessed in the structural model.

Among the control variables, previous SAP experience and gender were not significantly associated with the two dependent variables. However, age had a significant positive association with retention. The results indicate that older students are less likely to withdraw from the program than younger ones.

[Insert Table 6 Here]

5 Discussion

5.1 Discussion of the Results

The results indicated that three of the four hindrance techno-stressors were significantly and positively associated with techno-distress. Invasion (H2) had a significant and positive relationship with techno-distress (path coefficients = 0.22; $p < 0.01$). Complexity (H3) had a highly significant and positive relationship with techno-distress (path coefficients = 0.32; $p < 0.01$). Uncertainty had a significant and positive relationship with techno-distress (path coefficients = 0.13; $p < 0.01$). Among these three techno-stressors, complexity had the largest effect size compared to the other two hindrance techno-stressors. This supports the argument that these techno-stressors indeed create tension in students who perceive the online technology-enhanced course as being hard to understand, invading their lives, and constantly shifting and updating. Besides, it indicates that complexity is the greatest hindrance techno-stressor. Overload (H1) was found not to be a significant predictor of techno-distress. Overload is the situation where students were forced to learn at high speed and for an extended time. Contextually, online graduate students are used to learning at a fast pace and for extended periods of time because they are enrolled in eight-week accelerated classes. Thus, they can manage stress when it comes to learning technology online with tight time schedules, so that overload did not lead to significant distress. Another possible reason is that other strong factors may hide the effect of overload on distress. For example, the course load may be adjusted by the instructor so that students would not feel distressed. Future research is called for further investigation on the possible interplay between techno-overload and other factors in the development of technostress. A longitudinal study may be helpful to understand the effect of overload on the development of technostress over time.

There were two challenge techno-stressors, literacy facilitation, and technical support, in the model. Literacy facilitation (H5), which has been commonly associated with reducing techno-distress, was found to be a very significant predictor of techno-eustress (path coefficients = 0.28; $p < 0.01$). Technical support (H6) was positively associated with techno-eustress as well (path coefficients = 0.14; $p < 0.01$). These findings support the previous literature proposing that such mechanisms can be used by managers to "savor eustress" in employees (Hargrove et al., 2013; Califf et al., 2021). Compared to literacy facilitation, technical support had a smaller effect on techno-eustress. It indicated that online students perceived literacy facilitation as more relevant to techno-eustress than technical support did. A plausible explanation is that students do not ask for help from technical support because they are capable of completing the coursework by just utilizing literacy facilitation. Another plausible explanation is that students find other ways to solve technical issues (such as by reaching out to their peers) without looking for help from technical support. Therefore, technical support emerged as a non-significant predictor of techno-eustress.

The results showed that techno-distress significantly decreased both student satisfaction (H7) (path coefficients = -0.32; $p < 0.01$) and retention (H8) (path coefficients = 0.49, measured with reversed items; $p < 0.01$). Techno-eustress had a very significant positive relationship with student satisfaction (H9) (path coefficients = 0.37; $p < 0.01$) but did not establish a significant relationship with retention (H10). Consistent with the findings of Califf et al. (2020) and Van Slyke, et al. (2022), our study did not find a direct relationship between techno-eustress and retention. The results indicate that techno-eustress, while positively impacting an online student's satisfaction, may not significantly impact the student's retention. On the other hand, student retention is significantly influenced by techno-distress. Van Slyke et al. (2022) reported that distress had a stronger effect on outcomes than eustress. That could be why eustress did not have a direct positive impact on retention while distress did have a significant negative impact on it. Our results highlight how students' appraisal of and response to techno-stressors determine their perceptions and how students' experience with techno-distress and techno-eustress can impact their satisfaction with the quality of the program and their retention.

In addition, as an alternative approach to analyzing the data, we examined "ad hoc" results for the relationships between the different levels of the two kinds of technostress (i.e., high/low techno-eustress and techno-distress) and the two outcomes (i.e., student satisfaction and student retention). We present and discuss the results in the Appendix. We found that these results were consistent with the main tests.

5.2 Contributions, Implications, Limitations, and Future Research Directions

Our study extends previous technostress research in several ways. First, this study extends technostress to the context of online students learning complex technologies, which fills a void in the extant literature. The study aims to recognize the techno-stressors that online students deal with when they learn complex technologies. Second, through distress and eustress, the sub-processes inducing two different psychological states related to technostress, this study takes a step toward understanding how distress and eustress impact student satisfaction and retention. Understanding the two sub-processes associated with technostress in students learning complex technologies online is an important step to promoting student satisfaction and retention, and it contributes to the improvement of technical and policy designs in the context of online learning. Third, this study answers a call to recognize techno-stressors that may savor eustress (Hargrove et al., 2013). Rather than assuming technostress to be always negative, this study examines both the positive and negative sides of technostress and the associated techno-stressors and outcomes, based on a holistic research model.

The theoretical foundation of our study was a combination of several research models—the stressor strain model and its extension, the challenge hindrance framework (CHF), the holistic stress model (HSM), and the person-environment fit model (P-E fit). Grounded on these models, we decomposed core constructs into contextual factors that we adapted from a comprehensive literature review. As expected from the stressor-strain model, we found that most stressors, except for overload, induced strain and eventually affected outcomes. The study supported CHF with the finding that challenge stressors were distinct from hindrance stressors. In alignment with HSM, our empirical results confirmed that there were two subprocesses in the holistic stress process: the eustress subprocess and the distress subprocess. The appraisal of challenge stressors led to a positive psychological response which, in turn, generated positive outcomes. Although techno-eustress, a positive psychological response, did not significantly impact student retention, it had a very significant and positive relationship with the other outcome, student satisfaction. The appraisal of hindrance stressors led to a negative psychological reaction, which produced adverse outcomes. Consistent with the P-E fit theory, we demonstrated that a misfit between personal and environmental factors created distress. In sum, our results generally supported all the research models discussed here, although a couple of relationships were not significant on the contextual factors.

This study offers several insights for future research and practice on technostress. We expect this to be a major empirical study that investigates hindrance and challenge techno-stressors relevant to students learning complex technologies online. Based on an extant literature review about technostress, we contextualized four generally accepted constructs as hindrance techno-stressors and two well-known constructs as challenge techno-stressors related to online learning. These constructs are by no means the only ones that may be contextualized as hindrance and challenge techno-stressors. Future research may identify and examine the impact of challenge and hindrance techno-stressors and their related outcomes in other contexts.

Specifically, our empirical investigation contributes to understanding technostress among students learning complex technologies online and helps to locate the role technostress plays in student retention and student satisfaction. The main implications for higher education instructors and administrators would be to understand how online learning can be associated with positive and negative technostress and effects, so that they can develop and implement strategies and pedagogical methods to influence how online students cognitively appraise complex technologies. We found that invasion, complexity, and uncertainty were the hindrance techno-stressors that significantly increased techno-distress. The perception of techno-invasion could be reduced by setting schedules and deadlines for academic work in a way that students have sufficient time to complete their work without any adverse effects on their work-life balance (Upadhyaya & Vrinda, 2021). While we have found literacy facilitation to be a factor that positively influences students' techno-eustress, it can also reduce the intensity of students' perception of techno-complexity (Tarafdar et al., 2011). This can be achieved by providing clear instructions, documentation, and training for the complex technologies that students learn online. At our university, we have a full-time instructional associate to provide literacy facilitation to students learning the SAP tools online. Such literacy facilitation measures can also help alleviate techno-uncertainty by providing timely information on technology updates (such as frequent updates that are common for SAP software) and by helping students transition smoothly into the use of updated technology.

The literacy facilitation tools mentioned above that could be used to reduce techno-complexity and techno-uncertainty can also be used to positively impact techno-eustress, as a challenge techno-stressor, that enhances student satisfaction. This is further evidence that the perceptions of distress and eustress may coexist (McGowan, Gardner, & Fletcher, 2006; Horan et al., 2020; Maier et al., 2021).

Individual evaluations of technology may vary in that the technology may be appraised as negative, consisting of distress factors, or positive, consisting of eustress factors (Zielonka, 2022). Our model can be used to compare the appraisal of techno-distress and techno-eustress across diverse groups of students (e.g., traditional vs non-traditional, students from different cultural backgrounds).

Despite the contributions mentioned above, our study has several limitations which could be addressed by future research. First, this is a cross-sectional study and, therefore, our data cannot provide information on how the results may change as respondents gain more experience with the SAP software with time. Future research may investigate the change in the roles of techno-stressors on techno-distress and techno-eustress in longitudinal research settings. Additionally, future research may examine the interrelationships among techno-distress, techno-eustress, student satisfaction, and retention that might occur over a period of time. Another limitation of our study is that we did not focus on hypothesizing or testing possible mediating factors in our study. There would be too many indirect relationships to test for if we tested for the mediating effects of distress and eustress. Also, our data was collected from one mid-sized public university in the United States, so the results may not be generalizable across all universities, given there are academic and cultural differences between different universities. To gain a comprehensive understanding of technostress in the context of online learning, future research may examine technostress in other geographical areas and cultural environments. Furthermore, our survey considered SAP software as an aggregation of several technologies. Therefore, the perceptions of the survey respondents could vary in the types of technology they learn. Future research should examine the impact of specific features of the technology on technostress, as they may influence students' assessment of hindrance and challenge techno-stressors. Finally, future research should use a mixed-methods research design that combines qualitative and quantitative approaches. A qualitative investigation of students learning online may help researchers understand how students articulate and identify hindrance and challenge techno-stressors. Another possible future research topic would be to examine the impact of trust in technology on the appraisal of both distress and eustress leading to student satisfaction. Zielonka (2022) recently investigated the impact of trust on techno-stressors in a workplace context, but the investigation could be easily extended to an academic context of students learning complex technologies online. Trust in technology can be conceptualized as an individual's beliefs regarding the helpfulness, functionality, and reliability of the technology (McKnight et al., 2002).

Another future research direction could be a comparison between online and face-to-face students on the impact of techno-stressors. There may be factors in face-to-face teaching of complex technologies (e.g., immediate and more direct intervention on the part of faculty in efforts to reduce techno-distress producing factors) that might impact students' appraisal of techno-distress and techno-eustress. The results obtained in our study may be unique to the online mode of delivery.

6 Conclusion

While the majority of previous studies on technostress have focused on negative outcomes for employees and their organizations, little is known about how students experience technostress related to online learning of complex technologies. This study aims to develop a holistic view of technostress in the context of online learning. We use SAP software as an example of complex technology that students learn online. We empirically investigate challenge and hindrance techno-stressors and their effects in the context of learning SAP software online. By identifying and examining the effect of challenge and hindrance techno-stressors on student satisfaction and retention, we believe this study not only contributes to information systems research but also provides practical implications to all institutions using the online learning method.

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