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The influence of smartphones on academic performance

The development of the technology-to-performance chain model

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Abstract

Purpose – The purpose of this paper is to investigate the factors that influence college students' smartphone use for academic purposes by identifying the task-technology fit (TTF) of smartphones. A research model is proposed to explain how TTF of smartphones affects college students' perceived academic performance and smartphone use.

Design/methodology/approach – Online surveys were administered to college students at a South Korean university that has offered online academic services for more than five years, and 1,923 valid responses were analyzed. The study used partial least squares path modeling to evaluate the measurement model, and the bootstrapping technique to test the significance of the hypotheses.

Findings – The findings highlight that the TTF of smartphones has a direct influence on students' perceptions of performance impact and an indirect influence on smartphone use through a precursor of utilization, such as attitude toward smartphone use, social norms and facilitating conditions.

Research limitations/implications – Despite a reasonably large sample, a single cross-sectional survey has a likelihood of selection bias in the sample.

Practical implications – This study applies the TTF model to smartphone use among college students and suggests an effective way to motivate them to use mobile technologies for their academic activities.

Originality/value – The present study develops an empirical model to assess the adoption of smartphones and its effect on college students' academic performance. Above all, the study identifies a causal relationship among TTF, precursor of utilization, smartphone use and a perceived impact on academic performance based on the development and validation of the TTF constructs of smartphones.

Keywords Information technology, Higher education, Academic libraries, Communications technology, Digital libraries, Learning methods

Paper type Research paper

Introduction

Since the launch of iPhone in 2007, the adoption rate of smartphones has increased rapidly. According to the Pew Research Center (Smith, 2015), 64 percent of people in the USA had adopted smartphones in 2015. In particular, in South Korea, the adoption rate of

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smartphones was as high as 73 percent, which ranked second in the world (Google, 2015), and 98.8 percent of college students use their smartphones for an average of 2 hours and 20 minutes a day (Joo, 2015). Smartphones support a variety of functions that were once only available on computers, including easy access to the internet, and now serve as a convenient form of communication or interaction that is not provided by traditional cellular phones. E-learning, online lectures and digital library services are offered through mobile technologies in higher education, which has led college students to value smartphones when seeking information related to their academic tasks (Gikas and Grant, 2013).

Most current college students are of the digital generation and are surrounded by and use information and communication technology (ICT) in their everyday life and school activities (D'Ambra *et al.*, 2013). ICT, such as personal computers, wireless internet and mobile devices, has deeply penetrated their lives. In their academic environment, ICT has become a necessity for e-learning and web-based instruction, digital libraries and research tools, and computer-mediated student-professor interaction.

According to previous research (Dahlstrom and Bichsel, 2014; Head and Eisenberg, 2009), college students tend to use only one or two ICT devices, mainly cellular phones and personal laptop computers, in support of academic course work and communication. Recently, college students have taken advantage of smartphones in their academic learning (Jones *et al.*, 2008), despite the limitations of these devices, such as their inadequate battery life, slow network connections, device usability concerns, and discouragement of smartphone use in the classroom to limit distractions (Gikas and Grant, 2013).

There have been many studies that discuss factors or motivations for the adoption and use of smartphones (Cheon *et al.*, 2012; Chun *et al.*, 2012; Joo and Sang, 2013; Lee, 2014; Lopez and Yang, 2014; Park and Chen, 2007). Most studies have focussed on the use of smartphones in everyday life, whereas a few studies have identified the user's perception of using smartphones for learning purposes or their behavior in seeking particular information (Gikas and Grant, 2013; Joo and Sang, 2013; Park *et al.*, 2013). Little research has addressed the roles of smartphones in academic learning contexts to understand how smartphones assist students' academic tasks, which specific features affect their use of smartphones, and how smartphones influence their academic performance.

The present study, therefore, aims to understand the impact of smartphones on students' academic performance. The study was developed based on Goodhue and Thompson's (1995) technology-to-performance chain (TPC) model to identify the task-technology fit (TTF) of smartphones. Based on the test results of TTF, the study investigates the effects of TTF on college students' smartphone use and perceived academic performances. Specifically, the study attempts to analyze the relationships among the following variables: TTF, precursor of utilization, utilization and perceived impact on academic performance. Guided by the reduced TPC model, the present study addresses the research questions as follows:

RQ1. What factors motivate college students to use smartphones in the academic contexts?

RQ2. How does the TTF of smartphones influence students' smartphone use and perceived impact on academic performance?

Conceptual framework and hypotheses

Smartphone adoption

Most smartphone adoption studies employ attitude and behavioral theories, technology acceptance model (TAM) (Davis, 1989) or TAM in combination with other models, such as innovation diffusion theory (IDT) (Rogers, 2003), unified theory of acceptance and use of technology (UTAUT) (Venkatesh *et al.*, 2003), or uses and gratifications (U&G) (Palmgreen, 1985). Cognitive and psychological factors play a crucial role in individuals' adoption of smartphones. Joo and Sang (2013) explored the effects of users' motivations on smartphone acceptance in Korea, focussing on the user's intrinsic motivation by combining TAM with another theory from U&G theory. The research demonstrated that the adoption of smartphones by Koreans is affected by motivations based on instrumental and goal-oriented use rather than ritualized and less goal-oriented use (Joo and Sang, 2013). Hsiao (2013) attempted to explain the factors that influence the intention to adopt smartphones based on the theory of reasoned action and found that male users and higher incomes are significantly associated with smartphone adoption. Park *et al.* (2013) investigated individual psychological factors that influence use of smartphones within the framework of TAM; their study confirmed the TAM's proposition and identified the behavioral activation system and locus of control as psychological antecedents.

Some studies identified social influence (SI), price and hedonic enjoyment as important antecedents rather than traditional TAM factors, like perceived usefulness and ease of use. Chun *et al.* (2012) proposed an integrated model of smartphone adoption that incorporated SIs and perceived technicality as well as hedonic and utilitarian attitudes into TAM. The results indicated that users' attitudes and their adoption intentions are highly associated with SIs and positive self-image and that hedonic enjoyment is as important as utilitarian usefulness in predicting adoption intention (Chun *et al.*, 2012).

In the same vein, Kim *et al.* (2014) examined smartphone adoption behavior among American college students by combining all components of IDT, (TAM), the value-based adoption model, and the SI model. They investigated how each factor relates to the integrated model and its role in determining the smartphone adopter group. The study noted that smartphone adoption is less likely to be affected by perceived ease of use and perceived usefulness, whereas perceived popularity, perceived price and ethnicity are distinctive determinants between current adopters and non-adopters (Kim *et al.*, 2014). Lee (2014) discussed the factors that influenced smartphone early adopters by examining the smartphone adoption behavior of college students. The study considered the effect of normative peer influence on a college student's smartphone adoption as well as self-innovativeness, self-efficacy, a decision maker's attitudes toward products, the financial burden of using the products and familial influence. According to the study findings, early adopters were influenced by friends, financial burden and family members (Lee, 2014).

Although the number of students using the smartphone grows continuously, only a few studies have addressed the role of smartphones in the academic learning context. Shin *et al.* (2011) attempted to identify the key factors that motivate consumers, including college students and faculty members, to use smartphones as a ubiquitous learning tool by employing a modified UTAUT model with constructs from expectation-confirmation theory (ECT). The empirical findings confirmed that users' cognitive perceptions significantly influence their intention to use smartphones. Identifying the additional factors such as perceived usability and quality of smartphones is a worthwhile extension of the UTAUT/ECT in the smartphone learning context because these factors predict smartphone consumers' attitudes and behavioral intentions (Shin *et al.*, 2011). Regarding college students' perceptions toward mobile learning in higher education, Cheon *et al.* (2012) found that attitude, subjective norm and behavioral control positively influence the students' intention to adopt mobile learning.

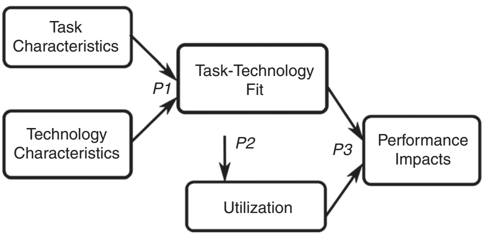
TTF

Major studies have identified various cognitive and social factors that affect the adoption of smartphones in the academic environment (Goodhue and Thompson, 1995; Dishaw and Strong, 1999). However, simply focussing on a user's perceptions regarding technology may not be sufficient to explain their usage and adoption. Goodhue and Thompson (1995) asserted the importance of TTF to solve the limitations of TAM, particularly its lack of task focus. They defined TTF as the degree to which a technology assists an individual in performing his or her tasks. The TTF model is the "fit"-focussed model drawn from the TPC model (Goodhue and Thompson, 1995). In the TTF model, the main concern is the fitness between the characteristics of the specific technology and the task requirements. Although users perceive a technology to be advanced, they may not adopt it if they think that it is unfit for their tasks and unable to improve their performance. Previous research has suggested that the combination of the TTF and utilization models explains the impact of IT on individual performance better than TAM alone (Dishaw and Strong, 1999). As presented in Figure 1, the TTF explains the relationship between the ability of IT and the demands of the task. Both task characteristics and technology characteristics have an impact on TTF, and TTF influences performance and utilization.

To understand college students' smartphone adoption in the academic context, it is necessary to examine the smartphone's fit to the task in the academic context. From an academic perspective, a few studies have explored the interrelationship of IT, affordances, academic information needs and TTF as well as performance. McGill used the TTF model in her series of research regarding the fit of the virtual learning environment for instructors and students (McGill and Hobbs, 2008); the fit of a learning management system to the students' grade and task (McGill and Klobas, 2009); and the fit of a learning management system to the skills of an instructor and his or her tasks (McGill *et al.*, 2011). Raven *et al.* (2010) applied the TTF model to address the use of digital video tools for oral presentation in the classroom. They found "a significant fit between digital video tools and improvement of oral presentation skill." D'Ambra *et al.* (2013) employed the TTF model to explore e-book adoption by college faculty.

TPC model

Goodhue and Thompson (1995) suggested that TPC model is a comprehensive model to explain the link between information technology and individual performance based on attitude and behavior theory (e.g. TAM, UTAUT) and TTF. They argued that a technology has a positive impact on individual performance when it must be used and has a good fit with the task's requirement. In particular, they highlighted the important role of TTF in addressing technology's effects on users' performance. The TPC model



Source: Goodhue and Thompson (1995)

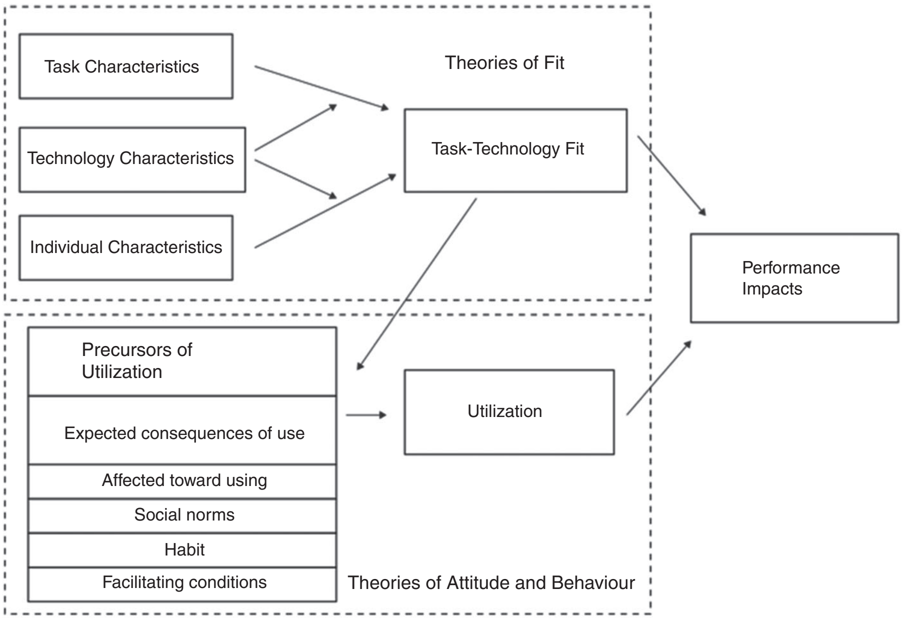
Figure 1.
Task-technology fit

has key constructs, as depicted in Figure 2. The task, technology and individual characteristics influence TTF. TTF directly affects performance and indirectly impacts use through precursors of use. The TPC model shows that TTF is the correspondence between task requirement and individual abilities, moderated by the functionality of the technology. This model proposes that TTF influences the 'precursors of utilization' and performance of the user. The precursors of utilization affect technology utilization, which in turn affects user performance.

The present study investigates how the TTF of smartphones influences college students' smartphone use and its perceived impact on their academic performance. Specifically, the purpose of the study is to measure and evaluate the relationship between the perceived "fit" of smartphones and the following three variables: precursors of utilization, smartphone use and performance in a causal model. In light of the theoretical frameworks discussed above, the TPC model is most appropriate to meet this study's purpose.

Task. Goodhue and Thompson (1995) defined tasks as "the actions carried out by individuals in turning inputs into outputs" (p. 216). The tasks performed by college students vary. According to an EDUCAUSE research (Dahlstrom and Bichsel), students use smartphones in the academic environment to look up information, photograph information, access digital resources, record instructors, and participate in activities. Based on the findings of Dahlstrom and Bichsel (2014), the present study specifies the tasks supported by smartphone technologies in academic contexts: managing electronic files, reading course materials, working on assignments, listening to or watching course-related audio-video files, and interacting with friends or instructors regarding courses.

Technology. A technology is defined as a tool individuals use for their tasks (Goodhue and Thompson, 1995). Previous studies have discussed the roles of mobile



Source: Goodhue and Thompson (1995)

Figure 2.
The technology-to-performance chain

technologies as learning tools (Cheon *et al.*, 2012; Gikas and Grant, 2013; Shin *et al.*, 2011). By providing a variety of new applications, or functions, smartphones can be used to assist a user's tasks or activities.

Individual. Individuals are people who use technologies in performing their tasks (Goodhue and Thompson, 1995). Individuals' motivation to use certain technologies or their experience with a related technology can influence their competence or confidence in using the technologies. With regard to smartphone use, previous studies have examined a user's characteristics, including experience with electronic resources, computer technology and smartphones (D'Ambra *et al.*, 2013).

A reduced model

As depicted in Figure 3, the present study employs the reduced model drawn from the full TPC model (Goodhue and Thompson, 1995) because it focusses on the effect of TTF on use and perceived impact on performance. It is guided by two previous studies; one developed and validated the TTF in e-books based on the perception of faculty (D'Ambra *et al.*, 2013), and the other confirmed the impact of the smartphone TTF on college students' academic performance (McGill and Klobas, 2009).

Our research model investigates the relationships among the following:

- TTF and attitude (which is one of the precursors of utilization constructs) (*H1*);
- precursors of utilization and utilization (*H2*, *H3* and *H4*);
- TTF and perceived impact on performance (*H5*); and
- utilization and perceived impact on performance (*H6*).

TTF. As discussed above (p. 6), TTF is "the degree to which a technology assists an individual in performing his or her tasks" (Goodhue and Thompson, 1995). In the present study, TTF can be defined as the capability of smartphones to support college students in performing their academic tasks.

Precursor of utilization. Precursor of utilization refers to a user's attitude or beliefs of utilizing a technology or system (Goodhue and Thompson, 1995). TTF influences a user's beliefs about a technology's usefulness and the advantages gained from using it. Dishaw and Strong (1999) indicated that TTF affects perceived ease of use and

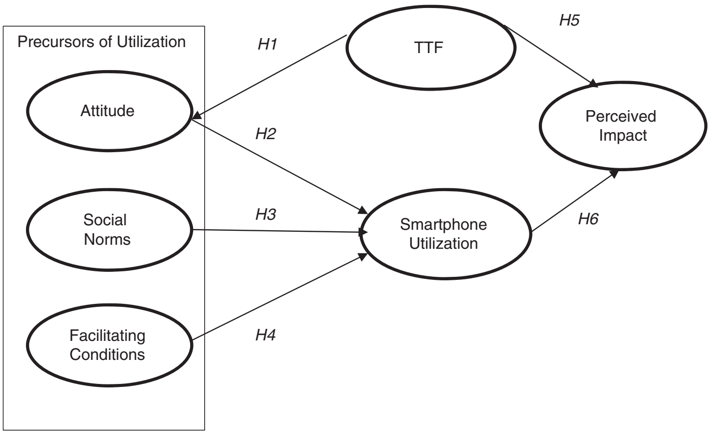


Figure 3.
A reduced model from TPC

actual use, whereas Chen *et al.* (2009) found that TTF, labeled "compatibility," affects perceived usefulness and attitude toward use. Based on theories about attitude (including beliefs or effects) and behavior (Bagozzi, 1982; Fishbein and Ajzen, 1975), the TCP model shows that a change in use, social norms and facilitating conditions provokes the individual's decision to use or not use a technology (Goodhue and Thompson, 1995). In the present study, the constructs of precursor of utilization are composed of attitude, social norms and facilitating conditions.

Attitude. Attitude refers to a person's favorable or unfavorable evaluation of an object (Fishbein and Ajzen, 1975). According to Staples and Seddon (2004), TTF has a significant impact on the attitude toward use of a technology only when use is mandatory, but not when use is optional. College students usually have smartphones with them in the academic environment. A variety of smartphones functions support communication and internet searching as well as e-learning, online lecture and digital library services. Thus, we can assume that student use tends toward mandatory. As smartphones increasingly support specific tasks or activities in academic contexts, users will be more likely to have a favorable attitude toward smartphones. This attitude tends to lead to smartphone use; therefore, the following can be hypothesized:

H1. TTF in smartphones has a positive effect on attitude toward smartphone use.

H2. Attitude toward smartphone use has a positive effect on using smartphones.

Social norms. Social norm refers to "the user's beliefs as to whether other individuals want them to perform the behavior" (McGill and Klobas, 2009). It influences indicators of technology success, such as utilization (Staples and Seddon, 2004; Shin *et al.*, 2011), and Lee (2014) found that the use and adoption of smartphones have been influenced by peer pressure. In academic contexts, an instructor influences students' technology adoption (McGill and Klobas, 2009) by encouraging smartphone use for class activities or interaction between instructors and students. Based on previous studies on social norms, the research model in the present study hypothesizes a positive relationship between social norms and use in adopting smartphones:

H3. Social norms have a positive effect on using smartphones.

Facilitating conditions. Adopting a new technology requires availability of resources (e.g. time, money), infrastructure quality (e.g. internet connection) or support of other technologies (e.g. technological compatibility) (Brown *et al.*, 2015). The lack of these resources can constrain the adoption of a technology. According to previous studies, various facilitating conditions support learning system use (Selim, 2007; Wang *et al.*, 2007). Liu *et al.* (2010) indicated that users' technology adoption is greatly influenced by facilitating factors, such as a strong internet connection and easy access to a particular technology. Guided by previous studies (Liu *et al.*, 2010; Wang *et al.*, 2007), the present study tests facilitating conditions, such as smartphones' availability and accessibility:

H4. Facilitating conditions have a positive effect on using smartphones.

Perceived impact on performance. Performance is an individual's accomplishment of a task. According to the TCP model (Goodhue and Thompson, 1995), TTF affects individual performance beyond promoting use. Goodhue (1997) argued that an individual will not always use the technology with the highest TTF but that at any given level of use, a technology with good TTF will give better performance. The research explored the fit of the virtual learning environment for instructors and students (McGill and Hobbs, 2008), the fit of the learning management system to the students' grade and task (McGill and Klobas, 2009), and the fit of the learning management system to an instructor's skills and tasks (McGill *et al.*, 2011); these studies revealed that TTF and utilization positively influence perceived impact on performance. Raven *et al.* (2010) applied a TTF model to the use of digital video tools supporting oral presentation in the classroom and found that they significantly improve oral presentation skills. It is difficult to elicit and measure the performance influenced by smartphones, but an approximate impact can be determined by seeking the individuals' own perception of a smartphone's impact on their academic performance. Thus, we can hypothesize the following:

H5. TTF has a positive effect on the perceived impact of smartphones on an individual's academic performance.

Utilization. Utilization is the choice to use or not use a technology for tasks (Goodhue, 1997). In the present study, utilization is the use of smartphones in academic tasks; it is a necessary but insufficient condition for technologies to impact performance (Trice and Tracy, 1988). Thus, impact on performance should be related to both TTF and utilization:

H6. Using smartphones has a positive effect on an individual's academic performance.

Research methodology

Sampling

The sample was defined as college students who had used smartphones in the past 12 months. The formal study conducted online surveys using Qualtrics (www.qualtrics.com) in May 2014. The surveys were administered to a top-ranked university in South Korea that had offered an excellent infrastructure for wireless online learning services for smartphones for more than five years. The university had diverse areas of study, including a college of liberal arts, social science, economics/business administration, education, law, natural science, engineering, medicine and art/performance. The survey offered a drawing for two Retina iPad minis as an incentive to perform the survey. A total of 3,479 responses were collected. After removing incomplete and invalid responses, 1,923 responses were used in the analysis.

Table I presents the demographic profile of the survey respondents. Men represented 62.8 percent of respondents, and women 37.2 formed percent. A majority of them (84 percent) were 21-30 years old. Most of the respondents belonged to science/engineering/medicine (46 percent) and liberal arts/social science/business/law (43.4 percent). Approximately 68 percent of them were undergraduate students, and 32 percent were graduate students. Approximately 70 percent of them had used electronic resources for over five years. Interestingly, both the mode and median of hours of using smartphones a day was three hours, and over 60 percent of the respondents used smartphones more than three hours a day.

Instrument development

The present study and its instrument are guided by two previous studies that address the adoption of the e-book (D'Ambra *et al.*, 2013) and smartphones (McGill and Klobas, 2009). Four faculty colleagues reviewed the instrument, and their feedback led to a number of improvements. It was then piloted on ten college students at the sample school, and their feedback was also used for a number of further improvements and to gauge the time required for completion. The instrument was composed of two parts:

Variables	Categories	No. of students (%)
Gender ($n = 1{,}923$)	Male	1,208 (62.8)
	Female	715 (37.2)
Age ($n = 1{,}922$)	Under 20 years old	75 (3.9)
	21-30 years old	1,615 (84.0)
	31-40 years old	188 (9.8)
	Over 41	44 (2.3)
Major ($n = 1{,}922$)	Fine art/theater/performance	81 (4.2)
	Liberal arts/social science/ business/law	835 (43.4)
	Education	65 (3.4)
	Science/engineering/medicine	885 (46.0)
	Others (e.g. double-major)	56 (2.9)
Length of academic year ($n = 1{,}923$)	Freshman	292 (15.2)
	Sophomore	13 (0.7)
	Junior	605 (31.5)
	Senior	390 (20.3)
	Graduate student	623 (32.4)
Experience of e-resources ($n = 1{,}923$)	Less than 1year	0 (0.0)
	1-5 years	621 (32.3)
	6-10 years	748 (38.9)
	11-15 years	404 (21.0)
	16-20 years	108 (5.6)
	More than 20 years	42 (2.2)
Length of using smartphones (minutes) ($n = 1{,}923$)	Less than 1 hour	88 (4.6)
	1-3 hours	673 (35.0)
	3-6 hours	835 (43.4)
	Over 6 hours	327 (17.0)

Note: $n = 1{,}923$

Table I. Descriptive statistics of survey respondents

demographic profile and TPC questions. TPC questions fell into four categories: smartphone TTF, precursor of utilization, utilization and perceived impact on performance. The study measured the items in the questionnaire using a seven-point Likert scale, labeled from "strongly disagree" to "strongly agree."

Findings

Exploratory factor analysis (EFA)

To develop and validate a TTF construct of smartphone technology in academic contexts, the study conducted factor analysis and then employed the structural equation model to test the overall TTF model. First, to identify the initial measurement scale, the study conducted EFA with principal component analysis and varimax rotation. Table II presents the results of the EFA of the 12 initial TTF constructs. The study used the Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity to assess measures of sampling adequacy and the validity of the study instrument. According to the results, the sampling was appropriate as KMO $= 0.890$ (> 0.50), and the instrument was valid, as Bartlett's test indicated significance (9,127.801, df $= 66$, $p = 0.000$). With the initial analysis, three factors were extracted with eigenvalues greater than 1. The three factors were: navigation (TTF1-3), filing (TTF4-8) and audio-video

Factor	Items	With a smartphone, I want to:	Communality	Item-total correlation	Eigenvalue	Cumulative variation	Cronbach's α
Factor 1	TTF1	Navigate course websites	0.807	0.702	6.796	28.870	0.917
Navigation	TTF2	Browse course materials	0.901	0.745			
	TTF3	Search course information	0.885	0.737			
Factor 2	TTF4	Download text files	0.657	0.651	1.586	26.253	0.842
Filing	TTF5	Upload files	0.696	0.616			
	TTF6	Copy and edit files	0.799	0.617			
	TTF7	Save files	0.837	0.647			
	TTF8[a]	Scan materials	0.464	0.594			
Factor 3	TTF9	Download video files	0.800	0.767	1.104	23.933	0.946
Audio-Video	TTF10	Stream video files	0.848	0.796			
	TTF11	Download audio files	0.904	0.745			
	TTF12	Listen to audio files	0.891	0.730			

Notes: [a]Items dropped due to low communality (< 0.50) and item-total correlations (< 0.60)

Table II. Results of exploratory factor analysis of 12 TTF constructs

(TTF9-12). Based on the criteria of communality and item-total correlation for selecting appropriate underlying factors, one item (TTF8) was removed due to low values of communality (cutoff value = 0.50) and item-total correlation (cutoff value = 0.60).

Table III presents the results of final reliability analysis with the remaining 11 TTF items. According to the final EFA, sampling, adequacy and instrument validity were significant with the KMO (= 0.874) and Bartlett's test ($p = 0.000$). The EFA produced

Factor	Items	Loadings	Eigenvalue	Cumulative variation	Cronbach's α
Navigation	TTF1	0.815	6.322	30.573	0.914
	TTF2	0.871			
	TTF3	0.867			
Filing	TTF4	0.626	1.564	25.980	0.847
	TTF5	0.787			
	TTF6	0.859			
	TTF7	0.876			
Audio-video	TTF9	0.801	1.148	25.575	0.946
	TTF10	0.817			
	TTF11	0.900			
	TTF12	0.908			

Table III. Reliability testing of exploratory factor analysis of final 11 TTF constructs three factors greater than 1: navigation (6.322), filing (1.564) and audio-video (1.148). The factor loadings of all items were satisfactory, with values above 0.50. The overall model explained 82.128 percent of the cumulative variance. The Cronbach's α of each factor exceeded the cutoff value of 0.60 (with 0.847 as the minimum Cronbach's α of the filing construct, as indicated in Table III). Accordingly, the final EFA ensured the reliability of the TTF construct, which consisted of three factors.

Confirmatory factor analysis (CFA)

The study conducted CFA to evaluate the overall measurement model and to test its reliability and validity. To evaluate both the measurement model and the structural model, the study used partial least squares (PLS) path modeling implemented in SmartPLS version 3.0. The study employed the bootstrapping technique to test the significance of the hypotheses. Table IV presents the results of CFA. All of the loadings of the results were significant ($p < 0.05$) and exceeded the cutoff value of 0.4 (see Table AI). The study assessed composite reliability and Cronbach's α to ensure reliability; all constructs exceeded the cutoff value of 0.7 for composite reliability and the cutoff value of 0.7 for Cronbach's α (D'Ambra *et al.*, 2013). Next, to establish convergent validity, the study checked the average variance extracted (AVE); all constructs satisfied the minimum requirement of 0.5 (D'Ambra *et al.*, 2013).

For TTF and utilization, the study used a second-order model to estimate their parameters. As indicated in Table IV, TTF is reflected by three constructs; navigation ($\beta = 0.856$), filing ($\beta = 0.851$), and audio-video ($\beta = 0.517$), which explained 86 percent, 85 percent and 52 percent of the TTF variance, respectively. Utilization is reflected by two constructs as well, searching ($\beta = 0.869$) and audio-video ($\beta = 0.901$), which explained 87 percent and 90 percent of utilization variance, respectively. All path coefficients in the second-order model are significant ($p < 0.005$) (see Table AII).

Finally, the study tested discriminant validity, for which the square root of AVE (in italics on the diagonal) and inter-construct correlations were calculated. As presented in Table V, all square roots of AVE were greater than the corresponding inter-construct correlations, which indicate that discriminant validity was ensured. The measurement model was thus confirmed in terms of reliability as well as convergent and discriminant validity.

Structural model

Figure 2 presents the results of the structural model estimated by PLS, which illuminates TTF for smartphone use in academic contexts. To assess the model quality, the study employed two criteria: the significance of the path coefficients and the R^2 to indicate the ability to explain the variance of the dependent variables. First, all paths are statistically significant ($p < 0.005$), which indicates that all six hypotheses are supported. TTF had a positive effect on attitude toward smartphone use (*H1*), explaining approximately 9 percent of the variance in college students' attitude toward smartphone use for academic purposes.

There was significant positive influence of precursor of utilization on smartphone utilization (*H2-H4*). Precursor of utilization is composed of three antecedents: attitude toward smartphone use (*H2*), social norms (*H3*) and facilitating conditions (*H4*). Together, attitude toward smartphone use ($\beta = 0.089$), social norms ($\beta = 0.061$) and facilitating conditions ($\beta = 0.351$) explained approximately 16 percent of the variance for smartphone utilization. TTF (*H5*) and utilization (*H6*) had positive effects on perceived impact on academic performance. TTF ($\beta = 0.268$) and utilization ($\beta = 0.132$) explained 10 percent of the variance of the perceived impact on college students' performance (Figure 4).

Latent variable	Construct			Composite reliability	Cronbach's α	AVE
TTF	With a smartphone, I want to:			0.882	0.845	0.519
	Navigation	TTF1	Navigate course websites	0.928	0.884	0.811
		TTF2	Browse course materials			
		TTF3	Search course info			
	Filing	TTF4	Download text files	0.877	0.813	0.642
		TTF5	Upload files			
		TTF7	Edit files			
		TTF8	Save files			
	Audio-video	TTF11	Download video files	0.938	0.913	0.792
		TTF12	Stream video files			
		TTF13	Download audio files			
		TTF14	Listen to audio files			
Utilization	I currently use a smartphone as a tool for:			0.888	0.855	0.500
	Searching			0.854	0.771	0.595
		UTS1	Access a library			
		UTS2	Navigate course			
		UTS3	Read materials			
		UTS4	Search course info			
	Audio-video			0.894	0.840	0.680
		UTA1	Record lectures			
		UTA2	Watch course video			
		UTA3	Listen to course audio			
		UTA4	Share course info			
Performance impact (PIM)	Smartphones help me to:			0.936	0.920	0.678
		PIM1	Accomplish my study more quickly			
		PIM2	Improve my academic performance			
		PIM3	Increase my productivity of course work			
		PIM4	Enhance my effectiveness of course work			
		PIM5	Complete my course work easily			
		PIM6	Control over my study			
		PIM7	Improve the quality of my learning			
Precursor of utilization	Attitude			0.930	0.900	0.768
		ATT1	Using a smartphone for my study is pleasant			
		ATT2	My frequent use of a smartphone for my study is good			
		ATT3	Using a smartphone a lot for my study is beneficial			
		ATT4	All things considered, using a smartphone for my study is great			
	Social norms			0.818	0.735	0.534
		SNO1	Everyone else uses smartphones for course-related communication			
		SNO2	My instructors think it is important for me to use a smartphone for school work			
		SNO3	My friends think it is important for me to use a smartphone for school work			
		SNO4	People respect me if I use a smartphone for school work			
	Facilitating conditions			0.916	0.876	0.731
		FAC1	A smartphone is easy to use			
		FAC2	A smartphone is available, since I can carry it with me			
		FAC3	I can use a smartphone anywhere			
		FAC4	I can use a smartphone anytime			

Table IV. Summary of measurement scales

Table V. Discriminant validity

Constructs	TTF	Attitude	Social norms	Facilitating conditions	Utilization	Impact on performance
Task-technology fit (TTF)	*0.720*					
Attitude	0.299	*0.876*				
Social norms	0.210	0.424	*0.731*			
Facilitating conditions	0.178	0.200	0.139	*0.855*		
Utilization	0.189	0.185	0.148	0.378	*0.707*	
Impact on performance	0.293	0.751	0.459	0.161	0.183	*0.823*

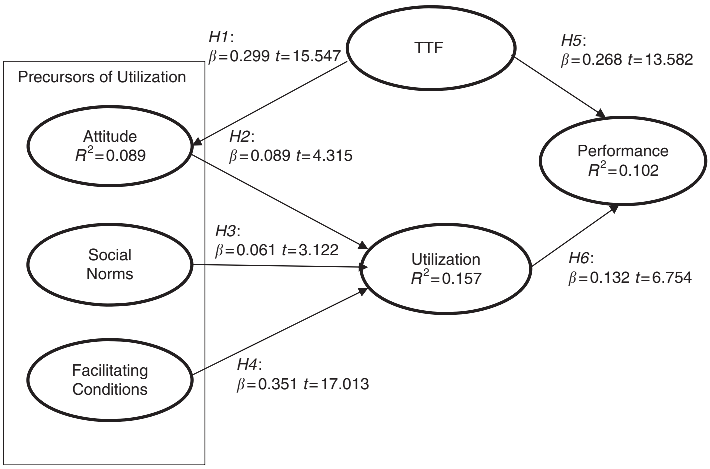


Figure 4. Structural model results: test of *H1-H6*

Discussion

The present study investigated the factors influencing college students' smartphone use for academic purposes and the perceived impact of smartphones' TTF on college students' academic performance. Although a majority of college students use smartphones, there has been little research on their perception of the smartphone TTF in performing academic work. The present study identified the TTF constructs, which are composed of three dimensions: navigation, filing, and audio-video. In sum, all correlations between variables were positive, and the internal consistency was significant.

The effect of TTF on attitude toward utilization

The TTF of smartphones significantly influenced one of the precursors of its use, attitude toward smartphone use, and the effect was moderately strong. The higher perception of TTF may increase students' smartphone utilization for academic purpose. The finding is consistent with many previous studies (Chang and Cheung, 2001; McGill and Klobas, 2009) but differs from Staples and Seddon (2004).

The effects of precursors of utilization

Prior to the present study, ten college students in the same university as the present study were interviewed about their information-seeking behavior using smartphones. Based on the findings of the interviews, the present study chose three antecedents: attitude toward smartphone use, social norms and facilitating conditions. Instructor norms (McGill and Klobas, 2009) and habit had little effect on students' smartphone use because only a few instructors utilized smartphone technology for academic purposes. The present study did not include the expected consequences of use as a precursor of utilization because the questions for expected consequences of use were similar to those of perceived impact of performance, which can cause confusion for the survey participants.

Attitude toward use. Attitude toward smartphone use had a significant effect on its utilization, and TTF indirectly influenced utilization through attitude toward use. The significant relationship between attitude toward use and utilization confirms that a positive attitude can increase students' smartphone utilization in performing academic activities. The finding is consistent with some previous studies (Chang and Cheung, 2001; McGill and Klobas, 2009) and contrary to others (Ngai *et al.*, 2007; Staples and Seddon, 2004).

Social norms. Previous research on social norms' effect on intention to use has presented inconsistent findings (Raaij and Schepers, 2008; McGill and Klobas, 2009). McGill and Klobas (2009) found that in the e-learning context, social norms do not influence students' learning management system use. The present study, contrary to previous research, shows that social norms have a significant effect on college students' academic use of smartphones, where the social norms are instructors, fellow students and friends. This study thus makes a salient contribution, as it identifies the role of social norms in smartphone utilization, particularly in the academic setting, whereas there have been only a few studies on the association between social norms and technology adoption in academic domains.

Facilitating conditions. Facilitating conditions have a positive effect on college students' smartphone use. Although this finding is inconsistent with previous research (Chiu *et al.*, 2007; McGill and Klobas, 2009), the present study ensures the significant role of facilitating conditions in smartphone adoption and use for academic work. The present study focusses on accessibility, which is one of the factors discussed in previous studies (Guo *et al.*, 2011; McGill and Klobas, 2009) and includes infrastructure quality and technical or personal supports. As McGill and Klobas (2009) suggested, the present study removes the factors of support and infrastructure quality because most college students in the present study were familiar with smartphones and did not need support or help to use its technologies. Additionally, the overall infrastructure quality is high in South Korea, where the sample was drawn. The findings of the present study indicate that the effect of facilitating conditions on utilization was moderately strong ($\beta = 0.351$).

Perceived impact on performance

TTF and smartphone use positively influence the perceived impact on college students' academic performance. TTF's perceived impact on performance ($\beta = 0.268$) is stronger than utilization on perceived impact on performance ($\beta = 0.132$). These findings suggest that a higher perception of TTF leads to a higher perception of impact on performance, while increased use of smartphones results in higher perception of impact on performance. The findings confirm that the roles of TTF and utilization have a direct influence on perceived impact on performance, consistent with previous studies (D'Ambra *et al.*, 2013; McGill and Klobas, 2009; Goodhue and Thompson, 1995).

College students' perception of the smartphone TTF and smartphone utilization significantly explains the variance of the perceived impact of academic performance. However, the variance of perceived impact on performance is relatively small, at 10 percent ($R^2 = 0.102$). Future research may identify additional constructs or variables of TTF or utilization by employing qualitative methods, such as interviews or focus groups, and modify the study protocol based on the findings of the qualitative studies. In addition, the present study does not employ instructor norms as a precursor of utilization, and little research has been done regarding instructors' perception of smartphone TTF in academic contexts. Future research may investigate instructors' view of the TTF and their belief or attitudes toward smartphone utilization for academic work, or their roles in facilitating students' smartphone use for academic purposes.

Overall, the present study makes notable contributions both to TCP models and practices. As for the former, it develops an empirical model to assess the adoption and diffusion of smartphones for college students' academic performance. It is most salient that this study identifies the causal relationship among TTF, precursor of utilization, smartphone utilization, and perceived impact on academic performance based on the development and validation of smartphones' TTF constructs. Regarding practical benefits, the present study suggests that the smartphone technologies resonated with academic tasks need to be enhanced in order to support academic interaction and to bring about better outcomes.

Conclusion

The present study addresses college students' interaction with smartphones in academic settings by examining the relationship between TTF, precursor of utilization, smartphone utilization, and perceived impact on the student's academic performance. The findings highlight that the TTF of smartphones directly influences students' perception of performance impact as well as indirectly affects smartphone utilization through precursor of utilization, such as attitude toward smartphone use, social norms and facilitating conditions. The model shows 15 percent of the variances in smartphone utilization and 10 percent of the variances in perceived impact of performance, thereby ensuring the considerable role of the smartphone TTF for smartphone use and perceived impact on performance. The present study thus makes a remarkable contribution by developing the TTF constructs and model that addresses the effects of the smartphone TTF on perception of academic performance.

Because the size effect is small, a future study needs to identify additional factors or variables that account for the effects of TTF, precursor of utilization, and utilization on perceived impact on performance. A further study may investigate what barriers college students encounter in using smartphones for their academic learning. By acknowledging the challenges of smartphone technologies and students' needs or preferences in relation to academic tasks, the study shares provide practical insights for offering effective academic information services that better support student learning in the academic environment. Above all, future research can also make contributions by applying the TTF constructs and models developed in this study to different technical and cultural contexts. Different levels of smartphone usage and different cultural values may influence how college students use their smartphones for academic information seeking, which in turn, will provide insight into what factors are more or less important in different environments.

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Appendix

Latent variable	Items	Loadings
TTF	TTF1	0.877
	TTF2	0.923
	TTF3	0.895
	TTF4	0.732
	TTF5	0.760
	TTF6	0.828
	TTF7	0.845
	TTF9	0.863
	TTF10	0.885
	TTF11	0.916
	TTF12	0.904
Utilization	UTS1	0.591
	UTS2	0.682
	UTS3	0.698
	UTS4	0.597
	UTA1	0.656
	UTA2	0.769
	UTA3	0.773
	UTA4	0.779
Perceived impact on performance	PIM1	0.872
	PIM2	0.870
	PIM3	0.878
	PIM4	0.772
	PIM5	0.740
	PIM6	0.871
	PIM7	0.843
Precursor of utilization: attitude (ATT), social norms (SNO), facilitating conditions (FAC)	ATT1	0.792
	ATT2	0.903
	ATT3	0.902
	ATT4	0.931
	SNO1	0.664
	SNO2	0.691
	SNO3	0.851
	SNO4	0.818
	FAC1	0.753
	FAC2	0.872
	FAC3	0.906
	FAC4	0.889

Table AI.
Item loadings

Paths	Path coefficients	SE	*t*-statistics
Precursor_1 → use	0.089	0.021	4.315
Precursor_2 → use	0.061	0.020	3.122
Precursor_3 → use	0.351	0.021	17.013
TTF → impact	0.268	0.020	13.582
TTF → Precursor_1	0.299	0.019	15.547
TTF → TTF1	0.856	0.005	156.755
TTF → TTF2	0.851	0.008	107.679
TTF → TTF4	0.517	0.016	33.080
Use → impact	0.132	0.020	6.754
Use → Use_1	0.869	0.007	121.177
Use → Use_2	0.901	0.005	199.517

Table AII. Path coefficients, SEs, and *t*-values

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