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Original research article

Application of the Task-Technology Fit Model to Structure and Evaluation of the Adoption of Smartphones for Online Library Systems

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ABSTRACT

Clearly, smartphone usage is increasing more than tablet usage, thus providing opportunities to evaluate how well the use of smartphones meets the requirements of patrons in an academic library setting. This study used the task-technology fit (TTF) model to explore the effectiveness of smartphones for interacting with online library systems, the need for smartphone support, and the "fit" of the device to tasks, as well as performance. The study used interviews and survey data to identify what are the core strengths and limitations of a smartphone construct that stimulate patrons to perform their tasks in an online library setting. Using exploratory factor analysis, preliminary findings confirmed Technology-Content, Technology-Ergonomics, Technology-Smartphone Support, Technology-Platform, and Technology-Interaction design as the core dimensions of the smartphone construct. The results of the structural model supported the overall TTF model in reflecting significant positive impact of task and technology in TTF for smartphones in a digital-library setting; it also confirmed a significant positive impact of TTF on individuals' performance.

Keywords: IT acceptance; Smartphone; Task technology fit model; Digital library system

1. Introduction

According to Gartner [1], worldwide shipments of smartphones are increasing faster than tablets. Even though tablets and smartphones have some similarities (e.g., hand-held touchscreens), they are used somewhat differently and have slightly different interaction-design constraints [2]. Most library patrons have used IT to interact with online library systems; friends or

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lecturers who are influential encourage them to use a smartphone to access data to meet their information needs [3]. Smartphones provide a potential support for the user's work such as accessing and even creating content [4] [5]. Currently, many academic libraries have developed online library services to provide digital resources to support learners and researchers, and tried to market them to their patrons. Patrons can acquire real-time a large amount of relevant information [6, 7]. This service could help traditional academic libraries improve their service quality. However, smartphones come with fundamental constraints: a small screen, short sessions, a single window visible at one time, and variable connectivity [2], thus providing opportunities to evaluate how well the use of smartphones meets the requirements of patrons in an academic library setting. To promote mobile smartphones, the researcher needs to fully understand the nature of the patron's task and the required smartphone support.

The researcher focused on the strengths and limitations of smartphone application in a digital library setting. This process evaluated the fit between patron's tasks and the smartphone characteristics the patron utilizes. The extant research has tried to explain the importance of the fit between the technology characteristics and task requirements, and proceeds as follows:

1. Task-Technology fit model (TTF) [8, 9] was used as a guideline for this study. It describes the fit between smartphone technology and the patron's task and explains how they affect the users' performance. This model has been modified e.g. by Jing, Z, H Jinghua and C Junquan [10] in empirical research on use acceptance of mobile search; however, they have no empirical results on which core component meets the patron's task in the online library setting. So, while the user usually uses a PC in the online library context, surely a smartphone can also solve the problem. However, smartphones come with fundamental constraints. Therefore, this study attempted to use an empirical study applying the model of TTF to user acceptance of smartphones in an online library setting.

2. Information gained from interviews is used for guidance in establishing a survey questionnaire. Adapting the TTF model introduces new measuring instruments that investigate the patron's task and the effectiveness of smartphone technology, and the patron's perception of fit between task and smartphone technology.

2. Theoretical Background

2.1 The technology-to-performance chain (TTF Model)

Goodhue [8], and Goodhue and Thompson [9] suggested a model named task–technology fit (TTF) to understand the linkage between information systems and individuals (Fig.1). In this model, technology characteristics refer to the technology used by individuals to perform their task. Task characteristics refer to the actions carried out by individuals in turning inputs into outputs [8]. Task-technology fit is the degree to which a technology assists an individual in carrying out his or her tasks. Thus, the technology will be accepted by individuals only if the functions of the technology correspond with the tasks to be performed. However, the original model is large and difficult to test in a single study [8]. For example, the technology-to-performance chain discussed in Goodhue and Thompson [8] includes task, technology and individual characteristics; only the first two constructs are discussed and tested in their study. The result indicated that individual characteristics revealed an ambiguous effect on TTF and no significant individual and technology characteristics interaction effect was found. Thus, Goodhue [9] concluded that the value of a technology depends upon the task. In addition, according to Goodhue's [9] research, only a subset of the model was empirically tested.

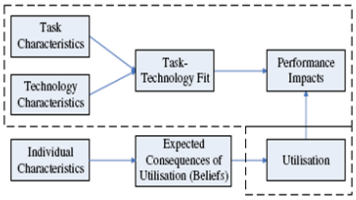

Fig. 1. The technology-to-performance chain (TTF Model).

2.2 Library Perspective of Smartphone Adoption

There is an emerging body of literature on the smartphone in the digital library context. Lippincott [11], in a conceptual paper, indicates that libraries have the opportunity to extend new types of services to users of mobile devices and to develop, license, or otherwise make available scholarly content that is configured for mobile devices. Ideally, libraries will become part of an institutional planning process for the development of services for mobile devices. In addition, Paterson and Low [12] provided quantitative and qualitative data on students' use of mobile devices and considered the benefit of academic mobile library services to students. They found the dramatic growth of smartphone ownership among students in an eight-month period was surprising. In addition, 68 per cent of students who plan to change their mobile handset would upgrade to a smartphone. Malhotra et al. [13] propose an architecture for accessing library book index data from a unique visual code marker attached to each library book spine. This implementation shows that mobile augmented reality is a promising tool for library management. A survey by Ilako [14] showed that the participants were aware of the advantages of using mobile phones for information access. Some suggestions for academic libraries choosing to introduce mobile services are incorporating a marketing plan, an important strategy to promote and publicize the new services. The subset included only task, technology characteristics, task-technology fit, utilization, and performance impact. According to the above discussion, it seems that individual characteristic play a less important role in predicting TTF. This construct was eliminated in this study. Chaddha [15] showed that students are keen to use library services through a smartphone. The services suggested by the author were very well received, and they expect that the quality of services will improve with the use of mobile technology.

2.3 Mobile Technology Adoption for Library Systems

With respect to the research on the use of mobile technology in library systems, Hui and Zhao suggested a mobile library application for smart phones. In their report, the application not only provides the traditional library system's service, but also has the following characteristics: high resource loading speed, low network traffic consumption, high system response speed, high reliability on concurrent access, high adaptability, novel forms of library service. [16]. Moreover, several studies on mobile technology adoption for library systems have focused on positioning technologies to expand mobile services provided from the library. For example, some libraries have applied NFC tags and QR codes, FRID or Wi-Fi, to provide mobile services to help their readers find books in a time-saving way [17-19]. Further, Zhu and Zhang analyzed the impact on the mobile data media in the university library. In their analysis report, they indicate that users can quickly retrieve library resources, and the emergence of new instant access and reading needs. However, because the phone screen is generally small, users have to continue to zoom through the library's pages to browse the entire site. Therefore, the library needs specially suited for mobile phone and mobile phone display library design [20].

2.4 The Task in an Online Library Setting

Because there were no existing items for task, the task needs to be derived from the point of view of 30 volunteers. During the interview, volunteers were asked to describe their task whenever they use their smartphone in an online library setting.

These descriptive words reflect the patrons' tasks: “I use a smartphone instead of a PC whenever I receive renewal notices, to check call numbers, to facilitate finding a textbook on a shelf, and to download and save contents and video on demand.” Moreover, as expected, patrons only use their smartphone to browse or scan documents because “I can no longer read articles on my smartphone.” Also, patrons expected to scan a smart phone like a library card, and use it to help them locate books and check them out.

Moreover, volunteers' interaction with IT on a smartphone begins when they perceive that the information or knowledge that they have is not enough and they need access to reliable and relevant data immediately [21]. They often use a smartphone to search, to facilitate finding a book from the shelf, and then to save the information that meets their needs. Prior research by Alqudsi-ghabra and Al-Dousari [22]; Marchionimi [23]; and Gonçalves, Moreira, Fox, and Watson [24] suggest that information sought in an electronic environment include the process of reading the results to evaluate the value of the data.

2.5 Smartphone technology

The device type categories in evaluation include: 1. traditional PCs (Desk-Based and Notebook); 2. the Ultramobile (Premium) category includes devices such as Microsoft Windows 10 Intel x86 products and Apple MacBook Air; 3. the Ultramobile (Basic and Utility Tablets) category includes devices such as Apple iPad and iPad mini, Samsung Galaxy Tab S2, Amazon Fire HD, Lenovo Yoga Tab 3, and Acer Iconia One; 4. Mobile phones [1], compared to traditional PCs, Ultramobile (Premium), and Ultramobile (Basic and Utility Tablets), smartphones are more widely used in academic institutes [12]. Smartphones are used for browsing online, downloading, and streaming. This means that access to documents, including e-books, e-journals, and audio-visual objects, searching databases and catalogs, downloading articles, and borrowing digital content from a digital library system can be accomplished by smartphone.

The guidelines for identifying core strengths and limitations of a smartphone in a digital library setting are set out in Budiu [2]; Shitkova et al. [25]; Kim, J.H., et al. [26]; Kang [27]; Lee [28]; Chang, Chen, and Zhou [29] and Palent and Salzmen [30]; Ketola and Roykkee [31]. These strengths and limitations are briefly discussed below:

1. Screen Size: makes mobile phones so convenient and portable. However, compared with desktop and even laptop screens, phone screens accommodate a lot less content. As a result, screen size is a serious limitation for mobile devices.

2. Portable: leads to interruptions. Because smartphones are used in a variety of contexts and situations, users are more likely to be interrupted when using such devices. An external event in the environment may command their attention and require them to stop whatever they were doing on the small screen. As a result, attention-span on mobiles is often fragmented and sessions on mobile devices are short.

3. Single Window: the limited size of the mobile screen has made it impractical to display multiple windows on the screen at the same time. Thus, users only see a single window and a single application or website at a time; user cannot split the screen and work with two different apps simultaneously.

4. Touchscreen: the finger driven touch interface of smartphone often

emulates the way actual objects behave. However, it's hard to type proficiently on a tiny virtual keyboard and it's easy to accidentally touch the wrong target. Touch typing is impossible in the absence of haptic feedback.

5. Connectivity: Wi-Fi, and Bluetooth are defined as connection ability. Support for Wi-Fi direct lets patrons connect directly to nearby peer devices over Wi-Fi, for more reliable, higher-speed communication.

6. Software Features: refers to any component, specification, capability, service or function that could lessen users' work. Smartphones come with many limitations, but also with many unique features— some of them available only to apps, others also accessible for websites. Now manufacturers have added new feature that are compatible and have reduced technical limitations.

7. Screen Resolution: is basically the amounts of pixels on the screen. The more pixels a screen has, the clearer the display will be. If the screen has enough pixels, a high resolutions display enables users to see more on the screen with much more clarity and detail.

8. Battery Life: is the duration of use, which gives exceptional capacity for its size and weight. Smartphones run on batteries, which means they must use power as efficiently as possible. It would not be feasible to provide raw, constant CPU power to a device powered by such a small battery.

9. Storage Capacity: refers to the external storage and virtual storage that facilitates the use of mobile technology provided by the service provider. Many manufactures provide removable memory such as SD card or micro SD cards. Moreover, with the prevalence of cloud storage services such as Google Drive, Microsoft Sky Drive and Drop Box which offer a lot of storage for free, users can save documents and photos online.

10. Digital Camera: Allows user to take digital photos and transmit the images wirelessly. Currently, the image quality is lower than what you might find in a digital camera.

11. Ram and Processing Power: these two components form the very basic core of the smartphone, allowing it to store program instructions and subsequently access and process these via the CPU. Smartphone enthusiasts are mesmerized by the remarkable array of phones with good processing power and memory. Each year, manufacturers stuff more and more memory and processing cores into their phones.

12. Accessories: friendly hardware such as S-pens refers to physical input devices that help users to create numerous documents quickly, and conveniently. In general, though, most phones come with the basics: USB charger, screen protector (sometimes) and ear phones.

13. Weight: Mobile phone manufactures consistently streamline their products; however, some phones are heavier and more awkward than others--a possible consideration for travelers. Smartphones are slightly heavier than the average mobile phone. And smaller is not always better; for instance, most users would not want to surf the Web on a postage-stamp sized display.

14. Ability to adjust lighting: staring at the smartphone all day is harmful to user's eyes. All those brightly colored pixels clashing with the lighting around the user is a recipe for eye fatigue and strain. If users work in a bright reflective environment, the ability to adjust lighting can provide relief.

15. Application: refers to process that is executed in the mobile device. Applications such as the office suite assist users to better perform their tasks.

16. Software factors: refer to physical characteristics including the characteristics of the interaction devices such as font size and color, and icon design on screen. The font size and spacing, etc. can make demands on time and attention.

17. Menu design: can be defined as the means of navigating between screens of

the mobile device, such as interaction logic or menu layout structures. These menu designs may facilitate the users experience of contextuality and in overcome technical limitations of mobile technology such as the small screen size.

18. Adapting the website to smartphone use: enables users to view the website optimized for the mobile device that the user wants to utilize. In practice, this means a new stylesheet is added to a list of stylesheets. When this stylesheet is chosen for a page of language layer, pages can be displayed on mobile units.

3. Research model and Hypotheses

3.1 Modeling TTF of Smartphone for Online Library Systems

Various theoretical approached for evaluating IT innovation have been published and utilized in the information systems research area. The 10 model are: 1) technology Acceptance Model: TAM [32], 2) Theory of Reasoned Action: TRA [33], 3) Theory of Planned Behaviour: TPB [34], 4) the motivational model: MM [35], 5) Innovation Diffusion Theory: IDT [36], [37], 6) Model of Personal Computer Utilization: MPCU [38], 7) the Social Cognitive Theory: SCT [39], 8) a model combining TAM and TPB [40], 9) Unified Theory of acceptance and use of technology: UTAUT [3] and Task-technology Fit :TTF [8]. However, in this study, the researcher focuses on the TTF model. Comparing an online library setting with a web search engine, a patron's main objective of using IT is for more specific purposes, such as for self-improvement [41]. Thus, new constructs and new measuring instruments are required to suit specific information system. Among these theories, the TTF model is a significant user-evaluation construct for understanding and predicting the utilization of a particular technology [42, 43]. Although the TTF model has not been as widely used as TAM, TTF attempts to solve limitations deemed to be the major weaknesses of TAM [44]. A weakness of TAM for understanding IT utilization is its lack of task focus [43]. Thus, its performance contributes to the varied results in IT evaluation [8]. While the concept of TAM's usefulness consists of tasks, the addition of more task characteristics could provide a better model of IT utilization. The TTF viewpoint addresses this problem [44].

In this explanatory work, smartphones take interaction with online library systems to a new dimension: smartphones have transformed the way users live and carry on everyday activities. Not only can users access almost any type of content on a mobile, but with most smartphones today users can renew or borrow e-books, sign digital documents, and even pay fines. Some of these tasks have become easier because of the existence of this new technology. This new context of smartphone usage takes the online activities in which academics engage as part of their learning process beyond the boundaries of traditional methods. Thus, the researcher includes exploratory, quantitative, qualitative and other approaches to fit this study [45, 46]. The researcher applied Churchill [47] to develop new items for task and technology characteristics by drawing on qualitative data collected from both users and potential users of smartphones in online digital settings. Exploratory information gained from interviews is used for guidance in establishing a survey questionnaire. The initial component and items for this construct includes the work of Budiu [2]; Shitkova et al. [25]; Kim, J.H., et al. [26]; Kang [27]; Lee [28]; Chang, Chen, and Zhou [29] and Palent and Salzmen [30]; Ketola and Roykkee [31]. Table 1 provides an overview of the research model.

Table 1. Research model for task-technology fit of smartphones in digital-library setting

Constructs	Items: Measure	Source
Task	I use smartphone… □ instead of PC whenever I received renewal notices. □ to check call numbers □ to locate textbooks □ to download or save content, and video on demand □ to browse or scan relevant documents □ to scan a smartphone as a library card □ to check textbooks out	Interview and adapted from e.g. Alqudsi-ghabra and Al-Dousari (2014); Marchionimi (1997); and Gonçalves, Moreira, Fox, and Watson (2007)
Technology	What are the core attractions of a smartphone that stimulate you to perform task with them? □ Screen Size □ Portability □ Single Window □ Touch Screen □ Connectivity □ Software Feature □ Screen Resolution □ Battery life □ Storage Capacity □ Digital Camera □ Ram and Processing Power □ Accessories □ Weight □ Ability to adjust lighting □ Applications □ Software factors □ Menu Design □ Website adapted to smartphone access	Interview and adapted from e.g. Budiu (2015); Shitkova et al. (2015); Kim, J.H., et al. (2014); Kang (2011) Chang, Chen, and Zhou (2009) and Palent and Salzmen (2002); Ketola and Roykkee (2001).
TTF (Task-Technology Fit)	□ I can get data that are accurate and reliable. □ I can gather data that meets my information needs. □ I can search across full text. □ I can open the result on the smartphone. □ I can use smartphone to perform my task immediately.	Adapted from Goodhue, Thompson (1995); Goodhue (1995)

Table 1. Research model for task-technology fit of smartphones in digital-library setting. (Continued)

Constructs	Items: Measure	Source
TTF (Task-Technology Fit)	□ I can use smartphone to complete my task smoothly. □ Overall, smartphone usage for e-library setting meets the task requirement.	Adapted from Goodhue, Thompson (1995); Goodhue (1995)
Performance	□ Smartphone is useful in digital library setting. □ Smartphone helps me to accomplish tasks more quickly. □ Smartphone increases my productivity.	adapted from Venkatesh et al. (2003).

Conforming to our research objective and model, we formulate the following hypotheses:

3.1.1 Task

In the TTF model, tasks are defined as actions carried out by individuals in turning inputs to outputs to satisfy their information needs [8]. In the exploratory study, the researcher constructed the tasks from the point of view of the volunteers. During the interview, tasks were customized by volunteers as described in 2.4 The Task in an Online Library Setting section. Moreover, tasks can vary in a number of dimensions, and task characteristics are those that a user might use IT to perform [43]. In a previous operationalization of the TTF approach, Goodhue [8] and Goodhue and Thompson [9] have used different dimensions and contexts of tasks to measure the task constructs: Non-routineness and interdependence. Ambra and Wilson [43] constructed the task as the activities in which academics engage as part of their teaching and research, and for which they use the content of books as an information resource. Therefore, we hypothesis:

H1: Tasks have a positive impact on TTF in smartphones.

3.1.2 Technology

Technology is the tool used by users in carrying out their tasks. The attributes of these technologies can affect usage and users' perception of the technology. The TTF model has suggested that the technology will be accepted by individuals only if the functions of the technology corresponds with the tasks to be performed [8]. As discussed in the TTF model, task and technology characteristics are the antecedents of TTF [8, 9]. In this study, the researcher constructs technology attributes from Budiu [2]; Shitkova et al. [25]; Kim, J.H., et al. [26]; Kang [27]; Lee [28]; Chang, Chen, and Zhou [29] and Palent and Salzmen [30]; Ketola and Roykkee [31] as briefly described in 2.5 Smartphone Technology section. Researcher considered those that the patron deemed critical in the usability of smartphones in the online library setting. Researchers have developed five dimensions for this construct: 1) Technology-Content (CO) consists of the functionality of smartphones that relates to content directly: ability to adjust the lighting, applications installed on the smartphone, and single window. 2) Technology-Ergonomics (ER) consists of the screen size, portability, screen resolution, and weight. 3) Technology-Smartphone Support (SS) consists of the ability to adapt the website to smartphone usage, connectivity, and software features. 4) Technology-Platform (PL) consists of battery life, storage capacity, and Ram and Processing power. 5) Technology-Interaction design (IN) consists of the touch screen, software factors, and menu design. Therefore, we hypothesize:

H2: The technology has a positive impact on TTF in smartphones.

3.1.3 Task- Technology Fit

Based on the definition of TTF, if the smartphone fits well with the user's task, the user will feel that the smartphone is useful for performing tasks [8] [9]. Furthermore, the TTF model has been linked to the criterion of personal performance, which can be used in the larger context of considering the impact of IT on individual performance [48-50]. The studies from Dishaw and Strong [44], Zhou, Lu, and Wang [51], and Jing, Jinghua and Junquan [10] found that TTF would affect a user's PE. Only when a user's task requires increased productivity, quicker accomplishment of tasks and greater convenience, do they feel that smartphone usage for digital library systems is useful and improves their performance [3]. Otherwise, they may adopt other substitute technologies such as tablets or traditional methods. In addition, previous research has shown that high performance implies a high level of fit e.g. Ambra and Wilson [43]. Hence, we hypothesize:

H3: The fit between the smartphone and task has a positive impact on user performance. Fig.2 show the Research model:

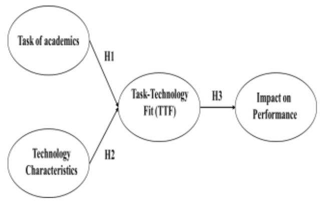

Fig. 2. Research model.

Fig. 2., shows the research model based on the TTF model [8,9], the point of view of volunteers as well as library acceptance literatures [22-24], and smartphone acceptance literature Budiu [2]; Shitkova et al. [25]; Kim, J.H., et al. [26]; Kang [27]; Lee [28]; Chang, Chen, and Zhou [29] and Palent and Salzmen [30]; Ketola and Roykkee [31]. Structure model is composed of two major parts. Independent variables include task (TA) and smartphone characteristics (TECH). Dependent variables include the Task Technology Fit (TTF), and performances (PE).

4. Instrument Development

First, the researcher conducted the first survey by asking 30 volunteers to answer the open-ended questionnaire. To identify the task construct, library acceptance literatures was a guideline for the interviews [22-24]. Then the researcher generated the initial component and items for smartphone following the work of Budiu [2]; Shitkova et al. [25]; Kim, J.H., et al. [26]; Kang [27]; Lee [28]; Chang, Chen, and Zhou [29] and Palent and Salzmen [30]; Ketola and Roykkee [31].

Second, we asked five experts to review these items. Based on their suggestions, we revised some items.

Third, the pilot test was made before the official commencement of the main questionnaire survey. The researcher conducted a pilot test at Burapha University (BUU) Sakaeo Campus. The questionnaire was subjected to reviews and test by 40 participants to purify all items and ensure their validity. However, participants in the pilot test were not included in the main survey. The reliability analysis results (Cronbach coefficient α) for the pilot test (N = 40) ranged from 0.713 to 0.887. These Cronbach's α values are all above 0.7, meeting the criterion of acceptability of Nunnally [52]. Furthermore, we also conducted test-retest reliability analysis, shown as Pearson's correlation coefficient, and the results show 0.707** for the total TTF model (8 factors), where p-value are all smaller than 0.05.

Fourth, we collected data and conducted a confirmatory factor analysis (CFA) to purify the items. We also tested the reliability of these constructs. The instrument included 8 constructs, comprising 33 questionnaire items. Each item was measured with a four-point Likert scale, whose answer choices range from "strongly disagree" to "strongly agree".

5. Research Sampling

Data were collected mainly from Burapha University (BUU), Sakaeo Campus. It was appropriate to include students in our sample because academic libraries provide a library skill curriculum. Subjects were chosen randomly in academic libraries while they came to the library, and they were asked whether they had experience with using a smartphone with digital library systems. Then, librarians identified patrons that had used smartphones for their tasks. These patrons were given the questionnaire to fill out based on their usage.

6. Results and Analysis

After considering all 458 collected questionnaires and removing those that had the same answer to all questions, or had too many missing values, we obtained 385 valid responses. Among the 385 available respondents, 58.4% of respondents were female. With respect to length of time using their smartphone on the digital library system, the highest percentage of the respondents averaged 1-2 hr (Finding books for study). Detailed descriptive statistics relating to the respondents' characteristics are shown in Table 2:

Table 2. Background of research participants. N=385

Variables	Classification	Number of participants	Percent age (%)
Gender	Male	160	41.5
	Female	225	58.4
Smartphone usage for searching library catalogs	Every day	53	13.7
	Once a week	72	18.7
	2-3 per week	143	37.1
	Less than 1 per week	110	28.5
	Other	6	1.5
Smartphone usage for searching online databases	Every day	13	3.3
	Once a week	13	3.3
	2-3 per week	15	3.8
	Less than 1 per week	338	87.7
	Other	6	1.5

Table 2. Background of research participants. N=385. (Continued)

Variables	Classification	No. of participants	Percentage (%)
Smartphone usage for finding books for study.	Less than 1 hr. 1-2 hr. More than 2 hr.	54 229 94	14.0 59.4 24.4
Smartphone usage for doing assignments such as reports, thesis or term papers.	Less than 1 hr. 1-2 hr. 3-4 hr. More than 4 hr.	11 242 106 26	2.8 62.8 27.5 6.7

6.1 Factor Analysis

Exploratory factor analysis refers to an analysis method that has exploratory purposes, and it can be utilized in studies that are not systematized theoretically. Hence, prior to conducting factor analysis on the data, it was considered useful to check the reliability of the scale used to confirm that the scale consistently reflected the scale they were measuring [53]. The common measure of scale reliability is Cronbach's Alpha. As shown in Table 3, all constructs meet the acceptable value of 0.70 [52].

Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity. These tests tell us about the appropriateness of running factor analysis on this data. The former measures sampling adequacy, while the latter is a test of sphericity. The KMO statistic varies between 0 and 1. Kaiser [54] recommends that values between 0.5 and 0.7 be considered mediocre while values between 0.8-0.9 are good values. Finally, values above 0.9 are considered excellent. Another condition to assess the appropriateness of running factor analysis is to ensure that Bartlett's test of sphericity is significant (that is $p<0.05$). As shown from the questionnaire information in Table 3, the KMO exceeded the recommended threshold values of 0.5 and significance at 0.05.

On the basis of the acceptable result reported above we were able to proceed with factor analysis. To extract the factors explored, the Principal Component Analysis (PCA) with Varimax rotation method was used. As a result of this rotation, 33 questions relate to Task characteristics (TA), five smartphone components (TECH), Task Technology Fit (TTF) and performance (PE). Reference needs to be made to the eigenvalue of the data. Kaiser [55] recommends retaining all factors with eigenvalue greater than 1. As shown from the questionnaire information in Table 3, eigenvalues exceeded the recommended threshold values of 1.0. This shows how the 33 items were grouped to 8 factors. This preliminary analysis resulted in 8 factors being selected for further factor analysis [55]. In additional, the result of the rotated solution indicates that all factors whose loading exceed +-0.30 are considered significant at 0.05 for a sample size of 350 or greater. (Appendix A) [56]. This shows that 33 items were loaded to each factor.

Moreover, as shown in Table 4, an exploratory factor analysis of 23 items with a varimax rotation yielded 5 factors based on an eigenvalue cutoff >1. The items loaded on 5 factors: Technology-Ergonomics (ER), Technology-Content (CO), Technology-Platform (PL), Technology- Smartphone Support (SP), and Technology-Interaction design (IN) under an overall technology construct, and 7 items of task constructs. Thus, the reliability of the Task and Technology construct was established. Next, the study conducted confirmatory factor analysis (CFA) of the overall research model.

Table 3. Result of KMO and Factor Analysis

Construct	KMO	Eigenvalue	Alpha
TTF	0.843	4.100	0.875
TA	0.768	4.873	0.723
TECH	0.866		
□ Ergonomics		2.016	0.842
□ Content		1.980	0.778
□ Platform		2.354	0.834
□ Smartphone support		2.920	0.913
□ Interaction			

Design		2.408	0.836
PE	0.675	1.989	0.735

Table 4. Results of Exploratory Factory Analysis of Task and Technology Constructs

Items	Factor1 Task	Factor2 Ergo-nomics	Factor3 Content	Factor4 Platform	Factor5 Smartphone support	Factor6 Interaction design	α
I use smartphone…							0.723
instead of PC whenever I receive renewal notices.	0.766						
to check call numbers	0.781						
to locate textbooks	0.693						
to download or save content and video on demand.	0.829						
to browse or scan relevant documents	0.820						
to scan a smartphone as a library card	0.806						
to check textbooks out	0.776						
What are the core attractions of a smartphone that stimulate you to perform tasks with them?							0.842
Screen Size		0.845					
Portability		0.857					
Screen Resolution		0.705					
Weight		0.831					
What are the core attractions of a smartphone that stimulate you to perform tasks with them?							0.778
Single Window			0.681				
Ability to adjust lighting			0.686				
Application			0.772				
What are the core attractions of a smartphone that stimulate you to perform tasks with them?							0.834
Battery life				0.778			
Storage Capacity				0.582			
Ram and Processing Power				0.750			
What are the core attractions of a smartphone that stimulate you to perform tasks with them?							0.913
Connectivity					0.853		
Software Feature					0.857		
Website adapted to smartphone access					0.787		
What are the core attractions of a smartphone that stimulate you to perform tasks with them?							0.735
Touch Screen						0.796	
Software factors						0.822	
Menu Design						0.759	

Digital camera and Accessory was dropped due to factor loading were not exceed +-0.030

6.2 Analysis of the measurement model

The researcher conducted a CFA to examine the reliability and validity, including convergent validity and discriminate validity. To validate the measurement model, two types of validity were assessed: convergent validity and discriminate validity. Table 5 shows LISREL output results for the internal consistency of the measurement model as assessed by composite reliability (CR). Table 5 indicates that all constructs meet the acceptable value of 0.70 [57]. This suggests a high internal reliability of the data existed.

Convergent validity shows whether each factor can be reflected by its own items [58, 59] and average variance extracted (AVE) from the measurements [60]. First, most indicator standardized factor loading should be 0.5 or higher and ideally 0.7 or higher, t-value should exceed the recommended value of 0.7, and significance at 0.001 (Table 5). As shown in the table, most item loading was larger than the recommended value. Second, AVE value should be greater than the generally recognized 0.50 cut-off [61], indicating that the majority of the variance is accounted for by the construct. The average variance extracted by the measurements ranged from 0.503 to 0.913, which are above the acceptable value. This testifies to the validity of the survey instrument for further analysis.

Discriminant validity indicates the extent to which a given concept is truly distinct from other constructs [58, 59]. One criterion for adequate discriminant validity is that the square root of the AVE for each construct should exceed the correlation shared between the construct and other constructs in the research model [61]. All AVEs are greater than the correlations between the construct and any other construct in the model, demonstrating discriminant validity. This can be observed in Table 6. Hence, the discriminant validity criterion also satisfied the CFA model, lending further confidence in the adequacy of the measurement scales. We also list the cross-loading matrix in Appendix A. Each item had a higher loading on its corresponding factor than the cross-loading on other factors. Thus, the items had a clear loading. Therefore, the derived CFA model was incorporated into the analysis of a structural equation model (SEM) with latent variables [61, 62].

In addition, this study also estimates the parameters of the technology construct as a second-order model. Smartphones are reflected by Technology-Content (CO) (β=0.86), Technology-Ergonomics (ER) (β=0.68), Technology- Smartphone Support (RE) (β=0.54), Technology-Platform (PL) (β=0.50), and Technology-Interaction design (IN) (β=0.45) constructs, which explained 86%, 68%, 54%, 50%, and 45% of overall technology variance, respectively (see Appendix B). Technology-Content had the greatest reflection of overall technology construct, followed by Technology-Ergonomics. All the path coefficients for technology constructs to their components are significant at $p< .001$. Thus, the study confirmed the measurement properties of the research model, which could now be used to test the hypotheses and measure the nomological validity of the overall model.

Table 5. CFA for the survey instrument validity

Factor	Item	Loading	t-Value	AVE	CR
TTF	TTF1	0.508	10.756	0.507	0.875
	TTF2	0.709	18.130		
	TTF3	0.836	23.327		
	TTF4	0.518	12.206		
	TTF5	0.831	23.212		
	TTF6	0.836	23.212		
	TTF7	0.656	15.944		
TA	TA1	0.685	15.787	0.913	0.902
	TA2	0.697	17.036		
	TA3	0.682	14.913		
	TA4	0.891	22.584		
	TA5	0.785	17.506		
	TA6	0.781	17.584		
	TA7	0.751	18.694		
TECH					
-ER	RE1	0.775	20.392	0.610	0.861
	ER2	0.804	21.931		
	RE3	0.647	15.083		
	RE4	0.877	23.766		
-CO	CO1	0.695	16.307	0.563	0.774
	CO2	0.874	25.086		
	CO3	0.671	16.783		
-PL	PL1	0.767	18.740	0.546	0.783
	PL2	0.617	14.254		
	PL3	0.824	22.443		
-SP	SP1	0.807	21.014	0.633	0.837
	SP2	0.853	24.052		
	SP3	0.721	17.997		
-IN	IN1	0.771	19.629	0.633	0.838
	IN2	0.854	24.572		
	IN3	0.757	19.146		
PE	PE1	0.766	19.715	0.503	0.745
	PE2	0.737	18.552		
	PE3	0.597	13.230		

Table 6. The square root of AVEs (Shown in bold at diagonal) and factor correlation coefficients

	TTF	PE	ER	CO	PL	SP	TA	IN
TTF	**0.712**							
PE	0.140	**0.710**						
RE	0.257	0.258	**0.781**					
CO	0.393	0.069	0.170	**0.750**				
PL	0.360	0.082	0.119	0.410	**0.738**			
SP	0.208	0.316	0.209	0.169	0.071	**0.796**		
TA	0.456	0.199	0.244	0.273	0.197	0.166	**0.955**	
IN	0.335	0.127	0.237	0.244	0.258	0.131	0.238	**0.796**

6.3 Analysis of the structural path model

The standardized solution was estimated by LISRES 8.8 program. The researcher had 385 respondents, so the sample size was large enough for LISREL. We conducted the path coefficients of the structural models only (4 factors). Fig. 3 shows that the r^2 and path coefficients provide support for the propose model. The model explains a substantial potion (17%) of the variance of the performance construct. The variance for TTF is 48%. All 4 causal paths are specified in the propose model. And all are statistically significant ($p<.005$) (see Appendix B). These paths reflect the significant positive impact of Task (H1), and Technology (H2) on TTF for smartphones in a digital library setting ($\beta=0.077$, $t = 2.619$ and $\beta=0.954$ $t=6.352$, $p<0.05$ for TASK->TTF and TECH->TTF, respectively). The results confirm the significant impact of TTF on performance (H3) ($\beta=0.520$, $t=6.553$, $p<0.05$). Overall, the TTF model was employed to explore its predictive power in terms of the use of smartphones by patrons in a digital library setting. The paths indicated in the model are all significant in terms of the direct and indirect effects of the TTF of the smartphone. Our results indicate that the task-technology performance chain is a suitable theoretical framework for assessing the acceptance of smartphones by patrons in a digital library setting. The actual and recommended values of model fit indices are listed in Table 7. This demonstrates a good fit between the model and the data [59, 63].

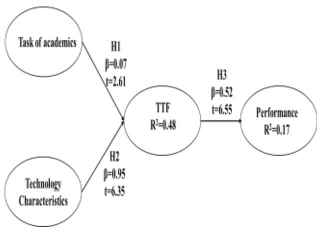

Fig. 3. Structure model results.

Table 7. Recommended and actual values of fit indices

Fit index	X2/df	GFI	AGFI	CFI	NFI	NNFI	MSEA
Rec. Value	<3	>0.90	>0.90	>0.90	>0.90	>0.90	<0.08
Actual value	2.39	0.944	0.916	0.974	0.957	0.965	0.051

Based on the existing TTF literature, the direct effects of antecedents on the smartphone TTF (task, technology) were examined. As predicted, task (0.08) and technology (0.95) had a significant influence on the smartphone. The antecedents of task and technology account for 48% of the variance in TTF. The graphical representation of the research model is given in Fig. 3. Support for each hypothesis can be determined by examining the sign and statistical significance of the t-value. As indicated, the model has an appropriate predictive power for most dependent variables. The research model as a whole explains 16.9% of the variance of the fit between the smartphone and the patron’s task. This provides support for previous research findings e.g. Yen, Wu, Cheng, & Huang [42]; Ambra and Wilson [43] Zhou, Lu, & Wang, [51]. Moreover, the results also show that there exist correlations between TTF constructs and PE. Consistent with finding in Keil, Beranek, and Konsynski [64]; Zhou, Lu, and Wang [51] found that task- technology fit (TTF) can impact performance. If patrons get services that are not a good fit with their needs, they will perceive these services to be of low usefulness and form a low performance assessment.

7. Conclusion and Contribution

The article makes a number of contributions:

- The findings confirm that the task of the user and the technology significantly influence smartphone TTF, which influence the user's performance.

- **:** The development and validation of a task and technology construct in a model validating the efficacy of the TTF model in measuring perceived fit of the smartphone to a library patron's task.
- **:** Extending the extant research in assessment of smartphones by employing higher-order factor analyses to incorporate a wide number of factors which constitute the current context of smartphone usage for digital library systems.

All referenced literature provides positive support that higher evaluations of smartphone technologies (Task Technology Fit) by patrons result in higher perceived performance impacts. This result was expected, and may be attributed to the patrons' belief that the smartphone can substitute for a personal computer since the patron can move easily to find the textbook on a bookshelf. The current result also indicates that smartphones that provide functionality related to content (Technology-Content) are significant. That is the ability to adjust lighting to alleviate eye fatigue and strain, applications that help them to execute the content on the smartphone, and the single window that cannot split the screen to work with two different apps, but makes all facilities available in one window [2]. This finding is consistent with previous research. The possible reason might be that Technology-Content elements impact the phone's usability and the user's satisfaction with the user experience [65]. Moreover, Forrester Consulting [66] showed that technology that supports content also impacts employee adoption of a particular activity. For example, Google Hangouts, an application that makes these devices ideal for accessing web meetings, and videoconferences. In comparison, employees use their PC to engage in these activities.

The researcher specified the technology construct as a first-order construct as indicators of the second-order construct, where a second-order factor, Technology characteristics (TECH), is introduced as the cause of the five first-order factors (Content, Ergonomics, Smartphone Support, Platform, and Interaction design), each measured by five reflective items. The correlation between any two measures is highly positive and internal consistency is significant. Therefore, individual measures can be removed to improve construct validity without affecting content validity [43]. Thus, the study confirms technology as a high-order reflective construct within the nomological context of smartphone research [56].

8. Practical Implications

Based on research results in this study, smartphone usage is rare for searching online databases (8.8 % or less than 1 per week). This means that downloading full-text or e-books, then reading the result to evaluate the value of data is not a suitable use for smartphones. Therefore, academic libraries should take into consideration the interaction of users with online databases. Compared to stationary-based systems and tablets, smartphones have limitations such as battery life and screen size which will be meaningful for viewing a large collection. Probably, if the interaction of users with online databases through smartphones departed from familiar work practices, users attention focus would deteriorate. Thus, the researcher would like to emphasize the differences of interaction with library catalogues, and online databases; the academic library should consider interaction with the library search system. For example, students should be able to select anywhere from one to all sources, and have the search results merge.

Moreover, smartphones can offer more opportunities for students to be actively engaged in their learning and to fully participate in the social nature of learning. It is important to realize that for students, the smartphone will increasingly become an instrument for creation of digital content, and not just a device for access to content [5]. So, librarians might encourage, through contests or other means, student development of apps that make library content and services more useful for specific groups of users [11].

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Appendix

Appendix A Cross loading Matric.

	TTF	PE	ER	CO	PL	SP	TA	IN
TTF1	**0.468**	0.145	0.049	-0.017	0.161	0.025	0.138	0.278
TTF2	**0.723**	0.041	0.061	0.047	0.033	0.125	0.100	0.101
TTF3	**0.809**	0.082	0.110	0.024	0.147	0.000	0.108	0.039
TTF4	**0.560**	-0.043	0.074	0.147	-0.090	0.084	0.145	0.252
TTF5	**0.809**	0.023	0.015	0.041	0.033	-0.017	0.137	0.048
TTF6	**0.829**	0.099	-0.003	-0.061	0.123	-0.022	0.159	0.044
TTF7	**0.660**	-0.050	0.026	0.208	-0.099	0.018	0.151	0.174
PE1	0.058	**0.773**	0.081	0.065	0.015	-0.031	0.084	0.123
PE2	0.074	**0.675**	0.078	0.059	0.029	0.120	0.063	0.138
PE3	0.106	**0.547**	-0.056	0.062	0.014	0.004	0.096	-0.026
ER1	0.059	0.042	**0.845**	0.050	0.077	0.027	0.021	0.034
ER2	0.030	-0.024	**0.857**	0.059	0.058	-0.005	0.057	0.100
ER3	0.072	0.034	**0.705**	0.097	0.015	0.050	0.005	0.015
ER4	0.040	0.038	**0.831**	0.094	0.132	-0.093	0.026	0.036
CO1	0.024	0.039	0.075	**0.681**	0.140	0.121	0.202	-0.001
CO2	0.126	0.189	0.232	**0.686**	0.201	0.105	0.143	0.089
CO3	0.100	-0.032	0.093	**0.772**	0.171	0.034	0.102	0.055
PL1	0.063	-0.031	0.118	0.148	**0.778**	0.135	0.185	0.040
PL2	0.089	0.101	0.162	0.339	**0.582**	0.163	0.111	0.145
PL3	0.118	0.030	0.114	0.202	**0.750**	0.109	0.172	0.051
SP1	0.034	-0.044	-0.015	0.052	0.142	**0.853**	0.095	0.075
SP2	0.046	0.006	0.021	0.040	0.119	**0.857**	0.132	0.057
SP3	0.049	0.101	-0.017	0.153	0.032	**0.788**	0.177	0.047
TA1	0.059	-0.064	0.148	0.075	0.129	0.045	**0.766**	0.029
TA2	0.068	-0.034	0.074	0.061	0.165	0.086	**0.781**	0.061
TA3	0.124	0.007	0.076	0.107	0.155	0.091	**0.693**	0.033
TA4	0.118	0.066	-0.017	0.050	0.035	0.044	**0.829**	0.092
TA5	0.097	0.007	-0.061	0.080	-0.015	0.070	**0.820**	0.061
TA6	0.121	0.148	-0.079	0.054	0.028	0.046	**0.806**	0.094
TA7	0.187	0.120	0.012	0.059	-0.025	0.092	**0.776**	0.128
IN1	0.163	0.018	0.030	0.043	0.067	0.067	0.158	**0.796**
IN2	0.192	0.069	0.063	0.009	0.068	0.022	0.147	**0.822**
IN3	0.167	0.137	0.119	0.087	0.034	0.114	0.138	**0.759**

Appendix B. Path coefficients, SEs, and t-tests**.**

Path in the research model	Path coefficients	t
Technology->Ergonomics	0.68	25.086
Technology->Content	0.86	22.443
Technology->Platform	0.50	24.052
Technology->Smartphone support	0.54	22.584
Technology->Interaction design	0.45	24.572
Task->TTF	0.07	2.619*
TECH->TTF	0.95	6.352*
TTF->PE	0.52	6.553*

* Significant at $p < 0.0$