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Towards an Understanding of the Intention of University Members to Use Indoor Positioning Systems: A Unified Theory of Acceptance and Use Perspective

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Abstract
Indoor positioning systems (IPS) have become increasingly important in various sectors (e.g., airports, malls, hospitals). They are relatively new to universities and have not been adequately addressed in research. We investigate behavioral intentions to use such IPS in universities to close this gap. The objective is to investigate the intentions of university members to use IPS in universities. The Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) is used to investigate the intention to use IPS in universities. For this, we designed use cases and questionnaires to be handed out to university members. Until now, we derived certain use cases for IPS in universities to investigate university members' intention to use this IPS. Those use cases will be investigated using the UTAUT2 questionnaire. As conclusion, a questionnaire for university members and use cases as well as an IPS user interface prototype based on those use cases have been developed. In future research steps we will utilize use cases and questionnaires to investigate our hypotheses and to measure university members' intentions and underlying reasons using partial least squares structural equation modeling.

Keywords
IPS, indoor navigation, LBS, location-based services, UTAUT2, Unified Theory of Acceptance and Use of Technology 2, digital university, human-computer interaction

1. Introduction

While navigation and spatial orientation are difficult for some individuals [1, 2, 3, 4] location-based services (LBS) and GPS-based systems help them navigate outside [5]. Due to the benefits of those LBS, indoor positioning systems (IPS) have become quite popular recently, as they allow companies to e.g. save time and resources [6]. Universities are important to investigate with regard to IPS as their building structures are typically complex [6] and members typically

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access different buildings with varying patterns. While some studies address IPS in universities (e.g., [7]), research is short on designing IPS for universities so that university members intend to use them. Hence, our research question is which behavioral reasons determine the intention of university members to use indoor positioning systems. In order to adress this question, this paper adopts the Unified Theory of Acceptance and Use of Technology (UTAUT2). In applying the theory, we design use cases and a questionnaire as a first conceptual step in this work in progress paper. This article is structured as follows: section 2 describes the theoretical background of the research by explaining IPS, presenting related work, introducing UTAUT2, and creating the structural model for our study. Section 3 describes the methods used, containing use cases and questionnaires. Finally, in Section 4 we discuss our results and we provide a conclusion in Section 5 including an outlook on future research steps.

2. Theoretical Background

2.1. Indoor Positioning Systems

An indoor positioning system determines an individual's or object's position within buildings or building complexes [8] using an algorithm that estimates the live position using a mobile client. For IPS, various technologies are used, such as Wi-Fi, Bluetooth-Low-Energy (BLE), Radio Frequency Identification (RFID), or ultrasound [9]. In addition, those technologies use techniques to determine a specific position, such as triangulation or trilateration [10]. For further information concerning IPS, we recommend the survey of Zafari et al. [6]. For developing an IPS, designing use cases and prototypes is necessary [6]. One such study was conducted by Bucheli Fuentes et al. [11], who used the evolutionary development model [12] to build a prototype to implement a BLE-based IPS that uses fingerprinting techniques and evaluated its accuracy. Next to the technology, the IPS user interface has to be considered for sufficient IPS [6]. Several studies investigated IPS user interface design, such as Aoki et al. [13] for hospitals or, e.g., [14, 15, 16] for universities. However, most of those studies evaluate IPS from a technological point of view, as Liu et al. [14] and Zafari et al. [6] proposed, leaving behind other important factors, such as intention to use. Nonetheless, intention to use concerning IPS was considered in a study conducted by Wichmann & Leyer [17], who used the Reasoned Action Approach (RAA) according to Fishbein & Ajzen [18]. They investigated IPS in hospitals and determined underlying reasons for intention to use IPS in hospitals but did not evaluate use cases or prototypes. Thus, research is necessary that combines both use cases and prototype evaluation on one side and intention to use on the other [19].

2.2. Indoor Positioning Systems for Universities

Recently, IPS have been the subject of various studies for different application scenarios, such as airports, libraries, and hospitals [6, 9]. Further, IPS are important for universities, as, e.g., Hammadi et al. [20] and Hadwan et al. [16] determined. Hammadi et al. [20] conducted a study in a university in the United Arab Emirates by designing an IPS for Android smartphones that are based on Near Field Communication (NFC) and Quick Response (QR) code technologies. They proposed several functions for IPS in universities, such as: (i) displaying contact information,

(ii) displaying a campus map, (iii) navigating to POIs, such as the nearest restroom, and (iv) information about available parking lots. Hadwan et al. [16] determined the preferences of university members towards IPS and evaluated an IPS prototype in a university in Saudi Arabia. The authors proposed functions for IPS in universities that are: (i) places and services nearby (e.g., the closest toilet or cafeteria), (ii) staff timetable and office opening hours, (iii) search function, e.g., search by name, map, places, and services nearby, (iv) navigating to lecture halls, (v) emergency exits, and (vi) library. Möller et al. [21] also generated and evaluated an IPS user interface for complex buildings, such as universities, with AR and VR technology to perform wayfinding. Their qualitative and quantitative experiments found that AR navigation provides reliable results even with inaccurate positioning. We consider this finding important, so the wayfinding and IPS should include AR functions. By conducting participatory workshops with students from a German university, Paetow et al. [22] determined functions for IPS in universities that are: (i) indoor navigation (e.g., to points of interest, lecture halls, or toilets), (ii) unique walkways, due to restrictions (e.g., based on the definition of entry and exit points due to the Corona Pandemic), (iii) a student organization planner (e.g., for book rooms in university buildings, arrange consultations with lecturers, integrate timetables), (iv) library (e.g., to find books in the library), (v) a parking lot finder (e.g., find parking lots near the starting points of indoor navigation). Based on those studies, we designed use cases that will be presented in the following. To the best of our knowledge, no research exists that investigates IPS in universities considering the user's acceptance and usage behavior. Thus, we apply UTAUT2 to use cases to close this research gap and identify further aspects when implementing IPS in universities.

2.3. The Unified Theory of Acceptance and Use of Technology

In 2003, Venkatesh et al. [23] established the Unified Theory of Acceptance and Use of Technology (UTAUT). It is dedicated to determining the intention (and underlying acceptance) to use new technologies and can be used by different stakeholders, such as managers. It takes several acceptance theories and models into account, such as Technology Acceptance Model (see [24]), Social Cognitive Theory (see [13]), and Innovation Diffusion Theory (see [25]).

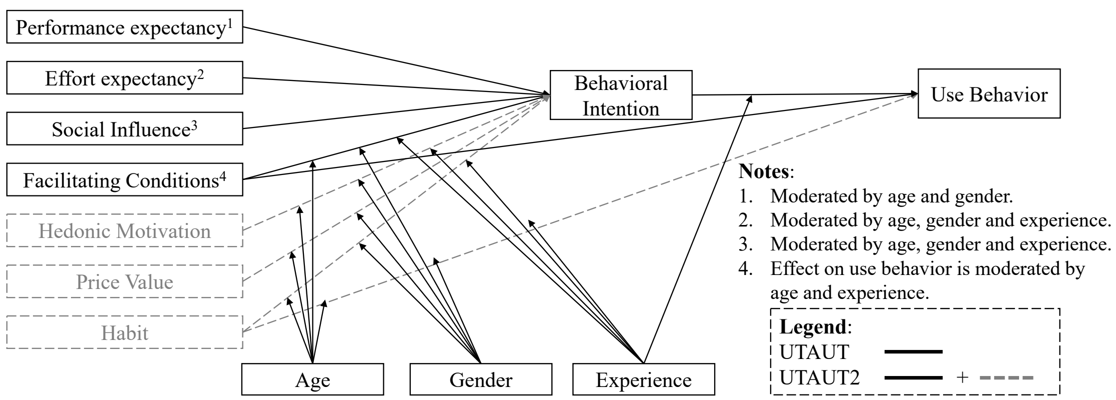

Figure 1: Unified Theory of Acceptance and Use of Technology 2

Further, it helps to explain underlying reasons for the intention towards a specific behavior. Since then, UTAUT has been frequently used in research [26]. It has been used for, e.g., implementing electronic health records in hospitals [27], several applications for food delivery services [28], or mobile payment applications [29]. In 2012, Venkatesh et al. revised their initial UTAUT model and proposed UTAUT2 [14]. UTAUT2 is shown in Figure 1.

2.4. UTAUT and Location-Based Services

Next to the aforementioned use cases, location-based services (LBS) were investigated using UTAUT2 [30]. LBS are increasingly important since the number of mobile applications evaluated using UTAUT is rising [26]. Ayuning Budi et al. [24] used the UTAUT model to explain the use of location-based applications in an emergency situation (the intention to use a "panic button" in this study) and proved that UTAUT is applicable to the context. They found that performance expectancy is one of the key drivers when using LBS like a panic button in an emergency. Further, privacy concerns and trust towards the provider of mobile applications are important for determining the intention to use LBS [24]. Those findings are supported by Yun et al. [31], who used UTAUT to investigate the intention to use LBS while considering privacy concerns. Their results indicate that privacy concerns are important for determining the intention and use of LBS. However, as they take groups with different privacy concern levels into consideration, their results show that the effect of performance expectancy on usage intention was stronger for users with a low level of privacy concerns [31]. Fu & Ai [32] used UTAUT to investigate the intention of LBS users to use management information systems. They added perceived risk according to [33] to their UTAUT model and determined that university users think LBS are risky regarding privacy concerns [32]. Hence, we add perceived risk to our study to investigate how privacy concerns of university members affect the intention to use IPS in universities. Further, Fu & Ai [32] showed differences in the influence of the factors of the UTAUT when looking at different groups of users. By adding perceived risk as one of the influential factors on behavioral intention, they showed that especially university users see a high risk in using LBS [32]. Thus, these studies indicate that users of universities see higher risk in using LBS due to privacy concerns. Privacy concerns can be defined as the control of personal information and the fear of losing this control of personal information, like the user's position to third parties who will use them for their own benefit [34, 31]. Hence, we add privacy concerns according to [33] to our UTAUT2 model to determine whether privacy concerns influence the intention to use IPS in universities. Performance expectancy, facilitating conditions, and effort expectancy seems to be three of the main drivers when it comes to the intentional use of LBS in tourism contexts [35, 36]. Further, Uphaus et al. [35] showed that hedonic motivation is an important factor in determining the intention to use LBS in tourism contexts. Those services include providing information based on the user's location or beacons (like QR-Codes), which interact with the user's smartphone and give them touristic information about their location [35]. Gupta & Dogra [36] showed that users' habits are an important factor to consider for the intention to use LBS. They investigated existing LBS (called "mapping apps" in their research) and the intention of tourists to use such services during vacation [36]. Performance expectancy, facilitating conditions, and effort expectancy seem to be the three main drivers when it comes to the intentional use of LBS in tourism contexts [35, 36]. Further, Uphaus et al. [35] showed in their study that hedonic motivation is an important factor in determining the intention to use location-based applications in tourism contexts. Those services include providing information based on the location of the user or provided by beacons (like QR-Codes) which interact with the smartphone of the user and give them (touristic) information on their location [35, 36]. Hence, those studies show that UTAUT and UTAUT2 are applicable to the context of LBS. However, we were unable to determine any research concerning UTAUT2 and location-based applications for universities. Thus, we aim to close this gap by applying UTAUT2 to the context of IPS for universities.

2.5. Hypotheses & Research Model

According to Venkatesh et al. [30], performance expectancy is the degree to which using technology will benefit consumers in performing certain activities. Therefore, performance expectancy is an essential predictor for adoption studies of LBS. Gupta & Dogra [36] determined that performance expectancy positively influences behavioral intentions towards using LBS. This is supported by other studies which determine performance expectancy as one of the key factors influencing the intention to use LBS [24, 35]. Further, Chen & Tsai [25] determined that information quality, system quality, and perceived usefulness positively influence the intention to use LBS. According to UTAUT2, which contains Technology Acceptance Model, those variables (information quality, system quality, perceived usefulness) are also crucial for ascertaining performance expectancy [30]. Thus, our first hypothesis is:

H1: Performance expectancy positively influences an individual's intention to use IPS in universities.

Effort expectancy is the "degree of ease/effort associated with consumers' use of the technology" [30]. Regarding LBS, Gupta & Dogra [36] state that effort expectancy positively influences the behavioral intention to use LBS. This proposition is supported by Uphaus et al. [35], who state that effort expectancy is one of the critical factors influencing usage behavior. Further, Wichmann & Leyer [17] determined that effort expectancy (called personal innovativeness in their study) positively influences the intention to use IPS in hospitals. Chen & Tsai [25] also state that effort expectancy (called perceived ease of use in their study) positively influences the intention to use LBS. Hence, our second hypothesis is:

H2: Effort expectancy positively influences an individual's intention to use IPS in universities.

Venkatesh et al. [23] define social influence as the "degree to which an individual perceives that important others believe he or she should use the new system." For IPS, social influence refers to the opinions of other individuals that are important to the individual in question, such as friends, family, colleagues, and superiors [9, 36, 18]. Both, Gupta & Dogra [36] as well as Wichmann [9] & Leyer [17] state that social influence positively influences the behavioral intention to use LBS [36] as well as IPS in hospitals [17]. Thus, our third hypothesis is:

H3: Social influence positively influences an individual's intention to use IPS in universities.

Conditions are ”consumers” perceptions of the resources and support available to perform a behavior [23]. UTAUT2 suggests that an individual’s perception of facilitating conditions directly influences technology acceptance. They confirmed that such acceptance was either supported or hindered by the surrounding environment of an individual [30]. For LBS, Gupta & Dogra [36] determined that facilitating conditions positively influence the behavioral intention to use LBS as well as their actual use. Hence, our fourth hypothesis is divided into two parts:

H4a: Facilitating conditions positively influence an individual’s intention to use IPS in universities.
H4b: Facilitating conditions positively influence an individual’s actual use of IPS in universities.

Venkatesh et al. [30] define hedonic motivation as ”the pleasure or enjoyment derived from using a technology.” For hedonic motivation, Brown & Venkatesh [37] state that it is an essential predictor of technology adoption and usage. Concerning LBS in a tourism context, Gupta & Dogra [36], as well as Uphaus et al. [35], determined that hedonic motivation positively influences an individual’s behavioral intention. Thus, our fifth hypothesis is:

H5. Hedonic motivation positively influences an individual’s intention to use IPS in universities.

In UTAUT2, Venkatesh et al. [30] state that price value is essential for behavioral intentions. They do so as consumers are more cost-sensitive than corporate employees are, as the consumers somehow have to pay for the service provided by the technology. If consumers think the perceived benefits of the technology are higher than the costs, the price value is positive, which positively influences behavioral intentions [30]. For LBS, Gupta & Dogra [36] state that price value positively influences behavioral intentions. Hence, our sixth hypothesis is:

H6: Price value positively influences an individual’s intention to use IPS in universities.

According to Venkatesh et al. [30], habit is the outcome of past behavior and experiences. Past and reoccurring behavior are main antecedents for predicting present actions [38]. For technology acceptance, several studies have proved that they are mandatory for technology acceptance (e.g., [15, 39, 40]). For LBS, Gupta & Dogra [36] determined that habit positively influences behavioral intentions and the actual use of those apps. Thus, our seventh hypothesis divides into two parts that are:

H7a: Habit positively influences an individual’s intention to use IPS in universities.
H7b: Habit positively influences an individual’s actual use of IPS in universities.

Ayuning Budi et al. [24] state that privacy concerns of users have a negative impact on the behavioral intention to use LBS. Further, the intention to use is lower for those individuals who have high privacy concerns in university contexts [6]. Since we apply our IPS in the context of a university and members of universities or scientific facilities seem to have a high level of privacy concerns [18], it is assumable that the privacy concerns influence the behavioral intention of the users. Thus, our eighth hypothesis is:

H8: Privacy concerns of users negatively influence an individual's intention to use IPS in universities.

For the intention to use IPS, Wichmann & Leyer [17] state that spatial abilities negatively influence intention. They determined that the intention to use IPS is lower for those individuals who are good at navigating themselves through buildings that are large and unknown to them. Hence, our ninth hypothesis is:

H9: Spatial abilities negatively influence an individual's intention to use IPS in universities.

Fishbein & Ajzen [18] state that intentions are an individual's willingness to engage in a specific behavior. Behavioral intention is often considered the predecessor of behavior, proven empirically [41]. For technology acceptance, those intentions are mandatory for predicting a specific behavior [30]. While Gupta & Dogra [36] determined that positive intentions support the use of LBS, Wichmann & Leyer [17] prove that intention is also important for IPS. Thus, our tenth hypothesis is:

H10: Behavioral intentions to use IPS in universities positively influence the actual use of IPS in universities.

Figure 2 summarizes the resulting research model.

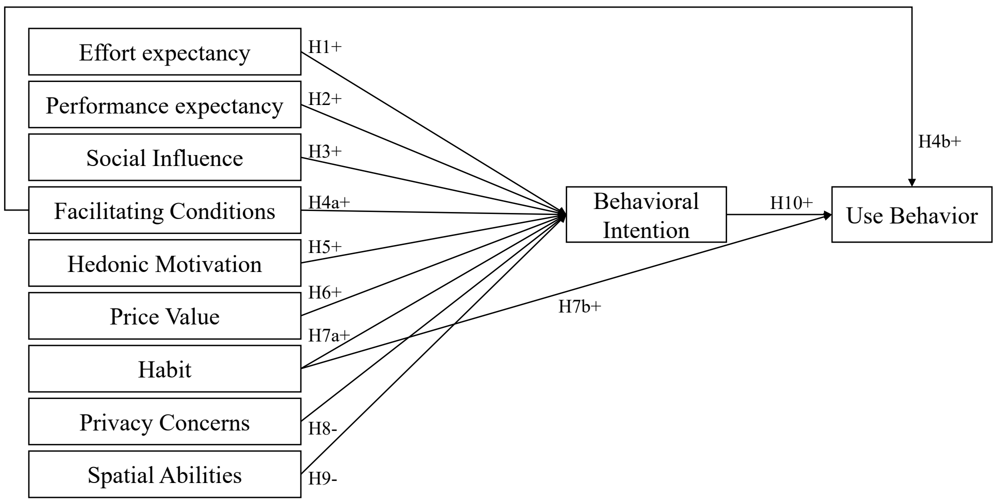

Figure 2: Research Model

3. Methods

3.1. Use Cases

We generated different use cases for our measures and created IPS user interface prototypes based on them. The IPS prototype, developed as a mobile application for smartphones, has five functions: (i) Search (see Figure 3), (ii) Map, (iii) Library. (iv) Parking lot Finder, (v) Planner. We developed use cases for each function to determine the intention to use the application due to the respective use case. For each of those functions, our individuals received a use case that is like the following for the IPS search function: The IPS has a search function. Thus, the IPS can find (i) individuals, e.g., professors, (ii) rooms, e.g., lecture halls, or (iii) points of interest. Concerning the latter, the IPS directs to, e.g., printing/copying stations or restrooms. The search function can be accessed via a button ("Search") on the main screen. The next screen contains a search bar. People, rooms, and point-of-interests can be searched. If the searched item is e.g., an individual, her/his room (i.e., assigned office) and the building are displayed as additional information, as well as the distance in meters based on the navigational route. Additional options are: (i) displaying her/his room using a 2-D map, (ii) navigating to the respective office, (iii) making a consultation appointment, and (iv) starting a phone call. Based on the selection of an additional option, different functions are triggered, e.g., AR navigation or map function.

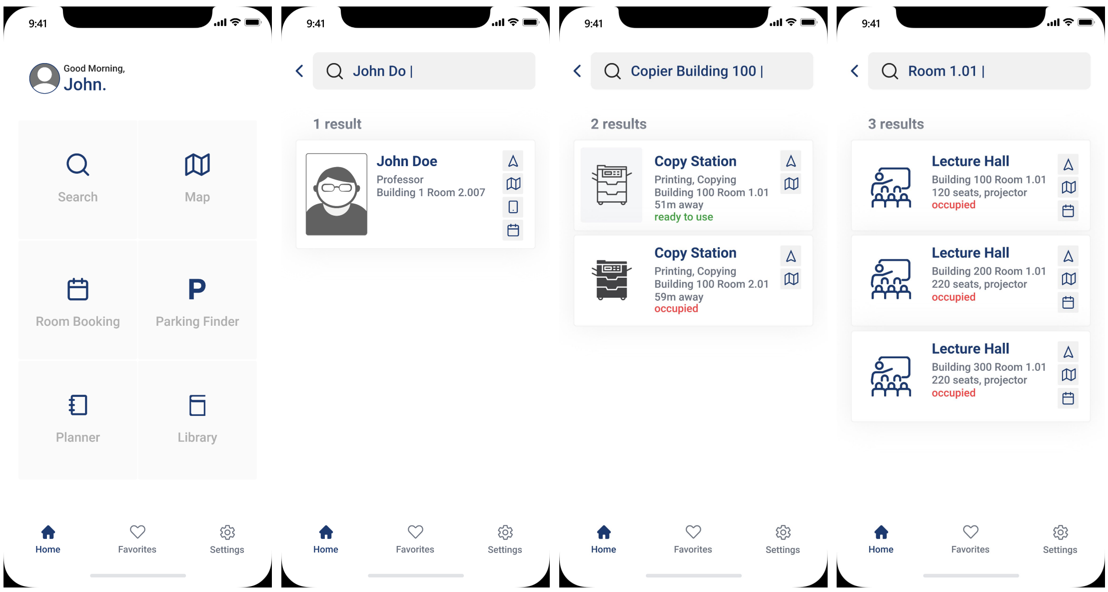

Figure 3: IPS user interface prototype for the search function

3.2. Questionnaire

To test our hypotheses and to determine the intention to use an IPS, we apply the questionnaire of Venkatesh et al. [30] that we combine with the propositions of Gupta & Dogra [36], Uphaus et al. [35], and Tamilmani et al. [26]. Further, we add questions of Xu [34] regarding privacy concerns. Yun et al. [31] showed that these questions are applicable in the context of LBS. For spatial abilities, we are using questions of Wichmann & Leyer [17]. Our questionnaire is shown in Table 1.

Table 1: Survey Questions

Dimension	**Survey Questions**
Performance Expectancy (PE)	PE1: I think that this IPS will be useful while being at the university; PE2: I think that this IPS helps me reach my destination conveniently; PE3: I think that this IPS saves time for me; PE4: I think that this IPS increases my productivity and helps me find objects
Effort Expectancy (EE)	EE1: I think that learning how to use this IPS will be easy for me; EE2: I think that my interaction with this IPS will be clear and understandable; EE3: I think that using this IPS will be easy for me; EE4: I think it will be easy for me to become an expert/skillful when using IPS
Social Influence (SI)	SI1: People who are important to me think that I should use IPS while moving through universities; SI2: People who influence my behavior think that I should use IPS while moving through universities; SI3: People whose opinions I value prefer that I use IPS
Facilitating Conditions	FC1: I think I have the resources necessary to use IPS; FC2: I think I have the knowledge to use IPS; FC3: IPS is compatible with other technologies I use; FC4: I can get help from others when I have difficulties using IPS
Hedonic Motivation (HM)	HM1: I think using this IPS is fun; HM2: I think using this IPS is enjoyable; HM3: I think using this IPS is very entertaining
Price Value (PV)	PV1: I think that the cost of using IPS is reasonable; PV2: Using IPS is worth the cost; PV3: At the current price, IPS provides a good value
Habit (HT)	HT1: When I compare this IPS with LBS that are familiar to me, I think using this IPS could become a habit for me; HT2: When I compare this IPS with LBS that are familiar to me, I think I could get addicted to this IPS; HT3: When I compare this IPS with LBS that are familiar to me, I think I must use it when I move through universities
Privacy Concerns (PC)	PC1: I am concerned that the university is collecting too much information about me; PC2: I am concerned that the university may not take measures to prevent unauthorized access to my location information; PC3: I am concerned that the company may keep my location information in an inaccurate manner in their database; PC4: I am concerned that the university may share my location information with other parties without obtaining my authorization; PC5: Overall, I feel unsafe about providing location information on the university through the use of the IPS

Table 1 – continued from previous page

Dimension	Survey Questions
Spatial abilities (SA)	SA1: I am good in navigating myself through buildings that are large and unknown to me; SA2: I am good in navigating myself through buildings that are known to me; SA3: I always find the shortest way through buildings that are large and unknown to me, while I am navigating myself; SA4: I always find the shortest way through buildings that are known to me, while I am navigating myself; SA5: I do not need assistance while navigating myself through buildings, that are large and unknown to me; SA6: I do not need assistance while navigating myself through buildings, that are known to me.
Behavioral Intention (BI)	BI1: I would definitely use such an IPS during my next visit to a university if it would be available; BI2: I intend to use such an IPS during my next visit to a university if it is available; BI3: I plan to use such an IPS during my next visit to a university if it is available
Use Behavior (UB)	UB1: How often do you use IPS?

Since we could not find a study in which the UTAUT2 was applied for an IPS, we will contribute to the research by applying the UTAUT2 for an indoor navigation service technology. We do so as we provide an IPS user interface prototype to university members that are based on current propositions about how to design IPS for universities [20, 16, 22]. Since our IPS is a user interface prototype, we consider our approach as an early adoption phase, according to Tamilmani et al. [26]. For IS adoptions in early phases, UTAUT2 is important, according to Tamilmani et al. [26], which is why we use UTAUT2 for investigating IPS. After the individuals have received the use cases, different user interfaces of the IPS functions are displayed. On this basis, the individuals will answer the questionnaire (see Table 1). A total of 32 items were obtained. To do so, we adapted studies to suit a questionnaire in the context of IPS in universities. The responses of the questionnaire participants to each of the items were measured with a 7-point Likert scale for each item (from 1 ”do not agree at all” to 7 ”completely agree”). We also include control questions (i.e., which building structure has the participant’s university that has visited most frequently in the past 365 days, and demographic data such as age and gender).

4. Discussion

Our objective is to investigate the intentions of university members to use IPS in universities. For this purpose, we have chosen UTAUT2 as methodology. In our opinion, it is well fitting because it was developed to evaluate the use of new technology in the consumer market which has been shown by several researches (e.g., [35, 36, 24]). UTAUT2 was used because, according to Tamilmani et. al. [19] it is the better model compared to other theory acceptance models (e.g., Theory of Reasoned Action (TRA), the Technology Acceptance Model (TAM), theory of planned behavior (TPB)) for the investigation of the intention to use technology. UTAUT, for example, would have been unsuitable because it is primarily about evaluating the use of a new technology within an organization. While there is existing research on IPS in complex environments such as universities (e.g., [20, 16, 21], these research were focused on developing an IPS not concentrating on the users but on the systems functions. Our research provides a use case of LBS in a university which is created based on these researches and focuses on the acceptance and intention to use such an IPS. Therefore, we extend the research in this field by adding factors that need to be considered in the development of an IPS in order for this system to be used. Thus, our research contributes different in that we are approaching social science research that goes beyond just IPS system functions. Fu & Ai [32] showed that especially users in an academic environment have a high perceived risk when using LBS. This finding makes it very interesting and difficult to design an IPS for a university since the risk evaluation of using an IPS has to be considered in the designing process. Therefore, our research aims to find out which factors outweigh the perceived risk of academic users. By doing so, we extend existing research in this field by providing a deeper insight in understanding the acceptance and using behavior of people with a high education.

5. Conclusion

In summary, we designed a questionnaire for university members based on related research and existing research using UTAUT2 in the area of LBS. Furthermore, we generated use cases and based on them IPS user interface prototypes. As a theoretical implication, a UTAUT2 questionnaire was adapted and generated for LBS in the context of universities. Our study design contributes to the literature as a further research base. As noted, related work addresses UTAUT2 and location-based services but not the explicit use case for universities. The questionnaire further focuses on the key users whose intention to use will be investigated: University members. As a practical implication, the questionnaire, in combination with the developed use cases and IPS prototype, can be the basis for practical investigations in universities. The questionnaire can be used with the developed use cases and the IPS prototype as a basis for practical studies in universities. The developed user interfaces and use cases can also be the basis for further developments. Our study is subject to limitations. Since the result is a developed questionnaire, there are no results. Thus, items are still subject to change. Furthermore, our questionnaire is addressed exclusively to users, the university members. Developers of the digital service are not considered. Finally, in future research steps, we will conduct our developed questionnaire and the use cases and IPS prototype using an online survey. All participants who fill out the questionnaire must be affiliated with a university, e.g., by being an employee or student. To verify this, test questions at the beginning and the end of the questionnaire so that the participant's self-declared status can be checked for correctness.

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