International Journal of Engineering & Technology, 7 (3.7) (2018) 4-8

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Potential Fit between Geotechnical Tasks and Mobile Computing Technologies

Aamer Shehzad, Mohd Zaidi Abd Rozan

Faculty of Computing, Universiti Teknologi Malaysia
Johor Bahru, Johor, Malaysia

Abstract

Trend of rapid pace in earthworks has forced geotechnical laboratories to increase their productivity and performance at organizational as well as at individual level. Though geotechnical work involves numerous mobile work processes but the true potential of rapidly growing mobile computing technologies (MCT) has not yet been effectively exploited mainly due to lack of realization of a potential match between features of this specific technological paradigm and major task requirements. To fill this gap, this study investigated and characterized salient task characteristics and features of MCT. Based on the theory of task-technology fit (TTF), an initial conceptual model is proposed which reflects hypothesized relationships for finding a fit between task and technology and consequently assessing its impact on performance of geotechnical field workers. This paper contributes to the knowledge pool of information system through development of an adapted TTF model in geotechnical mobile work context. Lastly, future research plan of using quantitative methodology for finding empirical support of this conceptual model is presented.

Keywords: *Geotechnical Field Work, Mobile Computing, Laboratory Information System, Task Technology Fit*

1. Introduction

Geotechnical engineering examines behaviour of earth materials. Its major applications are investigations of soil properties and underground water prospects for development of civil projects as well as for the prediction, avoidance and mitigation of natural disasters like floods, landslides, earthquakes and mud flows [1]. Due to various socio-economic factors, a trend of rapid pace in earthworks like reservoirs, offshore structures, tunnels, deposition of hazardous waste, oil platforms and onshore and offshore structures is being witnessed in recent years. This, along with the issue of scarcity of land with good soil and the increased awareness about safety related concerns regarding civil works, is mounting pressure on geotechnical enterprises to revamp their business processes so that contemporary challenges of increased productivity and performance can be met [2][3].

Business processes are improved or innovated usually by the incorporation of appropriate technologies. Geotechnical work processes comprise of numerous stages (as shown in figure 1) during which vast variety of information is fetched and dispatched [4]. A complete geotechnical investigation and analysis consists of an ample course of sample collection, laboratory and on field testing, and procedures involving analysis and assessment. Major activities involved in a typical geotechnical project are conducting field investigations, geologic surveying and mapping, preparation of preliminary boring log using the field results, conducting the subsurface investigation, performing in-situ tests, coordinating with all stakeholders and determining and conducting laboratory tests for the collected samples [5]. Estimated duration and cost of each activity varies based on the level of complexity, constraints and assignedresources.

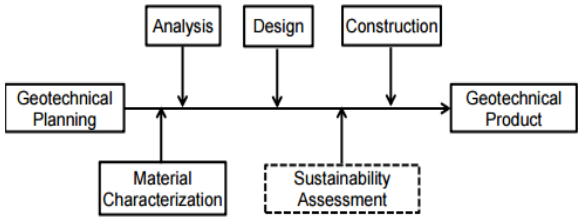


Figure 1. Processes of Geotechnical Engineering

These wide varieties of tasks require swift acquisition of accurate data and coordinated exchange of information and resources. This resultantly necessitates the use of appropriate information technologies. It is believed that use of information technology (IT) has the potential to make significant contribution in providing effective interaction between stakeholders, minimizing cost, increasing productivity and performance and consequently creating a competitive edge for an organization [3].

For industries involving large amount of field work, IT can more effectively act as a conduit for dispersed information as well as human resources. Examples of different technological applications for geotechnical professionals include Rugged Mobile Devices, Geographic Information System, Electronic Document Management System, Digital description of borehole logs, Digital Photogrammetry, Remote Sensing, Geotechnical Modelling, Laboratory Information Management System, E-Work Orders, Digital analysis of SCPT data, data loggers, and location-based services [2] [4][6][7].

Mobile computing technology (MCT) is passing through an era of rapid growth with its increasing capacities and availability [8].

Copyright © 2018 Authors. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Because of the fact that geotechnical processes involve great amount of field work ranging from sample collection to interaction between stakeholders so this makes MCT a potential enabler for its business process improvement. Due to varying requirements and existence of non-coherent groups of end users, contemporary research stresses on the customization of mobile information system for increase in productivity and performance of the organization as well as individuals [9]. This necessitates examining the determinants and relationships of a customized mobile information system and its impact on individual's performance and productivity in the domain of geotechnical industry.

On the basis of this problem background, this research aims to investigate following research question.

"Which mobile computing features are useful for different task requirements of geotechnical field workers?"

Thus in order to find a customized solution, next section critically reviews field worker's task characteristics and major mobile work support functions enabled by mobile computing technologies in the context of geotechnical work processes.

2. Literature Review

Customization of an integrated mobile computing enabled laboratory information system requires identification of task requirements and their respective potential mobile work support functions enabled by MCT.

2.1 Task Characteristics

An activity executed by the workers aimed at accomplishing a well-defined goal is defined as a task. Following three groups of literature have facilitated in characterizing the task requirements and defining major mobile task characteristics.

i. Concept of mobility and its dimensions
ii. Scope of geotechnical work processes and job descriptions of geotechnical field workers
iii. Previous researchers' identification and classification of task requirements

Understanding of what mobility means, how it has been used, and what are its underlying dimensions, are critical pre-cursors of determining its enterprise value. Mobility is defined along its three dimensions i.e. spatial, temporal and contextual [10]. These dimensions help in identification of task characteristics of mobile workers.

Secondly, scope of geotechnical engineering tasks encompassed by job descriptions of geotechnical professionals working in the field delineates core task groups of the domain of interest. Major activities involved in a typical geotechnical project are conducting field investigations, geologic surveying and mapping, preparation of preliminary boring log using the field results, conducting the subsurface investigation, performing in-situ tests, coordinating with all stakeholders and determining and conducting laboratory tests for the collected samples [5][6][11]. All these activities comprise of different individual tasks. For example, field investigation comprises of tasks like information access, data management and task scheduling. Similarly, other activities or phases of geotechnical engineering project may also involve the above stated tasks as well as other distinct tasks. Technological features are intended to support individual tasks rather than phases [12].

Tasks can be assembled jointly to outline key tasks based on their common characteristics. Previous researchers have analyzed tasks along different dimensions like complexity, temporal constraints, spatial dependence and contextual requirements. According to Basole [13], task can be described along temporal and spatial dimensions. Gebauer et al. [14] illustrated temporal boundaries of a typical task along further three sub dimensions of urgency, duration and punctuality. While Yuan et.al. [15] in their research elaborated that though stationary tasks can be illustrated along complexity and interdependence but for mobile work another important dimension called context is necessary to cover all aspects of task requirements.

Based on the critical review of above narrated literature and keeping in view the domain characteristics and context of this research, following three major task requirements have been characterized.

1) **Task interdependence**: It defines the degree of dependence of different tasks on each other for their respective accomplishment. Due to involvement of different personals for the accomplishment of a typical task, exchange of information and other resources is seen more frequently in geotechnical projects. Pearce et al. [16] modelled this interdependence using three different factors like depend on others, others' dependence and reciprocal dependence. Interdependence between tasks can be fostered through effective exchange and sharing of resources of all types (e.g. equipments, information and human etc.) either in series or sequentially [17].

2) **Time criticality**: It defines the importance of time for a given task both in terms of sequence and execution. Time criticality is recognized as a causative feature for effectiveness of mobile information system[14]. Time criticality is categorized in three attributes: time window, urgency and punctuality. Phases like analysis and collection of sample involve tasks which are temporally sensitive either in terms of time compression or urgency.

3) **Location sensitivity**: It defines that execution of task is how much affected by spatial dispersion or dependence. Geotechnical tasks involving sample collection and in-situ tests are massively dependent on spatial characteristics. Spatial dispersion is defined as the extent to which personnel are required to move to different locations in order to accomplish a certain goal [17]. Whereas, spatial dependence is defined as the extent to which location is considered critical in performance of a particular tasks [18].

2.2 Mobile Computing Technologies

Mobile computing technology (MCT) refers to portable handheld devices such as a smart phone, tablet PC or any other type or variation of a computing device that can be used during field activities to perform tasks that would normally be completed using other less technologically advanced data capture techniques like a pen and a pad [8].

Benefits of mobile technology can be viewed from two angles; one from individual perspective and the other from organizational perspective. From individual perspective, MCT improves users' effectiveness as well as efficiency through time compression. For organizations, MCT offers better control, flexibility, quality and transparency [19].

Features provided by MCT are previously classified along different dimensions like interactive, proactive, connective, informative, transactional, ubiquitous data access, collaborative, integration and automation of processes [9][20][21]. Different classes have been developed based on the focus of a particular investigation and objectives. Features of MCT, found relevant to support geotechnical field workers' portfolio of tasks, can be broadly categorized into following 3 types.

a. Mobile Information Access (Both textual and geo spatial)
b. Mobile Data Processing
c. Mobile Task Scheduling and Dispatching

2.3 Related IS Theories

Review of information system (IS) literature, comprising of relevant IS theories in the context of customization and compatibility of a system and ultimately examining the relationship between performance impact and its determinants, has helped in identification of three major and most relevant groups of previous research studies.

- TTF and Performance Impact [12][22]
- Analysis of Fit between task and technology [15][23]
- System Utilization and Performance Impact [22]

Concept of fit, in current research context, is quite similar to matching the demands with supplies and thus deciding what and how much it is useful or otherwise in the prevailing context. Fit in information system research can be measured in several ways like congruence, interaction and absolute difference [15]. But based on the fact that interaction and absolute difference take the view of relationship as a straight line usefulness relation rather than taking into consideration any other relevant factor like performance impact in our research. Congruence itself has two measurement techniques. One is 'Facets-of-fit' while the other is 'Predicted outcomes'. Facets-of-fit involves identifying important facets of the task requirements and assessing whether the tool meets each of them. The predicted-outcome method predicts the outcomes of tool use and whether they are as desired [22]. Predicted-outcomes method is used in this research to measure fit. This measurement is straightforward and the data are easy to collect; users can respond whether use of each work support function would assist them in their portfolio of tasks.

Task Technology Fit is considered most relevant theory for this type of research as TTF claims 'there must be a good fit between the technology and the tasks it supports' [12]. Many researchers have previously used TTF in mobile context. Deibert et al. [24] have examined factors influencing process performance of operational staff in construction industry setting. They then included mobile technology and technology intensity factor and analyzed the impact of these technology factors on the existing relationship. Their empirical research concluded that use of mobile technology has trade-offs and based on task requirements, incorporation of appropriate level of technology intensity (e.g. use of sensors, RFID etc.) brings improvement in process performance. Ahearne et al. [25] posit that performance impact is created by higher IT usage. An adapted TTF model was tested and validated in pharmaceutical setting. Yan & Lihua [26] targeted on finding which kind of tasks of sales workers can be effectively supported by what type of mobile technology. Their study used TTF model with testing individual characteristics effect on relationship between effectiveness of task-technology and actual usage of technology.

Similarly, many others researchers have also conducted both theoretical as well as empirical research regarding finding the effectiveness as well as performance impact of a technology in specific domain. Some researchers have done it in organization context while others have done it by focusing on individual unit.

3. Research Model

Based on review of related literature, a conceptual model, aimed at discovering a better fit between geotechnical task requirements and features of MCT and consequently finding the impact of effectiveness of MCT on performance of geotechnical field workers. Figure 1 shows the conceptual perceived performance model of this research.

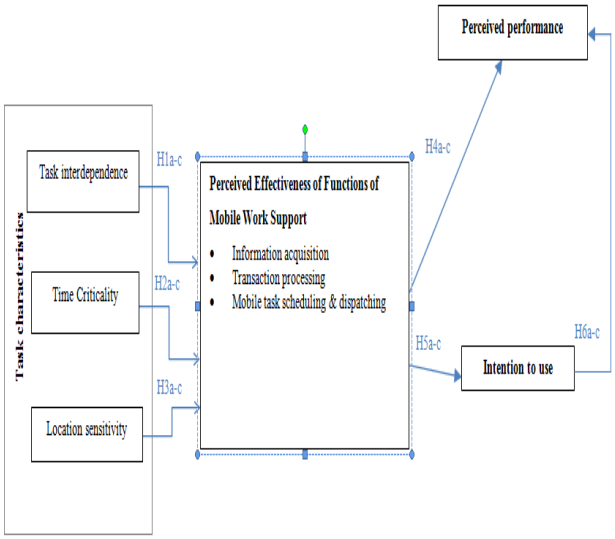


Figure 2: Conceptual Perceived Performance Model

3.1 Research Hypothesis

Task interdependence: The more workers rely on the execution of tasks of their colleagues for accomplishment of their own tasks, the more interdependent tasks will be and the more effective mobile work support will be [27][15][28]. Despite the fact that geotechnical laboratory workers theoretically work independently in their field work, coordination with their colleagues working in different capacities will remain a necessity especially in emergency situations. Mobile work support functions can facilitate this coordination requirement. Thus, on the basis of literature support, it is hypothesized that:

H1a-c: *Perceived effectiveness of mobile work support functions is influenced by task interdependence*.

Time criticality: Time criticality refers to the temporal dimension of mobility i.e. how critical timing is with reference to execution of job [13]. This study assumes that geotechnical field workers have to complete time-critical tasks. Mobile computing technology can help in this regard too [11][13]. Thus, it is hypothesized that:

H2a-c: *Time criticality is positively correlated with the perceived effectiveness of mobile work support functions*.

Location sensitivity: Most evident dimension of mobility is geographic variation or dependence. If geo positioning related data or activities are required in carrying out a task then this refers to location sensitivity [19]. It can be further gauged against two parameters. First is location variance i.e. degree of change in location for a worker while performing his duty. Second is location dependence, which measures the level of geo positioning information required to perform a task. For geotechnical laboratory workers, the information about their current location is very crucial as well as very basic one and mobile technology simply facilitates this as this is one of rudimentary feature of this technology [28]. Thus, it is hypothesized that:

H3a-c: *Location Sensitivity is positively associated with perceived effectiveness of mobile work support functions*.

Fit between task & technology and perceived performance impact: TTF Model states that if technology assistance is aligned with the demands of tasks then this will lead to positive performance impact [16]. Many researchers have tested and validated this relationship in different contexts [18] [21]. Thus, on the basis of literature support, it is hypothesized that:

H4a-c: *Perceived effectiveness of features provided by mobile computing enabled laboratory information system has a positive influence on perceived performance of geotechnical field workers.*

Impact of perceived effectiveness on intention to use MCT: According to technology acceptance model (TAM), behavioural intent to use a technology is affected by the effectiveness of that specific technology in carrying out requisite tasks [30]. This relationship is comprehensively discussed and tested in the literature [31][32]. Thus, on the basis of literature support, it is hypothesized that:

H5a-c: *Intent to use features, provided by mobile computing enabled laboratory information system, is affected by perceived effectiveness between mobile worker tasks and respective technology feature.*

Impact of intention to use MCT on perceived performance: Use of information system is considered to positively influence individual performance. This association has been tested and validated in various research studies [17][18][21]. Thus, it is hypothesized that:

H6a-c: *Perceived mobile work performance is influenced by Intention to use features provided by mobile computing enabled laboratory information system.*

4. Future Plan for Empirical Validation of Conceptual Model

Quantitative research methodology using survey as data collection instrument will be applied for empirical validation of proposed conceptual model. Research instrument will be developed through review of relevant literature and subsequently performing item refinement procedure. Simple random sampling will be chosen for the selection of sample from the population. Survey will be conducted in geotechnical organization working in Johor, Kuala Lumpur and Selangor as these geographical areas are witnessing massive civil works on soft soil. Second generation multivariate analysis technique, Structured Equation Modelling, will be used for analysis of data.

5. Conclusion

Based on extensive literature review, task requirements of geotechnical field workers have been grouped and their respective candidate mobile work support functions have been identified. Pair wise links have been created between task and technology characteristics so that a customized mobile information system in geotechnical context can be modelled for obtaining better fit and resultantly finding its increased performance impact on its potential end users. This study has augmented IS pool of knowledge by extending the theory of task technology fit in mobile work context, whereas in practical perspective, managers or practitioners can use this model as a guideline for development, implementation or procurement of a customized mobile laboratory information system. This study could have been further strengthened by conducting an exploratory field study regarding identification of task and technology characteristics. For future research direction, empirical study based on the proposed conceptual model in certain research settings, as described in future plan (section-4), will facilitate the process of validation of conceptual model.

Acknowledgement

The authors would like to express thanks to Universiti Teknologi Malaysia (UTM) for the Research University Grant Funding (RUG 2015 Q.J.13.0125.10311H16) provided for this research.

References

[1] S. Petiz, F. Ramos, and P. Roseiro, "The Use of Information and Communication Technologies in Construction," *Int. J. Adv. Corp. Learn.*, vol. 8, no. 1, pp. 4–11, 2007.
[2] I. Medved, D. Medak, and B. Pribicevic, "Conceptual model of Geotechnical Information System," *Assembly*, vol. 11, p. 8356, 2009.
[3] C. Yoo, "Integration of information technology into geotechnical engineering practice: concept and development," *Geotech. Geol. Eng.*, vol. 31, no. 3, pp. 965–978, 2013.
[4] P. Degebrodt, M. Mejstrik, F. Rackwitz, S. Savidis, F. Schley, and K. P. Holz, "Use of Internet Technology for the Improvement of Execution Management in Geotechnical Engineering Projects," *Tsinghua Sci. Technol.*, vol. 13, no. SUPPL. 1, pp. 132–137, 2008.
[5] B. M. Das, *Principals of Geotechnical Engineering*. Cengage Learning, 2010.
[6] M. B. Jaksa, K. K. S. Ho, and M. a Woodward, *Management, training and education in geotechnical engineering*, no. October. 2009.
[7] P. Child, C. Grice, and R. Chandler, "The Geotechnical Data Journey – How the Way We View Data is Being Transformed," pp. 83–88, 2014.
[8] E. Pemberton, J. Rankin, and I. Kondratova, "Mobile computing technology - Adoption issues for inspectors in the AEC industry," *Proceedings, Annu. Conf. - Can. Soc. Civ. Eng.*, vol. 2, no. November 2016, pp. 1081–1090, 2009.
[9] S. Stieglitz, C. Lattemann, and T. Brockmann, "Mobile applications for knowledge workers and field Workers," *Mob. Inf. Syst.*, vol. 2015, 2015.
[10] M. Kakihara and C. Sorensen, "Expanding the ' Mobility ' Concept," *Slggr. Bull.*, vol. 22, no. 3, pp. 33–37, 2001.
[11] S. Liew, "Role of Geotechnical Engineer in Civil Engineering Works in Malaysia," *G&P Geotech. Sdn Bhd*, 2009.
[12] D. L. Goodhue and R. L. Thompson, "Task-technology Fit and Individual Performance," *MIS Q.*, vol. 19, no. 2, pp. 213–236, Jun. 1995.
[13] R. Basole, "The value and impact of mobile information and communication technologies," *Proc. IFAC Symp. Anal.*, pp. 1–7, 2004.
[14] J. Gebauer and Y. Tang, "Applying the Theory of Task-Technology Fit to Mobile Information Systems : The Role of User Mobility," *Sixth Int. Conf. Manag. Mob. Bus.*, no. Icmb, p. 8, 2007.
[15] Y. Yuan, N. Archer, C. E. Connelly, and W. Zheng, "Identifying the ideal fit between mobile work and mobile work support," *Inf. Manag.*, vol. 47, no. 3, pp. 125–137, 2010.
[16] J. L. Pearce, S. M. Sommer, A. Morris, and M. Frideger, "A configurational approach to interpersonal relations: Profiles of workplace social relations and task interdependence," *Grad. Sch. Manag. Univ. California, Irvine, Novemb.*, 1992.
[17] E. Scornavacca, "An investigation of the factors that influence user acceptance of mobile information systems in the workplace" *Victoria Univ. Willingt.*, 2010.
[18] M. Lembach and M. S. Lane, "The fit of mobile work support functionalities with pharmaceutical sales-force worker tasks," *Proc. Int. Conf. Electron. Bus.*, pp. 346–353, 2011.
[19] H. Sheng, F. F.-H. Nah, and K. Siau, "Strategic implications of mobile technology: A case study using Value-Focused Thinking," *J. Strateg. Inf. Syst.*, vol. 14, no. 3, pp. 269–290, 2005.
[20] T. Brockmann, S. Stieglitz, and C. Lattemann, "Taxonomy of enterprise-related mobile applications," *Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics)*, vol. 8531 LNCS, pp. 37–47, 2014.
[21] Y. Chen and J. M. Kamara, "A framework for using mobile computing for information management on construction sites," *Autom. Constr.*, vol. 20, no. 7, pp. 776–788, 2011.
[22] D. S. Staples and P. Seddon, "Testing the Technology-to-Performance Chain Model," *J. Organ. End User Comput.*, vol. 16, pp. 17–36, 2004.
[23] A. Ahmed, "Role of GIS,RFID and handheld computers in emergency management: An exploratory case study analysis" *Journal of Information Systems and Technology Managemen*, vol. 12, no. 1, pp. 3–28, 2015.
[24] S. Deibert, E. Hemmer, and A. Heinzl, "Mobile technology in the construction industry - the impact on business processes in job production," *15th Am. Conf. Inf. Syst. 2009, AMCIS 2009*, vol. 8, pp. 5326–5335, 2009.
[25] M. Ahearne, E. Jones, a. Rapp, and J. Mathieu, "High Touch Through High Tech: The Impact of Salesperson Technology Usage

on Sales Performance via Mediating Mechanisms," *Manage. Sci.*, vol. 54, no. 4, pp. 671–685, 2008.
[26] YAN CHU and L. Huang, "Mobile Technologies Adoption: An Exploratory Case Study," *Tsinghua Sci. Technol.*, vol. 13, no. 3, pp. 300–305, 2008.
[27] M. Vuolle and J. Kapyla, "Theoretical Evaluation Models Used in Mobile Work Context," *2010 Ninth Int. Conf. Mob. Bus. 2010 Ninth Glob. Mobil. Roundtable*, pp. 425–431, 2010.
[28] N. Zhang, X. Guo, F. Wang, G. Chen, and Q. Wei, "Task-technology fit in mobile work: Exploring the links between task attributes and technology characteristics," in *Proceedings - 2011 10th International Conference on Mobile Business, ICMB 2011*, 2011.
[29] S. Deibert, E. Hemmer, and A. Heinzl, "Mobile Technology in the Construction Industry – the Impact on Business Processes in Job Production," *Proc. Fifteenth Am. Conf. Inf. Syst.*, pp. 1–10, 2009.
[30] Y. Chu and L. Huang, "Mobile Technologies Adoption: An Exploratory Case Study," *Tsinghua Sci. Technol.*, vol. 13, no. 3, pp. 300–305, 2008.
[31] W. Zheng, *The nature of mobile work and the needs for mobile work technology support: a task-technology fit perspective*. McMaster University, Canada, 2007.
[32] T.-P. Liang and C.-P. Wei, "Introduction to the Special Issue : Mobile Commerce Applications," *Int. J. Electron. Commer.*, vol. 8, no. 3, pp. 7–17, 2004.

AUTHORS PROFILE

Aamer Shehzad is a student of Master of Information Technology Management in Universiti Teknology Malaysia (UTM). His research inclinations are in web technologies, mobile computing and enterprise resource planning.
Dr. Mohd. Zaidi Abd Rozan is an Associate Professor in Faculty of Computing, Universiti Teknology Malaysia (UTM). His research interests are Technology Entrepreneurship, Natural Language Processing and IT Project Management. He is currently a Manager in UTM Technology Entrepreneurship Centre (UTMTEC).