Interaction between Theory and Practice in Civil Engineering and Construction
Edited by Komurlu, R., Gurgun, A. P., Singh, A., and Yazdani, S.

ISBN: 978-0-9960437-2-4

ADOPTING BIM IN ARCHITECTURAL DESIGN OFFICES

YELIZ TULUBAS-GOKUC[1] and DAVID ARDITI[2]

[1] *Dept of Architecture, Balikesir University, Balikesir, Turkey*
[2] *Dept of Civil, Architectural and Environmental Engineering, Illinois Institute of Technology, Chicago, USA*

Developments in technology such as Building Information Modeling (BIM) have recently created serious competitive pressures on architectural design firms and building construction companies. Design firms and construction companies need to adopt these new technologies to survive and thrive in this environment. Despite the advantages of BIM in building design, its adoption by architectural design firms has been slow due to obstacles such as lack of familiarity with BIM, lack of training in BIM, and lack of supporting resources such as hardware and software. The problems faced in adopting BIM were investigated by only few researchers who focused on the acceptance or penetration of BIM into construction firms. The objective of this research is to develop an integrated model to understand the adoption of BIM in architectural design firms. The model involves (1) the fit between the tasks to be performed by design professionals and the technology provided by BIM, (2) the fit between the organizational competency in the design firm and the capabilities offered by BIM, and (3) the fit between the designers' knowledge/skills in BIM and the sophistication of the BIM product. After a thorough review and synthesis of technology adoption models and theories, this paper proposes an integrated model to understand the adoption of BIM by architectural design firms. The model argues that using BIM depends on BIM's properties as well as the tasks at hand, the organizational competency of the company, and the perceived ease of use.

Keywords: Building information modeling (BIM), Technology acceptance model, Architectural design firms, BIM adoption, BIM technology fit.

1 INTRODUCTION

Design firms need to adopt new technologies to survive in the current environment. For example, Eastman *et al.* (2011) think that individual firms are motivated to adopt BIM, not only to improve their design and construction practices, but also to gain a competitive advantage in the marketplace. Building Information Modeling (BIM) is such a technology.

Despite the advantages of BIM in building design, its adoption has been slow due to some obstacles such as lack of familiarity with adopting BIM, lack of supporting education and training for use of BIM, and lack of supporting resources such as hardware and software (Lee *et al.* 2013). The problems faced in adopting BIM are treated only in a few studies that focus on the acceptance or penetration of BIM in construction firms rather than in design firms (Lee *et al.* 2013, Wang *et al.* 2013, and

Enegbuma *et al.* 2014). The variables that are used in these studies include organizational intention and support of leadership (Lee *et al.* 2013, Wang *et al.* 2013).

This research aims to develop an integrated model to understand the adoption of BIM in architectural design firms. The model involves (1) the fit between the tasks to be performed by design professionals and the technology provided by BIM, (2) the fit between the organizational competency in the design firm and the features offered by BIM, and (3) the fit between the designers' knowledge/skills in BIM and the sophistication of the BIM product.

2 INNOVATION ADOPTION MODELS

User acceptance of technology has been an important field of study. Many models have been proposed to predict and explain the acceptance or rejection of information technologies. Researchers have emphasized task-technology fit (Goodhue and Thompson 1995) and culture-technology fit (Lee *et al.* 2007). Information systems investigators have suggested intention models inspired from social psychology as potential theoretical foundations for research on the determinants of user behavior (Fishbein and Ajzen 1975, Ajzen and Fishbein 1980). Some of these studies were inspired from the Theory of Reasoned Action of Fishbein and Ajzen (1975) and the Technology Acceptance Model of Davis (1989). Some researchers fully implemented these models while others expanded these models by adding new variables. It must be noted however that the majority of the current literature concentrates on the user's acceptance of technology in different industries (health, telecommunications, tourism, banking, etc.), but not in the construction industry except for a small group of studies (e.g., Son *et al.* 2012, Lee *et al.* 2013, Park *et al.* 2012).

The first behavioral models are the theory of reasoned action (TRA) and the theory of planned behavior (TPB). Another behavioral model is the technology acceptance model (TAM) that was derived from the theory of reasoned action (TRA). These models are briefly described in the following subsections.

2.1 Theory of Reasoned Action (TRA)

Fishbein and Ajzen's (1975) theory of reasoned action is an especially well-researched intention model. It has proven successful in predicting and explaining behavior across a wide variety of domains (Davis *et al.* 1989). According to the theory of reasoned action, a person's performance of a specified behavior is determined by the person's "behavioral intention" to perform the behavior, and "behavioral intention" is jointly determined by the "person's attitude" and "subjective norms". The theory of reasoned action provides a model that has potential benefits for predicting the intention to perform a behavior based on an individual's attitudinal and normative beliefs. This model was extended to accommodate developments in the variables and the resulting model was named the theory of planned behavior (Southey 2011).

2.2 Theory of Planned Behavior (TPB)

The theory of planned behavior is an extension of the theory of reasoned action and was proposed by Ajzen (1991) to improve the predictive power of the theory of reasoned action by adding perceived behavioral control. Perceived behavioral control refers to people's perceptions of their ability to perform a given behavior.

2.3 Technology Acceptance Model (TAM)

The technology acceptance model was introduced by Davis (1989). According to Davis *et al.* (1989), the goal of the technology acceptance model is to provide an explanation of the determinants of computer acceptance that is general, capable of explaining user behavior across a broad range of end-user computing technologies and user populations, while at the same time being both parsimonious and theoretically justified. The technology acceptance model uses the theory of reasoned action as a theoretical basis for specifying the causal linkages between two key beliefs: perceived usefulness and perceived ease of use, and users' attitudes, intentions and actual computer adoption behavior. The technology acceptance model is considerably less general than the theory of reasoned action, designed to apply only to computer usage behavior. However, because it incorporates findings accumulated from over a decade of information systems research, it may be especially well-suited for modeling computer acceptance (Davis *et al.* 1989). To determine behavioral intentions, the technology acceptance model depends on two beliefs, perceived usefulness and perceived ease of use.

Perceived usefulness is defined by Davis *et al.* (1989) as the prospective user's subjective probability that using a specific application system will increase his or her job performance within an organizational context. Perceived ease of use is the degree to which the prospective user expects the target system to be free of effort (Davis *et al.* 1989).

3 PROPOSED MODEL

This research proposes an integrated model that was inspired by Venkatesh and Davis's (2000) technology acceptance model, Goodhue and Thompson's (1995) task-technology fit model, and various other research studies such as the work of Lee *et al.* (2013). Figure 1 shows the proposed model. The fit between design tasks and BIM-provided features, the fit between organizational competency and BIM implementation, and the fit between staff competency and BIM requirements are expected to explain the adoption of BIM in design firms.

3.1 Design Task - BIM Technology Fit

The task-technology fit model considers how tasks (i.e., actions carried out by individuals in turning inputs to outputs) affect an individual's use of the technology. Task-technology fit is the degree to which a technology assists an individual in performing his or her portfolio of tasks (Goodhue and Thompson 1995). More specifically, task-technology fit is the correspondence between task requirements and the functionality of the technology. Eight factors were developed by Goodhue and Thompson (1995) to measure task-technology fit: data quality, locatability, authorization, compatibility, production timeliness, systems reliability, ease of use/training, and relationship with users.

The model used in this study, "design task - BIM technology fit" consists of the fit between the tasks normally performed by designers and BIM-provided features. The statements that were used to assess "design task - BIM technology fit" aim to determine to what extent the features provided by BIM overlap with the design tasks normally performed in architectural design firms.

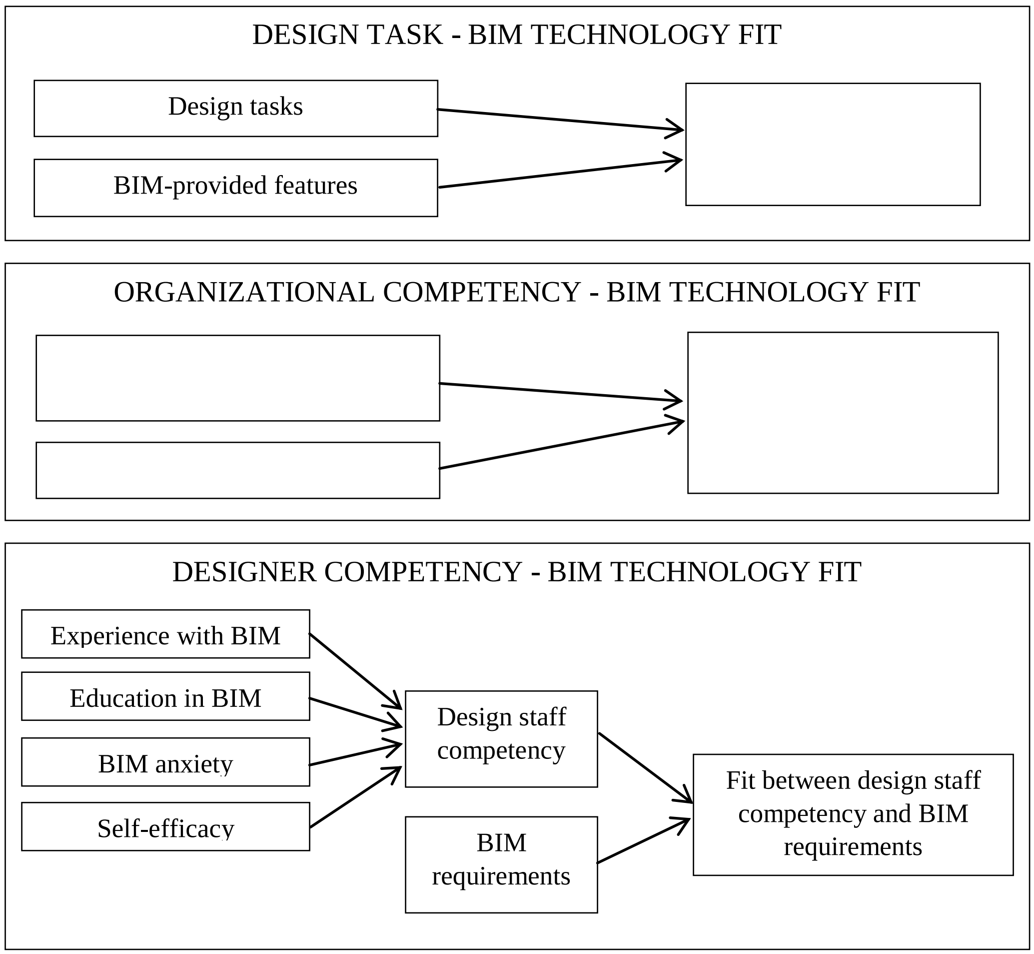

Figure 1. The proposed model.

3.2 Organizational Competency - BIM Technology Fit

Organization-technology fit involves the fit between organizational characteristics and technology implementation processes.

The model used in this study, "organizational competency – BIM technology fit" is defined as the degree of congruence between the know-how accumulated in the firm over the years and the implementation of BIM. In this study, the statements about the fit between organizational competency and BIM implementation processes were formulated by adapting to the BIM environment the findings of a research study conducted by Lee *et al*. 2007 where organizational competency was analyzed with respect to three dimensions: (1) collective efficacy, (2) organizational innovativeness, and (3) top management support. Collective efficacy refers to established beliefs in the organization, whereas organizational innovativeness is the willingness of an organization to try out a new technology. According to Lee *et al.* (2007), the decision by an organization to adopt a new technology may be risky unless there is a firm commitment from top management.

3.3 Designer Competency - BIM Technology Fit

User-technology fit can be defined as the degree to which a technology matches the skills and capabilities of individuals. If users have the necessary skills and knowledge to use a new technology, there is a good 'fit' between user and technology. According to Mohamadali and Garibaldi (2012), not only organizational capabilities but also user capabilities need to be evaluated to investigate the adoption of new technology. A user's knowledge, skills, expertise, and experience must match the requirements of the new technology. User-technology fit is an important factor in the adoption of BIM.

The model used in this study, "designer competency – BIM technology fit" measures the fit between design staff competency and BIM requirements by looking into user characteristics such as experience with BIM, education in BIM, BIM anxiety, and self-efficacy.

4 CONCLUSION

After a thorough review and synthesis of technology adoption theories, this paper proposes an integrated model to understand the adoption of BIM by architectural design firms. The model argues that the adoption of BIM depends not only on BIM-provided features, but also on the design tasks at hand, the organizational competency of the company, and the ease of use as perceived by design staff. An empirical study to justify the components of this model is underway. Once the model is validated, it is expected that it will shed light on the effect of the adoption of BIM on the performance of a design office.

References

Ajzen, I., The theory of planned behavior, *Organizational Behaviour and Human Decision Processes*, 50, 179-211, 1991.

Ajzen, I. and Fishbein, M, *Understanding attitudes and predicting social behavior*, Englewood Cliffs, NJ: Prentice-Hall,1-278, 1980.

Davis, F. D., Perceived usefulness, perceived ease of use, and user acceptance of information technologies, *MIS Quarterly*, 13(3), 319–340, 1989.

Davis, F. D., Bagozzi, R.P. and Warshaw, P.R, User Acceptance of Computer Technology: A Comparison of Two Theoretical Models., *Management Science* (35:8), 982-1002, 1989.

Eastman, C., Teicholz, P., Sacks, R., and Liston, K., *BIM handbook: a guide to building information modeling for owners, managers, designers, engineers and contractors,* Second Edition, John Wiley & Sons, 1-648, 2011.

Enegbuma, W. I., Dodo, Y. A., and Ali, K. N., Building information modelling penetration factors in Malaysia, *International Journal of Advances in Applied Sciences (IJAAS)*, 3(1), pp. 47-56, 2014.

Fishbein, M., and Ajzen, I., *Belief, attitude, intention and behaviour, an introduction to theory and research*, Addison Wesley Publishing Company, 1-573, 1975.

Goodhue, D. L. and Thompson, R. L., Task-technology fit and individual performance, *MIS Quarterly*, 19(2), 213-236, 1995.

Lee, S., Yu, J., and Jeong, D., BIM Acceptance Model in Construction Organizations, *Journal of Management Engineering*, 31(3), 2013.

Lee, I., Choi, B., Kim, J., and Hong, S. J., Culture-technology fit: effects of cultural characteristics on the post-adoption beliefs of mobile internet users, *International Journal of Electronic Commerce*, 11(4), 11-51, 2007.

Mohamadali, N. A. and Garibaldi, J. M., Understanding and addressing the 'fit' between user, technology and organization in evaluating user acceptance of healthcare technology, *5th International Conference on Health Informatics*, February, Vilamoura, Algarve, Portugal, 2012.

Park, Y., Son, H. & Kim, C., Investigating the determinants of construction professionals' acceptance of web-based training: an extension of the technology acceptance model, *Automation in Construction*, 22, 377-386, 2012.

Son, H., Park, Y., Kim C., and Chou, J. , Toward an understanding of construction professionals' acceptance of mobile computing devices in South Korea: An extension of the technology acceptance model, *Automation in Construction*, 28, 82-90, 2012.

Southey, G., The theories of reasoned action and planned behavior applied to business decisions: a selective annotated bibliography, *Journal of New Business Ideas and Trends*, 9(1), 43-50, 2011.

Venkatesh, V., and Davis, F. D., A theoretical extension of the technology acceptance model: four longitudinal field studies, *Management Science*, 46(2), 186–204, 2000.

Wang, Y., Xue, X., and Lia Y., Critical review on the impact factors of BIM application, *International Journal of Digital Content Technology and Its Applications (JDCTA)*, 7(8), 616-624, 2013.