THE EFFECT OF MTM AND THE TAM ON INNOVATION DIFFUSION: A CASE IN THE CONSTRUCTION INDUSTRY

GIBRAN DAWOOD
University of Pretoria, Department of Engineering and Technology Management, Graduate School of Technology Management, South Africa
gibran.dawood@aecom.com

KAI-YING CHAN
University of Pretoria, Department of Engineering and Technology Management, Graduate School of Technology Management, South Africa
alice.chan@up.ac.za (corresponding)

ABSTRACT

The construction industry is perceived as not being innovative. However, innovation is a source of competitive advantage in the industry. Past research has shown that if architectural and engineering design firms fail to understand the mechanisms that drive innovation, the associated likelihood of economic growth will not be enjoyed. This research has therefore focused on determining the influence of Multiple Team Membership (MTM) on innovation diffusion within the framework of the Technology Acceptance Model (TAM). The model developed for this research will aid with understanding the relationship between the TAM, MTM and innovation diffusion within teams. The results show that diversity dimension of MTM and Perceived Usefulness have impact on innovation diffusion. It is recommended that when an innovative technology is rolled out within an organisation, management should do so in teams of less diverse members and thoroughly educate employees on the usefulness of the innovation in their day to day jobs.

Key words: multiple team membership, innovation diffusion, technology acceptance model.

INTRODUCTION

Despite innovation's "cutting edge" qualities, it is not a modern concept. Joseph Schumpeter is believed to be the first economist who recognised the importance of innovation in the 1930's (Rogers, 2003). Innovation is considered to be a quintessential facet to many modern organisations' business strategies. It is no longer considered a driver of business success but a factor of business survival. Companies that innovate grow faster and perform better than companies that do not innovate (Roper et al., 2006), thus highlighting the importance of innovation diffusion within an organisation. Therefore if architectural and engineering design firms fail to understand the mechanisms that drive innovation, the associated likelihood of economic growth will not be enjoyed (Blayse and Manley, 2004). The approach to organizing has shifted from individual work in hierarchical structures, to team-based work in multi-team systems (multiple team membership) over the last century (O'Leary et al., 2011). For the rate of innovation diffusion to increase, it is proposed that multiple team membership plays a role because the user is able to develop more networks amongst these teams for information regarding the innovation to flow within an organisation. This research proposes two factors that facilitate innovation diffusion, namely multiple team membership and user's attitudes (which are framed within the framework of the Technology Acceptance Model). The main literature of these concepts is discussed further.

Diffusion of innovation

Diffusion is a process by which an innovation is communicated over time through certain channels among members of a social system (Rogers, 2003). Four elements are therefore required for the successful diffusion of an innovation:

1. The innovation: an idea, process or object perceived as new by a person or firm. The OECD (2005, pp.31) definition is by far the most widely used and authoritative and is adopted for this article:
2. "Technological product and process (TPP) innovations comprise implemented technologically new products and processes and significant technological improvements in products and processes"
3. Communication channels: the medium through which messages are exchanged between members of the social system
4. Time: Time is involved in diffusion in three areas: Innovation diffusion process, innovativeness and rate of adoption
5. A social system: a group of interrelated units who engage in joint problem solving to accomplish a common goal.

The rest of this section is adapted from Rogers (2003) and will describe the diffusion process within organisations in detail.

An organisation is a stable system of individuals who work together to achieve shared goals through a hierarchy of ranks and a division of labour. There are 5 stages in the innovation process within an organisation as depicted in figure 1 above. The 5 stages are broken down into two sub-processes namely the initiation and implementation sub-process.

The initiation sub-process consists of two stages, agenda setting and matching. These first two stages of the organisational innovation process entails all the information gathering, conceptualising and planning for the adoption of an innovation, culminating in a decision to adopt the particular innovation.

The implementation sub-process consists of three stages, redefining/restructuring, clarifying and routinizing. These latter three stages of the organisational innovation process entails all of the events, actions and decisions required to put the innovation into use within the organisation.

A brief summary of the 5 stages of the organisational innovation diffusion process is presented below:

i. Agenda setting: this occurs in the innovation process when a general organisational problem creates a perceived need for an innovation.

ii. Matching: is the stage in the innovation process at which a problem from the organisation's agenda is matched to an innovation.

iii. Redefining/Restructuring: In this stage the innovation is customised to suit the organisation's needs and structure.

iv. Clarifying: this stage occurs when the innovation is put into more general use in the organisation, so that the meaning of the new idea increasingly becomes clearer to the organisation's members.

v. Routinizing: this stage is reached when the innovation becomes part and parcel of the day to day activities of the organisation and has lost its distinct identity.

Looking deeper within firm level boundaries, the diffusion environment described above is clearly present in the modern day teams that work in architectural and engineering design firms. It is also common place for each member of these teams to be part of more than one other team. This may be the case either within the organisation and/or with other organisations.

Multiple team membership

O'Leary et al., 2011 developed a model which characterizes the effects of Multiple Team Membership on productivity and learning in terms of three constructs: individual context switching, temporal misalignment, and intra-organizational connectivity. These constructs affect the allocation of attention and information flow at the individual, team, and firm levels, respectively. It is argued that multiple team membership (defined as an individual working in multiple teams at the same time) increases intra-organisational connectivity. The level of intra-organisational connectivity is described by the number of projects that utilise common resources within a company as well as the number of connections between these projects. The most relevant finding of the O'Leary *et al.* (2011) study is that at moderate levels, multiple team membership can benefit individuals, teams, and organizations by more effectively diffusing information. O'Leary et al. (2011) therefore hints at a causal link between moderate levels moderate Multiple Team Membership and diffusion of innovation.

Technology acceptance model

The technology acceptance model (TAM) is a theory that attempts to predict how users will come to accept a technology (Davis, 1989). TAM was developed by Davis (1986). A key function of TAM is to provide a way to trace the impact of external variables on internal beliefs, intentions, and attitudes. It postulates that perceived ease of use, and perceived usefulness are the two most important factors in explaining technology acceptance or actual system use (Legris *et al., 2003)*.

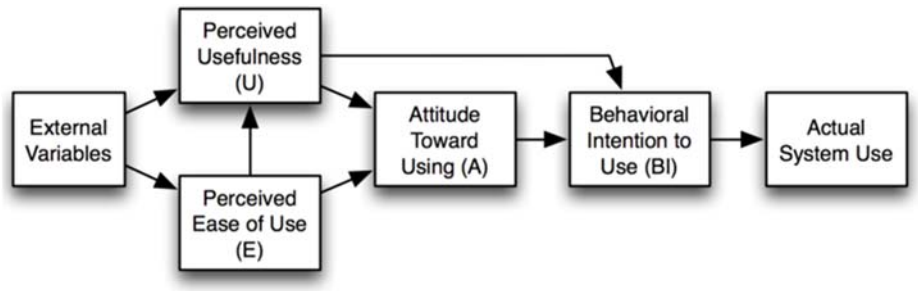

Figure 1: Technology acceptance model, Source: Davis (1986)

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et al., 2003). Therefore actual system use under this model coupled with Bandwagon pressures described by Abrahamson and Rosenkopf (1993) could lead to innovation diffusion.

One final aspect to consider is the apparent interdependency of actual system use under the TAM model and Multiple Team Membership. Actual use of an innovative tool or system by a single isolated individual/organisation in itself cannot cause the use of this innovation to spread. Diffusion theory covered above clearly indicates that the individual/organisation must be part of some social network, which communicates through certain channels over time in order for the diffusion of the innovation (Rogers, 2003).

Research objective and questions

The construction industry is perceived as not being innovative (Blayse & Manley, 2004). However, innovation is a source of competitive advantage in the industry (Eaton et al*.,* 2006; Manseau, 2005). The objective of this paper is explore how the relationship between the TAM, Multiple Team Membership and innovation diffusion could under cover key insights into ways of elevating the innovativeness of an organisation and thereby gaining a competitive market position.

Thus this study asks the following three research questions:

What influence does Multiple Team Membership have on innovation diffusion?

What influence does Multiple Team Membership have on perceived usefulness and perceived ease of use as described by the Technology Acceptance Model?

What effect does an increased perception of usefulness and ease of use by team members have on innovation diffusion in a multiple team environment?

CONCEPTUAL MODEL AND METHODOLOGY

This section presents the development of the conceptual method and methodology to investigate the effect of MTM and TAM on innovation diffusion within an organisation. The conceptual model is based on the TAM model.

Conceptual model

To answer the proposed research questions a conceptual model (see Figure 2) is formulated with relevant hypotheses.

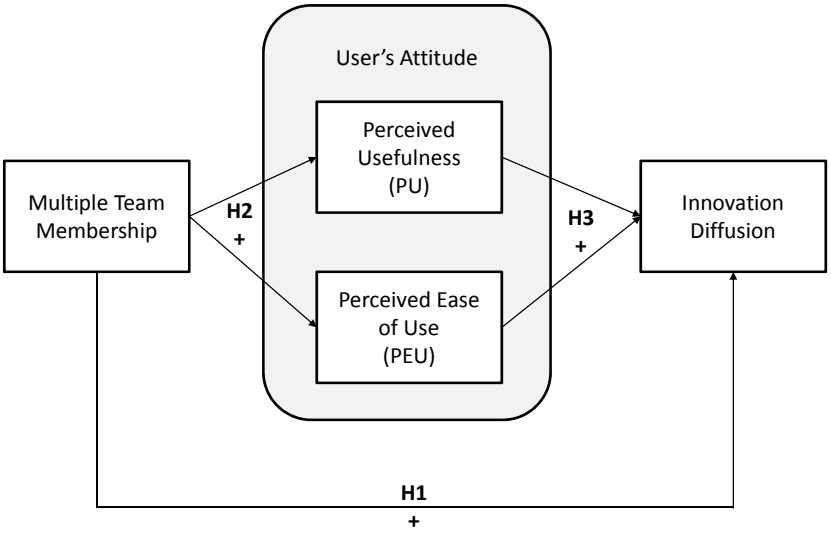

Figure 2: Conceptual model with hypotheses

The theoretical argument for Hypotheses H1 and H2 are based from the study by O'Leary et al. (2011). Firstly, they proposed that team productivity increases as MTM driven temporal misalignment increases because the temporal misalignment acts as a stimulus for more efficient work practices. From their proposition, we argue that an innovative product or process therefore diffuses in order to improve work practices to counter the effects of temporal misalignment. Theoretically this diffusion would take place where ever a member of the team is involved, be it internal or external to the organisation. Secondly, organisational learning increases as MTM intra-organisational connectivity increases due to increased paths for information flow and boundary spanning. Moreover, these paths for information flow within an organisation are described by Rogers (2003) as communication channels within a social system. Thus we argue that an increase in communication channels would foster a better environment for innovation diffusion. Based from the above two arguments, we propose that:

H1: There is a positive relationship between MTM and innovation diffusion.

For the second hypothesis in the conceptual model, we draw on the proposition made by O'Leary et al. (2011) that team learning increases as MTM driven temporal misalignment increases. The reason for their proposition is that team members spend more time apart from each other due to temporal misalignment resulting in more unshared information and experiences to share with the team. Teams gain diversity of perspectives through increased diversity of experience within members and across members. A team, therefore, with members who are each on one or more other teams draws on its own context as well as on all of the contexts to which its members are exposed to in their memberships of other teams. The context referred to by O'Leary et al., (2011) could well be a perception of usefulness or ease of use of an innovative product or process. In the Technology Acceptance Model, perceived usefulness (PU) is defined as "The degree to which a person believes that using a particular system would enhance his or her job performance". (Davis, 1989, pp. 320). Perceived ease of use (PEU) refers to "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, pp. 320). Both PU and PEU constitute to the theoretical construct namely User's Attitude. In an organisational environment the relationship between perceived usefulness and behavioural intention to use means that a person would develop

intentions toward behaviours that they believe would increase their work performance, in spite of their feelings about the behaviour (Davis et al., 1989)

A team drawing on this context means that MTM enhances the effects of perceived ease of use and perceived usefulness. Thus, the second hypothesis reads:

H2: There is a positive relationship between MTM and perceived ease of use (PEU) and perceived usefulness (PU).

As discussed above teams gain diversity of perspectives through increased diversity of experience within members and across members. A team, therefore, with members who are each on one or more other teams draws on its own context as well as on all of the contexts to which its members are exposed to in their memberships of other teams. (O'Leary et al., 2011). Therefore in an MTM environment, an easy to use innovation that is proven to enhance job performance which is shared in a team context would cause the innovation to diffuse to other team members as the team draws on its own context. This context will also spread to other teams where these individuals are members. Thus the third hypothesis is put forward as:

H3: There is a positive relationship between PU and PEU with innovation diffusion.

Research methodology

As the model proposed is untested current literature will not suffice in order to prove or disprove the hypotheses presented, it would only assist in hypothesis development. As this is the case a literature study was performed. To confirm the hypotheses proposed an empirical study will be conducted to draw on primary data.

The selected data collection method is Surveys research using questionnaires. This method allows for non-experimental hypothesis-testing. To this end the relationship between the following variables (with their definition) will be examined.

Variable 1: Multiple Team Membership – Membership of an individual in more than one team, internal or external to an organisation.

Variable 2: Innovation Diffusion – the implementation of a technologically new product or process

Variable 3: Perceived Usefulness – The degree to which an individual believes that using an innovative product or process would enhance his or her job performance

Variable 4: Perceived Ease of Use – The degree to which an individual believes that using an innovative product or process system would be free of effort

In order to have repeatable results the population, frame and sample must be defined. This study will be limited to the organisational boundaries of AECOM South Africa. The population of this study is 147 employees who will use BIM from. A total of 147 BIM users in AECOM were invited to fill out the questionnaire online, 59 employees responded. This gives a response rate of 40.14%.

As a quantitative research design is proposed, quantitative data analysis will adopted. Statistical validity will be used in order to find a relationship between variables proposed. This will allow a statistically valid conclusion to be met. The items in the questionnaire are detailed below together with their link to relevant literature. The measurements used in this research are shown in Table 1.

Table 1: Item(s) of Variables

Variable	Items with codings	Source
Control variables		
Gender	Please select your gender (Male =1; Female = 2)	n/a
Age	In which year where you born (=2014 minus the year the respondent is born)	n/a
Education	What is the highest education degree you have obtained (high school =1; bachelor's degree = 2; post graduate diploma =3; honours degree =4; masters degree = 5; doctorate =6)	n/a
Tenure	How long have you worked in your current company? (less than 1 year or stipulate how long if more than 1 year)	n/a
Position	What position do you currently hold? (employee = 1; first level manager = 2; middle management = 3; senior management = 4)	n/a
Multiple Team Memberships (MTM)		
MTM Number	Of the project teams you were involved in over the last 6 months, how many of them overlapped (i.e. you were involved in simultaneously / at the same time)? (none of them over lapped = 1; two project teams overlapped = 2; more than two projects = number stipulated)	O'Leary, et al. (2011)
MTM Diversity	On average, how many of your team members share the same technical knowledge background as yours? (5 point Likert scale: 1= with a few to 5=with everyone; reverse coded)	O'Leary, et al. (2011)
Innovation Diffusion		
Diffusion in my team (Diffusion)	How many of your team members do you share information about REVIT® with (5 point Likert scale: 1= with a few to 5=with everyone)	Rogers (2003)
User's Attitude		
Perceived Usefulness (PU) Cronbach's alpha = 0.956	6 items were used: • Using REVIT® in my job would enable me to accomplish tasks more quickly. • Using REVIT® would improve my job performance. • Using REVIT® would increase my productivity. • Using REVIT® would increase my effectiveness on the job. • Using REVIT® would make it easier to do my job. • I would find REVIT® useful in my job *(7 points Likert scale: 1= Extremely unlikely to 7= Extremely likely)*	Davis (1989)
Perceived Ease of Use (PEU) Cronbach's alpha = 0.918	6 items were used: • Learning to operate REVIT® would be easy for me. • I would find it easy to get REVIT® to do what I want it to do. • My interaction with REVIT® would be clear and understandable. • I would find REVIT® to be flexible to interact with. • It would be easy for me to become skilful at using REVIT®. • I would find REVIT® easy to use. *(7 points Likert scale: 1= Extremely unlikely to 7= Extremely likely)*	Davis (1989)

RESULTS

Descriptive analysis

Descriptive statistics of all variables used in the research are reported below in terms correlation matrix with their mean and standard deviation values.

From the correlation matrix table, none of the control variables correlate with innovation diffusion. The only control variable which has correlation with the variables in the conceptual model is age. Age is positively correlate at a moderate level (r=0.33) with MTM number. In other words, older individuals work in more multiple projects at a time. Diffusion has a slight negative correlation (r=-0.27) with MTM diversity. This means the more diverse the team that an individual is involved in, the less he/she with diffuse the innovation to the team. Both PU and PEU have positive correlations with diffusion (r=0.385, 0.238 respectively). The more the individual who perceives BIM to be useful and easy to use, the more likely that he/she diffuses this innovation into the team.

Table 2: Means and Standard Deviations

Variable	Mean	Std. Dev.	Correlation Matrix									
			1	2	3	4	5	6	7	8	9	10
1. Gender	1.18	0.39	1									
2. Age	32.01	7.74	-0.11	1								
3. Education	2.34	1.35	-0.14	-0.06	1							
4. Tenure	3.38	3.42	0.14	0.16	-0.16	1						
5. Position	1.39	0.71	-0.06	0.18	-0.05	0.43	1					
6. MTM number	3.93	5.64	-0.12	0.33	0.001	-0.05	0.34	1				
7. MTM diversity	2.91	1.21	0.07	0.08	0.197	-0.05	0.02	0.03	1			
8. Diffusion	2.79	1.57	-0.12	0.15	-0.13	0.16	0.14	0.054	-0.27	1		
9. PU	5.41	1.55	-0.03	-0.29	0.02	-0.04	0.103	0.075	-0.14	0.385	1	
10. PEU	5.22	1.09	-0.18	-0.09	-0.07	-0.14	-0.02	0.026	-0.28	0.238	0.56	1

Regression analysis

The regression analysis below tests hypotheses (Hyp.) 1 to 3. Variables are entered hierarchically into the model with control variables entered at the first steps, then the independent variables (IV) are entered as the second step. A summary table showing only the independent variables of interest in the conceptual model is presented in Table 4 which shows the independent variables (IV), dependant variables (DV), F value, ΔR^2 and regression coefficients (β value). The β value indicates the strength of the impact that IV has on the DV and the corresponding p values will indicate the statistical significance of the beta values. Thus with regression analysis one can determine whether to accept or reject the hypotheses. The F Value used in the regression determines the validity of the proposed regression model. As can be seen in Table 4 only portions of H1, H2 & H3 are statistically valid. The ΔR^2 percentage shows how much the IV explains the change in the DV. Again from Table 3 below V1 (MTM), V3 (PU) & V4 (PEU) have the highest ΔR^2 percentage and explains 36.7% of the change in V2 (Innovation Diffusion).

Table 3: Regression summary results

Hyp.	DV	IV		β	ΔR^2	F-value	Hyp. Accept /Reject
1	V2: Diffusion	V1: MTM	MTM number	-0.411	18.7%	1.775*	Reject
			MTM diversity	-0.268**			Accept
2	V3: Perceived usefulness (PU)	V1: MTM	MTM number	-0.059	11%	1.474	Reject
			MTM diversity	-0.116			Reject
3	V4: Perceived ease of use (PEU)	V1: MTM	MTM number	-0.101	16%	0.973	Reject
			MTM diversity	-0.258*			Accept
4	V2: Diffusion	Perceived ease of use		-0.083	36.7%	2.320**	Reject
		Perceived usefulness		0.415***			Accept

** : p<0.1; ** : p<0.05; *** : p<0.001;*

CONCLUSION

This research seeks to determine the influence of Multiple Team Membership on innovation diffusion within the framework of the Technology Acceptance Model in a single large South African Architectural and Engineering design firm. Based on an extensive literature review of relevant data, a model was developed to predict the effect of MTM on perceived usefulness, perceived ease of use and innovation diffusion. All the β values used in the proposed model are shown below in Figure 3.

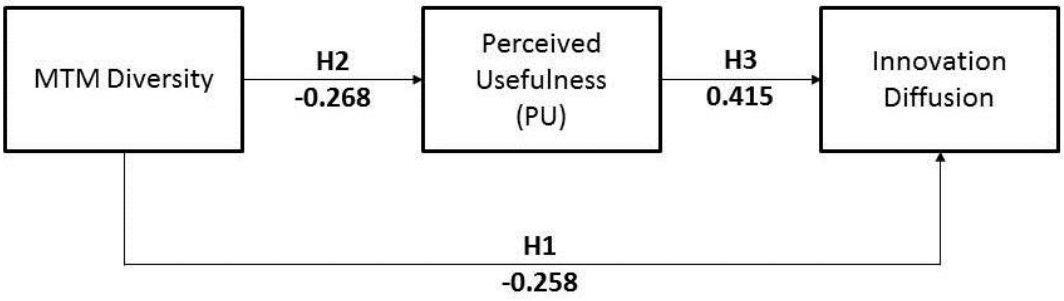

Figure 3: Research model showing hypotheses and significant values

MTM & Diffusion: From the regression analysis, MTM in terms of number of concurrent teams has no impact on the diffusion within a team, however the diversity of these concurrent teams have a negative impact on diffusion in a team. Thus if the management of the organisation wants a technological innovation to diffuse faster in a team, they should make sure that the team is not too diverse in terms of knowledge backgrounds amongst the team members.

Perceived usefulness & Diffusion: from the research data there is clear evidence which shows that an enhanced perception of usefulness supports diffusion of innovation. This result means that in order to support the adoption of an innovation within an organisation management should clearly show employees how the innovation would (from Davis' (1989) measurement of perceived usefulness):

i. Assist them to accomplish tasks more quickly
ii. Improve their job performance
iii. Increase their productivity

iv. Increase their effectiveness on the job

v. Make it easier to do their job

vi. Find it useful in their job

This can be done in a number of ways: interactive workshops; online discussion boards where Q&A sessions can be held; training sessions; Hands on sessions showing practical application to existing projects/tasks/objectives

For a future study it should be noted that this study was conducted on a small scale, within the boundaries of a particular company (AECOM). Further due to the nature of work AECOM conducts, the study was limited to the construction sector. MTM, TAM and diffusion are applicable to a wide cross-section of industries and this study can therefore be extended to include multiple sectors to develop a generic understanding of how the three factors influence each other. Once these factors are understood in a generic/global sense, implementation of any innovation in any sector could potentially be effectively executed.

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