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Administering AEC Professionals' Project Delivery Cross-Culture Productivity: Malaysia vs United Kingdom

(Mentadbir Produktiviti Penyampaian Projek Silang Budaya Profesional AEC: Malaysia lwn United Kingdom)

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ABSTRACT

Borderless world is transforming construction professionals on how to communicate and work across the globe. Many missed communication and different work culture could result in many variation orders and time wastage in construction. This paper looks to discuss the mixed research methodology results on how to administer architect, engineer and contractor (AEC) professionals' cross-work culture productivity during building deployment. 34 participants were selected for semi-structured interviews and participatory observations were conducted in two multidisciplinary teams of architect, engineer, and contractor from the United Kingdom (UK) and the Malaysia firms for six months. Then, SimVision® simulations were use as the Cognitive Organizational Theory (COT) protocols based on structural system and project dexterity parameters. Statistics corroborations were then conducted to obtain generalization and reliability. The case study results showed that the UK and the Malaysian team have similarities in operating nature of building deployment and differences in practice and value preferences when delivering a project, whilst model MMsRwB is the ideal for replicating UK's project productivity efficiency. The findings could guide international construction professionals or teams from developed and developing countries to joint venture in their country successfully especially for Malaysian context. The paper would firstly discuss the literature, secondly describe the mixed method methodology and then present the expected result. The paper recommends future research on formalizing communication system for AEC professionals through integrating Malaysian AEC transdisciplinary global practice in a design studio education program.

Keywords: Sustainable design culture; cross-work culture; cultural knowledge; transdisciplinary practice; AEC

INTRODUCTION

Green building and building information modelling (BIM) are driving profound changes within architecture, engineering, and construction (AEC) industry. AEC professionals will need to shift the way how they work and collaborate with global partners in future.

BIM can provide the information needed to improve the design and functioning of buildings. Through *Construction 4.0 Strategic Plan* (2021-2025)(CIDB Malaysia 2020), the Malaysian Government encouraged Malaysian AEC professional to apply BIM and industrialized project. However, some highlighted that building deployment and BIM were not fully accepted particularly in Malaysia due to BIM's cost, interoperable issues, and fragmentation difficulties in adoption during project deployment (Kamal Hasni et al. 2019). AEC professionals' cultural characteristics such as complacency with 2D drawings convention, previous tertiary training and previous project experiences are seen to make them averse to change (Ghaffarianhoseini et al. 2017; Okakpu et al. 2022; Toomey et al. 2017). This could be a major issue especially during cross-culture project delivery when global counterparts are planning to collaborate effectively with developing countries, consequently, impair project performance and increased variation orders. Therefore, the

paper seeks to inquire how to administer cross-work culture AEC professionals' productivity during building deployment.

LITERATURE REVIEW

Sacks et al. (2010) described that BIM is the Virtual Design and Construction (VDC) due to its similar principles, mechanisms, and processes. When the project team understands early during design stage about preassembly (Ibrahim & Abdul Ghafar, 2021; Kam et al. 2003); application and occupational problems (Gharouni Jafari et al. 2021; Lai & Deng, 2018), these could influence the project solutions. Knowledge flow is needed to hinder rework between team members during a complex dynamic project environment (Ghafar et al. 2018; Ibrahim & Nissen, 2007). Consequently, BIM application could aid streamlined construction industry's complex processes but would depend on how work culture manners and knowledge transfer differences among team members and building professionals' practices (Ghafar et al. 2018). New design tools are acquired when involved the east vs the west professionals' collaborations (Abdul Ghafar 2016; Horii et al. 2005).

This study anticipates that BIM technology visualization tools and culture could support AEC practices to undergo a new paradigm shift in building deployment (Ghafar & Ibrahim, 2020; Ibrahim & Abdul Ghafar, 2021). Hence, shaping professionals' culture knowledge is crucial (Abdul Ghafar, 2016; Horii et al. 2005). Tacit knowledge could not be lost (Arditi et al. 2017; Zheng et al. 2019) and could reduce unnecessary production wastage (Abdul Ghafar & Ibrahim, 2018). Unfortunately, not much research has been done on the micro-behaviour cross-project organization culture to improve project delivery productivity.

This shows that regardless of having competent BIM technology, cultural knowledge is needed to provide better output, information flow and interdependencies among members. Therefore, this study postulates that when cultural knowledge (work culture, knowledge management and professionals' collaboration) is enhanced between professionals and paring good tools, productivity competency can be improved, and production of construction wastage can be reduced in industrialized project. In determining the theoretical development, rationalizing correlation between theoretical operational constructs to consolidate the technique in obtaining data from field work is needed (Yin 2009). This study's theoretical proposition presents six theoretical operational constructs that are 1) work culture, 2) technology support, 3) production efficiency, 4) knowledge management, 5) professional collaboration, and 6) wastage reduction.

Work culture: this construct denotes that mitigating professional cultural differences in the early stage of design could hinder knowledge loss and facilitate productivity. The propositions guide this study to look further on impacts of project team performance. Participant-observational method is opted for this study because it takes place in the natural setting of the AEC professionals (Yin 2009). The findings are then encoded in computational experiment parameters to identify criteria for successful AEC professional's collaboration to reduce waste. *Technology support*: according to Babbie (2004) using a test or experiment on a controlled group could give comprehension and evaluation of a natural event with the effect of stimuli in real life. Here, hypothesis testing is appropriate to determine causes. This study implies computational experiment to test the hypotheses obtained from the field work. Therefore, this study hypothesizes that when productivity efficiency (PE) is high, waste production is low when work culture (WC), knowledge management (KM) and professional collaboration (PC) are controlled.

Productivity: This construct directs this study to compare between baseline models using BIM technology intervention to the actual models according to the project's workflow. From here, tacit and explicit knowledge flow characteristics will be determined. *Knowledge management*: this construct calls for establishing interdependency tasks that could affect the inflow and outflow of tacit knowledge during delivery. *Professional collaboration*: this construct looks at establishing practice attributes and value preferences. *Reduce waste*: in order to generalize understanding about a studied case, computational experiment is used to validate qualitative findings. Independent variable and dependent variable are implied for pre-testing and post testing using baseline models based on the hypothesis. The tested hypothesis is when productivity efficiency (PE) is high, waste production is low, while work culture (WC), knowledge management (KM) and professional collaboration−technology− (PC) are controlled.

METHODOLOGY

This study opts for a mixed-method research methodology. The qualitative part of the methodology is based on Taylor et al. (2011) and Yin (2009) in developing the case study research design (CSRD). The study's proposition has further directed the study to look on impacts of project team performance. Intellective *Cognitive Organizational Theory* (COT) experiments using SimVision® are utilised

to Malaysian and UK projects conceptual models to compare the optimum collaboration and productivity during industrialized building project in identifying prudent parameters for knowledge culture change.

The logic for the case study research approach is based on five components and four steps validation as highlighted by Yin (2009).(Refer Table 1). Table 2 illustrates the operationalized variable needed for the CSRD to confirm this study's theoretical proposition

TABLE 1. The Five Components and four step validation following

Components	Logic	Four steps validation
1. The main research question:	Starting with a *why* or a *how* denotes the logic to use case study research methodology Yin (2009). The main research question starts with "*How can improvement of productivity competency through visualization tools could reduce construction waste?"*	
2. Proposition statement:	Systematic and verifiable steps of key components are obtained using theoretical proposition (Yin, 2009). When cultural knowledge (*work culture, knowledge management and professionals' collaboration*) is enhanced between professionals and paring good tools, productivity competency can be improved, and production of waster could be reduced in industrialized project.	
3. Unit of analysis.	The subject implied in this study is a single case project team using multiple design case (Taylor et al. 2011; Yin, 2009) . This study uses two real life project cases from two different nation. One project is a Malaysian Project that has 16 members, and another project is a United Kingdom project that has 18 members. These two projects have comparable complexity with project characteristics of multi-disciplinary practice; practice parameters (such as hierarchy style, formal communication structure; application of BIM in project, and understanding of professional values among team members when doing task and making decision.	1) External validity ■ Generalization is obtained from the use of CSRD replication logic
4. The logic linking data to proposition.	Using the study's proposition, this study links and justifies the correlation between theoretical operational constructs to establish data collection approach. There are six measurable keywords that have been identified from the case study's proposition. This can be referred to in Table 3.	2) Construct validity ■ Multiple sources of evidence - Identification of successful cultural-reduce waste collaboration criteria during participant-observation. - Documentation of tacit matters and interdependence of task during DD-CI; identify the process of collaboration and tools in reducing industrial waste. - archived minute meetings were investigated to identify the numbers of rework and miscoordination. 3) Reliability ■ CSRD protocol is used for cases to build reliability. Financial matters are not covered in the project due to prior confidentiality agreement.
5. The criteria for interpreting the findings	This study predicts that 60% of time and delivery could be reduced when productivity efficiency value is 80% whilst BIM and professional culture (*work culture, knowledge management and professional collaboration*). being controlled.	4) Internal validity ■ hypothesis's dependent and independent variable would be used to derive pattern matching in testing the result and compare with the baseline model. Then this study gets affirmation from all the AEC professional team members to validate the hypothesis.

Source: Yin (2009)

TABLE 2. Theoretical proposition Operationalized Constructs

Construct	Definition	Evidence Sources	Result
Work culture	Work etiquette– *4D visual communication, detailing level, interoperability* – of an institution to back up agile collaboration and making decisions whilst reducing industrial waste	Literature Review (LR) Participant Observation	Identify culture criteria based on practices and value attributes
Knowledge management	Efficient method of tacit information transfer when processing workflow to reduce construction wastage	LR Participant Observation	Establish tacit knowledge area
Professional collaboration	Techniques of visual communication between stakeholders in reducing construction wastage	LR Participant Observation	Identify collaboration process

SEMI-STRUCTURED INTERVIEW PROTOCOL AND PARTICIPANT OBSERVATION PROCEDURE

The participant-observation technique is used in both mixed commercial-office-residential projects in Malaysia and in United Kingdom. Data was collected from Monday to Friday; 8am-5.30pm for six months, and the gatekeepers would give document and human resources access in the offices. A gatekeeper is a firm's admin that controls information and human resource in the office during data collection. Archived meeting minutes, interviews, and observation are the main sources of data. 16 participants come from the M Project and 18 participants from the UK Project. They are involved in one-hour interviews and transcribed by the end of the day. Discussion with the gatekeeper is done weekly to get feedback and get redirection when needed. Ten semi-structured interview questions are conducted, and results are inferred into themes of similarities and dissimilarities. The interviews delved into the professionals' collaboration approach, and BIM knowledge management and work culture of the respective teams use participant observation technique to identify the results. This method supports in meeting logic of the CSRD (Taylor et al. 2011).

In validating the hypothesis statement, this study needs to prepare for hypothesis testing to obtain confirmation from the Malaysian project (M) and United Kingdom project (UK) in having discontinuous operating characteristics (Ibrahim & Paulson 2008). Upon confirmation of discontinuous organization in both projects, then this study determines the work culture preference (Horii et al. 2005) for both projects. This study then starts to compare work culture preference between the M and UK. After that this study will provide recommendations to bring the M towards the UK productivity to reduce time and delivery waste.

COMPUTATIONAL EXPERIMENT VALIDATION

The aim of this study is to seek depiction the computational experiment in integrating cultural knowledge theory in organization design of a global project. This study is a first attempt to test how BIM technology with cultural knowledge could expedite the comprehension and productivity efficiency of a global project. This study extends an agent-based computational organization tool called the Virtual Design Team (VDT) (Jin & Levitt, 1996; Kunz, Levitt, & Jin, 1998) to test the hypotheses that include influences of cultural knowledge preferences in performance of project, and methodology on how this study extends the VDT tool. In doing so, Hofstede's national culture model is used to identify international organization (Beugelsdijk et al. 2017)

RESULT AND DISCUSSION

There are five consecutive phases in the life cycle of a building project identified by Ibrahim and Paulson (2008),: 1) *Feasibility- the phase when developer will approve or disapprove of the project; 2) Entitlement- acquiring the legal planning permission to build from authorities; 3)* Building permit- gaining permission to construct provision on site; 4) *Construction- starting physical construction works on site;* 5) *Property Management*–duration of the project's construction. Using these five sequential phases, the result of the case study is mapped. The results indicates that M and UK project's during deployment have sequential and multiple phases (Refer Figure 1 and Figure 2). Both projects illustrate the multiple interdependent in the AEC's workflow and the developer's workflow. This confirms the first two environment factors discovered by Ibrahim and Paulson (2008a) that are the 1) concurrent and sequential workflow, and 2) multiple interdependencies task.

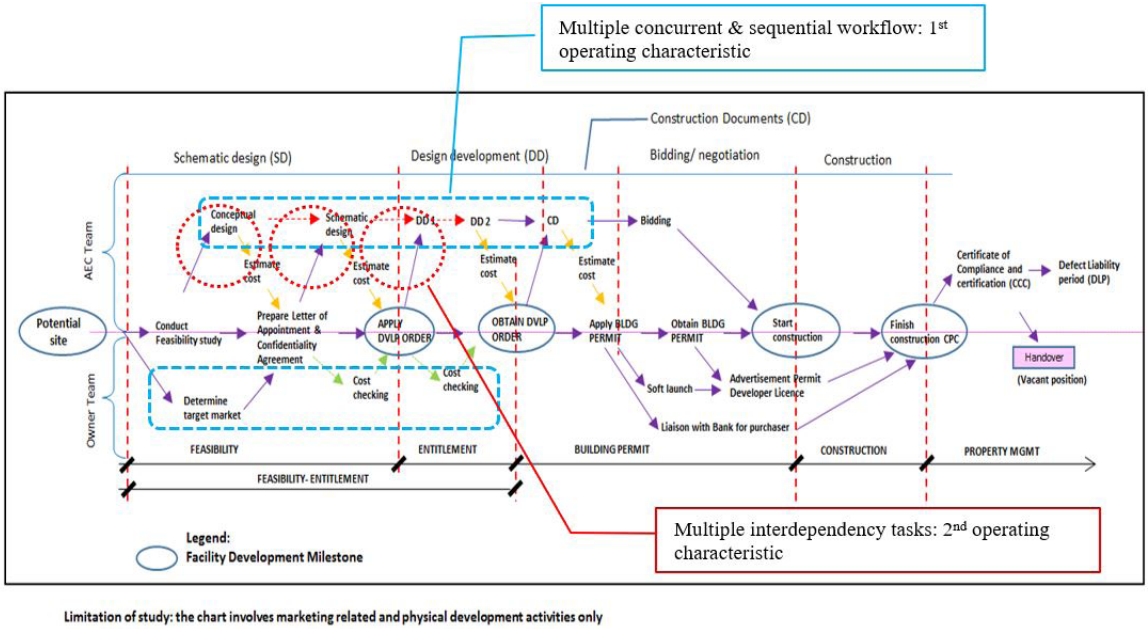

FIGURE 1. M Project Development Lifecycle Workflow

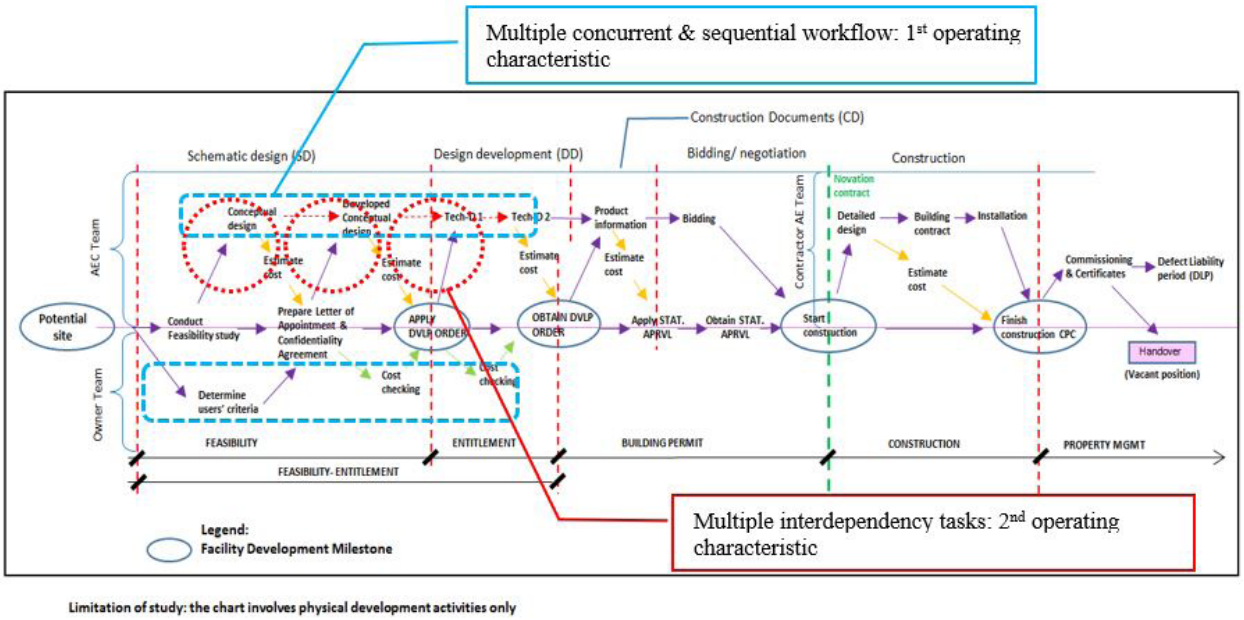

FIGURE 2. The UK Project Development Life cycle Workflow

Data shows that the Project M employs traditional procurement during the whole of the building deployment. Full-time equivalent (FTE) for each team is charted as eight-hour a day in a five-work-week value. Figure 3 and Figure 4 highlighted the variable number of memberships in different phases. These findings suggest the third environmental factor-the highly discontinuous memberships as opined by (Ibrahim & Paulson, 2008).

Agent's position/Phase	Feasibility-Entitlement	Building Permit	Construction	% involvement	
Phase	LAM: SD-DD	LAM: DD, CD, CI	LAM: CI		
Developer					
Development Manager	0.25	0.25	0.25	100%	Traditional Procurement
Dep. Snr. Manager	0.33	0.33	0.33	100%	
Snr. Exec. Dev. 1		1.0	1.0	60%	
Snr. Exec. Dev. 2			1.0	30%	
Exec. Development 1	1.0	1.0	1.0	100%	
Exec. Development 2			1.0	30%	
Snr. Exec. Contract			1.0	30%	
Snr. Mngr. Sales & Marketing			1.0	30%	
A-E consultants					
Architect		0.33	0.33	60%	
Planner	1.0			30%	
Landscape Architect			0.5	30%	
C&S Engineer	0.33	0.33	0.33	100%	
M&E Engineer		0.2	0.2	60%	
Quantity Surveyor	0.25	0.25	0.25	100%	
Total membership per phase	6	8	13		

Continuous member
Discontinuous member

Discontinuous membership: 3rd operating characteristic

FIGURE 3. The Staff Positioning, the FTE Allocation for M Project in Different Facility Development Life Cycle Phase (Adapted From (Ibrahim & Paulson, 2008))

Agent's position/Phase	Feasibility-Entitlement	Building Permit	Construction	% involvement	
Phase	RIBA: stage A-D	RIBA: stage E-F	RIBA: stage J-K		
Contractor					
Site Project Manager			0.5	30%	Design & Build
Site Quantity Surveyor		0.2		30%	
Site M&E			1.0	30%	
A-E novation consultants					
Architect	0.3	0.3	0.3	100%	
M&E Engineer	0.3	0.3	0.3	100%	
Quantity Surveyor	1.0	1.0	1.0	100%	
Structural Engineer 1	1.0	1.0		60%	
Structural Engineer 2			1.0	30%	
Total membership per phase	4	5	6		

Continuous member
Discontinuous member

Discontinuous membership: 3rd operating characteristic

FIGURE 4. The Staff Positioning, the FTE Allocation for UK Project in Different Facility Development Life Cycle Phase (Adapted From(Ibrahim & Paulson 2008))

In the UK Project, multiple concurrent and sequential phases occurred due to the rationalization process of designing another office space which they called "modern working environment" (MWE). MWE is a process within the larger project workflow and occurs during the schematic design phase. This study finds that during the schematic phase, the same consultant architect was appointed as the MWE team. This has made the consultant architect the source of project information and smoothed the informal knowledge movement needed for the UK Project. This results support Shumate, Ibrahim & Levitt's (2010) finding that the consultant architect was the "expert" continuous member for the discontinuous members to allocate project and confirming the fourth operating characteristic identified by (Ibrahim & Paulson, 2008), tacit knowledge regression. (Refer to Figure 5).

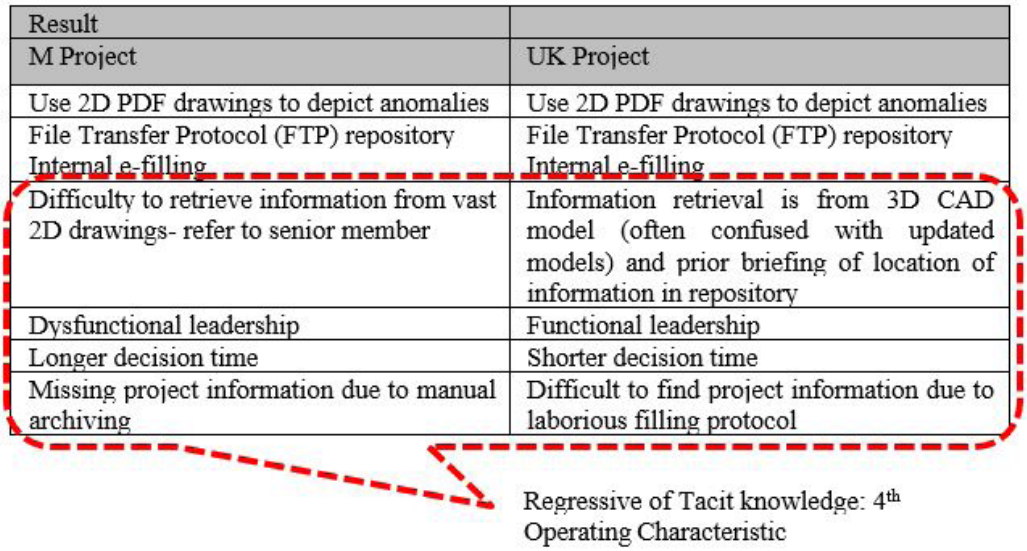

FIGURE 5: Confirmation of 4th Operating Characteristics: Regressive Tacit Knowledge (Ibrahim & Paulson 2008)

From the participatory-observation study, it has been proven that M and UK Projects exhibit the similar four operating environmental characteristics of USA projects (Ibrahim & Paulson 2008). This paper reiterates that the Project M and the Project UK have similarities of project characteristics and differences of practice and values work culture preferences (Horii 2005) while delivering a project. These similarities were shown in Table 3.

TABLE 3. Summary of Similarities of the Project M and the Project UK

Similarities Project Characteristics	Project M	Project UK
Operating characteristics	Multiple concurrent and sequential workflow Multiple interdependencies tasks Discontinuous members Regressive knowledge	
Full Time Equivalent (FTE)	8 hours per day work volume 5 days per week workdays	
Formalization of communication	Medium level of formalization	
Drawing Anomalies	2D- PDF drawings	
Drawing repository	FTP; Internal e-filling	
Collaboration techniques	Face to face meeting when collocated. Email and phone calls when non-collocate	

In conclusion, this paper infers that four characteristics suggested by Ibrahim and Paulson (2008) exist in building project operations due to the operating nature of building projects. Here, this paper conjectures that culture knowledge (*work culture, knowledge management and professional collaboration*) could be the prominent factor transcending the environmental characteristics, influencing organization's productivity.

To discuss further the culture knowledge result, this study adopts Horii (2005) cultural performance model dimensions: 1) practices preferences- associated to organizational structure; 2) values preferences- associated to description of project team members' decision making and communication behaviours. These preferences would illustrate the preferred coordination mechanism such as organization structure, independent of task complexity and organization configuration every nation (Hofstede, 1997). Organizational hierarchy for instance will inclined towards a particular decision making and communication behaviour that reflected by its own national culture index.

PRACTICE DIFFERENCES

The case study indicates that the M Project and the UK Project team have their own preferred set of organizational structure norm to conduct practices. The M Project's structure has a tight system, identified by high centralization, medium formalization and multi levels of vertical differentiation, while the UK Project's structure has a loose system, identified by medium centralization, formalization and matrix level, and a flatter configuration (Burton & Obel 1998; Horii 2005).

These distinctive structure configurations of the M Project and the UK Project are most likely influenced by Power Distance Index (PDI)–*dependence relationship in a country* (Hofstede, 1997) (refer Figure 6). Hofstede stated that in higher PDI and high Uncertainty Avoidance Index (UAI) countries, organizations tend to have a very high hierarchical system while low PDI together with low UAI countries are inclined towards standardized outcomes. This study acknowledges that national background has its own preferences and own configuration to suit their implicit model and cultural preferences.

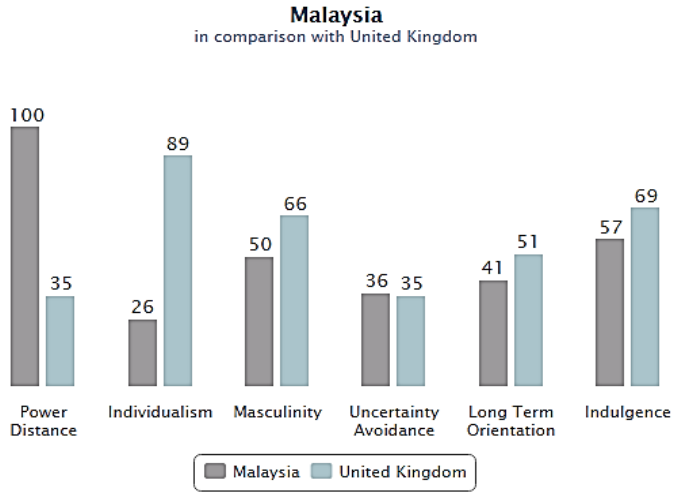

FIGURE 6. Insight of Malaysia and UK national culture models (Hofstede 2017)

This paper finds that both projects have almost similar UAI (M= 36; UK= 35) indexes but the UK has a higher reading of IND (IND=89). Hence, this implies that the UK Project tends to embrace result–oriented culture in most of their practices. The M Project's IND is lower (IND=26); therefore, it tends to embrace process–oriented culture in most of its practices.

VALUES DIMENSION

Field observation suggests that the M Project and the UK project have two sets of *micro-level behaviors* patterns in decision making and communication (Horii, 2005). The results found the M Project has formal centralized structure of information flow with de facto centralization and has shorter task-processes time due to allocation of multiple tasks as compared to the UK Project. This indicated that many risks and tasks are distributed among many groups and decentralized information flow. Consensual decision making and communication are majorly seen in M Project as compared to UK project.

In terms of knowledge flow, the UK Project uses BIM technology intervention to support information flow, while the M Project used 2D-CAD drawings to support information flow. These cultural value dimensions show distinctive interpretations of one's cultural knowledge between countries. Table 4 shows the results of the key culture characteristics differences between the M and UK projects.

TABLE 4. The M vs the UK Projects' Cultural Characteristic Differences (adapted from Horii et al. (2005))

Theme	Result	
Practice preference	M Project	UK Project
Centralization of authority	A centralized authority.	A decentralized authority.
Depth of hierarchy	A very bureaucratic system and high in hierarchy.	Flatter in hierarchy
Values preference	M Project	UK Project
	Seek consensus before making decision.	Individuals tend to make decision.
Decision making	No hesitation on authorization	Ambiguity on authorization.
	Less level of confidence in decision making	High level of confidence in making decision
	Longer meetings (every 2 weeks lasting circa 5 hours) to minimize miscommunication and decision making.	Shorter meeting (once every month lasting circa 3 hours) to place a discussion rather than deciding.
	Interference hardly occurs when a team member makes a discussion with another team member.	Discussion is made openly, any time, everywhere reciprocally. Sometimes other members would join in and give opinion
Communication	Uses WhatsApp application, face to face communication. Telephone and emails were used when non-collocate.	Most of the communication is face to face discussion. Non-collocate communication is via telephone and emails.
	Instructive communication manner is common, many single-way communication and praises are seldom.	Polite communication manners are used consecutively. Praises in the end of tasks, careful choice of words
	Working late is a normal routine and is not specified by superior.	Working late is seldom specified by superior and is not highly recommended.

The qualitative results also suggest that the M Project and UK projects have their own unique name for each of their phases (refer Table 5).

TABLE 5. Unique Terminologies of Project Activities equivalent in the M and UK Project

The M Project terminologies	The UK Project terminologies
Schematic design	Developed Conceptual design
Design development	Technical design
Contract document	Product information
Building design approval	Statutory approval

These findings have led this study to further test the hypothesis whether the M Project team can become like the UK Project team and perform equally as UK project team when they embrace BIM technology, when team members understand each professionals' cultural knowledge during design phases, therefore, improving project's productivity efficiency.

HYPOTHETICAL EXPERIMENT PARAMETERS

Here, this study presents the justification and discussion of the cultural characteristic parameters for the hypothetical experiment.*Organizational configuration*: Every national culture has its own preferred coordination mechanism (Hofstede, 1997). The results found that there are two types of organization configuration: The M Project's configuration and the UK Project's configuration. The style is made based on four elements: organizational hierarchy, centralization, formalization, and matrix strength (Table 6). This has proven that M Project and UK Project have different preferences independent of the task complexity, organization structure and team circumstances.

TABLE 6. Leadership style as organization hierarchy (adapted from (Horii 2005)

Leadership style	M Project	UK Project	Note
Centralization	High High PDI=100 Low UAI=36	Medium Low PDI=35 Low UAI=35	Challenging to have high collectivist versus individualist type decision making, if controlled would function to a desirable performance
Formalization and matrix strength	Medium High PDI=100 Low IND=26	Medium Low PDI=35 High IND=89	Both projects have similar equilibrium of acquiring current and precise information; and group attitudes, therefore both project average formalization and matrix strength.
Organizational hierarchy	Several hierarchical layers High PDI=100	Flat hierarchical level Low PDI=35	Challenging to have two different organizational structure, if controlled would function to a desirable performance

PDI= Power Distance index; UAI= Uncertainty Avoidance Index; IND= Individualism index

Project's intensity: Project intensity relates to task dependency. In the experiment, this paper limits the task interdependencies to intensive tasks intensity (implied by the M Project) and reciprocal tasks intensity (implied by the UK Project). The term "*reciprocal*" intensity refers to the minimum unit of interdependent workflow that stands between sequential and intensive workflow, and usually represents "design and build" projects. While an "*intensive"* intensity refers to an interdependent workflow and overlapping of project design and construction to reduce construction time and high rework due to high interdependence of tasks between multidisciplinary team (Chachere et al. 2009). Refer to Table 7.

TABLE 7. Setting of Project Intensity

Project Intensity Parameters (Adapted from Horii (2005))			Descriptions of parameters (Adopted from SimVision® 4.2.0 Help Files).
	Reciprocal workflow	Intensive workflow	
Info. Exchange Ratio (IE)	Medium (0.53)	High (0.6)	Information exchange probability is the communication links that shows amount of project's communication between responsible positions.
Project Error Probability (P)	Medium (0.11)	High (0.12)	Project error probability is the project involvement towards tasks and processes values. 0.05 signifies low value meaning many standard tasks and typical work routine processes while 0.12 signifies high value that refers to unusual task and innovative work processes. Intensive project workflow is usually high work volume and short project duration and thus having high project error probability. Reciprocal project workflow is also having high work volume but with longer project duration and thus having slight lower project error probability (0.11).
Functional Error Probability	Medium (0.1)	Medium (0.1)	Functional error probability is defined as the project involvement towards technology and work processes values. 0.05 (low) indicates to norm use technology and standard working processes; and 0.15 would refers to advanced working processes and unproven technology. BIM technology is used as intervening parameter in this study therefore, 0.05 value is used to reflect the use of technology, whilst 0.10 value for not using BIM technology.

In the SimVision® simulation, two types of models are illustrated: 1) data relationship- in this model data linkage is shown between two activities; and 2) work related- illustration of omission made from one activity that would have or no impact to other positions (Jin & Levitt 1996).

COMPUTATIONAL EXPERIMENT PROCEDURE

This study sets up Computational Organizational Theory (COT) experiment protocols using four theoretical concept models based on the IV and DV relationship by setting up the Baseline and the X-baseline concept models of the M Project's case study findings. These models are created using stimulus and intervening parameters in the SimVision®. At *project* level, models would consist numerous tasks series and parallel activities that signifies the putative conceptual of a design project (Figure 7).

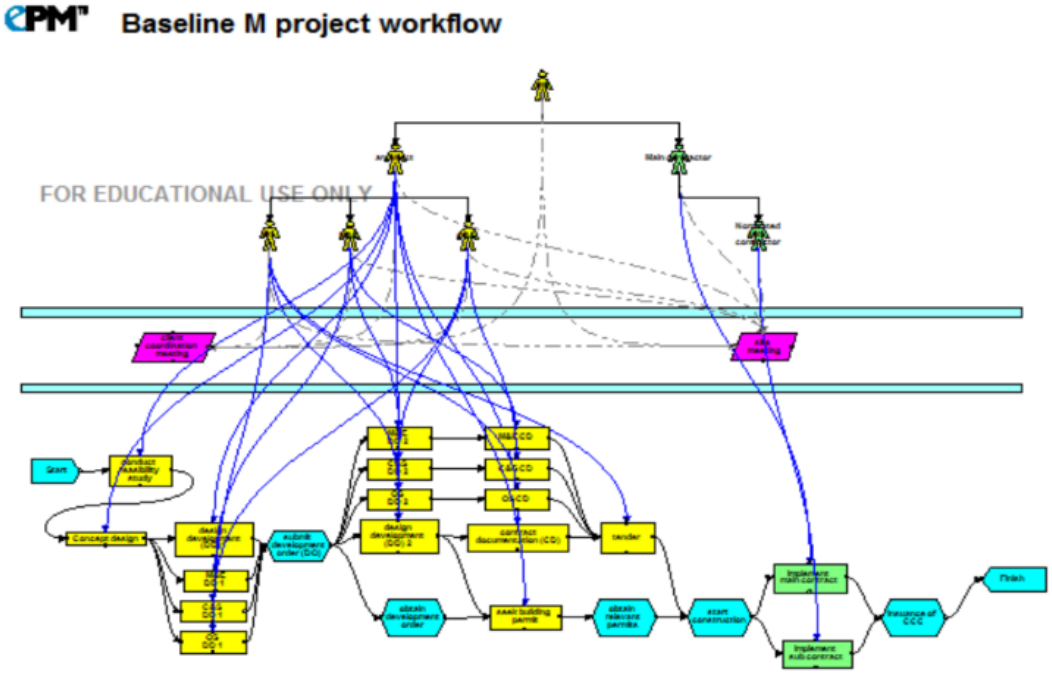

FIGURE 7. Exemplary of Idealized M Project hypothesized Organizational workflow in SimVision®

Below in Table 8 is the controlled and stimulus parameters that are recommended settings in the VDT (SimVision).

TABLE 8. The Hypothetical Model Parameter Setting in SimVision®

Model Controlled Parameter	Stimulus Parameter			
	Baseline model (Not using BIM)		X-baseline model (Using BIM)	
1. Team experience: medium 2. Work Volume per full time equivalent: 8 hours/ day 3. Workdays per week: 5 days/ week	M model with Intensive task complexity			
	MMsINB	M Project's with Multiple hierarchy structure implying M Project's organizational configuration and Intensive tasks complexity can be productive as UK Project when No BIM was used as technology intervention	MMsIwB	M Project's Multiple hierarchy structure that implies M Project's organizational configuration and Intensive tasks complexity can be productive as UK Project when BIM is used as technology intervention

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Model Controlled Parameter	Stimulus Parameter			
	M culture with Reciprocal task complexity			
4. Agencies, actor skills and position: 7 skill positions 5. Task: 18 tasks 6. Milestone: 5 milestones 7. Noise Probability: 0.15	MMsRNB	M Project's with Multiple hierarchy structure implying with M Project's organizational configuration and Reciprocal tasks complexity can be productive as UK Project when No BIM was used as technology intervention	MMsRwB	M Project's Multiple hierarchy structure that implies M Project's organizational configuration and Reciprocal tasks complexity can be productive as UK Project when BIM is used as technology intervention
	M with UK culture with Intensive task complexity			
	MFsUKINB	M Project's with Flatter hierarchy structure implying UK Project's organizational and Intensive tasks complexity can be productive as UK Project when No BIM was used as technology intervention.	MFsUKIwB	M Project's Flatter hierarchy structure that implies UK Project's organizational configuration and Intensive tasks complexity can be productive as UK Project when BIM is used as technology intervention
	M with UK culture with Reciprocal task complexity			
	MFsUKRNB	M Project's Flatter hierarchy structure implying UK Project's organizational configuration and Reciprocal tasks complexity can be productive as UK Project when No BIM was used as technology intervention.	MFsUKRwB	M Project's Flatter hierarchy structure that implies UK Project's organizational configuration and Reciprocal tasks complexity can be productive as UK Project when BIM is used as technology intervention

RESULT OF COMPUTATIONAL EXPERIMENT

The result from the computational simulations shows that when there is BIM technology intervention, projects productivity efficiency will be affected profoundly. The MMsIwB, MMsRwB, MFsUKIwB and MFsUKRwB models support this study's main research question. At *project* level, significant change is seen between Project Schedule Growth (PSG) and Risk Index (RI) from the baseline and X-baseline models. Communication, time waits, and rework are depicted through added indirect tasks. Ten set of 50 trials= 500 simulations are run and tested using one-way ANOVA was used to validate models. The ANOVA results show that MMsI, MMsR, MFsUKI and MFsUKR has significant differences by RI ($F(3,76) = 101.15$; $p < 0.001$. MMsI conceptual model represents the correct M project characteristics in conjunction with the high mean value among the models. The Tukey HSD does not show any significant indicating that the tested models are valid and adequate to be used in research discussions. There is no significant mean of RI when no BIM intervention versus with BIM intervention are further tested in a two-tail t-test at 95% ($t(18) = 1.116$; $p = 0.279$) as compared to PSG ($t(18) = 54.321$; $p = 0.00$). These results suggest that the differences of RI *p*-value (0.279) as to PSG *p*-value (0.00) indicate that there is a huge impact towards the M Project when BIM intervention is applied. This study take note that PSG would be one of the parameters that need to be alerted during global project delivery.

The true work culture depiction of M Project is portrayed in the MMsInB model. The *SimVision®* simulations results allude that the present characteristics of M project (*multiple hierarchy structure, high centralization, and intensive intensity without BIM technology intervention*) would not be realistic. For example, when traditional 2D drawing is a method to illustrate design aim, while having centralized decision making and having intensive workflow as cultural knowledge in M Project, future global partnership productivity would be impaired. The *SimVision®*

experiments demonstrate that BIM intervention and reciprocal processes could positively enhance M project's performance.

DISCUSSION

First, there are performance changes in PSG for MMsIwB, MMsRwB, MFsUKIwB and MFsUKRwB models in the intellective experiments. This supports this study's theoretical proposition when BIM culture is understood, it could enhance AEC collaborations and knowledge management. Through ANOVA test, it confirms that MMsI, MMsR, MFsUKI and MFsUKR models are having significant differences by RI value ($F(3, 76) = 101.15$; $p < 0.001$) and no difference in PSG value. Significant differences were found in performance change at PSG level ($t(18) = 54{,}321$; $p = 0.00$) as compared to the RI ($t(18) = 1.116$; $p = 0.279$) when BIM intervening was applied during project. This study surmises that when omission is controlled with the use of BIM technology, it could improve and enhance better time coordination and decision-making productivity.

Second, results from the simulation shows there are substantial performance changes seen from flat-hierarchy organizational structure as rivalled to multi-hierarchy organizational structure (Refer magenta and blue markings in Figure 7). The magenta marking shows the current true M Project's performance, and the blue marking indicates the true UK Project's performance.

	Model	Risk Index							Project Schedule Growth (days)				
		Process Quality Risk	Product Quality Risk	Project Risk Index	Function Risk Index	Communication Risk	Meeting Risk	Coordination Risk	Critical Path	Work	Rework	Coordination	Decision Wait
Multi-	MMsInB	0.26	0.29	0.31	0.27	0	0.36	0.117	3.7	245	19.6	98.3	7.4
	MMsIwB	0.25	0.14	0	0.28	0	0.35	0.117	0	245	9.7	89.5	3.7
	MMsRnB	0.25	0.14	0	0.27	0	0.35	0.118	3.7	245	19.8	98.3	7.6
	MMsRwB	0.25	0.14	0	0.28	0	0.35	0.118	0	245	9.7	89.3	3.3
Flat-	MFsUKINB	0.29	0.16	0	0.31	0	0.35	0.116	3.2	245	18.7	98	4.8
	MFsUKIwB	0.29	0.16	0	0.32	0	0.35	0.117	0	245	9.4	89.1	2.3
	MFsUKRNB	0.29	0.15	0	0.31	0	0.35	0.116	2.3	245	18.9	97.9	4.9
	MFsUKRwB	0.29	0.16	0	0.32	0	0.35	0.117	0	245	9	88.8	2.4

Productivity efficiency has been improved by more than 80%

Time and delivery project have been reduced by 60%

FIGURE 7. Differences Inferences of Project Performance between Models

Significant performance differences are seen in the intellective experiments when M organizational structure was changes from multiple to flatter hierarchy to mimic the UK productivity even without the BIM intervention. This evidently implies that to change organizational hierarchy structure is not easy due own normative cultural system (M's PDI= 100; UK's PDI=35) that can affect operations and information processing. This study agrees with scholars (Burton & Obel, 1998; Hofstede, 2001) that organization structure is been instil by "symbols, heroes and rituals" of their nation. Therefore, having to restructure the organizational hierarchy would be unacceptable. Therefore, FUKsIwB model culture characteristics would not be advantageous towards M project.

Third, it is noticeable that when M project preserves the multiple hierarchy structure in organization and opt for reciprocal workflow (MMsRwB model), during project, M project could be of similar productivity as the UK Project (refer to blue against yellow marking in Figure 7). This shows that when a norm value such as organization structure is instilled and absolute (Hofstede, 1997), changing the operation processes such as tasks intensity would be ideal. Here, this paper proposes changing the M Project's intensive tasks intensity to reciprocal tasks intensity during project workflow. Therefore, MMsRwB model is the pragmatic solution for the M Project to be equally productive as the UK project. This paper conjectures that multiple hierarchy structure with high centralization, medium formalization and matrix strength, and reciprocal tasks intensity with BIM technology intervention are principally fit for the M Project to be equally productive as the UK Project during project

delivery. The experiment results from Figure 7 confirmed that 80% of productivity could be improved during the project.

CONCLUSION

This study used case study research design and a COT intellective experiment to test and validate how the M Project's AEC team can be equally productive as the UK Project's AEC team when UK cultural knowledge and BIM technology were embraced by the M Project during project delivery. This study establishes that when omission is controlled with the use of BIM technology, it could improve and enhance better time coordination and decision-making productivity.

This study also finds that in attaining organizational structure fit, normative culture must be considered, otherwise change would not be acceptable. This study identifies that by changing the operational process from intensive to reciprocal tasks intensity together with and BIM technology could give similar effect as organizational hierarchical structure change from multiple hierarchy to flatter hierarchy. This study purports that MMsRwB model is the ideal fit for the M Project to be equally productive as the UK project. The characteristics of the MMsRwB model are multiple hierarchy structure with high centralization, medium formalization, and matrix strength, and having reciprocal tasks intensity with BIM technology intervention during project delivery.

DATA AVAILABILITY STATEMENT

Data generated or analysed during this study are available from the author by request.

All data generated or analysed during this study are included in the submitted article or supplemental materials files.

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DECLARATION OF COMPETING INTEREST

None.

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