

# OPTIMIZING MALAYSIAN AEC'S ORGANIZATIONAL TEAM REWORK PRODUCTIVITY USING MINIMAL COLLABORATIVE TECHNOLOGY DURING INDUSTRIALIZED PROJECT DELIVERY

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## ABSTRACT

*CITP 2016-2020 Strategic and SDG 17 Sustainable development through global partnerships has been the driving force for architects, engineers, and contractors (AEC) professionals to opt for global industrialized project delivery in the future. The purpose of this study is to identify the baseline communication preferences that can help policy makers and building professionals to prepare themselves to export their professional services in delivering transdisciplinary global project implementation. The case study found that AEC's professional culture, method of knowledge transfer, and educational programs could affect several dimensions of their beliefs and values in ways of delivering global transdisciplinary projects. Results include documentation of triadic and dyadic rework iterations communication culture of professionals. This study is limited to the effect of a professional's human factor during IPD's design development stage. The study recommends formalizing AEC professionals' communication system through application in integrated design studio education program in preparing future Malaysian AEC transdisciplinary global practice.*

**Keywords:** *Transdisciplinary work culture; AEC; professional education; collaborative technology*

## 1. INTRODUCTION

Today global environmental concerns have become a mainstream goal in a build environment. The phenomenon is urgent due to global climatic change in recent years (Raouf & Al-Ghamdi, 2019). Emerging trends of green building and building information modeling (BIM) are driving profound transformation within the architecture, engineering, and construction (AEC) industry. This paradigm shift requires AEC to change how they do their work and collaborate with global partners in the future. BIM is found to be ideally suited to the delivery of information needed for an improved design and building performance. The two most significant benefits of BIM for sustainable building design are integrated project delivery (IPD) and design optimization (Ma, Ma, & Li, 2017; Wong & Fan, 2013). Globalization has made the Malaysian AEC industry needing to employ collaborative paraphernalia during international partnership project delivery with other respective counterparts in other countries. With the Malaysian **Construction Industry Transformation Program** 2016-2020 (CITP 2016-2020) to facilitate and redirect the Malaysian construction industry's future and towards productivity, technology, capabilities, and proficiency.

The authors have seen a lack of emphasis on the human factor especially in terms of users' socio-culture issues whilst using these collaborative tools. The paper supports Delavari *et al.* (2011) that more studies are needed that emphasis on the following issues: 1) greater control of humans over tools, 2)

returned speedy feedbacks to users, and 3) how these tools give value-added to users during the collaboration phase. In predicting the future works in these areas, the paper would propose to identify the minimal collaborative technology infrastructure that could effectively support trans-disciplinary work culture differences among Malaysian AEC professionals during the industrialized projects. With BIM-enabled technology as the new paradigm shift for Malaysian construction industry, the Malaysian AEC Professionals need to understand the beneficial insight of human visual-collaborative communication. It is here where the authors intend to focus in this paper by identifying the minimal collaborative technology infrastructure whilst supporting Malaysian organizational professionals' team culture during the design phase in industrialized project delivery.

## 2. BACKGROUND LITERATURE REVIEW

AEC stakeholders use Professional Collaborative Tools such as synchronous or asynchronous tools as a medium for communication. Utilization of technology among AEC professionals' communication is crucial in leveraging construction activities and implementation progresses. These communication processes of collaboration augment self-examination of one's behavior and communication (Horii, 2005). The authors agree with Abdul Ghafar (2016) engineer and contractor that Information technology (IT) could provide effective collaborative tools and facilitate both in augmenting and powering collaboration process and culture (Kam, 2015). Henceforth, the authors propose focusing on the asynchronous tools as these tools reflect much of the AEC operating environment characteristics. Nevertheless, there is resistance among AEC team members to use new applications and delivery, because they are familiar with their visualization techniques. In like manner, this paper takes note that each collaborative tools need to have an interoperability factor to be readable between synchronous tools (Leal, Guédria, & Panetto, 2019; Pauwels, Zhang, & Lee, 2017). This would cause delay and inadequate distribution (Hamil, 2012).

Hofstede (1997; pg. 10) deems that culture is a several levels of mental programming which within themselves creates different mental layers of personality, culture and, human behaviors. Another mental layer programming is the societal national culture differences in which reflects region, religion, gender, generation and class, and organizational culture. In this study, the authors see that much organizational culture is much influenced by AEC characteristics, such as a 2D complacency method to deliver projects (Abdul Ghafar, *et al.*, 2018). This peculiarity is inherited from their early tertiary training and previous project experiences (Ibrahim & Pour, 2010; Rahimian & Ibrahim, 2011). This has made

them resistant to accept a new way of delivering projects. For this reason, the authors suggest investigating how this culture and mental programming could boost AEC productivity and therefore reduce industrialized waste.

In literature, many scholars underline that higher waste product are the result of a lack of professional awareness (Jalaei, Zoghi, & Khoshand, 2019); inadequacy dichotomy of professionals responsibilities in handling waste (Sáez & Osmani, 2019); lacking professionals' attitude and behavior in waste management (R. Jin, Yuan, & Chen, 2019). The definition of waste in this context is adding cost without giving efficient resources and capital to a product (Koskela, 2000). Ohno (1988) found seven categories of industrial waste namely: 1) 1) overproduction, 2) inventory, 3) extra processing steps, 4) motion, 5) defects, 6) waiting, and 7) transportation; and later Koskela (2004) found the eighth category of waste that is the make-do waste. Here the authors foresee that the production of industrialized waste is due to cultural knowledge. The authors also concur with (Toomey, Knight, & Barlow, 2017) that to make these technologies accepted and corroborated, cultural and social factors need to play equal roles in the construction industry. Moreover, a study by Abdul Ghafar & Ibrahim (2018) conjecture that organizations would govern by professionals' work culture, knowledge transfer manners for discontinuous membership in a building project, and further extension of professional education programs. In the same vein, an adaptation of synchronous technologies together with professionals' culture, during the early design stage could alleviate successful communication practices to reduce industrialized waste. The authors are anticipating that consolidation of synchronous technology characteristics and professional's culture during the early design stage could avoid knowledge loss whilst reduce industrialized waste. In turn, it would promote fabrication efficiency. In view of the above, the study posits that professional work culture knowledge and technological provision could allow good interoperability, precise information and reduce rework in the subsequent production process. Therefore, the authors posit that technological support such as synchronous collaborative tools together with professionals' work culture could enhance effective communication, decision making, and rework during the design phase in industrialized project delivery.

## 3. CASE STUDY RESEARCH METHODOLOGY

The study uses and refers Yin's (2009) case study research method to build the case study research design. In answering the logic of Case Study Research Design (CSR D), the authors use Yin's five components of logic to CSR D (refer Table 1).

Components	Logic
<b>1. The study's research question:</b>	The main research question (MRQ) is: <b>How</b> to support organizational professional culture with collaborative technology during the design phase in industrialized project delivery in Malaysia?  Yin (2009) acknowledges that when a research question starts with a <i>how</i> or <i>why</i> it verifies the suitability of using case study as a research methodology.
<b>2. Proposition statement:</b>	The theoretical proposition for the study: Technological support such as synchronous collaborative tools together with professionals' work culture could enhance effective communication, decision making, and rework during the design phase in industrialized project delivery.  In Yin (2009; p. 28) "each proposition directs attention to something that should be examined within the scope of study". This case proposition helps to clarify the systematic and verifiable steps needed to investigate the key components. This proposition is driven by (Maszura Abdul Ghafar & Ibrahim, 2018) and Abdul Ghafar, et al.(2018) work culture and cultural knowledge theory in reducing industrial waste.
<b>3. Unit of analysis.</b>	A single AEC Malaysian project team that consists of an architect, an engineer, and a contractor, with experiences ranging from five to more than twenty years in two different project settings. One baseline case is using collocate face-to-face communication with manual apparatus to run a 3-hour project, while another x-base case is using non-collocate communication with the support of synchronous collaborative technology to run a 3-hour project. Each project setting has similar complexity with multidisciplinary characteristics, practice's characteristics (such as organizational style, authority, formalization of communication, and organizational hierarchy), usage of collaborative tools in delivering a project, and comprehension of professionals' value preferences (such as task coordination and decision making).
<b>4. The logic linking data to proposition.</b>	Having the theoretical proposition, it would guide the study to justify the relationship between operational constructs and amalgamate the method in inquiring data from fieldwork. Two theoretical operational constructs are presented for the study to work on concerning CSR. The operationalized constructs are professional work culture and effective communication for rework during the design phase. Refer to Table 2.
<b>5. The criteria for interpreting the findings</b>	The study anticipates that 60% of the time and delivery waste could be reduced when productivity efficiency value is high (80%) when technology (BIM) and culture ( <i>work culture, knowledge management, and professional collaboration</i> ) is controlled.

Table 1: The Five components of logic to CSR (Adapted from Yin, 2009)

Construct	Definition	Sources of evidence	Result
Professional Work culture	•Visual collaborative communication utilization techniques between stakeholders in reducing rework	•Local AEC professionals •Observation	•Frequency Table of dyad and triad communication •Comparison table of dyad and triad communication based on professional culture
Effective communication for rework during design phase	•Efficient collaborative technology to support effective communicate during design process	•Local AEC professionals •Observation	• Documentation of communication frequency and direction of inflow and outflow of communication • New definition of Professional Culture-communication

Table 2: Operational Variables of the Constructs

The authors employ Yin's four tests of validation in CSR to build an unbiased explanation of the data.

Tests	Case study tactics	Phase of research in which tactics occurs
1. Construct validity	■ Several sources of evidence - <b>Video-Observation:</b> Identified cultural criteria for successful collaboration to reduce waste. - <b>Archival records:</b> used recorded video and transcription of video to identify number of rework and miss-coordination	Data collection
2. Internal validity	■ Confirmation of all participants	Data analysis
3. External validity	■ Re apply the theoretical proposition in second case and findings affirmed the same result	Research design
4. Reliability	■ Used case study protocol for case	Data collection

Table 3: The Four Steps of Validation Tactics for CSR (Adapted From Yin (2009))

The study postulates that time and delivery waste could be reduced when communication efficiency is high when collaborative technology and professional's work culture are controlled.

### 3.1 Result of Case study

This section reports the results of the case study data. Then, it discusses the video observation findings. In Horii's (2005) study, he identified work culture as practices preference and values that link to the behavior of decision making and communication. There are two types of practices: organizational practice and institutional practice (Horii, 2005). *Organizational practice* refers to organizational structure such as the level of *centralization*, the level of *formalization*, and the organizational *configuration*. An organization structure is how the individuals are communicating and/making decisions within a constrained or controlled coordination mechanism (Baligh & Burton, 1981; Baligh & Damon, 1980; Malone, 1987). *Centralization* is the degree of involvement of a top manager to gather and interpret information to use it in decision making and execution of decisions (Burton & Obel, 1998). *Formalization* refers to ways to obtain coordination, control, and rules in an organization (*ibid.*), and influenced individuals' communication actions (Jin & Levitt, 1996).

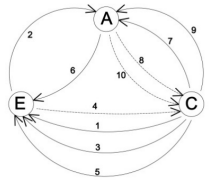
In a highly centralized organization, most decisions are made from top to bottom and in this case, are made by the Architect. Centralization is much related to leadership style and is influenced by the national culture index (Hofstede, 1997, 2019). Leadership behaviors are related to the micro-involvement relationship. The higher the leader's micro involvement is, the less likely the leader delegates tasks and decision making (Burton & Obel, 1998). This type of leader only reactive in decision making, do not focus on the long term and focus on the past, is risk adverse and control subordinates rather than motivate by inspirations (*ibid.*).

In the study, the authors investigated effective communication during an early stage of design that is during the design phase. The result showed that the Malaysian AEC team tends to have longer and recurring inquiries during communications to minimize miscommunication and decision making. When a team member communicates with another team member, a third member would not interfere. The study also found that the WhatsApp application is optimally used as compared to email or yahoo group application. WhatsApp Videophone is thoroughly used when the team members are non-collocate.

Common instructive communication manner, with one-way communication and praises, are seldom. The team would refer to a "senior" or experienced member to gain information and affirm correct information about the project.

Many times, team members have seen "socialization" during design coordination to gain trust, acceptance, and affirmation. "Socialization" is a way to interact to transform tacit knowledge to explicit knowledge among individuals in an organization (Nonaka, 1994). Trust is the high level of benevolence, ability, and integrity accepted between stakeholders to build a relationship (Zolin, 2002). The architect always used 2D sketches to depict anomalies or to clarify team understanding about the project. At the same time, the experienced member would share sufficient explicit knowledge movement with other team members using paper sketches and WhatsApp application to succeed in the next step of actions and decision making.

During negotiation and decision making, the authors found that the Malaysian AEC team members have dyadic and triadic communication iteration recurring during project delivery to solve complex issues and to consolidate uncertain decisions. Dyadic communication is dialogic communication that involves two close people who exchange ideas, thoughts, and feelings on a mutual basis (Brown, Paz-Aparicio, & Revilla, 2019). Whiles triadic communication refers to three or more people who are familiar and working towards a common objective (Hastings, Hoover, & Musambira, 2005).

Type of iteration	Iteration Description
 <p>Collocated Rework Triad for Services Requirement</p>	<ol style="list-style-type: none"> <li>1. Contractor inquires engineer on other missing M&amp;E requirements</li> <li>2. Engineer gives suggestion</li> <li>3. Contractor reminds engineer about other missing M&amp;E requirements</li> <li>4. Engineer adds more information on M&amp;E requirements</li> <li>5. Contractor clarifies again M&amp;E requirements</li> <li>6. Architect inquires the total space requirements M&amp;E sizing</li> <li>7. Contractor revisits staircase information</li> <li>8. Architect gives alternative and recommendation</li> <li>9. Contractor agrees with architect's recommendation</li> <li>10. Architect confirms with the final solution</li> </ol>

Type of iteration	Iteration Description
<p>Non - collocated Triad for services requirement</p>	<ol style="list-style-type: none"> <li>1. Engineer gives realization of fire department requirements</li> <li>2. Architect clarifies by showing in the proposed design</li> <li>3. Engineer suggests alternatives</li> <li>4. Contractor inquires of missing services function</li> <li>5. Architect clarifies information</li> <li>6. Engineer counters architect's suggestion and proposed alternative suggestion of services location</li> <li>7. Architect agrees with engineer's recommendation</li> <li>8. Contractor suggests different alternative</li> <li>9. Architect agrees and confirm</li> </ol>

A= Architect; E=Engineer; C = Contractor

**Table 4:** Triadic Rework Iterations

Type of iteration	Iteration Description
<p>Collocated Rework Dyad for Services Requirement</p>	<ol style="list-style-type: none"> <li>1. Architect inquires on agreed floor height</li> <li>2. Contractor inquires the required specifications</li> <li>3. Architect clarifies the requirement</li> <li>4. Contractor acknowledges</li> <li>5. Architect suggests a solution</li> <li>6. Contractor counters and clarifies againts required specification</li> <li>7. Architect verifies the solution</li> <li>8. Contractor agrees</li> <li>9. Architect confirms final agreement</li> </ol>
<p>Non - collocated Dyad for services requirement</p>	<ol style="list-style-type: none"> <li>1. Architect clarifies lost floor space</li> <li>2. Contractor adds further information</li> <li>3. Architect clarifies on the total floor lost</li> <li>4. Contractor verifies total floor lost</li> <li>5. Architect inquires of total needed space requirements</li> <li>6. Contractor clarifies space requirements</li> <li>7. Architect acknowledges requirements</li> <li>8. Contractor inquires additional floor space needed</li> <li>9. Architect reconfirms requirement needed</li> <li>10. Contractor agrees</li> <li>11. Architect confirms with the final agreement</li> </ol>

A= Architect; C = Contractor

**Table 5:** Dyadic Rework Iterations

Professional Culture	Dyad						Triad					
	Collocated			Non-Collocated			Collocated			Non-Collocated		
	A	E	C	A	E	C	A	E	C	A	E	C

#### Practice preference

1. Centralization of authority	ü			ü			ü			ü		ü
2. Formalization of communication	H		H	H		H	H	L	M	H	H	H
3. Depth of hierarchy	High			Flatter			High			Flatter		

#### Value Preference

1. Decision making	Individual (Architect)	Individual (Architect)	Individual (Architect)	Consensus (Architect + Contractor)
2. Communication	<ul style="list-style-type: none"> <li>• Directive</li> <li>• Shorter meeting time</li> <li>• No interference</li> <li>• Use sketches</li> </ul>	<ul style="list-style-type: none"> <li>• Casual</li> <li>• Longer meeting time</li> <li>• No interference</li> <li>• Use WhatsApp Video &amp; Internet</li> </ul>	<ul style="list-style-type: none"> <li>• Directive</li> <li>• Longer meeting time</li> <li>• Non-interference</li> <li>• Use sketches</li> </ul>	<ul style="list-style-type: none"> <li>• Casual</li> <li>• Shorter meeting time</li> <li>• interference</li> <li>• Use WhatsApp Video &amp; Internet</li> </ul>

H: high acquiring and precise information

M: medium acquiring and precise information

L: Low acquiring and precise information

**Table 6:** Professional Culture Collocated vs Non-collocated Communication

## 4. DISCUSSIONS

This section discusses the Professional's communication culture, in using the synchronous collaborative tool for effective communication culture. The discussion starts with non-collocated communication culture followed by the synchronous collaborative tool for effective communication.

#### 4.1 Non-collocate communication culture

From the case study, the authors conjecture that with non-collocate communication the Malaysian AEC still can perform project delivery effectively. Actions and decisions made by team members are made, openly, any time reciprocally rather than formalized meeting mode. Decision-making is documented, and many team members are aware of decisions made and are made consensually. Some members would impart advice based on their experience, giving advice before a decision is made. For example, in many situations during the case study, the architect speedily confirms a complex decision on the mechanical matter. In traditional communication, an engineer would wait for the architect to finish his drawings first before addressing sufficient mechanical matters. However, in non-located communication, correct information is available at the right time and the right phase. Therefore, would reduce meeting time, improved and enhanced resulting in better project performance.

#### 4.2 Synchronous collaborative tool for effective communication

The authors agree with (Hofstede, 1997, 2019) that since norm values are usually absolute, firmly in place, and difficult to change, changes in operational processes would be ideal. In this manner, the authors recommend changes from face-to-face manual conventional communication to effective synchronous collaborative communication during project delivery. This is to prepare Malaysian construction industry towards the globalization transformation. Use of WhatsApp application to communicate shorter meeting time and helps in an experienced team member to boost the confidence level in decision making. Speedy collective decision agreement is achieved due to lesser bureaucratic procedures and formalization. The authors agree with Rahimian & Ibrahim, (2011) that conventional drawings offer implicit knowledge to AEC team members but synchronous collaborative tools would make implicit knowledge turn into explicit information.

### 5. CONCLUSION

This study can conclude that the implementation of collaborative tools such as WhatsApp together with cultural knowledge certainly can give better production output and enhance effective communication and explicit information flow between multi-disciplinary members. This confirms the study's theoretical proposition that technological support such as synchronous collaborative tools together with professionals' work culture could enhance

effective communication, decision making, and rework during the design phase in industrialized project delivery. Globalization is changing how AEC communicates and negotiates for information. This will certainly benefit the AEC industry across the globe particularly in developing countries like Malaysia. The triadic rework iterations could be the one of professionals' culture on how to make a decision and communicate among multidisciplinary stakeholders. The findings from the case study would be translated into a future diverse transdisciplinary studio teaching in Universiti Putra Malaysia. The authors recommend applying the Transdisciplinary teaching (TDT) model in the studio for future graduates in Malaysia. The benefits in implying the TDT model would further enhance professionals' education curriculum and programs. However, the study still foresees a lack of AEC professionals' control over tools whilst using collaborative tools. Nevertheless, the study foresees that this phenomenon could allow AEC in both developed and developing countries to partner successfully in implementing joint global projects.

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