Building Architect, Engineering and Contractor Communication Culture Through the Integrated Futures Studio

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Abstract—Building information Modeling (BIM) has changed how Architects, engineers and contractors (AEC) professionals communicate and deliver due to technological demands of smart cities in the future. The purpose of this paper is to identify what is the base line communication preferences that could aid AEC professionals to prepare themselves to deliver in the smart city implementation. The study found that AEC's professional culture, methods of knowledge transfer and educational programs could affect several dimensions of their beliefs and values in ways of delivering projects therefore, influence how they communicate and deliver projects. Integrated Futures Studio (IFS) is a multidisciplinary design studio education program that is recommended as a part of the Malaysian future AEC transdisciplinary training for smart cities deployment. This paper supports Malaysian Construction 4.0 Strategic Plan (2021-2025) for the Malaysian construction industry. Human processes during the early design stage of Integrated project delivery are documented. Future studies are recommended to assess actual implementation in design studio setting and apply for industrialized project delivery.

Keywords: Transdisciplinary work culture, AEC, Professional education, Collaborative Technology

I. INTRODUCTION

Technological advancements of informatics and communication technology in smart cities along with rapid urbanization, globalization and industrialization have been the factors shaping the smart cities development (Lee et al., 2014; Gracias et al, 2023). Smart cities use systems such as the Internet of Things (IoT), data analytics, and artificial intelligence to create efficient, resilient urban environments (Zanella et al,2014). With projections suggesting that nearly 68% of the global population will reside in urban areas by 2050 (Voumik et al, 2023), the development of smart cities offers a critical response to growing demands for better resource management, environmental sustainability, and enhanced urban living (Zanella et al,2014). When globalization became a part of smart cities developments, many partnerships projects with other countries had become crucial and, synchronous and asynchronous collaborations across multiple professionals has been the professional communication culture (Abdul Ghafar, 2024). Globalization has made Malaysian AEC industry needing to employ collaborative paraphernalia during international partnership project delivery with other respective counterparts in other countries.

Two of the major Thrusts in the Malaysian Construction 4.0 Strategic Plan (2021-2025) (CIDB Malaysia 2020) are encouraging AEC professionals to improve their productivity and increase internationalization. These thrusts necessitate the Malaysian construction industry to alleviate its building professionals' current skills, technology capabilities and professionals' proficiency. In becoming theses champions, BIM implementation through practice is crucial to enable Malaysian AEC to perform locally and globally. Unfortunately, BIM

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implementation is a costly execution and many professionals resist to adopt BIM in their practice (Latiffi et al., 2013). Here, this paper would direct the study toward human factors regarding users' socio-culture issues when using BIM-visualization tools. This paper agrees with Delavari et al. (2011) that these resistant has to do with the issues of lacking control of human over tools, slow user feedback when using tools and lacking added value of tools during collaboration phase. In predicting how the future works in these areas, this paper seeks to propose finding out what is the minimum collaborative technology infrastructure to support Malaysian AEC professionals' collaboration effectively during industrialized project. The study intends to support a useful overview of the minimum Malaysian BIM-supported human visual-collaborative communication infrastructure that could be used effectively during industrialized project delivery.

II. 2.0 LITERATURE REVIEW

III. 2.1 Tools for Professional's Collaboration

When a leader is coordinating multi teams in many locations, technology use is crucial for sharing knowledge, communication, achieving project mission and vision, and providing value to client. Synchronous or asynchronous tools would be ideal for professionals to work in real time and different times over longer time frames. Using these tools could augment a professional's communication behavior (Horii,2005) and aid successful problem solving. This paper agrees with Abdul Ghafar and Ibrahim (2018) and Kam et al. (2003) that technological tools could augment collaboration and facilitate collaboration processes and culture. Therefore, this paper is keen to focus on asynchronous collaborative tools as it assimilates much of the AEC operating environments characteristics.

In reference to prior discussion, this study agrees with McKinney and Fischer (1998) that the critical part of AEC interactive experiences is to have a comprehensive tool that could simulate and depict construction processes (Weigert et al., 2022), well-coordinated work, effective communication (Engel, et al.,2023), and information sharing to make decision between multi stakeholders (Chen & Hu, 2020). This comprehensive tool needs to have characteristics of interoperability factor to be able to read between asynchronous tools (Froese, 2003; Jezernik & Hren, 2003; Kam et al., 2003; Schreyer et al., 2005); and deter inadequate information distribution and reception (Hamil, 2012). Hence, this study foresaw that interoperability plays an important characteristic to further improve and support fragmented AEC industry.

IV. 2.2 Fabrication and cultural knowledge

Hofstede (1997) manifested that culture is a several layers of mind programming in a society that creates personality, habits and human behaviors. Hofstede further denotes that this mind programming affects societal "national culture" differences that reflects region, religion, gender, generation and societal class; and organizational culture. It is here that this study saw that much of the AEC organizational culture is influenced by AEC characteristics such as complacency using 2D method in delivering projects (Fischer, 2006). This distinctiveness is because AEC professionals are used to the 2D method during their early tertiary training (Ibrahim & Pour, 2010; Rahimian & Ibrahim, 2011). This has resulted resistances in accepting new way of delivering project. In the same vein, this study recommends investigating how these cultural knowledge programming could lift AEC productivity and therefore reduce industrialized waste.

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Scholars denoted that high waste production is the result of lack awareness among stakeholders (Poon et al., 2004); lacking waste management conduct (Osmani et al., 2006; Begum et al., 2009); and wasted cost surplus that did not add value to product capital efficiency (Koskela, 2000). Industrial waste in this context are categories in eight waste production such as overproduction waste overproduction waste, inventory waste, extra processing; steps waste, motion waste, defects waste, waiting waste, transportation waste (Ohno, 1988) and make-do waste (Koskela, 2004). Many of these waste categories are caused by deficient professionals' awareness, behavior and conduct towards waste. It is here, this paper agrees with Abdul Ghafar et al. (2014) that industrialized waste is a result of cultural knowledge.

This paper is in line with Abdul Ghafar et al. (2018) that organization cultural knowledge and waste reduction behavior have resulted from knowledge transfer among project members and professionals' education programs. In order to develop cultural intelligence in the construction industry, this paper agree with Knight and Sass (2010) that establishing cultural and social factors would be prudent in construction industry. Through improving and modifying communication practices via synchronous tools and cultural knowledge during early stage of design could reduce industrialized waste. This step could avoid knowledge loss and instill effective fabrication. Here this study posits that professional work cultural knowledge and synchronous technological platform could give good interoperability, sufficient information and reduce of rework in subsequent project delivery phase. Thus, this study conjecture that synchronous collaborative tools together with professionals' work culture would enhance effective communication, decision making and deter rework during design phase in industrialized project delivery.

2.3 Enhancement of AEC Education

Having determined the idea and concept of how the BIM technology could improve project delivery by being more efficient, effective, flexible, and innovative, this paper now discuss the need to further improve and reform the AEC education curriculum particularly in Malaysian industry. During the early phase of AEC professional education, they are still being conducted separately between architect, engineer and construction programs. This is in line with Hofstede (1997) notion that societal or organizational culture instills AEC professionals with 2D working culture as part of their early tertiary education and trainings. Therefore, when considering the use of IT by the AEC professionals, the need for human-computer-interaction (Delavari, et el., 2011) factor is recommended to deter rejection of IT implementation (in this study, BIM integration). This study foresees that when socio-cultural issues are dissipated, AEC professionals would not resist using collaborative visualization tools.

2.4 Malaysian's AEC education curriculum

Together with understanding of the AEC's cultural knowledge, it could improve implementation percentage of BIM technology in the industry. In adapting towards this direction, reformation of AEC curriculum is needed. This paper believes that in the current Malaysian AEC education curriculum, it could be further supported with some form of cultural knowledge dimension when delivering building projects. For instance, in the Malaysian national culture index (the Culture Factor Group, 2024) it's national having a high PDI, the Malaysians tend to prefer centralized and multi hierarchical structure in organization, while in the UK, due to low PDI, they tend to opt for a decentralized and flatter structure in their organization (Abdul Ghafar & Ibrahim, 2023). Refer to Table 1.

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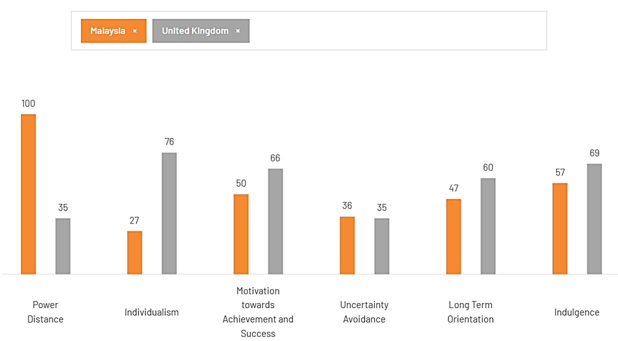
Table 1: Hofstede's National culture model comparison between Malaysia and United Kingdom



Another example is that, due to the high PDI and low IND, the Malaysians tend to have a consensual decision making and communication as opposed to the British where they tend to have an individual decision making and communication processes (Abdul Ghafar, 2024).

A greater concern now arises when future AEC graduates are open towards global markets and global cross-trans-disciplinary building project delivery challenges where they will be required to work collaboratively and efficiently. In line with Malaysian Construction 4.0 Strategic Plan (2021-2025) objectives, the Malaysian construction industry would need to revisit the earlier IT-integrated AEC curriculum (Ibrahim, et al., 2007) called as the Architectural-Construction Integration (A-CI). This study proposes the human factors found in this study to be embedded in the A-CI curriculum to enhance further the graduates' knowledge skills in cross-disciplinary work environment.

In preparing the AEC's younger generation for smart cities competition and globalization in the construction industry, this paper foresees that there is a need to empower the younger professional generation with agile Integrated Project Delivery (IPD) in cross-trans-disciplinary global distributed project teamwork using advanced synchronous and asynchronous collaboration technologies. Effective collaborative tools such as IT based tools such as BIM enabled technologies could aid predefined and solved problem while effectively augmenting and powering collaboration such as process. Reliable coordination and accurate information would change traditional delivery methods to advanced manufacturing methods. This would require the AEC's education curriculum in universities to reform the fundamentals of their curriculum. Future graduates need to learn how to use new design tools and to design differently than present curriculum. This paper presents the reformation of the A-CI curriculum in the following manners: 1) Theoretical foundation for the A-CI curriculum 2) About A-CI curriculum and 3) Proposal for human factors integrated in the A-CI curriculum.

i) Theoretical foundation for the A-CI curriculum

The study found that the fragmentation culture of AEC is inherited from their earlier tertiary training and previous experiences during projects (Ibrahim & Pour, 2010; Rahimian & Ibrahim, 2011). This has created "siloness" working culture and creating coordination problems, communication challenges, and risk of argumentative decisions between team members at a higher level. This study saw that transdisciplinary delivery is much needed and is crucial to close the AEC fragmentation gap. Transdisciplinary learning entails global new vision and lived experience. It can transform one self's orientation of knowledge, unity of knowledge, and create the new art of living in the 21st century society (Nicolescu, 1999).

Transdisciplinary learning emphasizes the four pillars of learning in education: learning to know, learning to do, learning to live together, and learning to be (Nicolescu, 1999). These learning processes support the ever-needed

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learning reformation by the future AEC graduates as opposed to the traditional "siloness" learning system. In Ibrahim, et al. (2007) study, they highlighted that Bruder's (1994) notions of transdisciplinary learning as an educational model which allows academicians to support knowledge and skills collectively with industrial and non-industrial members in determining the services that most benefit a student.

ii) About A-CI curriculum

Extending Bruder's (1994) concept, Ibrahim et al. (2007) bring the transdisciplinary learning in the architectural education system to build stakeholders' comprehension of present environment and unity in design, engineering, financing, socio-cultural, etc. The proposal of the Architectural-Construction Integration (A-CI) emulates the Problem-Project-Product-Process-People-Based Learning™ (P^5BL) Laboratory from the Stanford University (Fruchter, 1999; Fruchter & Townsend, 2003) due to similarity of cross-trans-disciplinary global distributed project teamwork learning but focuses on the early design phase of a project's design development phase.

Adapting the Stanford's P^5BL AEC Global teamwork model (Fruchter, 1999), the A-CI curriculum offers one year 2-semester design studios. It engages 4 to 12 AEC project management students from developing countries geographically distributed worldwide. Each AEC team has an owner or a client with a building program, a location, a budget and a timeline. Each student has four challenges: 1) cross disciplinary teamwork, 2) use of advanced collaboration technology, 3) time management and team coordination, and 4) multicultural collaboration. The minimal infrastructure needed to support the A-CI transdisciplinary exercises are shown in Table 2 below:

Table 2: Minimal infrastructure support for A-CI

Infrastructure	Description
Network infra	LAN/ WAN, internet and the wireless zones;
Interactive devices	PDA's, tablet PCs for mobility, Web cameras, Smartboards, to the iRoom (Johanson, Fox, & Winograd, 2002) for collaborative synchronous review and decision support;
Collaboration platform and application	To cater asynchronous and synchronous communication, feedback and interaction, direct manipulation, knowledge capture, sharing, reuse, and data collection and analysis;
Networking and learning spots	Various places of private, public and local for the P^5BL students to work as learning and networking hubs
Industry engagements	Engagements of various discipline ranging from students, faculty, and industry's mentors from experienced AEC professionals.

Careful structures mentoring techniques are used in the A-CI model. Students participate in regular meetings between students and mentors. Apart from the normal project review and project's crits, the A-CI curriculum introduces the Fishbowl session. A Fishbowl session is a

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project review session where students watch industry mentors participate in real-life how AEC professionals work together on solving a problem (Fruchter, 2006). The student is at times the center of activity, supported by mentors, and other times observing mentors at work. The mentors in turn, learn how to use the technologies they observe, while the students make new IT practices explicit, and are able to bring these ideas and technologies into their workplace (Fruchter & Lewis, 2003).

Emulating Stanford's P^5BL AEC Global teamwork model objective, the A-CI curriculum tries to make all or majority of the students position themselves in the center to gain learning experience and understanding. To gauge their learning experience and understanding, the A-CI follows the cross–disciplinary assessment (CDL) which transforms "island of knowledge" to "island understanding of goals, languages and representations of the other disciplines" (Fruchter & Emery, 1999; pg 4). The A-CI curriculum is anticipated to form high performance team that use collaboration and communication technologies effectively while exhibiting these two behavioral and process changes (Fruchter & Chao, 2004):

1) Collaboration readiness that requires early and continuous knowledge sharing, responsiveness, and timeliness; and
2) The third way entails establishing a team communication process based on the team's preferences for communication channels, protocols and norms. Any technological choice leads to behavioral, process, and team dynamic changes.

2.5 Proposal for Human Factors Integrated in the A-CI Curriculum

Having studied the A–CI curriculum, this study proposes extending the A-CI model with embedded professionals' collaborative culture model integration to leverage better human and technology innovation collaboration to produce higher quality professional graduates, products, and more economical-environmentally friendly global projects delivery, which it is named as the Integrated Futures Studio (IFS). The researcher anticipates the IFS curriculum framework could be the real-life experience needed, while mitigating cultural differences in the early design phase of a project.

The objective of the IFS curriculum is to provide hands on engagement and adherence of AEC's work culture with computational infrastructure for collaborative communication that would bring different geographically located teams from multiple disciplines together. The IFS curriculum embeds cultural knowledge together with BIM technology implementation into the curriculum at master level to expand the current professional competency requirement in the AEC education program. Since cultural knowledge is a function of work culture, knowledge management and professionals' collaboration, this study proposes dichotomizing the postgraduate curriculum into two semesters design studio. Table 3 summarizes the proposed IFS curriculum.

Table 3: Sequence of IFS Transdisciplinary Design Studio Curriculum (Adapted from Ibrahim et al. (2007)).

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Sem.	Transdisciplinary Input	Project Type	Design Challenge
One	● Professional culture ● ICT infrastructure ●Tasks interdependency ● BIM infrastructure	University's library	● Preparing conceptual due-diligence report that include financial cash flow projection following the regulatory planning procedure and design phases ● Preparing conceptual due-diligence report that include financial cash flow projection following the regulatory planning procedure and design phases ● Culture impact to project's performance. ● Determining team's structure and configuration based on culture ● Determining task inter-dependencies and workflows based on culture ● Design proposal ● Refining financial feasibility and project design through value engineering with the incorporation of selected energy efficiency components into the finalized conceptual design proposal
Two	● Project Team's Knowledge flow	University's library	Deliberating on design decision between students from developing countries with their counterpart from developed nations

In the IFS P^{5}BL model, through usage of BIM technology as the project's communication, it breaks the insufficiency of 2D conventional communication culture between professionals. In P^{5}BL transdisciplinary learning, technology is crucial to the collaboration and design processes, therefore, without it, participants would not be able to collaborate across geographical distances (Fruchter & Lewis, 2003). BIM technology is needed to bridge the AEC's gap of communication, transform implicit knowledge to explicit knowledge for stakeholders, and accelerate project comprehension. In order to instill the BIM communication culture in AEC practices especially in developing countries like Malaysia, alteration to the AEC education system is needed. The younger AEC's professional generation must be equipped with the fundamentals of 3D and 3D CAD modeling, and BIM technology in order for them to compete in the global market.

Many western universities together with their industries partners have formed forte groups and enhanced their AEC curriculum to improve their inadequacy of AEC communication techniques. Here, this study highlights that if the local universities are interested to implement the same BIM education's forte and techniques as the western universities, a fit change is needed to fit national culture model as per suggested by Hofstede (1997). This is supported by Abdul Ghafar & Ibrahim (2023) that organizational norm values are usually absolute, firmly in place and difficult to change (Hofstede, 1997). There is a

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need of change from the 2D conventional techniques to 3D and 4D CAD model techniques in the Malaysian AEC's education. However, this study predicts that further research is needed to find appropriate measures for BIM technology's implementations during the IFS design activities. In this light, this study sees that the proposal of IFS curriculum could be successful if it is tailored towards local context to suit the Malaysian AEC delivery and culture.

CONCLUSION

The IFS curriculum is proposed to emulate the P^5BL ecosystem developed at Stanford University. The AEC design studio offers engagement of other students from other disciplines and work together in a studio project. Good network infrastructure is recommended such as high-speed WLAN, WIFI and greater wireless connectivity to support the trans-disciplinary program. The industry mentors and main industry players need to learn and diversify the way in delivering projects like the students so that the program can work. Nevertheless, the faculty, department and university support are crucial in developing the IFS infrastructure and human resource developments. Reformation of the Malaysian AEC professionals' education could upgrade future Malaysian AEC's graduate skills with trans-disciplinary learning and advanced decision-making processes. The recommended IFS curriculum could bridge the AEC's fragmentation gap by understanding other discipline's cultural knowledge in the early design process.

Instilling of the BIM communication in the IFS curriculum is hoped to encourage and prepare the Malaysian AEC graduates with skills and to be competitive in the global market. With the proposed IFS curriculum, the Malaysian AEC education system would depart further as the AEC global transdisciplinary learning but locally contextualize to suit the Malaysian AEC delivery and culture. In conclusion, this emerging "BIM behavior" could provide a solution to close the gap for developing countries like Malaysia to have successful partnership with counterpart from developed countries.

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