HCI to Engage Design Team Members in IT-integrated Design Collaboration Process

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Abstract: Design Collaboration is an activity that requires participation of project team members for organizing design tasks and sharing experience and information. Currently, in this process the project team members are yet to fully utilize computer technologies while communicating in non-collocated design collaboration. Correspondingly, many still prefer to communicate face-to-face. However, miscommunication and lack of efficient collaboration is observed among them. The purpose of this paper is to integrate Human Computer Interaction (HCI) in design collaboration process in order to engage design team members in IT-integrated design collaboration process. Based on the extensive literature survey analysis, we identify the current gaps and deficiencies in design collaboration process. Consequently, to fulfil the current gaps, the study proposes HCI solution to current non-collocated design collaboration process. The authors identify that engaging professionals in human computer interaction is a solution to the deficiencies of current IT-integrated design collaboration process. Our literature survey will include design collaboration in building project team, technology in communication, HCI and engagement studies. The result of this analysis and proposed solution is presented by a model. This model indicates that identification of key human factors during design collaboration process is essential to engage professionals in collaborating using IT/ICT technology. Additionally, the study recommends the key human factors supporting IT-supported design collaboration. Consequently, the identified key human factors will lead us to identify the most dominant parameters that engage design team members in IT-integrated design collaboration. It will potentially help to improve collaboration among team members trough IT technologies.

Key-words: Engagement, HCI, non-collocated design collaboration, human factor, IT-integrated design collaboration process, IT/ICT.

1 Introduction

Globalization [1] has motivated building industries to increase the establishment of non-collocated design collaboration. This potentially led to an increase demand in adaption of collaborative technologies in design collaboration process. Therefore, IT/ICT makes it possible to integrate geographically dispread designers, design system, resources and services together and make them operate in a global collaborative environment beyond the boundaries of physical and time zones. However, IT/ICT integration in design collaboration impose building professional to collaborate uncomfortably with Information system. Therefore, establishing a successful collaboration in non-collocated design collaboration leads the research toward developing an IT-supported design collaboration that support not merely the organizational need but rather human understandings and needs of human in utilizing the system [2, 3]. On the other hand, Human Computer Interaction (HCI) concerns with designing computer systems that support people

so that they perform their activities safely and productively [4]. Consequently, HCI aims to integrate human or user aspects into system development [3]. Therefore, the resulting systems are designed based on human need as well as organizational need. As a result, the author believes that for the establishment of successful IT-supported design collaboration, the research leads toward the application of HCI in IT-supported design collaboration to improve the interaction of human and computer by emphasizing on human aspects of system use [2].

Furthermore, the central part of HCI is engaging interactivity within IT-supported and computer-based applications. Consequently, failing to engage design team members in IT-supported design collaboration has resulted to being unmotivated, inattentive or uninterested interaction to the collaborative technologies. Accordingly, among the broad HCI issues this study leads to the engagement of building professional in IT-supported design collaboration. Therefore, this study leads toward incorporating HCI in IT-supported design collaboration process to engage building professional to the interactive collaboration process. Finally, the result of this study bridges the interdisciplinary approaches including design collaboration process in building design process, computer science, HCI and human cognition psychology to reveal the human key factors by demonstrating the relationships between IT-integrated design collaboration process and HCI in engaging design team members.

This is a theoretical paper whereby, first it presents a brief introduction and background problem. Section 2 presents the studies on design collaboration in building project team, technologies used in communication. Section 3 and 4 present HCI related studies and HCI used in design collaboration process respectively. Section 5 presents the engagement related studies. Section 6 discusses various engagement models proposed by earlier studies. Section 7 presents the solution to IT-integrated design collaboration process based on the analysis of current work basis. Section 8 presents the key human factors supported in design collaboration based on theories of adopting technologies and parameters of engagements. Finally, Section 9 concludes and discusses the whole paper.

2 Design Collaboration Trend

Design collaboration process among design team members is accomplished by sharing and organizing design idea, resources and expertise for an agreed design task [5]. According to the various communication and collaboration methods in design collaboration process, the author divides the reviewed literature into three clusters including traditional collaboration, IT-supported collaboration and advanced studies in design collaboration. In the next section, these clusters and the appropriate studies are discussed and explained.

In traditional collaboration, the studies have not emphasized on using IT/ICT technology during the processes. In this category of studies, the authors evaluate collaboration and communication based on the originality of communication issues. In this regards, Chiu [6] attempted to present the role of organization in design collaboration and its affects in communication and collaboration. He has successfully suggested that a structured organization can facilitate design communication and consequently contribute to the success of the design project. However, there is lack of a proper computational system in the organization to evaluate and improve the communication level among design team members. Subsequently, the next category of studies encompasses computational techniques to enrich design collaboration process. These studies particularly examine the role of collaborative technology in supporting designing based upon an authentic real-life design problem or communication deficiencies. Computerized design collaboration process has enabled the team members to work in a distributed design environments [7, 8] or virtual design studios (VDS) [9, 10] synchronously or asynchronously.

Haymaker et al. [11] state that to improve the communication in design collaboration, where there are difficulties in negotiating across different domains with different language and way of representation, implementing a new type of design including ‘filters’ is very beneficial. They proposed this new approach called ‘Filter Mediated design’ in which these mechanism is augmented using agents for achieving coherence and innovation in remote collaboration design. It serves to reformulate the construction and flow

of information in collaborative design. The intent is to reduce some of the verbal communication to improve efficiency and allow for more people to participate in the design process. Even though, the use of computerized filter mediated system has simplified the team members' collaboration, but it has also decreased the creativity level of design team members. Thus, this paper will attempt to evaluate a computational medium for simplifying design collaboration while maintaining the creativity level and attraction of expert.

Another study by Larsson [12] in the category of IT-supported design collaboration has successfully presented an observational study of the essence of a true collaboration that design team members 'think together' rather than just exchanging information. This study gives us a broader view of how a collaborative design team member communicate and negotiate common ground in collocated collaboration effectively, subtly, fluently and effortlessly such as negotiating by telling stories, and using indexical representation. He uses a wide variety of tools including, physical prototype, sketches, verbal languages, gesture, chairs, even their own bodies and all possible types of objects to visualize and describe their meaning. However, the study does not present a global design team where the collaboration is applied using the IT-supported technologies in more natural and user-friendlier way. Therefore, this paper will use HCI and evaluate an environment where the IT-supported collaborative technologies are used as a tool to determine the human factors that make the system working more naturally and user-friendlier.

Increasing the globalization and international collaboration, has led an increase demand in improving the communication in design collaboration process. Accordingly, improving the communication in distributed design environment requires the use of more advanced information technology. This is the place where the third category of our literature study in design collaboration takes place. Currently, the collaboration across different time zone or geographical, functional and cultural environment has created global virtual team [13, 14, 15, and 16]. In order to work with multiple design ideas in parallel and real time collaboration, Hailpern et al. [17] facilitate creative design process by providing re-interpretation and reflection-on-action capabilities. Their study developed a novel system that satisfies the requirement of real-time collocated design collaboration (keeping multiple design ideas visible simultaneously, providing clearly delineated personal and group spaces, allowing multiple levels of sharing, shared idea should always remain in the collective consciousness, allow rapid access to personal and shared designs, minimize social inhibitors of group work) that support creative group work collaboration. However, for the success of a collaborative group work, the human dimensions should be considered accordingly. Therefore, this paper will consider how the consideration of human key factors would improve the IT-supported design collaboration.

Erickson and Kellogg [18] focus on designing socially translucent systems in collaborative design. In fact, these systems are the design digital systems that support human-human communication and collaboration by using the properties of physical world. Their designed system is called 'Babble' and it is designed by making participant and their activities visible to one another in a collaborative network. Therefore they can make inferences about the activities of others and to imitate one another. This socially translucent system integrates three characteristics (visibility, awareness, and accountability) in it. However, their study merely focuses on three characteristics of a socially translucent system which support the cognitive or usability concern of human-human communication. Therefore, this paper will focus on human key factors as a whole in collaborative design system to not only affect the cognitive human need but additionally design team members' emotional and behavioural need.

Apart from improving the collaborative technologies in design collaboration such as display sharing abilities, Plaue et al. [19] present the importance of social and technology routines as well as technology improvement. They analyze the behaviour of designers and determined the technological and social routines of individuals using devices and sharing information across spaces and multiple meeting. They describe social and technological routines

of users includes: i) device arming, ii) ephemeral personal device usage, iii) at-a-glance information is important, iv) physicality comfort and reassures, v) non-technical factors are critical for success, vi) rooms must be versatile. These routines are defined with consideration of cognitive or usability of the collaborative system. Therefore, this paper will focus on IT-supported design collaboration where the realization of human psychological dimension is more than just physical and cognitive aspects.

In addition, many studies present the more natural and direct use of 3D digital modelling and tangible user interface (TUI) in collaborative design process [20, 21, 22, and 23]. TUIs are useful to construct internal and external design representations to designers, therefore strengthening their spatial cognition. Kim and Maher [23] improve the collaborative design environment by tabletop systems which employ TUI through an empirical study. They present the impact of TUI in changing designer's spatial cognition and therefore improving their problem-finding behaviour. This potentially improves the design process. This study highlights TUI which directly impact designers' spatial cognition by perceiving external representations. However, there is still lack of sufficient emphasis on the human aspects of system use. Therefore, this paper will emphasize in an IT-supported design collaboration process that meets the human requirements. Because the ultimate concern of design team members interacting with technology is for supporting their experiences with technology for collaboration enrichment and successful communication.

3 Human Computer Interaction (HCI)

HCI is defined as ''a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them'' [24]. According to Preece et al. [4] human-computer interaction is the process of designing computer systems that support people so that they perform their activities safely and productively. Zhang et al. [3] define HCI as the way that human interact with information, technologies and tasks within various contexts.

HCI is the study of how people use computer systems to perform certain tasks. It is a multidisciplinary science which concern about computer, psychology, sociology and anthropology, industrial design, ergonomics and linguistics. The goals of HCI are generally to make tasks easier, more effective, more satisfying to perform and safer based on human understanding [25]. Accordingly, design collaboration process which is integrated with collaborative technologies should be investigated on how the system affects the user's perception and human evaluation factors.

Usability is a well-defined concept in most of HCI research studies [26, 27, 28 and 29]. Chou and Hsiao [30] define ''Usability'' as the extent to which the user and the system can ''communicate'' clearly and without misunderstanding through the interface. His study presents the effects of ageing in usability of computer systems based on a project that has been executing to encourage unemployed adults, particularly middle-aged workers, to learn elementary computer skills, enabling them to operate computers; therefore, more user-friendly computer interface is required. For instance, the usability analysis among middle-aged learners have more similar user characteristics in keyboard or monitor usage, application preference, software use difficult, and also the view on present interface design. This will help to satisfy the designer in the collaborative process through the result obtained from previous empirical study. However, usability is not the only human factor in designing an interactive human computer application. It is one of the human factor under human cognitive dimention in HCI. Eventhough cognitive psychology plays an important role in HCI, but the realization of human has more than just cognitive aspects.

HCI is recognized as an interdisciplinary field where many domains contribute to study and apply it in their systematic processes. These systems propound the importance of human-centred system development (HCSD). Zhang and Li [34] stated that there is also no emphasis on the human/social aspects of MIS system use and these systems focus more on organizational need rather than human need. They draw an overview picture of the HCI subfield in Management

Information System (MIS) [32]. The assessment of their studies in the previous publication patterns presents an increasing number of HCI in the field of MIS. In addition, Zhang et al. [3] successfully integrate human or user aspects into Systems Development Life Cycle (SDLC) [33] and improved these processes by proposing a new HSDLC model which considers user's constraints. Consequently, Despont-Gros et al. [34] state that, there still is no reliable model of dimensions in user evaluation of Clinical Information System (CIS). Their study develops such a model for summative evaluations of user interactions with CIS from the end-user point of view. They successfully proposed a model of HCI by determining the key dimensions (CIS characteristics, user characteristics, development process, and context of use) of user evaluation. Similarly, human computer interaction and interface have shown their importance in product apearence design and manufacturing. This is due to the lack of emphasis on human and social aspects in current CAD (computer-aided design) systems. The computer aided product design systems are designed by its physical features from the the function of product and the model of Function-Behavior-Structure (FBS) design model. However, FBS model do not consider the human-machine design and does not emphasis on human as the core in product design [35]. This model is improved by considering human computer interaction and interface (HMI&I) into the design processes.

Considering human constraints has been an important fact in designing HCI system and they potentially improve the system functionality. Subsequently, these human constraints have been defined in MIS, CIS and HDLC. However, this paper will identify the key human factors in design collaboration process where the design team members collaborate with IT-supported technologies.

4 HCI in Design Collaboration Process

As stated above, the related studies in HCI and design collaboraiton process indicate that to motivate building professional in performing their activities in IT-integrated design collaboration and satisfy their human need, there is an urgent need to integrate HCI into design collaboration processes. There are few studies concerning the application of HCI in design collaboration process. In the following section, these studies are explained and analysed.

He and Han [36] state that there is an indirect and time consuming collaboration among the individual designers in standalone and distributed CAD systems. Traditional standalone and distributed CAD are system-centered rather than being human-centered. Collaborative CAD is aimed to provide human to human interaction and instant collaboration among group designers. Their study successfully presented a descriptive, prescriptive and computer-based model of human-human interaction in collaborative design to support human-human interaction.

In addition, Sener and Wormald [37] state that HCI of current CAD systems does not fit industrial designers' needs for designing product form. 3D CAD is not direct towards their own creative practice for defining the form of a product and the underlying need for sketching. Currently, computer interfaces have been identified as a potentially desirable, immediate and intuitive means of HCI for industrial designers. His study successfully enhance CAD to fit better to industrial designers' needs for conceptual form creation in virtual workshops and intelligent environments using smart material, haptic holograph representation and automated 2D-to-3D translation and then illuminate ways that computers provide improved support. They prioritized customer needs for improved digital tools for industrial design.

Rahimian and Ibrahim [38] utilizes collaboration in real-time using vitrual reality to improve communication for geographically dispread locations. They illustrate usefulness of 3D sketching in CAVE collaborative design environment [38]. In this regards, Ye et al. [39] state that designers have not been fully satisfied with the design functions and UIs (the mouse/keyboard and 2D display interface) that most commercial CAD systems have provided. These disabilities include, i) no freeform shape creation for designers, ii) not allowing 3D freehand sketching type usage and iii) not allowing designers to follow their own design paths. Especially in conceptual design stage,

there is lack detailed 3D modeling expertise in using conventional systems. The designer prefers to use paper and pencil for conceptual design. Their study developed an innovative conceptual design system called LUCID (Loughborough University Conceptual Interactive Design) system, to improve the interaction between designers using Virtual reality technology, a human computer interface over the conventional CAD systems. It enables to create, touch, view, manipulate and listen to CAD digital models more effectively by taking advantages of designers' visual, auditory and tactile sensor channels. This system presents more natural interaction between the designer and the CAD system in conceptual design phase.

The above studies by Ye et al. [39], He and Han [36] and Sener and Wormald [37] have presented the importance of human factors in current CAD or collaborative CAD system. However, these studies are all applied in product design manufacturing process. Therefore, this study will use the factors of human in design collaboration process where the design team members collaborate with each other using IT-supported collaborative tools.

5 Engagement and Related Studies

Engagement is a term appears in HCI research. Engagement theory was initially emerged in educational domain by Greg Kearsley and Ben Shneiderman's experience in distance and electronic education teaching [40, 41]. It is defined as a conceptual framework for technology-based learning and teaching [41]. The primary idea of engagement theory in an educational domain is that the students must be engaged in learning activities through interaction with others and other academic tasks.

In order for a computer-based application to be fully engaged, they have to attend the user senses, they have to be functionally accurate, they have to attend the cognitive, behavioural limitation of users and they have to function or affect accordingly. The earlier research studies are highly relevant to engagement theory, although they are not explicitly conducted in the context of engagement theory. Alavi [42] studied on collaborative learning and tested among two groups of students, one in electronic classroom and the other in a traditional classroom. The teaching and learning activities are the same expect that the electronic classroom uses a groupware program (VisionQuest) for collaborative learning exercise. The result of this study shows that technology-mediated collaborative learning resulted in higher levels of self-learning and perceived skill development. In addition, Hiltz [43] and Harasim et al. [44] evaluated an online and virtual learning in New Jersey Institution of Technology which includes messaging, conferencing, online notebooks, databases, exams and grade books. The result of this study reveals that virtual classroom environment resulted in greater student satisfaction and mastery in course material.

Liu and Rutledge [45] and Liu [46] have successfully engaged high-school students in a learner-as-designer environment using professional Multimedia tool to motivate students in learning and acquiring some important design skill by directly working with clients and designing for real audience. They found that participating in the learner-as-designer environment increases their intrinsic motivation and the students have significantly higher self-efficacy scores. However, his study is merely based on cognitive apprenticeship principles, such as modelling, coaching, scaffolding and fading, articulation, reflection and exploration to improve students' learning achievement and design skill. Therefore, this study will use the collaboration technology in a design collaboration process to engage design team members and determine the factors that cause engaging the members in design collaboration process.

A study by Persell [47] presents the usage of digital technologies in enhancing student engagement to reading and sociological idea of other student. These technologies use Blackboard as course management software for organizing discussion board rather than a designed-from-scratch course website. He identifies many criteria that helped students to learn from web-based discussion, such as availability and ease of review, hearing from silent classmates, raising valuable new questions, becoming knowledge producers and seeing the excellent work of others. While the above studies use technology to

improve the student engagement, but it does not identify the factors that causes students to be engaged in educational environment. Therefore, this study will use the collaboration technology to identify the factors that causes design team members to be engaged in IT-supported design collaboration processes.

Zyngier [48] states that disengagement among students can be seen in terms of individual student dropout rate or problematic behaviour at school. But there is a more important reason, which is in terms of school failing to encourage and motivate students to achieve their potential. He proposed four criteria based on the engagement among teacher and students. These are i) Connecting: with student's cultural knowledge, ii) Owning: ability to feel and see themselves in the work, iii) Responding: ability to actively and consciously responding to student's lived experience, iv) empowering: ability to feel what they do will make a difference in their life. However, these factors are the result of engagement neglecting technology. Therefore this study will use collaborative technology as a tool to determine the factors of engagement and disengagement among design team members.

There are many studies that presented the importance of technology as a tool for engagement. Riche et al. [49] presented the use of the technology probe methodology to facilitate engaging researcher in participatory design process. They successfully deployed an observation tool called Zebra to engage users in fieldwork of using tool and design exercises of the tool. Participant engaged with probe in ways ranging from playful performances through abounding social spaces.

Annetta et al. [50] has successfully presented that the students who played computer-based Multiplayer Educational Gaming Application (MEGA) are more engaged in the instruction and they are more motivated to interact with learning environment rather than the traditional one. Additionally, Nguyen and Trimarchi [51] successfully demonstrate an empirical study on using technology to promote student engagement and active learning. The result of this study reveals that student respond more favourably to learning technology and their mark performance are boosted. The study demonstrates how a learning technology enhances student engagement and active learning. The electronic communication improves student-instructor interaction. It potentially helps the instructor to save time on course management process especially for large classes and automate the routine tasks. It allows students to participate more in class activities. This study resulted in determining student engagement and active learning through the use of collaborative technology. However, all the above studies do not reveal the factors that engage or disengage students to learning process. Therefore this paper will determine the engaging key human factors that cause design team members to be engaged in IT-supported design collaboration process.

6 Alternative Models of Engagement

Naps et al. [52] introduced Engagement Taxonomy (ET) for the first time. They stated that the visualization technologies are only useful when they are used to engage learners in an active learning environment by graphically demonstrating the computer science concepts. The main idea of ET is that the higher engagement between the visualization tool and the learner, the higher positive effect on student learning outcome is. It primarily consists of six levels of engagement between the visualization and user. These levels are; 1) no viewing, 2) viewing, 3) responding, 4) changing, 5) constructing and 6) presenting. Though the level of engagement from level 1 to 6 increases, but the relationships among these levels are not a simple hierarchical relationship. Therefore, Naps et al. [52] has illustrated these levels in the form of a Venn diagram with the possible overlaps among the last five engagement category. Accordingly, there are many studies that have utilized and supported ET in development of Algorithm Visualization (AV) tools [53, 54].

Similarly, Myllerer al. [55] have successfully presented a new way in research on engagement in collaborative learning with visualization. They improved the ET and proposed a new engagement model called Extended Engagement Taxonomy (EET). They suggest that increasing the level of engagement between learner and visualization tool result in a higher positive

impact of collaboration with visualization tool. These level of engagement are categorized into which defined as, "no viewing", "viewing", "controlled viewing", "entering input", "responding", "changing", "modifying", "constructing", "presenting" and "reviewing". This study gives us a strong view of student engagement in collaborative learning environment. However, this study reflects the type of engagement support found of Program Visualization (PV) in pedagogical environment. Therefore, this paper will identify the effective factors of human in IT-supported design collaboration process to engage design team members while collaborating with each other through IT-supported technologies.

In addition, Bilda et al. [56] state HCI is critical in improving the communication between participants in interactive artwork environment. Their study has successfully applied creative engagement with interactive artwork system by considering the system that "gains attention" and "maintain that attention" to the system's users (audience and expertise). To propose a model of engagement, the author first identified the cognitive components of interaction (interaction modes, phases and states of audience engagement) as a basic element of the model. They have identified five modes of interaction: unintended, deliberate, intended/in-control, intended/uncertain, and unexpected. However, this model is the result of experiencing with interactive artwork system, where there is no collaboration among the artist, audience and interactive art work system. Therefore this paper will use the idea of this model of engagement and apply it for design team members who collaborate tightly in IT-supported design collaboration process.

7 Solution to IT-integrated Design Collaboration Process based on the Analysis of Current Work Basis

This section presents the summary analysis of design collaboration studies and identifies the proposed HCI solution to these studies (refer to Table 1). First column of this table presents the three clusters of design collaboration studies discussed above. Relatively, the analysis result of these studies leads the research to identify the existing gaps in design collaboration process which is presented in column 2. Column 3 presents the analytical suggestion to each cluster of studies. Relatively, based on column 3, the proposed HCI solution is presented in Column 4.

Table 1: Proposed HCI Solution to Design Collaboration Process based on Current Work Analysis

Cluster of Studies	Current Gap	Design Collaboration process Analysis	Proposed HCI Solution
Traditional collaboration [6]	There is lack of a proper computational system in the organization to evaluate and improve the communication level among design team members	Need to consider the IT-supported technology as a tool to improve the communication in design collaboration process	Developing an IT-supported design collaboration which engages professional design team members based on the key human factors.
IT-supported design collaboration [11, 12]	Decreased the creativity level of design team members and there is lack of natural way of communication for global collaboration.	Need to evaluate a computational medium for simplifying design collaboration while maintaining the creativity level and attraction of expert. Need to use HCI and evaluate an environment where the IT-supported collaborative technologies are used as a tool to determine the human factors that make the system working more naturally and user-friendlier.	
Advanced studies in design collaboration [17,18, 19, 23]	There is still lack of natural way of communication for global collaboration. In addition, there is still lack of sufficient emphasis on the human aspects of system use.	Need to focus on human key factor as a whole in collaborative design system to not only affect the cognitive human need but additionally design team members' emotional and behavioral need.	

Correspondingly, the result of studies where the collaboration is performed by traditional method of communication presents that there are still lacks of proper computational method. Therefore, this paper considers IT-supported technology as a tool to improve the communication in design collaboration process. In addition, the result of the studies which perform collaboration using computational technologies shows that the technologies have either decreased the creativity level of designers or there is lack of natural way of communication for global collaboration. Therefore, there is a need to evaluate a computational medium for simplifying design collaboration while maintaining the creativity level and attraction of expert and producing more natural way of communication through applying key human factors in the IT-supported design collaboration. Furthermore, the result of author's studies in advanced IT-supported collaboration technologies in design collaboration presents that there are often lack of human understanding from the systems and thus frustrating to use. As a result, this paper proposes a human-cantered collaboration to design team members that emphasize human-centeredness and consider HCI issues on human factors together with collaborative design issues throughout the entire collaboration process.

In addition, this paper uses the former frameworks of HCI dimensions [57, 24, 4, 34, 31] and the human dimesnstions presented by Zhang et al. [3] and concern extensively on human factors as the core element of HCI in a design collaboration process. In addition, the successful HCI applications in MIS, CIS, HDLC, product design and manufacturing have presented maximized interactivity and efficiency through the use of human need in system designing. In addition, many studies have stated that cognitive psychology plays an important role in HCI, but the realization of human has more than just cognitive aspects. Therefore, this paper will define and use the factors of human in design collaboration process where the design team members collaborate with each other using IT-supported collaborative tools.

Furthermore, the studies have shown that there is still no unified approach to understanding engagement. Apart from that, although, no empirical studies have been conducted in engaging design team members in IT-supported design collaboration; related research suggests that engaging experiences are effective. Then, the author identifies the key human factors that integrate both users and interface by considering psychology and human computer interaction. Consequently, this paper uses the engagement model proposed by Bilda et al. [56], Myllerer al. [55] and Naps et al. (2002) to discover the complete key human factors to collaborative technologies. Additionally, this paper extends the earlier studies by highlighting the design team members' cognitive, affective, and behavioural contributions to human-computer interactions. As a result, the authors will use the former models of engagement and related studies to determine the key human factors of engagement among design team members who tightly collaborate with each other in IT-supported design collaboration process.

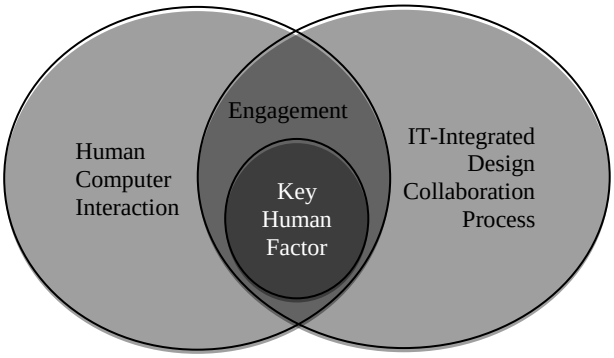

Fig.1: Model of Integrating HCI in IT-integrated Design Collaboration Process

In conclusion, based on the extensive study on design collaboration, HCI and engagement it is identified that the professional design team members still have lack of efficient collaboration and communication in non-collocated collaboration. Therefore, the authors propose that the design team members should be engaged in IT-integrated design collaboration process in order to fully utilize communication and collaboration. The result of literature analysis is presented as a proposed model by the authors demonstrating the integrating of these disciplines (Fig.1). The authors identify that engaging professionals in human computer interaction is a solution to the deficiencies of current IT-integrated design collaboration process.

Accordingly, based on HCI in order to effectively engage design team members in IT-supported design collaboration, the authors identify that key human factors should be determined. We define key "human factors" as a set of factors that are important to be considered in designing the systems from the human perspectives. Consequently, the process of identifying the key human factors is explained in the next section.

8 Key human Factors Supported in Design Collaboration

The analysis result of previous studies on design collaboration process presented that HCI is essential to be integrated in current design collaboration process. In addition, the importance of HCI in design collaboration process presented that human is the key factor in designing collaborative systems in design collaboration process. As presented in model (Fig.1), the key human factors which cause design team members to be engaged in IT-integrated design collaboration process are critical to be identified.

In order to identify the dominant key human factors in engaging professional to the IT-integrated design collaboration, first the numbers of key human factors based on the previous literatures are identified. Next, the study on theories of adapting technology is accomplished. Subsequently, using the related design collaboration studies, the supporting key human factors dominant for engaging design team members are identified.

The previous studies suggested that engagement consists of many parameters. These parameters consist of user control [58], focused attention-relevance to users' tasks [59], novelty [59], aesthetic and affective appeal [60], motivation [61], challenge [62, 63] and feedback [62]. Engaging involves user's cognitive, behavioural and affective expression to a computer application. Therefore, the result of this study is specifically on identification of various key human factors which engage design team members in IT-integrated design collaboration.

In addition, few models have been proposed for adaptation and use of IT-supported technologies. These models investigate the factors affecting the acceptance of technology by users in organizations. These models are Technology Acceptance Model (TAM) [64], the Theory of Planned Behaviour (TPB) [65] and the Unified Theory of Acceptance and Use of Technology (UTAUT) [66]. A summary of these theories are presented in Table 2 which presents the key constructs appropriate to each theory.

Table 2: Theories of Accepting Technology and Their key Constructs

Theory	Keyword	Key Constructs
Technology Acceptance Model [64]	TAM	Perceived Usefulness (PU)
		Perceived Ease-Of-Use (PEOU)
Theory of Planned Behavior [65]	TPB	Intention
		Behavioral Control
Unified Theory of Acceptance and Use of Technology [66]	UTAUT	Performance Expectancy
		Effort Expectancy
		Social Influence
		Facilitating Condition

Furthermore, to identify which of the above factors are the most dominant to engage design team members in IT-integrated design collaboration, an extensive literature in design collaboration studies are performed. The result of this analysis presents the key human factors which are supported by IT-integrated design collaboration studies (Table 3). As shown in Table 3, Column 1 presents the different models of technology adaptation. Subsequently, Column 2 presents the key constructs appropriate to each model. Column 3 presents the corresponding human factors supported by IT-integrated design collaboration process. Finally, column 4 indicates the related references to each supporting human factors.

Table 3: Key Human Factors Supported by IT-Supported Design Collaboration

Models of Technology Adaptation	Key Constructs Pertaining Technology Acceptance	Human Factors Pertaining IT-integrated Design Collaboration	Related References Pertaining Human Factors in IT-supported Design Collaboration
TAM	Functionality	✓	Adriaanse et al. [67]
	Usability	×	×
TPB	Intention	×	×
	Behavioral Control	✓	Popov et al. [68] Moum [69]
Other models	feedback	✓	Popov et al. [68] Forcada et al. [70]
	Novelty	×	×
	Aesthetic and Affective Appeal	×	×
	Challenge	×	×
	Simulation Interaction	×	×
	Construct Interaction	×	×
	Immediacy	×	×
	Pre-defined Goals	×	×
	Attention	×	×
	Enjoyment	×	×
	Interest	×	×

As presented in Table 3, Adriaanse et al. [67] supports the factor "functionality" in designing the system. They develop a model for successful use of interorganizational IT/ICT in construction industry. They presented that perceived benefit of ICT use would personally motivate team members to use the system. In addition, clarity of procedural agreement and clarity about the operating ICT provide them with sufficient knowledge and skills to use ICT. Furthermore, Popov et al. [68] supported the factor "behavioural control and feedback" in designing the system. They developed 5D virtual project development concept to improve the cooperation and sharing of information among participant considering the time of project implementation and the scheduled resources. In this regards, Computer-aided evaluation system (CASE) based on building Information Modelling (BIM) concept provide users with the possibility to evaluate economic expenditure of resources, the planned operation and cost at any stage of design project. This program provides feedback to the user by storing all information about operation and resources in a general database called Case database of Typical Structural Elements (DTSE). In addition, the system provides control over the related technological processes by including particular solutions, graphical views, tools and equipment, sequence of technological operations and provision of health and work safety.

Similarly, Moum [69] supports the factor "behavioural control" in designing the system. In this regards, Moum supports collaboration and more shared understanding of project intention between architects and engineers especially at the earlier stage of process using 3D object models in Concert- and Congress Centre (CCC-project). The 3D object models provide better control of geometrical relationships between the disciplines. Moreover, Forcada et al. [70] support "feedback" as a human factor in designing the system. They enhance communication and collaboration among designer by presenting a web-based System for Active Knowledge Management (SAKM). They suggested that SAKM can potentially improve the information transfer by centralizing all the information. It is designed to collect and analyse feedback from SAKM by assesses the information objects (IO: either textual or graphical), associating a satisfaction score (from 0 to 5) and commenting on the relevance and suitability of the location of IO in the domain and media knowledge map. In addition, the feedbacks are analysed by information manager on the score less than 2.

The above studies in IT-integrated design collaboration indicate that the key human factors which have great influence on engaging user to the collaborative technologies are feedback, control and functionality. Among all the engagement parameters and the key constructs explained in theories of adopting technologies, the studies in design collaboration presented that these factors are supported by professionals. Relatively, if the collaborative technologies provide sufficient control to the professionals then they will be motivated to use the system. In addition, the system should provide immediate feedback to the users, and the system should be functional to professional design team members. As a result, the authors recommend that integrating these factors with current systems would potentially engage professional design

team members to IT-integrated design collaboration process.

9 Conclusion

This research utilizes collaboration among building professional by integrating HCI into the processes. The analysis result of previous studies on design collaboration process presented that HCI is essential to be integrated in current design collaboration process. In addition, the importance of HCI in design collaboration process presented that human is the key factor in designing collaborative systems in design collaboration process. Moreover, the study presented that to fully integrate HCI in the current IT-supported design collaboration process; the systems should engage professionals to these systems. In this regards, the model of integrating HCI in IT-integrated design collaboration process was proposed by the authors. This model presented the importance of key human factors for engaging design team members to collaborative technologies. Subsequently, the study recommended three key human factors in IT-integrated design collaboration process. These factors are control, feedback and functionality. If the current collaborative technologies in design collaboration processes are integrated with these three factors, the professional design team members will be engaged to the IT-integrated design collaboration process. Because the ultimate concern of design team members interacting with technology is for supporting their experiences with technology for collaboration enrichment and successful communication. The final result of such systems will potentially improve collaboration among team members trough IT technologies.

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