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Critical conversations as a tool for students' tacit knowledge construction: An interpretive research in interior design studio interactions ☆

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ABSTRACT

The explorative study presented in this paper aims to improve the understanding of design students' tacit knowledge acquisition in the interior design studio's social context. Constructivist theories and studio pedagogical concepts form the basis of the enquiry. The Environment and Interior Design (BA) program of the School of Design, The Hong Kong Polytechnic University, was chosen as a case study for this interpretive research. A key linkage that emerged from the themes was the role of critical conversations in the facilitation of tacit knowledge. Findings of the study contribute towards recommending teaching and learning strategies that can improve the efficacy of tacit knowledge construction and in the process, improve design students' self- efficacy as learners and designers.

1. Introduction

Tacit knowledge, a component of design knowledge, is so inextricably interwoven into the act of designing that its contribution to design education is often downplayed and taken for granted. Its perception as a mysterious skill undervalues its potential as a powerful creative and innovative source (Von Krogh, Ichijō & Nonaka, 2000 , p. 47). Polanyi's (1969) argument that *"all knowledge is either tacit or rooted in tacit knowledge"* (p. 144) underlines its importance. Hisseminal work on tacit knowledge has continued to be a crucial reference point that has influenced many related studies in diverse professional fields over the years.

The intuitiveness and spontaneity associated with tacit knowledge make it difficult for designers to articulate their expertise and actions (Schön, 1985). This difficulty permeates design education, where a heuristic approach coupled with an over-reliance on the learning-by-doing pedagogical model can be challenging, especially for novice students. Moreover, as tutors lack a structured approach to share their tacit knowledge, their *"seasoned tacit presumptions"* may not match the *"learners' tacit presumptions"* (Perkins, 2006, p. 40). The study argues against this one-dimensional approach, which appears to over-simplify complexities in tacit knowledge acquisition.

Secondly, complexities in designed environments place newer demands on the skills and abstract knowledge they need to practice (Guerin & Martin, 2004). Design problems are no longer discipline-specific. They extend to cultural, societal, economic, or political spheres, with technology playing a pivotal role in altering designed environments. These changes become a pedagogical barrier that students must overcome in education to belong to the discipline's professional community (Smith, 2013). As a result, existing studio practices must be assessed in terms of their ability to provide the liminal learning space necessary to develop the profession's required design expertise.

Perkins (2006) suggests a constructivist approach in response to the challenge of teaching tacit knowledge that consists of the three elements of learning: active, social, and creative. However, an understanding of how students construct tacit knowledge in the field of interior design is limited. Another aspect that needs further investigation is how tacit knowledge is socially orchestrated as much as it is internally and self-constructed.

Based on the identified issues, the research question formulated was:

How do social interactions in the design studio facilitate students' construction of tacit knowledge?

An objective of the study was to provide a holistic understanding of the influences of the teaching and learning environment on tacit knowledge construction. Therefore, the in-depth study was conducted using the perspectives of tutors, students and interactions between the significant and generalized others in the social milieu of studios. A part of the studies conducted in the physical settings of interior design studios using spatial knowledge as a form of tacit knowledge are discussed in this

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paper. Social interactions through design conversations are the focus of the study.

2. Tacit knowledge construction

Nonaka and Takeuchi (1995) describe the characteristics of tacit knowledge as:

Highly personal and hard to formalize, difficult to communicate or share with others. Subjective insights, intuitions and hunches fall into this category of knowledge. Furthermore, tacit knowledge is deeply rooted in action and in an individual's commitment to a specific context, as well in the ideals, values, or emotions he or she embraces (p. 21).

Opinions are divided about the cognitive and social dimensions of tacit knowledge construction. From a cognitive perspective, it is embodied and internalized through experiences (Ignatow, 2007; Polanyi, 1966), ingrained or represented as mental models (Nonaka & Takeuchi, 1995) and is a self-productive process that is context and situation-dependant (Koskinen, Pihlanto & Vanharanta, 2003 , p. 284). However, it is also a result of agents' collective and co-produced actions (Loenhoff, 2015) through shared experiences (Nonaka & Takeuchi, 1995). Sensibilities, dispositions or tastes are gained through collective experiences and determined by social and cultural conditions (Mareis, 2012). Intuition, a form of design expertise, needs a collaborative environment where sharing intuitive perceptions provides legitimization and alternate ways to intuit (Raami, 2015; Tonetto & Tamminen, 2015).

Burbules (2008) advocates for tacit teaching that is not standardized or directed towards explicit learning outcomes (p. 669). It supports enquiry learning by scaffolding learners' inferences, connections and understanding. Keeping in mind the uncertainty and ambiguity in design, Adams, Forin, Chua and Radcliffe (2015) advocate for a *"suggest don't tell"* teaching approach that encourages self-expression and experimentation in design students (pp. 447–448).

Needless to say, tacit teaching finds resonance in constructivist theories. A constructivist approach is effective for acquiring advanced knowledge levels where students learn to deal with complex and ill-structured problems (Ertmer & Newby, 2013, p. 60). In the view of Andjomshoaa, Islami and Mokhtabad-Amrei (2011) , the emphasis on knowledge as a constructivist process results in meaningful learning outcomes, leading to knowledge retention. Over time the retained knowledge generates tacit knowledge. Schön (1985) suggests that during problem-solving, meaning is constructed on the spot through reflection-in-action. Related constructivist theories of symbolic interactionism and transformative learning stress the modification and re-interpretation of meaning through social interactions. Self-awareness of how alternate worldviews shape one's meanings indicates an attitude of reflexivity or meta-learning abilities (Driscoll, 2005).

Knowledge construction, according to Collis and Moonen (2005), is a *"process by which knowledge new to the individual or group is created, based on a generative process"* (p. 283). Though they do not elaborate on the generative process, they mention that active engagement in generative activities is an aspect of constructivist pedagogy (p. 278). In design terms, these activities could include ideation, conceptualization, or problem-solving. Correspondingly, outcomes such as new ideas or concepts, problem re-framing, new processes, or methodologies indicate knowledge construction. The design activities and the outcomes have their domain in tacit knowledge. Therefore, a working definition of tacit knowledge construction adapted from the above is *a generative process where an individual is actively engaged to create new and tacit outcomes*.

3. Studio learning and the interactive environment

In a pedagogical sense, studio learning is conducive to knowledge construction. It provides the infrastructure for experimentation and generative activities, active engagement in experiential learning, offers multiple viewpoints and sensory experiences and the environment for critical and participatory discourses (Kurt, 2009; Ucar & Kandemir, 2011). However, studio learning is a distinct pedagogy of design where the praxis, epistemology, and pedagogy find coherence in the studio (Ferreira, 2018, p. 73). Studio education carries the pedagogical responsibility of teaching a design discipline's skills, language, and problem-solving approaches (Ledewitz, 1985).

However, Ledewitz (1985) points out that the studio's inherent characteristic of keeping the teaching content tacit and ambiguous can confuse novice students. The use of minimal guidance leads to uncertainty in novice students of *"not knowing what and how to do"* (Van Dooren, Boshuizen, Van Merriënboer, Asselbergs & Van Dorst, 2014 , p. 82). Students have to understand complexities in learning design processes, communicated only through action and not talk (Schön, 1985; Winters, 2011). It leads to a loss of confidence and dependency on tutors (Ledewitz, 1985; Schön, 1985). Power conflicts in the studio affect efficacy in learning and transformation of identity (Belluigi, 2016).

Additionally, there is a contradiction between the explicit and implicit messages of the teacher. As teachers find it challenging to externalize their expertise, they rely on the apprenticeship or learning-by-doing model (Cross, 2006, p.9). Cross (2006) asserts that *"teachers of design have a responsibility to be as articulate as they possibly can about what it is they are trying to teach, or else they can have no basis for choosing the content and methods of their teaching"* (p. 9).

The process of reciprocal reflection-in-action wherein the instructor and the student reflect on the *"tacit assumptions and strategies"* employed in designing can avoid the predicament of a learning bind, according to Schön (1985, p. 71). Additional ways to deal with the above issues include balancing power by encouraging students to engage in dialogue and critique (Dutton, 1987), supporting peer learning and facilitating meta-learning in students (Winters, 2011).

Van Dooren et al. (2014) propose a framework of elements for tutors to explicate the design process to students. The explication can build the confidence of students in their learning process. Though their study results reveal that teachers use the elements, it is unclear how tutors articulate their tacit knowledge or expertise.

3.1. Studio conversations

The crit, desk reviews and juries are the prevalent forms of communication in the studio. Conversations in the studio lie in a continuum of formal-informal, formative-evaluative and object-laden -language-laden (Ferreira, 2018; Fleming, 1998). Dialogues or conversations in the studio are pedagogical meaning-making tools (Schön, 1984. They reveal teaching nuances and design thinking, and the expertise of coaches (Adams, 2015). According to Shreeve (2015) , the dialogue is a student-centered approach that engages students to practice arguments, clarify the thinking process and learn design languages (p. 88). Uluoğlu (2000) observes that the intervention of tutors decreases in the later years of education. Goldschmidt, Casakin, Avidan and Ronen (2015) maintain that meta-discussions held in the studio through the pedagogical strategy of double-loop learning cause the re-adjusting of values and developing new ones action strategies. This results in a positive learning outcome (p. 460).

Interactive experiences in the studio underscore the importance of dialogical learning as an essential pedagogical tool (Salama, 2015, pp. 230–231). The studio serves as a collective storehouse of knowledge, which encourages critical and constructive conversations. These exchanges bring into light the implicit understandings of design teaching and learning. A phrase that summarizes these kinds of conversations is critical conversations. This study's working definition for critical conversations is *conversations that aim to analyze, assess or evaluate a project through different perspectives to resolve issues, suggest alternatives, or make* a judgment.

Existing models on studio interactions mainly focus on tutor-student interactions. In-depth studies of the influence of studio interactions on constructing tacit knowledge are insufficient. For example, the convergence of meaning between the coach and the student, as Schön (1985) researched, has other influencing factors. Ferreira (2018) contends that conversations between the teacher and student, mediated through design artifacts, can result in new understandings and insights. However, the processes by which interior design tutors share their expertise and facilitate a shared environment for tacit knowledge construction requires further exploration.

Investigations in a similar area of design reviews conducted by Sonalkar, Mabogunje and Leifer (2015) conclude that reviewers and students articulate and co-construct professional vision expression while interacting with the design artifacts. It is also worth investigating the influence of interactive spheres and spaces beyond disciplinary and professional boundaries.

From a broader perspective, the studio *"acts a bridge between academic and professional communities"* (Brandt et al., 2013 , p. 329). Dutton (1987) states that the *"design studio as a producer of knowledge and as a social practice"* (p. 17) has connections that influence political, economic and societal dimensions.

4. Research design

The elements of the research design framework composed of epistemology, methodology, the strategy of enquiry and methods were based on models proposed by Creswell (2003) , Crotty (1998) and Maxwell (2013). The elements scaffold each other and are justified in their choice to address the research question.

4.1. Epistemology and methodology

Constructivism was chosen as an epistemological stance as it is concerned with interpreting meanings of multiple realities and socially shared perspectives. Rather than generating a theory, the aim was to develop concepts and gain insights into students' learning processes and interactive experiences. Therefore, the preferred methodology was interpretive research. Data collection were conducted along the lines of interpretive procedures suggested by Merriam and Grenier (2019). It commenced with developing a theoretical framework from existing literature on interior design education and constructivist theories. However, data analysis was conducted on Denzin's (2001) prescribed approach that leans towards a grounded theory approach.

4.2. Strategy of enquiry

A single case study with purposive sampling supported the research intent of inquiring into the complexities of studio interactions within an interior design program. Purposive sampling can yield rich information to *"understand the phenomenon in-depth"* (Patton, 2015, pp. 149–150). The Environment and Interior Design (BA) program of the School of Design, The Hong Kong Polytechnic University, was chosen as an appropriate case study for the holistic understanding of the phenomenon of tacit knowledge construction. The program's lean towards constructivist learning approaches related to the theoretical propositions of the study.

The emphasis of the 4-year full-time Environment and Interior Design (BA) program is a studio-based culture that is an experimentation site for innovation and a learning context for shared intellectual capacities. Students are expected to initiate and activate their learning processes by following an enquiry-based pedagogical model. It is designed to develop students into competent spatial designers who study interior design's broader impacts at societal, educational, and territorial levels (PolyUDesign 2020).

Eight students and their learning processes within different years of the program formed the unit of analyses, studied within the studios' context. Respective studio tutors and other group members of the students were additional participants in the study. Individual consent forms and departmental approvals were obtained to adhere to rules of privacy and research ethics.

4.3. Data collection

Data collection methods primarily consisted of observations and interviews. A non-participant and unobtrusive role served to capture and compare the dynamics of interactions in the studio's natural settings. Semi-structured interviews conducted in several rounds were carried out to follow learning processes such as detecting changes in understandings, triangulating observations with interview responses, and comparing multiple perceptions of tutors' and students' perspectives. Data were collected and analysed in four stages.

Stages one and two were considered pilot studies to gain entry into the field, map studio activities, and select participants for the study. Participants were observed and interviewed in studio projects across the four years of the program. The criteria for selecting students through purposive sampling were based on: (1) A student's approach to spatial problems and (2) Representing the variables of gender, cultural and educational backgrounds. The numbers were chosen to concentrate on the depth rather than on the breadth of enquiry and were subject to resources and time limitations.

Participants in stages 3 and 4 were intensively observed and interviewed in four semesters of the program. A total of 191 studio observations covered desk reviews, interim and final presentations, and interactions in social media groups. Forty-seven semi-structured interviews included individual and focus group interviews. Data collection sources were notes, photographs, audio and videotapes. Experience sampling through Whats-App texts helped keep track of students' immediate responses to design review feedback. Program documents, subject briefs and process books served as supporting methods for data evidence.

4.4. Analytical process

Steps in the analytical flow, adapted from Merriam and Tisdell (2016) and Schatzman and Strauss (1973), Miles, Huberman and Saldaña (2014) , comprised of preliminary analyses, abstraction, consolidation, and verification. A cyclic process of induction and deduction occurred throughout the analytical process. Recording reflections were an essential part of the interpretive analyses (Fig. 1).

Analytical processes for stages 1 and 2 consisted of transcribing, conducting preliminary analyses, initial coding, and developing theoretical frameworks. It was followed by running the raw data through MAXQDA with page-wise coding, abstraction using different coding levels, and mamboing. Analytical categories were formulated into an analytical framework and re-categorized for consolidation. The consolidated results were synthesized as preliminary findings and insights, thus moved the research towards a preliminary deductive stage.

Insights from the previous stages were combined with the theoretical framework to conceive conceptual entries for stages 3 and 4. Conceptual frameworks were continuously refined to align the literature review, research question and empirical data. Coding schemes were initially developed from conceptual frameworks and revised according to newly emerged data in MAXQDA. Data analysis through MAXQDA played a substantial part in the rigour of analysis.

Memos created in each student's transcribed studio observation were exported from MAXQDA, combined and re-analyzed with all the students' memos in each studio observation and interview. All the memos were then summarized for each year of the program. The purpose of the memos was to interpret the data into new concepts to answer the research question. It thus spearheaded the interpretive process in the abstraction stage of data analysis.

The insights were integrated into the conceptual framework. The process of refining the conceptual framework and developing the coding

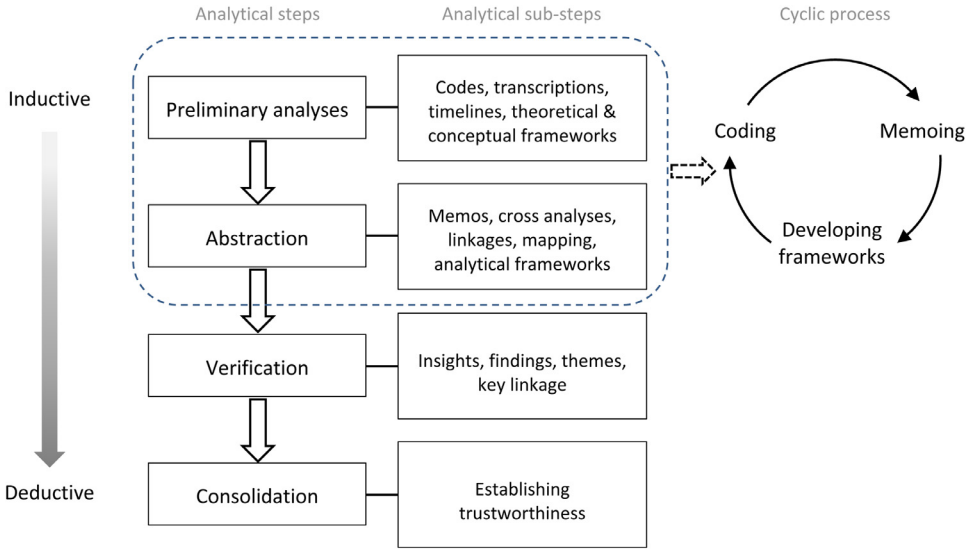

Fig. 1. Analytical Flow. Adapted from Miles et al. (2014) and Merriam and Tisdell (2016); Schatzman and Strauss (1973).

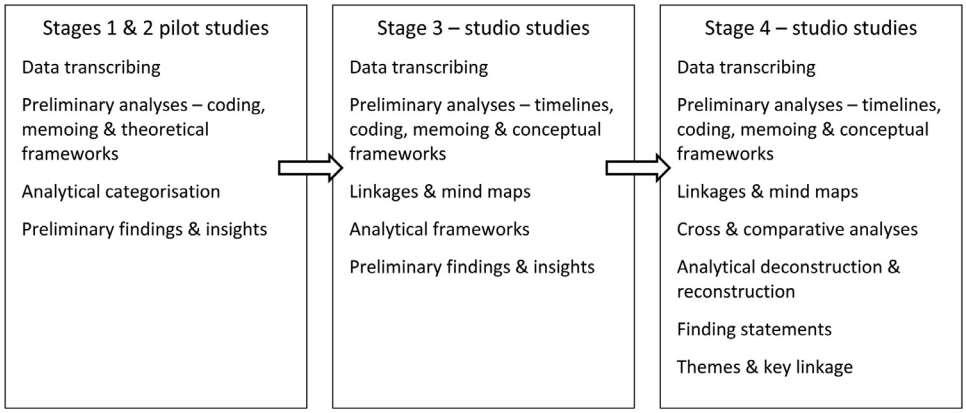

Fig. 2. Stage-wise Analytical Process.

scheme and memos continued with the emerging data until saturation. In other words, the data did not yield any new contributions to the study.

Coding categories were linked and re-organized as mind-map diagrams to tease out new understandings. New concepts that emerged from the memos and linkages were combined with the conceptual framework to direct the categorization process. It marked the beginning of the final deductive phase of the analysis.

Analytical results of tutors' and students' interview responses were cross-analyzed. Analytical results from each year group were comparatively analyzed and deconstructed to visually compare results across all the years. An in-depth analysis of sub-components was followed by a reconstruction exercise that generated findings and finding statements. Fig. 2 maps the analytical process in the four stages.

4.5. Establishing trustworthiness for interpretive research

Seale (1999) contends that since qualitative research represents multiple realities, positivistic criteria for validity and reliability can be revisited using interprevistic criteria. He recognizes the translated terms of credibility (internal validity), transferability (generalizability), dependability (reliability), confirm ability (objectivity) and authenticity put forward by Lincoln and Guba as a means to establish the trustworthiness of a naturalistic investigation (Seale, 1999, pp. 45–46).

Credibility in this research was established through triangulation of evidence, comparative analysis, clarifying the researcher's position, and reporting deviant cases. Transparency in the research process, triangulation of the coding process and reflexivity ensured dependability (Mason, 2018). Confirmability was demonstrated through triangulation of information, methods and coding systems, spending considerable time on the field, maintaining a database and showing the audit trail of the analytical process (Patton, 2015). Transferability rather than generalization was ensured by providing rich descriptions and highlighting the uniqueness of the case (Maxwell, 2013). Ethical issues were addressed by ensuring the confidentiality of participants and maintaining protocol during data collection.

5. Research findings

The analytical categories were consolidated as a statement of findings. The statements are interpreted results that reflect the perceptions of the tutors and students. They highlight the internalization of tacit knowledge as influenced by social interactions in the studio.

5.1. Interpretation of feedback influences the generation of tacit knowledge construction processes

It was found that the way students interpret tutors' feedback, their choice of which feedback to act on, and co- interpretation of feedback followed a deliberation process that affected tacit knowledge construction. Year 1 student groups had different interpretations of tutors' feedback as confirmed through interviews and observations. According to a

Fig. 3. Developing Materiality through Scales of Spatial Inquiry.

Fig. 4. Peer Learning in Studio Spaces.

tutor, students had pre-conceived notions or put constraints on themselves not suggested by him, which affected their generative processes.

Therefore, tutors needed to guide the generative process of tacit knowledge construction by stressing the stepwise abstraction and development of ideas. Tutors expected students to follow an intentional discovery process while emphasizing a connection to previous learning. However, students in a group had individual discovery processes. Some groups succeeded in integrating their processes through a common intent.

Students had defining or learning moments in their project when they explored solutions together in their group. Group dynamism, acceptance of ideas, communication, critical reflection and building on each other's strengths were attributed to the creative moments shared by students in the interviews. Likewise, success or failure in achieving desirable outcomes was dependent upon the above factors.

Almost the entire Year 2 studio had misinterpreted the design brief and felt confused about the topic. Though tutors mentioned that the ambiguity of the brief was intentional, they had to hold a class discussion to allow students to express issues and clarify expectations. Students found the discussions reassuring and inspiring to push their design proposals further.

5.2. Designer sensibilities are nurtured through micro and macro contextual discussions

Materiality as a tacit ability for designers can range from tangible to intangible concepts. Students had difficulties in their understanding and expressing some of their sensibilities. These difficulties included the justification of intuitions, the ability to turn complicated spatial problems into new creative possibilities and actualizing conceptual images into material manifestations. Tutors nurtured materiality by directing discussions on different types and scales of spatial inquiries (Fig. 3). However, students needed guidance and encouragement to deal with the complexities of intangible material concepts. Tutors seemed unclear as to how students could develop or justify intuitive perceptions.

5.3. Values are mentored and negotiated in the design studio

Though students were allowed to act independently, students in the junior years were more dependent on tutors for decision-making and judging their design value. Senior students took guidance from tutors to extend their ideas, technical expertise or presentation of ideas. It was found that peer learning became more important over the years (Fig. 4). Senior students sought the testing and evaluation of ideas from their peers compared to junior students. Students also mentioned influencing others with their ideas or being influenced by other thinking and working styles. Correspondingly, a tutor said that she expected individual perspectives to change in a group.

The choice of projects reflected students' value frames. This was more evident in Year 3 and Year 4 students, who were more influenced by their internships and developed a deeper understanding of their role as designers in society. On the other hand, discussions in the studio revealed that tutors influenced the values by re-framing their design problems to broader social, cultural or political dimensions. Tutors expressed their values and ideologies in the process of sharing their experiences and expertise with students.

5.4. Meanings and meaningfulness in learning are verified and internalized through the shared environment

It was observed that tutors were explicit in their feedback only in appropriate contexts. What was appropriate was based on the tutor's assessment of the student's capability of understanding. Not providing explicit answers coupled with a tolerance of ambiguity in design (Adams et al., 2015) implies that tutors encourage students to actively construct meaning through the experiential cycle.

Taking responsibility and self-awareness of the learning process indicated students' meta-learning abilities. Findings revealed that students adapt or build on previous knowledge, which they find meaningful. This realization provides pointers to tutors to design meaningful learning experiences.

Students took credit in developing their methods, controlling their process, meeting challenges, and expressing confidence in ideas, a sense of achievement in executing ideas and gaining expertise through their projects. Self-initiated measures such as self-study, finding references, seeking help from other year groups, or even cross-disciplinary collaborations indicated control over learning processes. Ownership in learning meant identifying challenges and confusion in learning, admitting mistakes, dealing with emotions and self-doubt, accepting critique comments, and feeling the need for change and improvement. Most of the students were aware of their thinking or working style. For example, top-up students were able to compare their learning from their previous design school.

Students varied in the quality and quantity of critical reflections they entered into their design process books. It further revealed the importance they give to critical thinking. In turn, tutors brought self-awareness of students' learning by pointing out their learning moments. Meta-learning processes, thus stimulated, can aid the internalization of tacit knowledge.

Fig. 5. Critical Conversations Mediated through Artifacts.

5.5. Engagement in critical conversations enhances tacit knowledge construction

The kind of exchanges between tutors, students, and external crit observed at different interactive levels could confirm the definition of critical conversations as previously mentioned. Specific attributes of critical conversations were identified and categorized as inquisitive, explorative, argumentative, provocative, evaluative, and projective critical conversations. These attributes can have different cognitive and social implications for tacit knowledge construction.

Tutors communicated their expertise through spatial vocabularies or meta-language that explicated their critical thinking and tacit ability. Though the emphasis was on the use of visual language, it was found that there was a need for students to use appropriate terminology and articulation to help people understand their thinking processes, design intentions or for defending their decisions. The artifacts led, mediated or provoked critical discussions (Fig. 5).

The dynamics of the conversations shifted according to the type of design reviews. Though desk reviews were mostly tutor-driven, students took over critical conversations from tutors in higher years. They also strategized their interactive environment for the crit reviews through the use of artifacts. The external crit mainly controlled dynamics in external jury sessions.

Social interactive factors affected tacit knowledge construction. Willingness to participate and participation level was some of the main factors that affected tacit knowledge construction. Several reasons were identified for low participation rates, such as cultural and educational background issues, difficulties in using English, the lack of ability to articulate ideas, perceived relevance to one's project, and tutors' dominance. In addition, almost all the tutors considered that the lack of time and insufficient resources such as inadequate staff caused difficulties in facilitating an environment for critical discussions.

To summarize, findings have revealed that the acquisition of skills and dispositions are not the only recognizable forms of tacit outcomes. Interpretation of meaning, the quest for meaningful knowledge and construction of values are tacit outcomes that go through a process of internalization and socialization.

6. Discussion

A key linkage or a common emergent theme deduced from the above findings was the significant relationship between critical conversations and tacit knowledge. The term 'critical conversations' covers the cognitive and social dimensions of tacit knowledge construction. They are the forums for creating sensibilities, deconstructing and reconstructing meanings, and producing new judgments of value. When subjective perceptions and sensory experiences are questioned by critical criticism, sensibilities are shaped and conditioned. In the process, subjective values are disputed and re-framed. The study has identified critical conversations as a tool for conducting meta-discussions for validating subjective values.

Correspondingly, meanings are verified, negotiated and co-created. The search for meaning is also about reaching a consensus in understanding. It relies on communication and interaction with those involved in transmitting, sharing, and reception of knowledge. Students are exposed to alternate worldviews that shape their meanings (Driscoll, 2005). Students construct knowledge that is meaningful during this process, which triggers their intrinsic motivation to learn. Thus, critical conversations are meaningful conversations.

Multi-dimensional and cross-disciplinary conversations through the studio's collaborative atmosphere broaden and extend the cognitive dimensions of tacit knowledge construction. They often serve the task of extending the design problem's boundaries. This expansion is particularly needed during the process of tacit knowledge construction, where critical conversations are instrumental in the generation of 'Eureka moments' and the evaluation of intuitive decisions. Ferreira (2018) suggests that outcomes are unpredictable and can *"result in a new understanding of the design situation"* as the teacher and student discuss ill-defined problems through design conversations (p. 88). It should be added that a time of incubated contemplation contributes to the critical element of conversations, which causes fresh insights.

Quite often, the importance of self-reflection (or internal critical conversations) in the tacit knowledge construction phase seems to be undervalued by students. However, exposure to various ways experts guide critical conversations may help students critically analyse their ideas and prepare a holistic and well-founded design argument, be it contextual, practical, technological, or theoretical. Therefore, critical conversations offer students the opportunity to be engaged in a design discipline critically and creatively. According to Stone (2007) , this intellectual involvement is essential rather than addressing the industry's demands.

Experience sharing requires robust (or inspiring) critical conversations as it introduces learners to different perspectives. This is achieved by an environment that is conducive to sharing. Informal settings initiated by students encourage students to share experiences, but whether the sharing results in critical conversations is questionable. Therefore, the tutor's formal settings may be required to train students to conduct a critical conversation in the early years. Critical conversations also identify strategies used by tutors for tacit knowledge construction. Some of the strategies are intentional or ad hoc that were emerged out of various design reviews. As suggested by Adams et al. (2015) , cognitive apprenticeship through thinking-aloud processes can effectively make tutors' critical thinking explicit to students.

With the use of unique disciplinary terminology, the nature of conversations can become more tacit than in earlier years. In Year 2 students, this transition was apparent as they began to use such terminologies to define spatial qualities in their design. The complexities of students' design problems prompt the use of meta-language, which students may have developed during their learning. As described by Heylighen, Bouwen and Neuckermans (1999) and Schön (1985) , meta-language is a design language that describes strategies and insights in the design process. Advanced students may develop more stable mental models to imagine their spatial intentions, but their critical reflective abilities determine how well they can articulate their visualizations. The skills are better nurtured and honed through critical conversations in the studio.

Peer interactions offer a valuable platform for students to hold critical dialogues, rehearse arguments and for confidence-building. The importance that students give to the input of their peers, however, differed. In contrast to the junior students who relied on the teacher to make decisions, senior students valued classmates' opinions. Some of the students

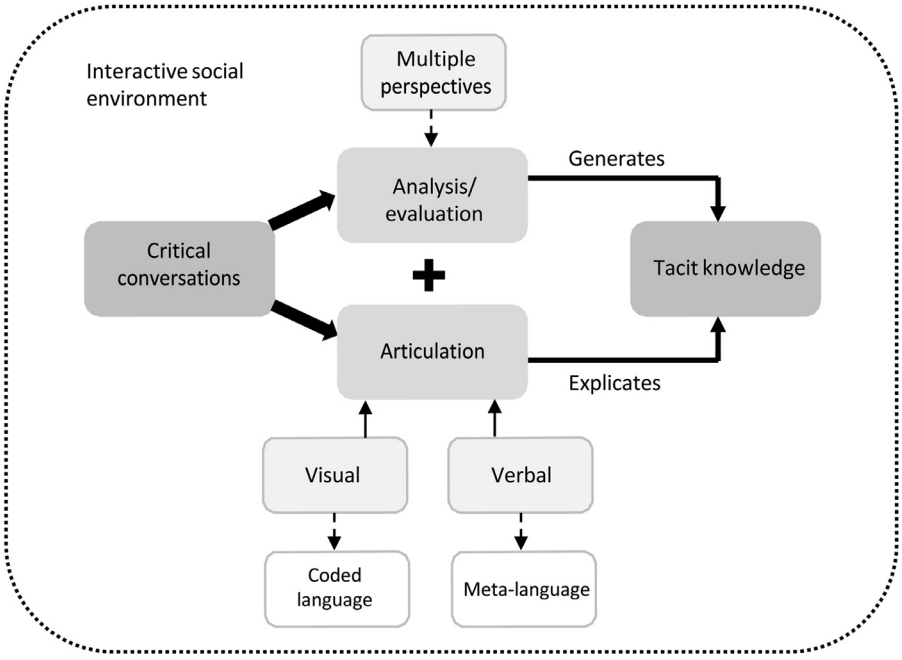

Fig. 6. Critical Conversations Lead to Tacit Knowledge Construction.

also stated that they had more critical conversations in the studio than at crits.

Subsequently, through the years, the visual language becomes more implicit. Spatial cues for materials, for example, can become more symbolic. That is, the visual language begins to get more complex and coded.

Verbalizing design arguments is always a point of contention amongst tutors due to drawings been regarded as a designer's voice. Images and drawings are considered central in provoking debates and explaining the thought process. Simultaneously, according to a tutor, conveying the robustness of their ideas through words reveals students' critical reasoning skills. Poggenpohl (2018) states that concepts will require even more expansive discussions and arguments if they are radically new (p. 185). She adds that designers will need to defend their ideas using verbalizations in collaboration with people from other non-design disciplines. Design students must be trained to participate in discussions with other disciplines on an equal footing using a common verbal language.

Fig. 6 summarizes how critical conversations can be used as a tool for tacit knowledge construction. Social and collaborative learning environments form the backdrop for critical conversations where multiple perspectives critically analyze and evaluate shared experiences. The tacit is constructed as new understandings and sensibilities are generated. Visual or verbal languages may be correspondingly converted to coded knowledge, and meta-language articulate tacit knowledge. Critical conversations thus link the tacit and explicit parts of design, in that some aspects of design knowledge remain inherently tacit while some need to be shared explicitly.

Drawing from the study's definitions and findings, the main components for effective critical conversation are socialization, cognition, and articulation. The sub-components are reviewed in detail after Fig. 7 below.

6.1. *Multiple perspectives*

In recent years multi-disciplinarily has been prominently featured in several discussions on design practice trends, mainly because of the multi-faceted nature of problems designers are now facing. Leveraging multiple stakeholders' potential and harnessing collective human intelligence and wisdom can address these challenges and contribute to societal value (Gardien, Djajadiningrat, Hummels & Brombacher, 2014).

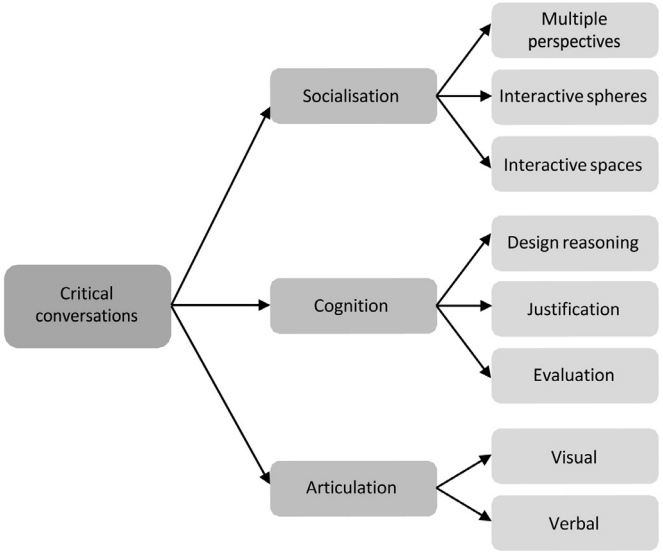

Fig. 7. Components of Critical Conversations for Tacit Knowledge Construction.

Interaction with diverse teams exposes individuals to others' perspectives in decision-making. As a result, new innovative solutions are co-created in the process. Polysemy is another notion related to multiplicity in design thinking, where multiple meanings to ideas and concepts are co-created, leading to greater cognitive flexibility and creativity (Georgiev & Taura, 2014).

At the fundamental level, the studio serves as a site for provocative debates. More exposure and opportunities to discuss within their field can strengthen students' design basics. They can use the design language effectively in future collaborative projects. Although collaborative projects are already part of the curricula, a multiple perspective approach through critical conversations needs to be emphasized as a transferable skill.

6.2. Interactive spheres and interactive spaces

Critical conversations take place within different levels and spheres of social interaction, which are internal and external. The conversations occur at the self-reflective level, between students and tutors, students and peers and extend to broader academic or professional spheres. Several liminal or transitional learning spaces are created within the intersections. Each of these spaces affects the nature and dimension of critical conversations. They offer tangible and intangible interactive experiences, physical and digital interfaces and offer localized and globalized venues for interactive exchanges. Knowledge is constructed and co-constructed in the synergies of the spheres and spaces. It is manifested in the attributes, types and scales of critical conversations and conveyed verbally or visually, as mentioned in the findings. Such intersections are facilitated by tutors or initiated by students. Conversations that extend beyond the studio prolong learning and knowledge construction.

6.3. Design reasoning

Design reasoning is a valuable part of the cognitive dimension of design thinking. Summarizing McDonnell's (2015) views about design reasoning can be defined as an ability to deal with and frame ill-defined problems with flexible approaches and synthesize multiple solutions. She suggests that students' processes be recorded and provide opportunities to *"share and justify their perceptions with each other"* (p. 116).

Critical conversations provide the means to nurture design reasoning in design education. As mentioned by Dorst (2015) , abductive reasoning can be developed through probing, challenging, and provoking debates that give rise to new approaches to framing design problems. Thus, it takes the practice and the praxis of design to a higher level.

6.4. Justification and evaluation

Justification is an inherent part of the design reasoning process wherein ideas and actions need to be challenged to provoke breakthroughs. Justification is also indicative of students' meta-learning abilities. When students can analyze, discern and justify their actions through a critical reflection in conversations, they become aware of their learning. It thus triggers the construction of new creative knowledge and re-creating the self.

Justification is followed by evaluation, which leads to forming judgments and subsequently constructs new understandings and knowledge. As with justification, it is an internal construct at the self-reflective level and a reconstruction at the social level through external verification and testing of previously formed ideas or decisions. When design projects are evaluated through multiple perspectives in critical conversations, intellectual development is promoted, creating new value judgments.

6.5. Visual and verbal articulations

Artifacts are the means and the end by which designers communicate and share their ideas. They are tools for cognitive and sensory development that carry and convey embodied experiences. Meaning is constructed through the use of coded language embedded in the artifacts and the studio's visual environment. The visual environment and the artifacts in the studio, which are co-constructed by the tutors and students, contribute to tacit design information's cognitive processing.

However, difficulties in the explication necessitate the use of verbal language. Tutors' tacit ability to read and interpret artifacts such as drawings is verbalized through meta-language. Meta-language is more evident as conversations in the studio become more implicit in nature. Though it explicates the tutors' expertise and tacit knowledge, it is also co-constructed between students and tutors depending upon the nature of the design projects. A lack of articulation skills in students is often due to a lack of critical thinking which can be developed through critical conversations in the studio.

As a learning skill that is rehearsed and shaped in the studio milieu, critical conversations can develop students' confidence to participate in discourses beyond the disciplinary boundaries and extend their learning beyond the studio. In doing so, the student's self-efficacy is nurtured by transforming his/her capabilities, behavior and values as a learner and designer.

7. Recommendations for tutors and concluding thoughts

Tacit knowledge construction is a self-initiated internal process and an external socialized process enabled through the synergies of the design studio's various interactive spheres and spaces. An environment conducive to the sharing of experiences aids the construction of tacit knowledge. Shared ideas or experiences need to be critically analyzed or evaluated through multiple perspectives and dialogue to generate tacit knowledge. Social and collaborative learning environments form the backdrop for these dialogues. The study has identified these dialogues as critical conversations, which are the platforms for developing sensibilities, deconstructing and reconstructing meanings, and creating new value judgments. They play the dual role of interactive agents for articulation and construction of tacit knowledge. Therefore, it is proposed that *critical conversations should be adopted as a pedagogical tool for tacit knowledge construction*.

It is strongly recommended to nurture proficiency in engaging in critical conversations from the early years of design education. Tutors can encourage this ability by providing an environment of trust to express viewpoints and offer constructive guidance on critiquing and challenging various perspectives. Providing ample interactive spaces with polysemous and meta-discussions exposes students to multiple perspectives where meanings are verified and intuitive perceptions are evaluated. As students mature, they should be allowed to initiate critical conversations and strategize the interactive environment. It builds their confidence to participate in discourses, even beyond disciplinary boundaries. More importantly, it improves their self-efficacy in learning.

Tacit knowledge construction is a self-initiated and internal process. Tutors impact the internal constructs by nurturing meta-learning and meta-cognitive abilities. To activate meta-learning processes, tutors may have to point out learning moments to students. Designing meaningful learning experiences can trigger students' intrinsic motivation to construct meaningful knowledge, which becomes their lifelong learning pursuit and goal in education. On the other hand, facilitating an environment for sharing experiences, as mentioned before, provides the platform for students to have more meaningful conversations.

Though the study contributes towards a deeper understanding of the complexities involved in tacit knowledge construction, it has limitations. Teaching approaches and learning styles differ. Therefore, selecting the appropriate number and type of participants will always prove problematic for any interpretive study.

Secondly, several interactive learning spaces were inaccessible for the study. Thirdly, other multimodal sources such as emotions, body language, gestures and engagement of senses that affect tacit knowledge acquisition remain to be explored.

Unanticipated changes in the global scenario that occurred after conducting this research open a new set of design education discussions. Virtual spaces expand the studio's socio-cultural spheres, suggesting new interpretations of disciplinary knowledge. It serves as the basis for a more thorough examination of current studio pedagogical approaches. The shift to online learning and the adoption of technologies such as artificial intelligence in design opens new frontiers for research in tacit knowledge.

That being said, the implications of this study are not limited to design education. The unique ways in which design students construct tacit knowledge can give educators pointers in other disciplines. They can

compare or adopt similar teaching practices to enhance creativity and push the boundaries of knowledge construction.

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