An Integration of Project-based Learning and Haptic Senses: A Case Study in Architectural Education
การบูรณาการการเรียนรู้ด้วยโครงงานและการใช้ประสาทสัมผัส: กรณีตัวอย่างด้านการศึกษาสถาปัตยกรรม

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Abstract

This research examines a mixed pedagogical approach that improves students' learning capabilities in multidimensions, ranging from architectural knowledge and skills, collaborative ability, to communication proficiency with foreign peers. Based on their own initiatives and interests, students utilized their haptic senses--the characterization of formal and spatial perceptions obtained through bodily movements, touches, and other sensibilities--to develop and explore the selected objects and subjects of inquiries on architecture of central and northern Thailand via workshops and field trips, which become a basis for this study.

Being an integration of a project-based and haptic way of learning, the upcoming investigations look into several phases of scholarly activities, including selections of the applicants, topic proposals, analyses and syntheses of case studies, presentations, as well as exhibition of students' works. As for its methodological tools for data collection and interpretation, the research employs a combined quantitative and qualitative means--e.g., evaluative and observatory worksheets coupled with satisfactory questionnaires--to assess the academic performance, architectural skills, behavioral parameters of the participants, providing a ground to argue that: 1) the students had gained a higher body of knowledge and architectural skills via their haptic experiences with the built environment; and 2) such a project based-learning (PBL) had contributed to substantial improvements on the academic performance of the students.

บทคัดย่อ

งานวิจัยชิ้นนี้ทำการศึกษาเกี่ยวกับการเพิ่มศักยภาพของนักศึกษาด้านความรู้ ตลอดจนทักษะทางสถาปัตยกรรม การทำงานเป็นกลุ่ม รวมถึงพัฒนาการและบูรณาการด้านการใช้ภาษาต่างประเทศในการทำงานร่วมกับชาวต่างชาติ ผ่านโครงงานที่นักศึกษาคิดค้นและกำหนดขึ้นเอง โดยที่กระบวนการเรียนรู้ดังกล่าวนั้น จำเป็นต้องใช้การรับรู้ผ่านประสาทสัมผัสต่าง ๆ เพื่อบรรลุซึ่งความเข้าใจในงานด้านสถาปัตยกรรม

จากเหตุข้างต้น สาระของงานวิจัยจึงเป็นการบูรณาการการเรียนรู้ด้วยโครงงานและการใช้ประสาทสัมผัส เข้าด้วยกัน ทั้งนี้ ขั้นตอนสำหรับกระบวนการวิจัยประกอบไปด้วย การคัดเลือกนักศึกษาเพื่อเข้าร่วมโครงการ การให้ข้อมูลเกี่ยวกับสถานที่ศึกษาดูงานภายใต้หัวข้อ "สถาปัตยกรรมภาคกลางและภาคเหนือของประเทศไทย" การนำเสนอโครงงานโดยนักศึกษา การวิเคราะห์และสังเคราะห์ข้อมูลร่วมกันระหว่างนักศึกษาในกลุ่ม และการนำเสนอผลงานในรูปแบบของนิทรรศการ โดย

อาศัยเครื่องมือที่ใช้วัดและประเมินผลการเรียนรู้อันได้แก่ แบบวัดผลสัมฤทธิ์ทางการเรียน แบบประเมินผลงานทางสถาปัตยกรรม แบบสังเกตพฤติกรรมในการทำงาน และแบบประเมิน ความพึงพอใจของนักศึกษาต่อกิจกรรม อนึ่ง ผลการประเมินในภาพรวม สรุปได้ว่า 1) นักศึกษามีความรู้และทักษะด้านการวิเคราะห์ทางสถาปัตยกรรมเพิ่มขึ้น และ 2) การเรียนรู้ด้วยโครงงานนำมาซึ่งการพัฒนาผลสัมฤทธิ์ทางการเรียนของนักศึกษา

Keywords (คำสำคัญ)

Architectural Education (การศึกษาทางด้านสถาปัตยกรรม)
Project-based Learning (การเรียนรู้ด้วยโครงงาน)
Haptic Senses (การใช้ประสาทสัมผัส)
Learning Achievement (ผลสัมฤทธิ์ทางการเรียน)

1. Introduction

The current National Education Act mandates that the Thai educational system has a duty to provide students all necessary knowledge and skills that would benefit their life-long learning activities, whereas the teaching methods must facilitate this goal (Office of the Education Council, Ministry of Education, 2002 Amendment, p. 4). In a process of doing so, a large numbers of scholarly publications have indicated that teachers are the most important factor contributing to students' progress and success in learning outside the home environment (For instance, see: Gage, 1985; Eggen & Kauchak, 2001; Gerhard, 2007; Schunk, Pintrich & Meece, 2008).

For more than three decades, the Division of Architectural Education and Design, Faculty of Industrial Education, King Mongkut's Institute of Technology, Ladkrabang (KMITL) has produced its graduates who have: 1) served in vocational colleges throughout the country; and 2) worked in the design and construction industries, where the demands for highly-trained professionals remain high. Being an amalgamation of educators and architectural practitioners, the graduates are taught to synthesize and make use of the knowledge from both fields of professions, as well as to develop their creative minds and multidimensional problem-solving skills.

In maintaining such a dual-occupational qualification in collaboration with academic excellence of the forthcoming graduates, the KMITL instructors has been insisted on employing various combinations of teaching techniques and methods, tailored to suit different groups of students. Among these widely adopted pedagogical approaches is the Project-based Learning model (PBL), originally used in a classroom setting, but subsequently applied to other academic disciplines, including architectural education. Via a series of "real-world" assignments, students are able to acquire necessary skills to understand, analyze, synthesize, and apply, lessons learned from the instructors, in proportion to the five orders of the cognitive domain in Bloom's Learning Taxonomies, i.e., evaluation, synthesis, analysis, application, and knowledge (Diagram 1).

To cite an example, KMITL students collaborated with local residents and professionals in a "design-built program" to provide temporary shelters for the 2004 Tsunami victims at Baan Nam Khem in Phang-Nga province in 2005. Under a close supervision of the instructors, not only did such a PBL project encourage and assist the students to generate new bodies of knowledge by themselves, but also advance their learning abilities and appreciation of the physical world through their intimate experience with the devastated areas.

On that account, it can be argued that the PBL--in which this research utilizes as its mode of problematization--is a part of what O' neil (2001, p. 3) called the current architectural discourse, whose scholarly foci are shifting towards the influences of a variety of our corporeal senses in understanding the built environment. By promoting the students' understanding of the physical world, the PBL fosters an exercise of the character of formal and spatial perceptions obtained through their bodily movements, sights, touches, and other sensibilities--known as the haptic senses--which have become quintessential to explore, experience, and appreciate architecture, urban space, and natural landscape.

In early 2013, the aforementioned observations on the connections between PBL and haptic way of learning were put into practiced and tested for their pedagogical applicability, when a united group of faculty members coupled with students from KMITL and the College of Architecture and Planning, University of Colorado, Denver, U.S.A. (UCD), organized a series of workshops and field trips to study arts and architecture in the central and northern regions of Thailand. Hypothetically, the academic merits of the proposed PBL activities would enable the participating students to: 1) obtain a higher body of knowledge and architectural skills via their haptic experiences with the built environment by constructing

the perceptions of the places where they visited; and 2), arrive at a noticeable scholarly improvement and/or achievement.

Apart from the said premises, the upcoming inquiries and discussions seek to demonstrate and reaffirm that: 1) educators must not overlook a realm of human spatial experience in training future generations of architectural professionals; and 2) the pedagogical practice in architecture should not depend solely on a "historic overemphasis on seeing as the primary sensual activity," as promulgated by Bloomer and Moore (1977, p. 49).

2. Theoretical Foundations and Methodological Approaches

2.1 Project-based Learning

Project-based Learning (PBL) is an educational model that shifts away from the normal classroom practices of short, isolated, and teacher-centered lessons. On the contrary, it emphasizes on the learning activities, which are long-term, interdisciplinary, and student-focused, as well as integrated with real-world issues and solutions. To put it differently, the concept of PBL denotes a concentrated and experiential way of learning, structured around inquiries to find appropriate resolutions for messy everyday situations, incorporating both minds-on and hands-on sets of problems. In an academic setting, Torp and Sage (2002, pp. 15-16) envisioned that a PBL curriculum could render authentic experiences for students that would promote their active learning, construction of knowledge, and natural integration between school and real-life lessons, yet at the same time addressing troubles on improving educational standards nationwide.

In general, the Center for Youth Development and Education (1994, as cited in Eiamsa-ard & Thammakittipob, 2009, pp. 44-52), maintained that the overall pedagogical aims of PBL are to: 1) engage students in complicated issues and problems, aside from allowing them to select and define topics or troubles of their interests; 2) require students to exercise their inquisitive minds and critical thinking, in company with their research, planning, and problem-solving skills in executing assignments; 3) teach students to apply content-specific skills and standards together with knowledge from a variety of contexts to their works, 4) give opportunities for students to acquire and practice interpersonal skills as they cooperate with each other as a team or with adults in a workplace and community; 5) urge students to use an array of skills needed for their adults lives and future careers, such as allocation of time, prioritization of resources, individual responsibility, etc.; 6) make students realize and accept the expected accomplishments based on particular criteria to assess their scholarly performances, which are linked to the educational standards of the school and/or nation; 7) incorporate reflexive activities that encourage students to critically contemplate on their experiences and associate those encounters with specific educational benchmarks; and 8) demonstrate a concrete proof of learning accomplishments according to certain evaluative criteria and/or methodology, which have been agreed upon in advance with the students.

Despite the fact that PBL has widely been adopted by architecture schools in Thailand, a close examination discloses that the numbers of published academic literature in architecture employing the method are somewhat limited. Even though not necessarily dealing with the subject of haptic senses, these researches nonetheless exhibit energizing and innovative ways of applying a PBL project to develop students' creative and critical thinking skills. For instance, Hengrasmee and Chansomsak (2011) introduced an experimental design studio for an environmentally friendly office building, featuring a pedagogical flexibility to accommodate a wide rang of students' academic interests on sustainable/green architecture.

2.2 Bloom's Taxonomies

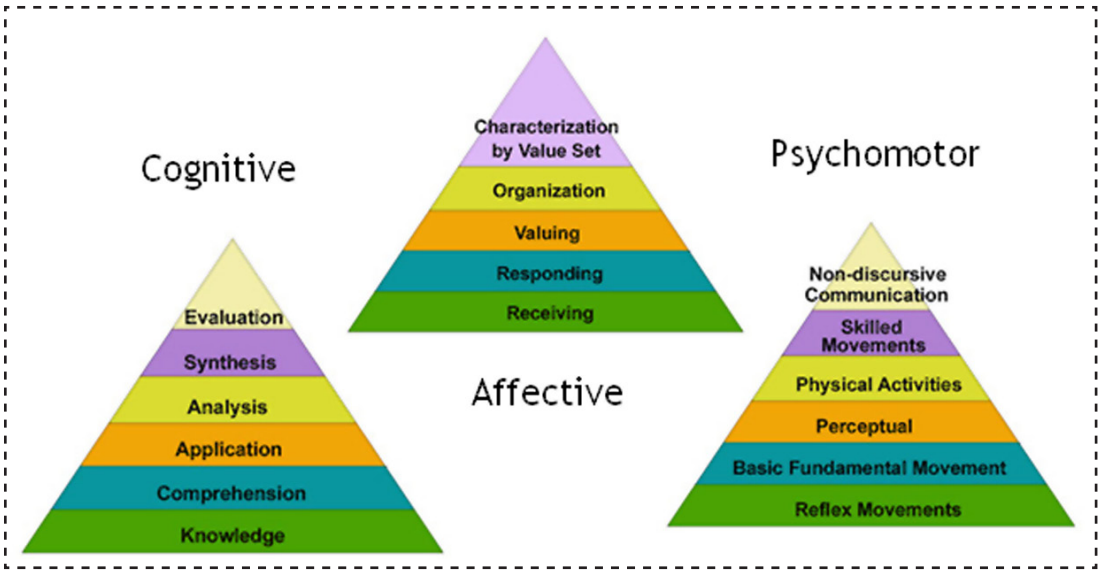
In behavioral science, the act of learning cannot be separated from the following realms in the human mind: 1) the cognitive; 2) affective; and 3) psychomotor domains. Although we generally possess all the three, human beings differ from each other when it comes to our ways of balancing and correlating one area with another, owing to our dissimilarities in various aspects.

As stated by a famous American educational psychologist, Benjamin Bloom, (1956a, p. 7; 1956b, p. 1) the cognitive domain revolves around knowledge, comprehension, and critical thinking on a specific topic. According to him, there are six levels of taxonomy in this realm. The lowest order is knowledge, whereas highest one is evaluation. As for the affective domain, attitude describes the way in which people react emotionally, accompanied by their ability to sense another living being's feelings. Affective objectives typically target the awareness and growth in attitudes, emotion, and feelings. There are five levels in the affective domain; receiving is the lowest order as opposed to characterizing, which is the highest one. Finally, psychomotor alludes to the ability to physically manipulate a tool or instrument, comprising of five levels in which imitation is the lowest whereas naturalization is the highest order. Psychomotor objectives usually concentrate on change and/or development in behavior and/or skills (Ibid).

Taken as a whole, the cognitive, affective, and psychomotor domains are among the fundamental factors that contribute to our understanding of, perception on, and feeling about the physical world respectively (Diagram 1).

2.3 Heidegger's Phenomenology

Since antiquity, human beings have contemplated on the meanings of the built environment through the question of what it means to "be-in-the-world." Martin Heidegger (1971, pp. 150-151), a renowned phenomenologist philosopher, wrote that our trouble with dwelling today does not lie merely in a lack of houses, but instead in the fact that we must learn to dwell by searching for the nature of dwelling. The process is a quest to comprehend the essential significance of being-in-the-world. Dwelling is, therefore, to remain in place and to be situated in a certain relationship with existence, a relationship, which is characterized by nurturing, enabling the world to as it is.



Source: Tom Gram. (http://gramconsulting.com/2009/02/fun-with-learning-taxonomies/)

Diagram 1. Bloom's Learning Taxonomies.

In other words, as suggested by Mugerauer (1994, p. 73), Heidegger's remarks implied that humankind must continue to explore how architecture and urban space evoke a sense of belonging, which in return generates a sense of place that contributes to our existential significations. In built things and forms, we belong to a disclosed reality, and in this reality, we are able to realize our own mortal nature, together with our proper relationship to the earth, its water, heavens, and seasons, and even to the hidden divinity. The "built" then becomes a "place," which makes "space" for an ontological event for us to experience via our corporeal senses. In any case, not only did Heidegger's statements call for the architectural profession to address human sensibilities beyond visual aesthetics in creating and understanding the built environment, but cause a major paradigmatic shift in architectural education as well.

2.4 The Haptic Way of Learning about the Built Environment

Since the 1980s, students have been taught to acknowledge the movements of their bodies through space for architectural design and studies. Correspondingly, a number of methods to effectively scrutinize the phenomenon of "place" through the haptic senses have been established, particularly in terms of design and research tools. For instance, Lyndon and Moore (1994, p. xiii) pointed out that physical activities, bodily movements, and intimate contacts with both built forms and natural landscape provided students opportunities to formulate knowledge about places that could not otherwise be achieved, if they were to rely exclusively on the visual means. Moreover, in his reviews on the methodological approaches of early 21st-century architectural pedagogy, O' Neil (2001, p.3) discovered that many broader inquiries using the concept of haptic senses have resulted in multidimensional new and exciting knowledge about the place experience in a culturally complicated and socially interconnected world.

In conjunction with the above theoretical propositions, this research was inspired by Schütz (1979, p. 35), who advocated the idea of going beyond everyday assumptions of our natural attitude to search for essential meanings and foundations of taken-for-granted life experiences. Similarly, by adopting Schütz's principle as the *modus operandi*, the academic activities of the KMITL and UCD students during the workshops and field trips encompassed: 1) the exploration and appreciation of architecture, urban space, and natural landscape through their corporeal senses; 2) the acts of recording, describing, and analyzing the phenomenon of places; and 3) the synthesis and reconstruction of their haptic experiences--did not restrict data to make sense out of the world, but admitted on equal terms, non-sensory data like relations and values, as long as they presented themselves intuitively.

In essence, as noted by Stefanovic (1998, p. 33), the problem-solving exercises utilizing haptic senses--like the ones employed during the workshops and field trips--were primarily intended to discover and describe the world spontaneously and pre-reflectively, instead of validating hypotheses, analyzing causal relations, or synthesizing conjectural theories of existence. In a corollary view, by alluding to a remark from Bachelard (1969, p. xxiii), it can be contended that while practicing their haptic way of learning about the built environment, the KMITL and UCD students' subconscious psychological level resulting from their corporeal senses--containing an interplay between the perceptions, which could be consciously reflected upon and the impressions which arose spontaneously within the activity of the transcendental imagination--would occupy a crucial role in experiencing and understanding the arts and architecture of central and northern Thailand.

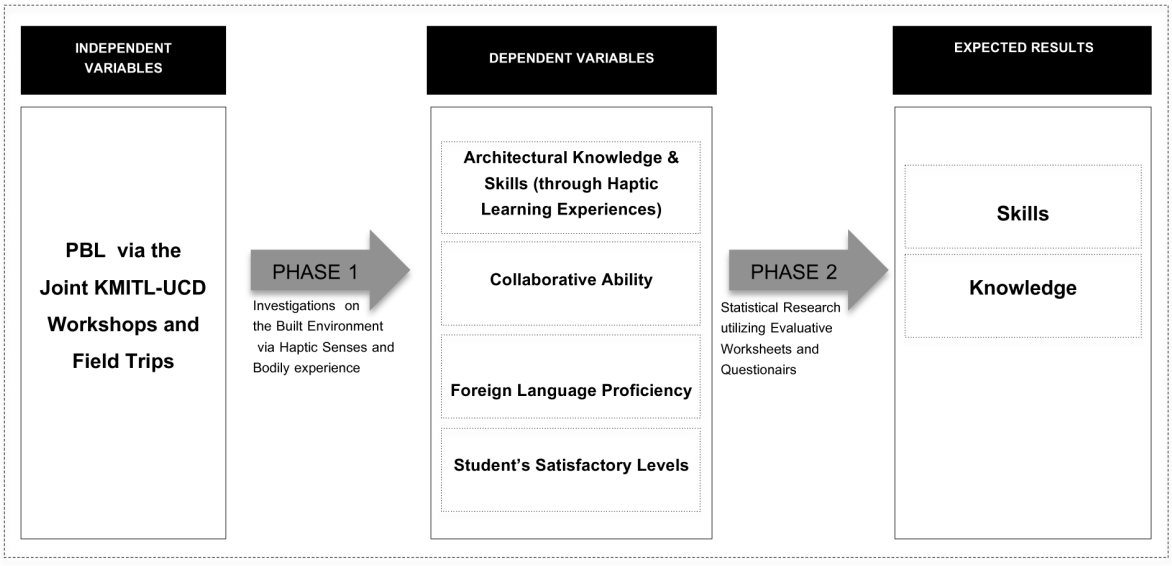
3. Themes of Discussions and Mode of Problematization

Before proceeding further, it is necessary to elaborate on the thematic organization of the article. Guided by the theoretical approaches of phenomenology, haptic way of learning, and PBL, the forthcoming discussions first evolve around project based-learning assignments, illustrating the ways in which the students: 1) explored and appreciated the built environment through their bodily senses--i.e. *ophthalmoception* (sight), *audioception* (hearing), *olfacoception* (smell), and *tactioception* (touch); 2) recorded, described, and analyzed the phenomenon of places that they encountered; and 3) synthesized and then reconstructed their haptic experiences--including other stimuli beyond those governed by the traditional senses, such as *thermoception* (temperature), *proprioception* (kinesthetic sense), *equilibrioception* (balance), *kinesthesioception* (acceleration), *nociception* (pain), and *chronoception* (time)--by using a variety of techniques and methods of representations.

Secondly, informed by the methodological applications of Bloom's learning taxonomies and PBL, the focus of the scholarly dialogues then shifts to a statistical research--relying on evaluative worksheets and questionnaires as its tools for data collection and interpretation--in order to: 1) verify the pedagogical validity for the haptic way of learning; 2) substantiate its positive relationships with the PBL; and 3) measure the students' progress and achievement from their corporeal experience with the built environment under a certain academic standard. Devised by the instructors, these investigative tools were consistent with the learning objectives approved by an educational specialist from outside the division to ensure that a conflict of interests would not occur.

On that basis, it may be construed that, on the one hand, the joint KMITL-UCD workshops and field trips act as the independent variable for the upcoming statistical analyses. On the other hand, architectural knowledge and skills, collaborative ability, along with language proficiency and students' satisfactory levels assume the role of the dependent variables (Diagram 2).

Furthermore, as mentioned earlier, the instructors employed evaluative worksheets to assess each student's performance in order to measure a scholarly improvement and academic achievement of the students. These worksheets aimed to evaluated students individually on his/her ability to work as a team member, ability to communicate with international students, and ability to analyze the relationships between architectural works, lifestyle,



Source: The Authors.

Diagram 2. The Methodological Approach and Procedures of the Research.

and culture. On the exhibition day, the instructors examined the final work presented by every student on the subject of his/her appreciation of the built environment via the bodily senses. At the end of the program, all students were asked to rate the degrees of their satisfaction with the workshops and field trips through questionnaires.

Bloom (1956, p. 7) identified three domains of educational activities; cognitive refers to knowledge, affective as an attitude, and psychomotor as skills. This taxonomy of learning behaviors can be thought of as "the goals of learning process." That is, after a learning episode, the learner should have acquired new skills, knowledge, and/or attitudes. Grounded upon Bloom's definitions, the term "knowledge" in this research refers to an understanding on architecture of the central and northern Thailand, and "skills" denote a process of team working, communication ability, and problem solving ability.

Nevertheless, the statistical studies used here merely address the cognitive and psychomotor domains, and do not touch upon the affective realm of learning due to the following reasons. 1) The affective domain related with emotionally, such as feeling, appreciation, enthusiasms, motivations, and attitudes. So, within a short period of time, instructors had a limitation to evaluate this domain. 2) Since the UCD students were nearly devoid of any prior knowledge on Thai architecture, it would be methodologically unsound to evaluate them on the affective domain, as opposed to the Thai counterparts who possessed a significant amount of knowledge on the same subject matter. 3) In order to present their final projects at a public exhibition, an evaluation on the affective domain had to be skipped; otherwise students would not have sufficient time to complete their works.

Owing to the above rationales, the inquiries on the cognitive realm therefore materialized from the instructors' evaluative worksheets, while those on the psychomotor emerged from the quality of student works presented at the exhibition. For the instructors, the evaluation forms included: 1) Student Performance Evaluation; and 2) The Psychomotor Domain's Checklist, whereas those of students encompassed: 1) The Cognitive Domain Self Satisfaction Evaluation Form; and 2) The Satisfaction Evaluation Form from Attending the Workshops and Field Trips.

4. A Haptic Way of Learning about the Arts and Architecture of Central and Northern Thailand by KMITL and UCD Students: A Case Study in Architectural Education

From January 7-19, 2013, a group of faculty members and students from KMITL and UCD embarked on a series of workshops and field trips to examine arts and architecture in the central and northern regions of Thailand. On the one hand, the instructors collectively agreed upon the itineraries, programs, and schedules of the study tour, which: 1) covered a distance of approximately 1, 473 kilometers or nearly 1,000 miles to travel; and 2) encompassed several significant historic sites in Bangkok, Ayutthaya, Kamphaengphet, Phitsanulok, Sukhothai, Lampang, Chiang Mai, and Saraburi provinces (Map 1).

Source: The Authors.

Map 1. The Itineraries of the Study Tour.

On the other hand, the students were responsible to come up with both the subjects and objects of inquiries, developed from their own initiatives and interests ranging from vernacular to urbanism, sacred space to tectonics, as well as materiality to building typologies. Their academic activities embraced a set of problem-solving exercises, such as topic proposals, analyses and syntheses of case studies, presentations, as well as exhibition of the final works.

With respect to the demography of the population group, the participating individuals consisted of twenty-one undergraduate students from KMITL (fourteen females and seven males) plus seven graduate students from UCD (five females and two males). As demonstrated in Table 1, each group of the students separately worked and prepared their projects until January 7, 2013 when the joint KMITL-UCD workshops and study trips officially commenced in Bangkok.

In addition, derived from the theory of phenomenology as explained earlier (see: Husserl, 1958; Bachelard, 1969; Heidegger, 1971), the students were assigned to keep "journals" to record their haptic experiences during the study tour, including notes and sketches supplemented by photography and/or other media, utilizing several techniques and methods of representations. They were subsequently evaluated through the research tools in relation to their scholarly merits--e.g., quality of presentation, documentation, coupled with analyses and syntheses on the phenomenon of the places--prior to a public exhibition of their works at KMITL on January 19, 2013.

In short, with regards to the issue of haptic learning, six united KMITL-UCD teams--containing four to six persons with at least an American student attached to each--reconstructed their phenomenon of places by using the following techniques and methods of representations.

Table 1. The Program and Work Schedule of KMITL-UCD Field Trips, Workshops, and Exhibition.

Activities	Timing	Outputs
Preliminary teaming up between the instructors from both universities	September 2012	Arranging an initial agreement to conduct the joint-workshops and field trips between the KMITL and UCD parties
Official announcement of the project	October 2012	Securing approvals for the project from the both universities
Recruitment and selection process / interviews of the applicants	November 2012	Choosing 21 students from KMITL in conjunction with enrolling 7 UCD students for the workshops and field trips
Detailed programming and scheduling for the workshops and field trips	November 2012	Preparations for the trips and their related activities coupled with presentations of the proposed subjects of study by the students
English intensive course	November 2012	KMITL students undertaking a six-week training class on English communication
Final presentations on the subjects and objects of investigation	December 2012	Concluding the subjects and objects of study, as well as their methodology, before assigning each student to a group of similar interests
Orientation	January 7, 2013	First group meeting between KMITL and UCD students
Workshops, field trips, and journal keeping	January 8-16, 2013	Recording the works of each student during the workshops and field trips
Exhibition preparation	January 17-18, 2013	Finalizing the student works and preparing for a public exhibition
Exhibition	January 19, 2013	Exhibiting the completed works to the public

Source: The Authors.

4.1 Intuitive Bodily Movements through Space

The first party, consisting of five members, investigated the phenomenon of place via a mixture of sensibilities, centered on the relationships between their body positions and the physical locations of the built environment. In consistence with the approach advocated by Gibson (1966, p. 7), these students concentrated on their bodily efforts in moving across space, which in turn gave them internal corporeal knowledge about the settings of the environment with which they had immediate contacts.

The group chose two case studies on the arts and architecture of central Thailand. The first was the interior space of the *vihara* (chapel) at Wat Phra Sri Rattana Mahathat: a Buddhist temple whose origin dated back to the 14th-century. Located in Phitsanulok province, the building enshrined Phra Buddha Chinnarat, arguably the most beautiful Buddha portrait in the country. The second example was Wat Mahathat in Sukhothai Historical Park, a 70-sq. km. of land covering the ruins of the 13th-century capital of Sukhothai Kingdom. The entire area was declared a UNESCO's World Heritage Site in 1991.

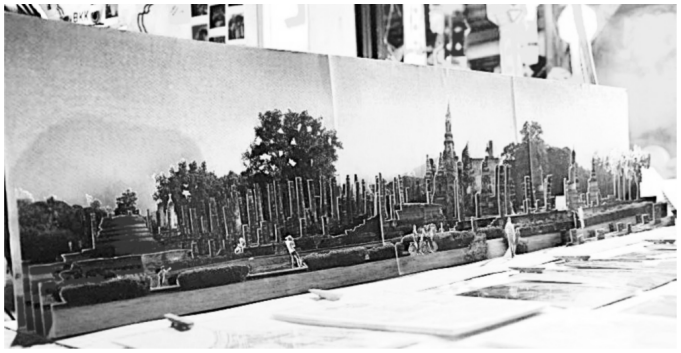
In examining those historic places, the team resorted to a technique of Fotomo (photo model), invented by a Japanese photographer Kimio Itozaki, to create dioramas by shooting photos on the street from all different angles and then assembled the photos to regenerate the perspectives. Apparently, Fotomo is a method to make a three-dimensional object from photo prints of real-world scenes by cutting and piecing together layers of photos into collages, which could be viewed from multiple points.

For that reason, Fotomo became a medium par excellent for the participants to explore their movements through the architectural space of the chapel (Figure 1), the ruins of the temple, and the ancient city (Figure 2), aside from narrating their haptic experiences while preserving tangible memories of the places. Drawing upon the lessons learned from Hiss (1990, p. 3), it may be construed that while the images captured the atmosphere and immortalized the moments, they marked the locations of the surroundings in terms of the "space-time relations" to the positions of the psyches and physiques of the students, whose perception of space referred to a complex geographical experience, namely their positional awareness (proprioception), balance (equilibrioception), movements (kinesthesioception), depth of field (ophthalmoception), and memories of previous moments (chronoception).

In sum, as shown by the KMITL-UCD photo models, the actual three-dimensional reality of the models and the virtual three-dimensional space of the photo merged with one another to produce a unique experience of the places. Moreover, as noted by Itozaki himself, the perspective in the photographic images "conveys a feeling of depth within a limited

Source: The Authors.

Figure 1. A Fotomo Regeneration of the *Vihara* of at Wat Phra Sri Rattana Mahathat.



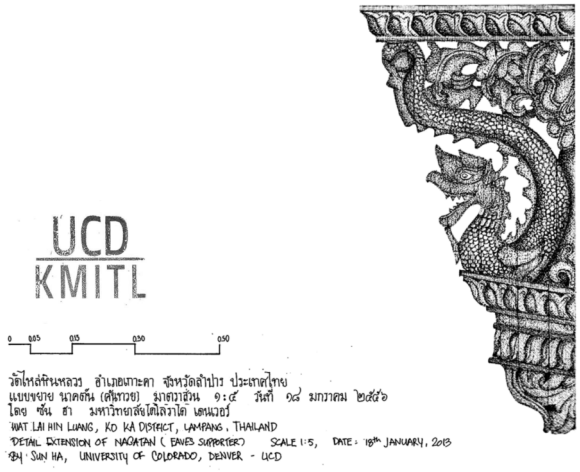
Source: The Authors.

Figure 2. A Fotomo Reconstruction of Wat Mahathat and Sukhothai Historical Park.

space, and because the Fotomo is a real three-dimensional object than you [the audience] can view from various angles, it has a unique realism that gives the viewer a real sense of being there" (Itozaki, 2007).

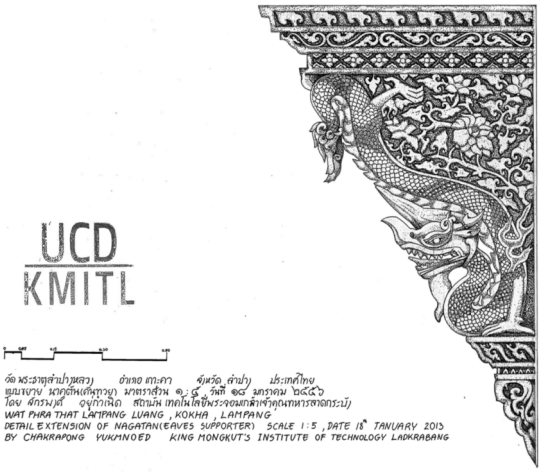
4.2 Intimate Encounter with the Textures and Surfaces

With a great interest on the sensory impressions caused by touching upon certain surfaces and textures, five individuals pursued their scholarly quest on the cultural heritages of Thailand by means of architectural documentation. To accomplish the intended goal, the group decided to focus on a specific decorative element of the northern-style religious structures: the wooden corbels (or *kantuay* in Thai). These brackets--devised in the forms of *Naga* or *Nagatan*: the serpent king, and *Hanuman*: the monkey deity, in the Hindu-Buddhist mythology---projecting from the walls to support the roofs came from four temples situated within the city of Lampang: 1) Wat Lai Hin Laung; 2) Wat Phrathat Lampang Laung; 3) Wat Pongsanook; and 4) Wat Phra Too Pong.



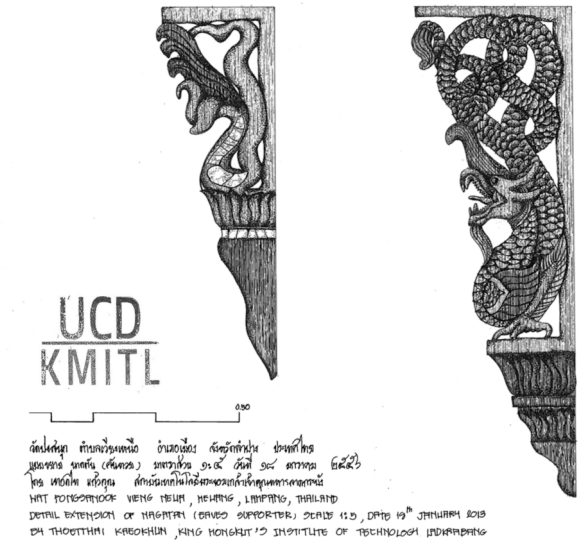
Source: The Authors.

Figure 3. A Vernadoc Drawing of *Naga* at Wat Lai Hin Luang.



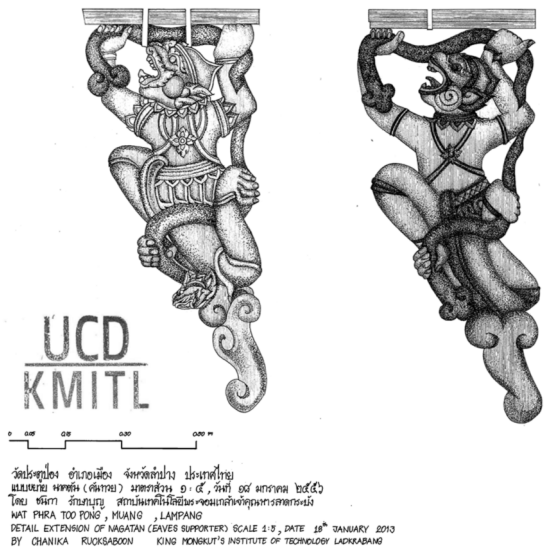
Source: The Authors.

Figure 4. A Vernadoc Drawing of *Naga* at Wat Phra That Lampang Luang.



Source: The Authors.

Figure 5. A Vernadoc Drawing of *Nagas* at Wat Pongsanook.



Source: The Authors.

Figure 6. A Vernadoc Drawing of *Hanumans* at Wat Phra Too Phong.

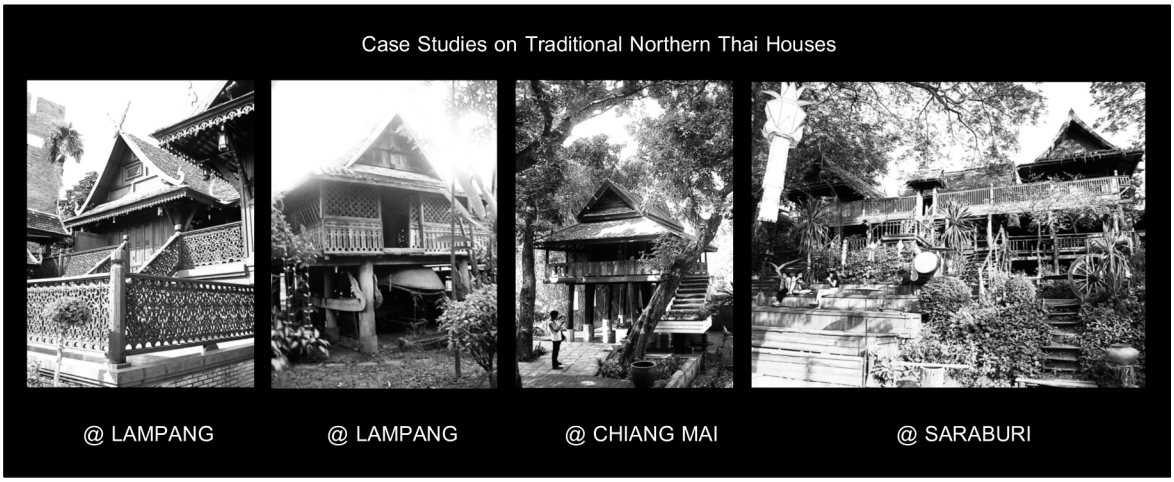
In scrutinizing the corbels, the partakers substantially relied on their hand-and-eye coordination skills. Not only did they use the hands to measure the dimensions and to record the physicality of the brackets through sketches, drawings, and photographs, but to feel the textures of the corbels, which were made from different types of wood and covered in dissimilar kinds of surface finishes, such as wax, lacquer, oil, varnish, paints, stucco, as well as gold and stained glass inlays. In doing so, the students intimately resorted to a combination of their sensory receptions, notably the ophthalmoception and tactioception awareness, accompanied by the proprioception and equilibrioception cognizance.

Overall, this "hands-on experience" gave a rare chance for each member of the team to exercise their haptic senses of olfacoception (smelling) and thermoception (temperature)--or even nociception (pain)--in unison when studying arts and architecture, thanks to different chemical odors evaporating from the finishing materials, coupled with the thermodynamic quality of the wood. Nonetheless, a caution must be heeded too. Although a Vernadoc inquiry offered a fairly sterling service to the haptic way of learning about the built environment, it was far from functioning as an ideal mode of representation. As demonstrated by the student works (Figure 3-6), their vernacular documentation heavily counted on the visual aesthetics. As a result, the problem of fully articulating the phenomenon of place to the audience beyond the visual means--like scent and temperature--still persisted.

4.3 A Tactile Interpretation of Time and Space

Another band of five persons looked into several distinctive characteristics of traditional houses in northern Thailand (Lanna), with regard to the spatial configuration, tectonics, materiality, and functionality, in relation to the social, cultural, and spiritual practices of the dwellers. By using the so-called "ethnographic approach," the group visited a number of wooden residential buildings for some consecutive days in the cities of Lampang and Chiang Mai, apart from staying overnight at a Tai-Yuan village in Saraburi province (Figure 7). (Note: in spite of the fact that Tai-Yuan people migrated from the north and settled down in the central region long time ago, they are able to preserve their socio-cultural practices and ethnic identity).

By appropriating an investigative approach from Metheny (1975, p. 96), the partakers rigorously engaged themselves with a cyclical connection between sensation, perception, feeling, thought, and action. Their haptic experiences with the phenomenon of place stemmed from unselfconscious knowledge by moving into and across space. Dwelling on a



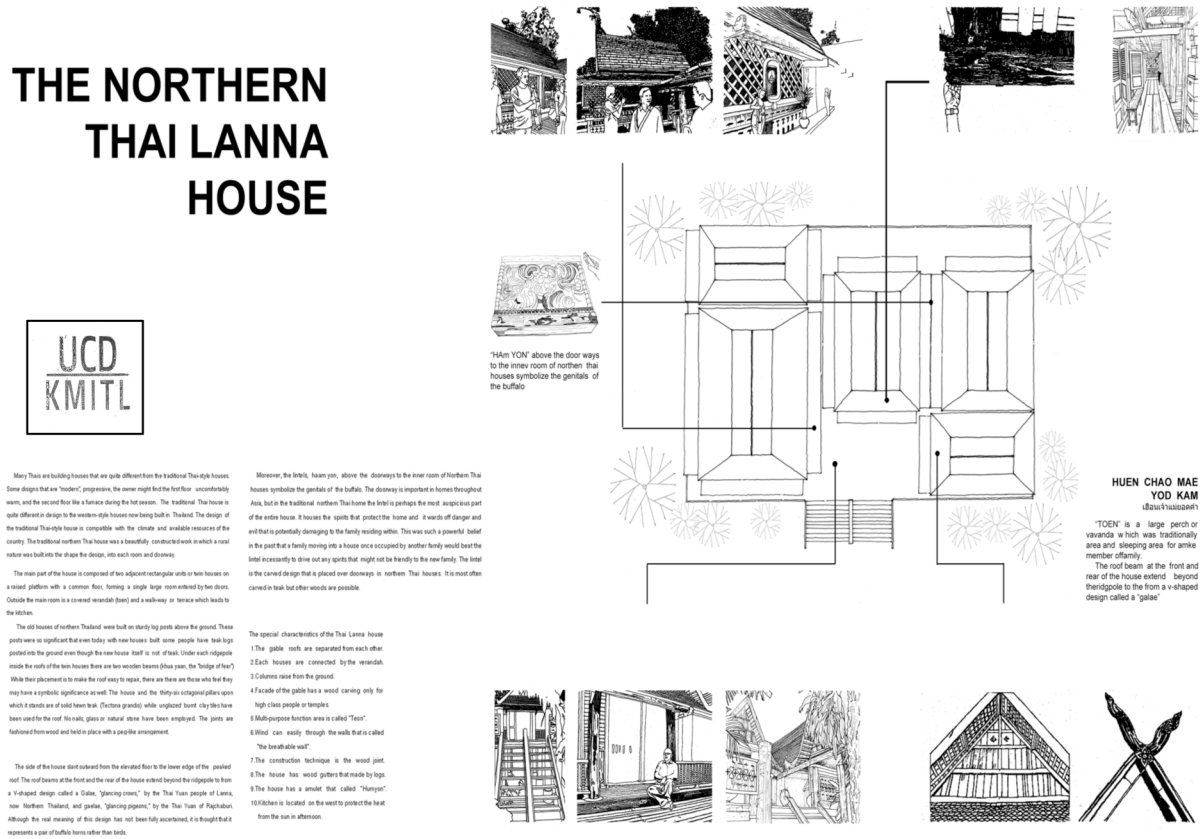
Source: The Authors.

Figure 7. The Case Studies on Traditional Northern Thai (Lanna) Houses.

theoretical foundation established by Straus (1966, p. 11), the students developed a conception about the identity of the houses via the sensory receptions and memories, which was strengthened by their emotional connections with architecture and surrounding landscape.

During the field trips, the team collectively adopted the method of spatial mapping to introduce a holistic system of phenomenological understanding, especially for the sense of spatiality created by the whole sensory envelope. Analogous to the research method employed by Maltzahn (1994, p. 79), each member composed a "time-space routine" map: a set of diagrammatic records on his/her kinesthetic habitual behaviors that usually took place when he/she entered the buildings (Figure 8). Aided by digital photographs and measuring tapes, the participants later combined and compared all maps with one another, before analyzing and interpreting the overall "space-time routines" to construct a comprehensive analysis of the spatial arrangement of the houses, as evident by their architectural sketches, drawings, and diagram (Figure 8).

The said KMITL-UCD "time-space activities" necessitated total physical engagements with the built forms and their settings. Through repeated occurrences of ordinary events in visiting each Lanna house, the students: 1) virtually exercised all of their sensibilities--with merely an exception of gustaoception (taste)--to develop what Seamon (1980, pp. 157-158) called a strong sense of place together with its meanings; and 2) were thus able to identify the following prominent features found in typical Lanna residential structures, i.e., separated gable roofs, connecting verandahs, raised columns, the use of wood carved pediments exclusively for temples and



Source: The Authors.

Figure 8. Analytical Sketches, Drawings, and Diagram of Typical Lanna Residences.

homes of the local ruling class, multifunctional area or *teon*, breathable walls, wood joint construction, wood gutters made from logs, decorative elements called *humyon* to ward off evil spirits, and westward facing kitchens.

4.4 Listening to the Sounds of Frozen Music

Inspired by a beautiful quote from an iconic 19th-century German poet Johann Wolfgang von Goethe (1908) that "Architecture is like frozen music" *(Baukunst eine erstarrte Musik nenne)*, a party of five individuals collaborated on experimenting with the acoustic quality of a built environment that impinged on their haptic experiences with the phenomenon of place. Their quest, however, involved more than simply recording the sounds from various places during the field trips, but required each person to exert astute interactions between his/her senses of ophthalmoception and audioception, as much as shrewd coordinations between his/her intellect and sensation.

Theoretically, Goethe's allegorical connection between the two branches of arts is profoundly influential, notwithstanding the fact that his metaphor of architecture as music that had been subjected to myriad interpretations. On the one hand, similar to music, architecture encompasses rhythm, beat, cadence, tone, style, etc., which could be experienced in many ways, either slowly, quickly, forcibly, gently, or sweetly. Likewise, both music and architecture use the same aesthetic principles of proportion, scale, contrast, harmony, rhythm, etc. Actually, some of the greatest architects happen to be accomplished musicians too. For instance, Frank Lloyd Wright was a proficient pianist, who learned to play the instrument at a very early age (Dietrich, 2012). The legendary architect once explained: "Music and architecture blossom on the same stem: sublimated mathematics... Mathematics as presented by geometry" (Novak, 2007, p. 1).

On the other hand, Goethe's proposition could be reversed from an acoustic point of view as well by saying: "Music is architecture in movement" (Xenakis, 1992, p. 5). In which case, as aptly pointed out by Novak (2007, p. 1), "The intuition that allows us to even consider architecture as 'frozen music' or music as 'molten architecture' comes from a deep and ancient understanding that, in its very essence, architecture exceeds building, as music exceeds sound."

By using still digital images in association with sound and video clips, the students produced a fifteen-minute animation, narrating their collective bodily experience of the places, which with they had intimate contacts. This piece of work, in effect, presented a series of the ontological events that generated a shared internal corporeal knowledge about the built environment among members of the group through their sight and hearing. In a nutshell, the whole efforts revolved around one fundamental question: if architecture is "frozen music," then what does it sound like?

The aforementioned question acted as a *modus operandi* for the team to explore the arts and architecture of the central and northern Thailand. As exhibited by the screenshots of the animation (Figure 9), the participants intuitively pieced together the recorded sound clips with the photographs and videos capturing: 1) several architectural elements, forms, and space; 2) the natural landscape; and 3) socio-cultural activities, such as performing arts as well as religious/spiritual rites and rituals. They also instinctively selected certain musical themes and compositions to convey the phenomenon of places to the audience.

4.5 Tracing Memories

Next, four individuals investigated a connection between the sense of ophthalmoception and the mentality in constructing the memories of places by means of photo tracing (Fototrace). Their inquiries dwelled on the topic of architectural space at Kad Kong Ta weekend walking-street market in the city of Lampang, which operated in terms of a backdrop for the embodiment of local people's activities (Figure 10).

Source: The Authors.

Figure 9. Screen Shots of the Animation.

Source: Nuttakarn Thachan

Figure 10. A Panoramic View of the Atmosphere of Kad Kong Ta at Dusk.

Literally speaking, Fototrace denotes a method of utilizing a pen or pencil to delineate the shapes and forms of objects appearing in a printed photographic image on a sheet of Mylar or vellum paper, which is laid on top of the photo itself. To put it differently, Fototrace is a kind of artworks, made by placing a copy paper on the photo and tracing all the lines and shadows in that image. As remarked by Poomsawai, (2010), the technique permits a person to see every tiny detail that he/she might miss at first glance.

In a nutshell, the concept and practice of tracing in association with human recollection originated from the Causal Theory of Memory developed by Martin and Deutscher (1966), promulgating that common sense concepts of memory stemmed from a reliance on the existence of some kind of "memory trace," as a continuous bridge across the temporal gap, which causally connected the past and present. Apart from collecting the firsthand information on buildings and their surroundings to preserve the corporeal recollections of the places, Fototrace helped the students to analyze how the virtual three-dimensional space in the perspective was created. By tracing those images, the participants deconstructed and subsequently reconstructed the actual three-dimensional reality by their hand-and-eye haptic interface. At the same time, they learned how the eyes and the mind unselfconsciously functioned in concert through their sense of chronoception, or the memories of previous moments.

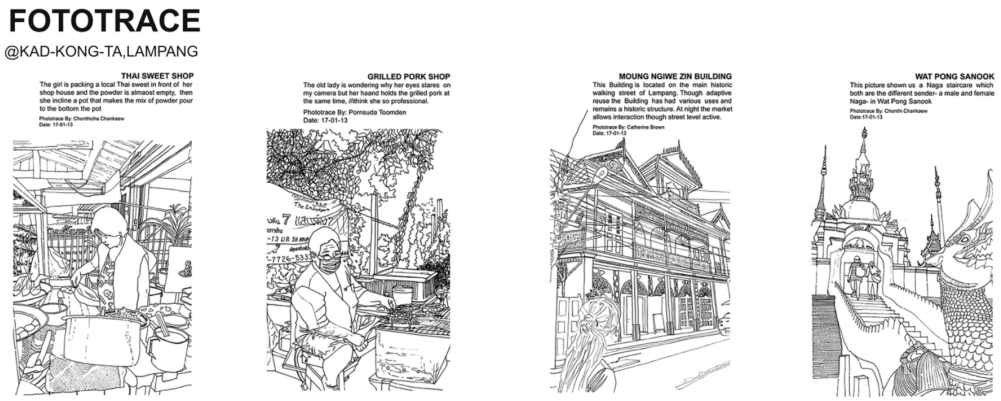
In a somewhat comparable fashion to Fotomo, Fototrace offered a versatile medium for the students both to explore and represent their haptic experiences with Kad Kong Ta (Figure 11). Yet, an advice must be issued that tracing photos should be done exclusively by hand, rather than by image editing programs in computers despite the fact that

the latter supplies a less time-consuming manner and better quality of works than the former. The deployment of computers in this circumstance would be counter-productive because it would not be conducive for an individual to exert his/her bodily senses, intellects, and recollections as one.

In order to prevent a failure to grab the core of the Fototrace technique, the students were strictly forbidden from employing any computer graphic program to aid their practice of Fototrace during the workshops and field trips. Correspondingly, not only did the instructors closely monitor the progress of the Fototrace works, but also thoroughly check that all were done manually.

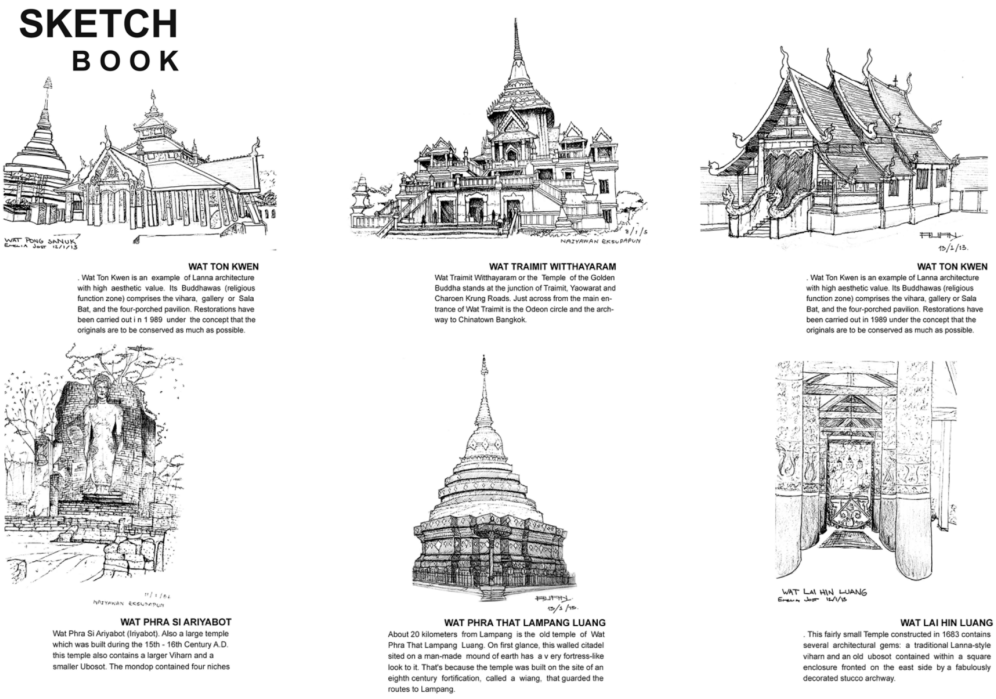
4.6 Instantaneous Interactions and Reflections

The last team, constituting four members, employed the most conventional way of examining the phenomenon of place primarily via the bodily sense of ophthalmoception by producing architectural sketches and drawings. Their inquiries mainly dealt with a topic of sacred space and structures of Theravada Buddhism in central and northern Thailand (Figure 12).



Source: The Authors.

Figure 11. A Set of Fototrace Renditions on Kad Kong Ta, Lampang.



Source: The Authors.

Figure 12. A Set of Hand Drawings and Sketches on Buddhist Temples.

In making the architectural sketches and drawings of those exquisite buildings, the corporeal senses of the students bled into each other, depending on one another for the contextual references, spatial configurations, formal compositions, and structural grounding (the force of gravity). Apparently, most of the works anchored the viewpoint to a single-point perspective (Figure 12), resulting in an instant haptic experience, which was the touch of the eyes between the reality and representation.

Psychologically, each person's past encounters and recollections of the said simultaneity further affected his/her vision and touch, giving rise to the sense of texture and feel through looking (the tactio-ception). When viewing the temples, the partakers ran their eyes across the lavishly decorated surfaces. Nonetheless, they could felt without touching any. This haptic sense, therefore, allowed them to investigate the buildings and their surroundings with the mental ability, while moving the actual, physical, bodily fingers--hands and pencils--in accord with the touch by the minds.

In actuality, when sketching and drawing the temples, the students' perception indeed moved and led their hands. In switching in and out of prominence, the silhouette of a building was predominantly vision proper, whereas shifting towards its form, surface, and texture turned out to be more haptic; hence the proprioception (kinesthetic sense) took hold. The hands recognized where those entities were, as the eyes gazed the structure.

Moreover, another significant aesthetic attribute of architectural sketches and drawings was shade and shadow--or light--that contributed to the haptic way of appreciating the places. In drawing with black pencils on white or mid-tone paper, the students haptically probed where the light and shade fell on each religious structure, thus touching light as if it were not imagery and virtual, but tangible and somatic. As articulated by Karmel (2012), because the sketches and drawing always portrayed a variation of brightness and darkness, it alluded to the sense of thermoception by creating such a basic visual sensation.

Be that as it may, it is highly recommended that in order to successfully engage with the haptic senses, architectural sketch and drawing of existing buildings as well as natural landscape should be executed *in situ*, as opposed to copying still images in a totally climate-controlled room. Exposure to the elements of whether--e.g., temperature, humidity, precipitation, wind speed, air pressure, and visibility--are crucial for realizing the phenomenon of place through our bodily experience, which could not be replicated inside a studio. Through vision, we registered our haptic sense, memory, and proprioception. Our eyes are complex and multisensory as are all senses, which have no clear boundaries (Ibid). Hence, the partakers of the KMITL-UCD joint workshops and study trips were encouraged to make their architectural sketches and drawings at the real locations as much as possible.

5. Evaluating A Success on the Haptic Way of Learning in Architectural Education

As previously explained, because the haptic way of learning derives from the acts of experiencing and appreciating the built environment through the bodily senses, it concentrates on skill and therefore dwells on the realm of psychomotor. All five instructors examined the students mainly on their architectural skill, analytical ability and synthesis ability through a measurable order of psychomotor domain from the least, imitation, to the most order as described as naturalization. In order to do so, all the instructors were individually asked to appraise each student work through a checklist on the five psychomotor orders. Each of the orders required at least three out of five approvals from the instructors in order to be recorded in the below table. These correlations can be seen from Table 2.

Table 2. The Psychomotor Domain's Checklist.

Order/Meaning	Fotomo	Vernadoc	Spatial Map	Animation	Fototrace	Sketch
Imitation: Observing and patterning behavior after someone else	✓	✓	✓	✓	✓	✓
Manipulation: Being able to perform certain actions by following instructions and practicing	✓	✓	✓	✓	✓	✓
Precision: Refining and becoming more exact with fewer errors committed	✓	✓	✓	✓	✓	✓
Articulation: Coordinating a series of actions while achieving harmony and internal consistency	✓	✓	✓	✓	✓	✓
Naturalization: Having a naturally high-level performance without thinking much about it	n/a	n/a	n/a	n/a	n/a	✓
Haptic senses employed	pr, eq, ki, op, ch,	op, ta, pr, eq, ol, th, no	op, au, ol, ta, th, pr, eq, ki, ch	op, au, th, pr, eq, ki, ac, ch	op, pr, ch	op, ch, pr, ta, th

Source: The Authors.

Remarks
op is ophthalmoception (sight).
ol is olfacoception (smell).
th is thermoception (temperature).
eq is equilibrioception (balance).
ch is chronoception (time).
au is audioception (hearing).
ta is tactioception (touch).
pr is proprioception (kinesthetic sense).
ki is kinesthesioception (acceleration).
no is nociception (pain).

Since the necessary skills for the psychomotor are described as imitation, manipulation, precision, articulation, and naturalization, the domain can be interpreted in terms of a capability to:

- Observe and be able to duplicate, follow, or identify a problem.
- Be able to perform a task with ease.
- Be able to perform a task with minor error and higher skill.
- Be able to perform a task with least mistake.
- Be able to perform a task naturally.

Consequently, in order to grasp the benefits from skill developments, which are quintessential for architectural education, not only must students be challenged to explore different techniques and pursue their own interests, but their significance skills--or the lack thereof--also need to be identified, acquired, and/or resolved. However, as evident from Table 2, the quality of the works undertaken during the joint KMITL-UCD workshops and study trips: 1) indicated that the skill development for most--if not all of--the participants could hardly reach the level of naturalization; and 2) demanded the instructors to come up with a teaching technique and/or method that could advance the students to attain their possible highest psychomotor order.

6. The Analytical Results, Interpretations, Discussions, and Suggestions

At the end of the exhibition, each student was required to evaluate total of twelve items in a 1-5 Likert scale in a self-evaluated questionnaire. After distributing and collecting the questionnaires, a series of mean calculations were conducted on each category of the data to determine the depth of knowledge, skill level, and degree of satisfaction (the dependent variables) of all the twenty-eight participating students, via the below score criteria:

Average 4.50 – 5.00	means	highest practice/ satisfaction.
Average 3.50 – 4.49	means	high practice/ satisfaction.
Average 2.50 – 3.49	means	medium practice/ satisfaction.
Average 1.50 – 2.49	means	low practice/ satisfaction.
Average 1.00 – 1.49	means	very low practice/ satisfaction.

As for the method of data collection, twenty-one KMITL and seven UCD students (the population group of twenty-eight persons) were requested to fill out the questionnaires for self-evaluations in examining their satisfactory levels with the workshops and field trips (the independent variable), as evident from the outcomes in Table 3.

Aside from evaluating the cognitive domain of the population group from the lowest to highest orders (from knowledge to evaluation), Table 3 demonstrates that both KMITL and UCD students had gained a higher level of improvement in all aspects. For the students from KMITL, their most noticeable improvements were comprehension, analytical and synthetic skills, with a slightly advancement in knowledge, due to the fact that: 1) they already took some classes on the arts and architecture of the central and northern Thailand before embarking on the workshops and field trips; and 2) as Thai citizens, they were socially and culturally familiar with the objects and subjects of their inquiries. On the contrary, since the UCD students did not possess such backgrounds, they progressed more on the knowledge, especially when comparing to the KMITL counterparts.

Table 3. Self-evaluation Scores from the Students.

Items	21 KMITL Students		7 UCD Students	
	Before $\overline{X}$	After $\overline{X}$	Before $\overline{X}$	After $\overline{X}$
1. An understanding on architecture of central and northern Thailand (K)	2.52	3.81	1.57	4.29
2. An ability to analyze the architectural work (An)	3.00	4.10	3.71	4.14
3. Communication skills (listening, speaking, reading, writing) for analyzing architectural works (An)	2.62	3.76	4.00	4.00
4. An ability to work with international students (C)	2.43	4.10	3.29	4.57
5. An ability to communicate with international students (C)	2.48	3.76	2.86	4.43
6. A knowledge and comprehension on Thai and American cultures (C)	2.52	4.10	2.14	4.43
7. An ability to understand the meaning of architectural works (C)	2.67	3.81	3.71	4.14
8. An ability to use data/information in many ways (S)	3.05	4.05	4.29	4.57
9. An ability to analyze the relationships between architectural works, lifestyle, and culture (An)	2.81	4.10	4.29	4.57
10. An ability to synthesis information for an exhibition or presentation of student's works (S)	2.95	4.05	4.00	4.29
11. An ability to judge the values of architectural works (E)	2.71	3.95	4.29	4.29
12. An ability to present the works to the public (Ap)	3.24	4.48	4.14	4.43
Average	2.75	4.00	3.52	4.35

Source: The Authors.

Remarks K means knowledge. C means comprehension.
Ap means application. An mean analysis.
S mean synthesis. E means evaluation

Furthermore, because all the KMITL students were studying in the undergraduate level, their comprehension, analytical and synthetic skills had yet to be fully developed and/or acquired. In contrast, all the UCD partakers were graduate students who had been mastering these skills for a while, as typically required by graduate schools in the U.S.A. So, it should not be any surprise to witness a marginal improvement on the comprehension, analytical and synthetic skills by the Americans.

As regards the evaluation skill, the mean calculations disclosed that this highest order in the cognitive domain did not increase for the UCD students, but it was substantially developed by the KMITL students, owing to their close collaboration with the graduate students from UCD. The reason behind this omission of comparative study on the evaluation skill between the KMITL and UCD members of same team was that all UCD students studied in the graduate level (M.Arch.), while all KMITL participants were undergraduate students (B.S.I.Ed. in Architecture). Thus, it would have no significant impact in a statistical term to make a comparison between the two groups.

On the opposite side, total number of five instructors (four from KMITL and one from UCD) whom involved in this project from the beginning and traveled with students throughout the trip also assessed the progress made by each of their students in terms of group working ability, communication ability, in conjunction with architectural comprehension, analytical, synthetic, and evaluation skills through evaluative worksheets, as exemplified by Table 4.

Table 4. Scores of Instructors' Evaluations on the Students.

Items	21 KMITL Students		7 UCD Students	
	Before $\overline{X}$	After $\overline{X}$	Before $\overline{X}$	After $\overline{X}$
1. An ability to work as a team member	3.60	4.15	4.43	5
2. An ability to listen to other team members	3.63	4.17	4.71	4.86
3. An ability to express a useful idea or information to teammates	3.31	3.76	4.28	4.57
4. An ability to give an advice during a working process and provide an assistance to other members of the team	3.28	3.81	4.28	4.86
5. A unity in working as a team	4.08	4.52	4.43	4.71
6. An ability to communicate by speaking in a foreign language	2.06	3.06	1.71	2.14
7. An ability to communicate by reading in a foreign language	1.95	2.60	2.00	2.14
8. An ability to communicate by writing in a foreign language	1.57	2.22	2.00	2.00
9. A responsibility for the assignment / work ethics	4.05	4.56	4.43	4.86
10. Group participation.	4.17	4.52	4.86	5
11. An ability to communicate with international students	2.41	3.16	2.71	3.57
12. An ability to understand the meanings of architectural works and their settings (C)	2.62	2.67	3.86	4.71
13. An ability to use data/information in many ways (S)	2.73	3.40	4.43	4.71
14. An ability to analyze the relationships between architectural works, lifestyle, and culture (An)	2.63	2.59	3.57	4.71
15. An ability to judge the values of architectural works (E)	2.51	2.92	3.71	4.57
Average	2.97	3.47	3.69	4.16

Source: The Authors.

The mean calculations in Table 4 reaffirmed that both the KMITL and UCD students had made a significant improvement in every category, notably their abilities to work as a team member, and to share significant information to other members of the team. As noted before, the student projects were rather focused on a group process due to the time constrain imposed upon the UCD students to fully understand both the subjects and objects of their inquiries. In fact, even the KMITL students, who possessed more knowledge and experience on the subject matters than their American counterparts, would encounter a great difficulty in completing the same assignments/ projects themselves. For that reason, it may be concluded in a general sense that group collaboration is a useful and effective teaching method for developing the working skills of a person and his/her teammates at the same time.

Moreover, statistical analyses confirmed the result on each group of the students, which mutually corroborated that communication skills were the principal element of success in understanding foreign colleagues who neither spoke the same language nor shared similar socio-cultural heritages. Therefore, it is mandatory for a responsible educator to: 1) recognize the value of foreign language proficiency, namely English; and 2) prepare his/her students for it as a prerequisite to advance their skills and abilities in today's globalizing world.

In final, via an evaluative form, each of the students was requested to rate his/her satisfactory degree with the joint KMITL-UCD workshops and field trips in order to: 1) gather their comments, suggestions, and critiques; 2) study the pros and cons for organizing a similar kind of activities again; and 3) identify rooms for future improvements. The overall feedbacks from the students are presented in Table 5.

Table 5. Scores of Satisfactory Levels by the Students with the Workshops, Field Trips, and Exhibition.

Items	21 KMITL Students $\overline{X}$	7 UCD Students $\overline{X}$	$\overline{X}$
1. Preparation for the uses of foreign languages and proficiency in communication skills	3.76	3.57	3.66
2. Information on the workshops and field trips provided before the program started	3.76	3.29	3.52
3. Information given during the workshops and field trips by the instructors	4.00	4.57	4.29
4. The route and schedule of the workshops and field trips	4.05	4.71	4.38
5. Format and process for the presentations and exhibition of their works	3.95	4.00	3.97
6. A opportunity for each student to choose his/her own technique and presentation	4.57	4.29	4.43
7. Project participation	4.57	5.00	4.78
8. Transportation and vehicular access during the trips	4.24	5.00	4.62
9. The itineraries and programs of the workshops and field trips	4.43	4.29	4.36
10. Timing and duration of the project.	4.38	4.57	4.47
11. Lectures from both the KMITL and UCD instructors	4.38	4.57	4.47
12. Students presentations and public exhibition of works	4.05	4.43	4.24
13. Overall satisfaction with the program	4.43	4.57	4.50
Average	4.20	4.37	4.28

Source: The Authors.

The feedbacks on the levels of satisfaction from the students revealed that the KMITL and UCD partakers alike gave their lowest scores to: 1) the information on the workshops and field trips provided before the program started; 2) preparation for the uses of foreign languages and proficiency in communication skills; and 3) the format and process for the presentations and exhibition of their works.

In effect, the students' satisfactory levels testified that both the duration and frequency of the occasions for disseminating information on the workshops and field trips prior were inadequate. Likewise, a similar vein of criticism could be applied to the preparatory process for participants from both sides on the topic of foreign language proficiency too: English for the KMITL members and Thai for the UCD personnel.

Taken together, the said critical appraisals--despite their negative connotations--had single out several keys areas that need to be fixed, particularly on the allocations of resources and time from both universities. True, organizing such an international academic collaboration for the first time was far from being impeccable, but the lessons learned from the 2013 joint KMITL-UCD workshops, field trips, and exhibition must be seriously heeded and put into practice, if these activities were to be conducted again in a near future.

7. Conclusion

The analytical and critical discussions throughout this article elucidated that all the participating students have obtained a higher body of knowledge and architectural skills through their haptic experiences with the places visited during the workshops and field trips. To cite some examples, students' self-evaluation in Table 3 indicated a substantial improvement on levels of knowledge, as attested by a comparison between the scores in which the students gave themselves during and after undertaking their projects. Likewise, the overall analytical results of measuring the ability of the students in improving their levels of psychomotor domain by the five KMITL and UCD instructors were also positive as shown by Table 2.

Furthermore, as substantiated by the preceding statistical inquiries, project based-learning (PBL) has led to a number of scholarly improvements in addition to academic achievements for the KMITL and UCD students alike. Despite the fact that the projects/assignments challenged the students to come up with unique approaches to execute them, utilizing both the psychomotor domain and haptic senses were mandatory in order to solve these PBL problems. In a nutshell, the studies demonstrate that PBL has rendered several positive effects on the acquisition and development of many crucial skills and abilities for the students, regardless of their differences in genders, ages, ethnicities, nationalities, races, and levels of education, as well as cultural, social, and economic backgrounds.

As an ending note, the examinations on the joint KMITL-UCD workshops and field trips reiterate that a solution to address the deficiencies of the PBL and haptic way of learning in architectural education rests on a careful supervision in cooperation with close interactions between instructors and students in a manner that promotes: 1) hand-on and mind-on activities outside classroom; 2) chances for the students to pursue their interests and/or passions by relying on their own learning process and technique; and 3) exercises and lessons that advocate the students' skills and abilities required for their adults lives and future careers in the design and construction industries or related professional fields.

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