Evaluation of Isometric Shade and Shadow Projection Methods used in the Technical Drawings of Traditional Thai Architecture Pedestal Moulding: The Interior Architecture Students Case Study

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Received: 31/05/2021
Revised: 23/10/2021
Accepted: 10/11/2021

บทคัดย่อ

การวิจัยเกิดจากการบูรณาการเรียนการสอนในวิชาหลักการเขียนแบบเบื้องต้นกับวิชาสถาปัตยกรรมภายในไทย โดยมีวัตถุประสงค์การวิจัยเพื่อศึกษาประสิทธิผลของวิธีการเขียนแบบไอโซเมตริกในการหาตำแหน่งร่มเงาของฐานลวดบัว สถาปัตยกรรมไทยและความพึงพอใจของนักศึกษาในวิธีการนี้ ซึ่งฐานลวดบัวมีระนาบโค้งเป็นองค์ประกอบ มีคำถามการวิจัย คือ 1) มีฐานลวดบัวแบบใดบ้างในงานสถาปัตยกรรมไทย 2) การเขียนแบบร่มเงาฐานลวดบัวในแบบไอโซเมตริกแบบใดยากที่สุด และ 3) การเขียนแบบร่มเงาฐานลวดบัวนั้นนักศึกษาพอใจใช้สัดส่วนกล่องแสงใดและวิธีใด ทั้งนี้วิธีการวิจัยเป็นวิจัยเชิงทดลอง ได้ศึกษาฐานลวดบัวพระอุโบสถจากวัดในภาคกลาง 12 แห่ง และทดลองให้นักศึกษาภาควิชาสถาปัตยกรรมภายในจำนวน 112 คน ทดลองเขียนแบบแล้วตอบแบบสอบถามเพื่อประเมินความพึงพอใจ

ผลการวิจัยคือ 1) ฐานลวดบัวแบ่งได้สามกลุ่ม คือ ฐานหน้ากระดาน, ฐานปัทม์ และฐานสิงห์ และ แบ่งองค์ประกอบที่ทำให้เกิดเงาได้สามกลุ่ม คือ ฐานยกเก็จ, พนักพลสิงห์, และ เสานางเรียง 2) ฐานลวดบัวที่เขียนแบบยากสุดคือ ฐานสิงห์, ฐานปัทม์, และ ฐานหน้ากระดานบัวหงายบัวคว่ำ ตามลำดับ และนักศึกษาแสดงความเห็นต่อองค์ประกอบที่ทำให้เกิดเงาบนฐานลวดบัวที่ยากสุดในการเขียนแบบคือ ฐานยกเก็จ, พนักพลสิงห์, และเสานางเรียง ตามลำดับ และ 3) นักศึกษาแสดงความพึงพอใจกล่องแสงที่สัดส่วน 1:1.5 และใช้วิธีที่ 3 คือใช้เส้นแสงหลักร่วมกับเส้นแสงด้านข้าง ในการเขียนแบบ ทั้งนี้ผลวิจัยนี้สามารถใช้ปรับปรุงกระบวนการเรียนรู้ในการเขียนแบบไอโซเมตริกเพื่อหาตำแหน่งร่มเงาของฐานลวดบัวจากแบบที่ง่ายไปยากตามลำดับและช่วยนักศึกษาเข้าใจองค์ประกอบฐานอาคารของงานสถาปัตยกรรมไทยดีขึ้น

คำสำคัญ: ฐานลวดบัว ร่มและเงา กล่องแสง เขียนแบบไอโซเมตริก สถาปัตยกรรมไทย

Abstract

This study is a part of the fundamental drawing lessons within the Thai Interior Architecture class for the Interior Architecture students. The main objectives of this investigation focus on categorizing the types of pedestal or moulding base used in the central Thai *ubosot* (Buddhist Temple's ordination hall) architecture, and to determine the effectiveness of two shade and shadow projection techniques in isometric drawing of the traditional these traditional Thai architecture moulding pedestal. In this light, the research questions entail: 1) how many styles of moulding base are in the traditional Thai architecture? 2) which type of moulding base is the most difficult to render shade and shadow in isometric drawing? and 3) which combination of light ray boxes ratio and proportions methods the students deem proficient for the creation of isometric shade and shadow projection? Collections of mouldings base from 12 *ubosot* central Thai Buddhist temples were used as material for 112 students from the department of interior architecture to experiment with isometric shadow projection lesson. Then, the students were asked to rate the level of

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effectiveness toward such techniques. The results indicate that 1) the central Thai *ubosot* pedestals can be divided into three groups including pedestals with cyma recta and cyma reverse, *lotus* pedestal, and *lions'* pedestal while the elements that cast shadows over the moulding are the pillar or colonnade, the stucco handrailing (*panuk phonla singha*), and the recess base (*yok ket*); 2) the most challenging moulding base for technical drawing are *lions'* pedestal, *lotus* pedestal, and pedestals with cyma recta and cyma reverse in that respective order; the students expressed biggest contributors to difficulties in shading and shadowing to be recess base, followed by stucco railing and lastly the pillar; 3) the students prefer the combination of the 1:1.5 light ray box ratio and the intersection light sources along with vanishing point projection to render shade and shadow of the moulding pedestals. These results can be used to improve the learning process of projecting shade and shadows in isometric drawing lessons and help the students to gain insights into varieties of the traditional Thai architecture elements.

Keywords: Moulding Pedestal, Shade and Shadow, Light Ray Box, Isometric Drawing, Thai Architecture

1. Introduction

Fundamental Principles of Drawing of Drawing class are requisite for The Bachelor of Architecture program. The class begins by introducing the students with the technical isometric shade and shadow rendering on basic geometric shapes, and gradually move to the increasingly complex shape and form such as those of the Thai architecture and its decorative patterns.

The traditional Thai architecture is known for its intricate architectural elements and can be challenging for the novice to decipher in a technical drawing exercise. However, only through these exercise, the students understanding of three-dimensional objects and its properties when interacting with light, which is one of the most important environmental factor impacting architecture, will be greatly enhanced.

Thus far, it has neither been a record of a formal study on the isometric shade and shadow on the traditional Thai architecture elements. Only examples from Basic Drawing Principles by Chulseni (1994) and architectural drawing by Rattanatasatia (2007) indicate the 1:1 light ray box ratio (30° in the isometric drawing) as recommended guideline. Due to the complexity of Thai architecture's isometric drawing, the aforementioned approach would be a daunting task and discouraging for a beginner.

Kuisorn and Bunyarittikit (2015) devises another alternative using the 1:1.5 light ray box ratio for rendering isometric shade and shadow of basic geometric shapes, which proves to shorten the drawing process. Kuisorn (2017) experimented with the 1:1.5 light ray box ratio on the isometric shade and shadow projection on stairs with handrails. The method is also found to be quite effective on the Thai architecture with intricate decorative elements.

Through the preliminary field survey of the *ubosot,* the researcher find that moulding pedestals are commonly used both within an interior and exterior of the building structure. Thus, it would be fruitful to compare and contrast the effectiveness of both the 1:1 and the 1:1.5 light ray box ratio techniques on these complex architectural elements. Especially, when assigned as class exercise, the students' feedback, and rating on the proficiency of the techniques may be used to inform the instructor of appropriate drawing methods as well as learning sequence for the isometric drawing lessons. This will help overcome the students' frustration of being exposed to unintended steep learning curve while familiarizing them with the traditional Thai architecture elements through the technical drawing lesson.

2. Purpose

The purpose of this paper is to the evaluate the effectiveness of two isometric shade and shadow projection techniques while determining the degree of students' perceived proficiency of such methods when applying to Thai architecture in isometric drawing isometric drawing exercises.

3. Concepts and Theories

3.1 Shade and Shadow

Shadows are the produced by the combination of three elements: 1) light, refers to the brightness, something that stimulates the sight and makes things visible (Office of the Royal Society, 2003), source, and direction of light, 2) exposure object or solid object blocking the path of light, and 3) shadow receiving plane or shadow receiving ground. The distance between the object and the shadow receiving plane needs to be taken into consideration along with the opacity of objects, as it will affect the shape of shadows. When light paths collide with the object it creates the surface area on the object where light does not reach, shade or high shade, and creates projection onto the receiving plane due to light path being blocked which appears in the shape of an object that obscures the path. This experiment will demonstrate the understanding of how the shade and shadow of the solid or opaque objects, that do not allow light to pass through, cast on the receiving plane in an isometric drawing. In this case, the exposed objects are the architectural elements of the *ubosot* such as pillar or *yok ket* and the like, while the projection plane will be the moulding pedestals of the *ubosot* and possibly might be on the base of the exposed object itself.

3.2 Isometric Projection

Isometric projection is a method for visually representing three-dimensional object in two-dimensions in technical and architectural drawings. Isometric projections, sometimes called isometric drawings, are a method of showing how measurements and components fit together. The word isometric derived from Isos meaning equal is a way to draw using three-axis that meet at one point and make 120° angles with each other. Therefore, isometric drawing must adjust the other angles onto a 30° angle with all three axes having equal proportion, for example, 1 unit in x, y, and z-axis equivalent to 1 meter.

3.3 Shade and Shadow Projection Method in Isometric Drawing

The first step for isometric shade and shadow projection is to identify the light source, which usually is the sun. Then, the angle of the light ray is adjusted to be 45° angle from the plan and elevation to simplify the drawing of the shadow orthographically. This will result in the main light source with the angle of 30° within the isometric drawing (1:1 light ray box ratio) hence easier shadow projection on the receiving plane (Chulasanic, 1994; Ratanatassanee, 2007). The study by Kuisorn and Bunyarittikit (2015) suggests way in which the 1:1.5 light ray box ratio may be used as alternative for isometric shade and shadow projection of basic geometric shapes, and later successfully apply on a more complex form such as stairs with curved handrails (Kuisorn, 2017). Thus, further proves the effectiveness of the 1:1.5 light ray box ratio method.

3.4 Moulding Pedestal in Thai Architecture

Thai architectural structure can be divided into 3 parts: base, body, and the peak or the roof. The base refers to the location or place for support (Royal Institute Dictionary, 2011), in architecture, there are two ways to categorize the base by the shape and function. Sinnugool (2014) classified shape of the bases pedestals as pedestal with cyma recta and cyma reverse, *lotus* pedestal, *lotus* petal base, *lotus* pedestal with *lotus* sheaths, and trim pedestal. On the other hand, the classification of through functions can be described as pithy base, *pratuksin* pedestal, *vanfa* pedestal, and *chukchi* base. The preliminary study of this research, implement the pattern classification system which entails pedestal with cyma recta

and cyma reverse, *lotus* pedestal, and *lions'* pedestal. The increasing complexity of moulding base categorization may also be added by increasing layers of moulding pedestals, patterns, height and so forth.

Thai bases of the traditional Thai architecture are divided into four types namely 1) plinth, the lowest level without moulding pedestal, 2) pedestals with cyma recta and cyma reverse with top board, ridge, panel, ridge, and bottom board, 3) *lotus* pedestal with the front part, top panel, ridge, supine *lotus*, ridge, panel, pointed torus, ridge, upright *lotus,* ridge, and bottom plane, and 4) *lions'* pedestal with the top board, ridge, supine *lotus*, ridge, plane, pointed torus, ridge, plane, ridge, and bottom board (Jirathutsanakul, 2016). This highly complex base was very popular during the late Ayutthaya period and early Rattanakosin period (Phrombhichitr, 1952; Sathapitanonda and Mertens, 2012).

3.5 Satisfaction

Khetpiyarat and Vikromprasit (2010) explained that satisfaction is an abstract concept. Satisfaction can be observed through the elaborated actions, making it hard to directly measure the level of satisfaction. The students' attitude towards a subject may differ due to their experience and level of interest in the subject of study. According to Abrah H. Maslow's hierarchy, students are often satisfied, if the instructors teaching style and lesson structure meets their expectation and freedom of expression.

4. Research Method

To define the scope of the study, this investigation commences with field survey to collect appropriate moulding pedestal and architectural component that commonly cast shadow on the moulding pedestals of the *ubosot*. Then the example components are used as inputs to create model on the computer to study the light projection outputs, and to generate variety of models that are realistic and not overly complicated for isometric drawing. The realistic model is better for the comprehension for the students' exercises. The moderate difficulty model is suitable for completion within class time while not causing frustration for the novice. Finally, 112 students, in Fundamental Principles of Drawing class, are assigned to create isometric drawings with shade and shadow projection using 1:1 and 1:1.5 of light ray box ratio approaches. The data collected included the students' isometric drawing as well as their rating on the perceived proficiency and opinion toward the methods. (Figure 1)

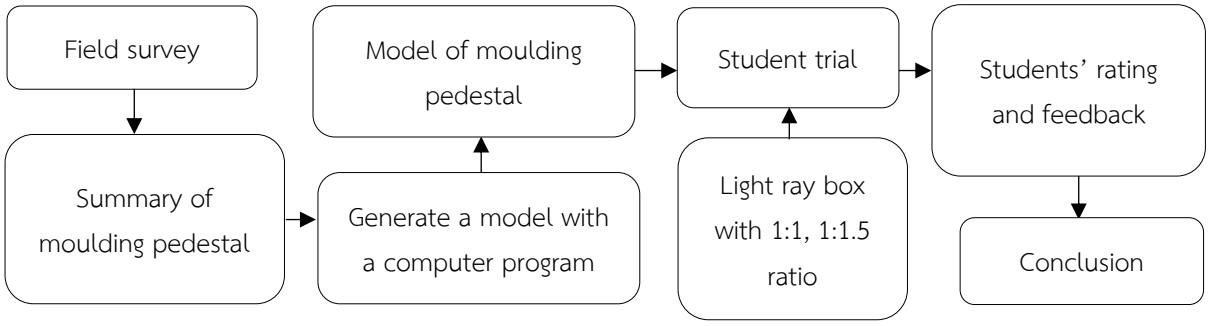
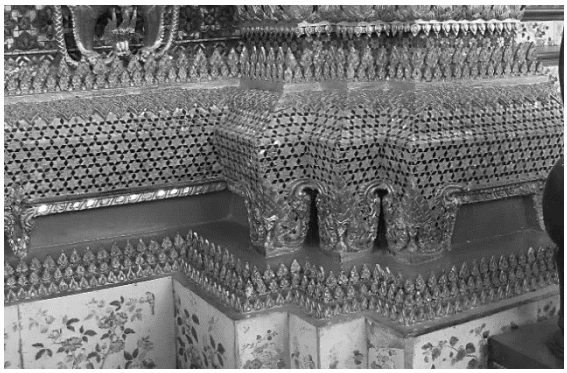


Figure 1 A Diagram of experimenting steps of the study.

4.1 Study of Thai Architectural Moulding Pedestal

Thai Architectural moulding pedestal of the *ubosot* used in this investigation are: *lotus* pedestal, *lotus* pedestal with a torus, and *lions'* pedestal and architectural elements of the *ubosot* that typically casts shadow on pedestal moulding include: pillar or colonnade, stucco handrailing (*panuk phonla singha*), and indented moulding pedestal (*yok ket*).

Field survey of Traditional Thai architecture and interior architecture elements are drawn from 12 central Thai Buddhist temples' *ubosot.* These include 4 temples from Bangkok Metropolitan area: the *Temple of the Emerald Buddha*, *Chetuphon Wimonmangkalaram*, *Ratchabophit Sathit Mahasimaram Ratchaworawihan, Suthat Thepwararam Ratchaworamahawihan* (Figure 2); 1 temple from Nakhon Pathom province: *Phra Pathom Chedi Ratchaworamahawihan*; 3 temples from Phra Nakhon Si Ayutthaya province: *Phra Meru Rachikaram Worawihan, Sala Poon Worawihan, Kasattrathirat Worawihan* (Figure 3 and 4); and 4 temples from Phetchaburi province: *Yai Suwannaram Worawihan, Sa Bua, Khao Bandai It*, and *Koh Kaew Suttharam* (Figure 5).



Temple of the Emerald Buddha

Chetuphon Wimonmangkalaram Temple

Ratchabophit Sathit Mahasimaram Ratchaworawihan Temple

Suthat Thepwararam Ratchaworamahawihan Temple

Figure 2 The bases of *ubosot* case studies from Bangkok.

Phra Pathom Chedi Ratchaworamahawihan Temple, Nakhon Pathom province

Phra Meru Rachikaram Worawihan Temple *(Na Phra Men)*, Phra Nakhon Si Ayutthaya province

Figure 3 The bases of *ubosot* case studies from Nakhon Pathom and Phra Nakhon Si Ayutthaya provinces.

Sala Poon Worawihan Temple

Kasattrathirat Worawihan Temple

Figure 4 The bases of *ubosot* case studies from Phra Nakhon Si Ayutthaya province.

Yai Suwannaram Worawihan Temple

Sa Bua Temple

Khao Bandai It Temple

Koh Kaew Suttharam Temple

Figure 5 The bases of *ubosot* case studies from Phetchaburi province.

4.2 Moulding Pedestal Model

According to the data collected from Thai Interior Architecture course's field trips, the moulding pedestal model of the *ubosot* may be explicated as 1) two types *lions'* bases; *lions'* base, and pointed torus *lions'* base, found at the *Temple of the Emerald Buddha* (A), *Chetuphon Wimonmangkalaram* (B), *Suthat Thepwararam Ratchaworamahawihan, Ratchabophit Sathit Mahasimaram Ratchaworawihan* (C), *Phra Pathom Chedi Ratchaworamahawihan* (D), Archway of *Sa Bua* (E), Archway of *Koh Kaew Suttharam* (F), and 'special' *lions'* base at *Chetuphon Wimonmangkalaram* (Figure 6),

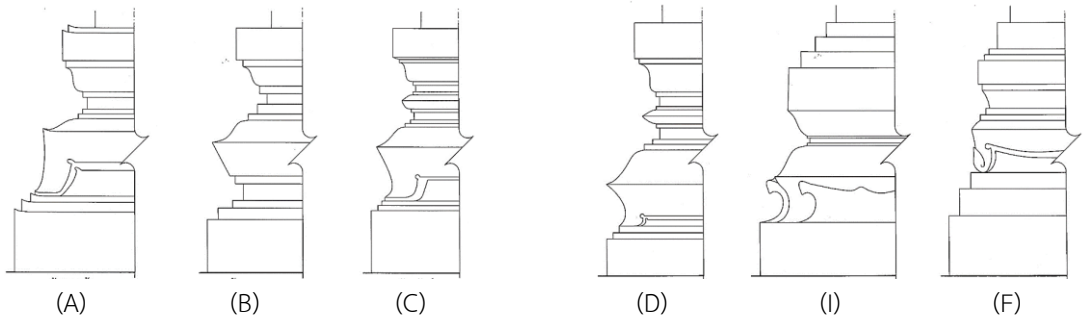


Figure 6 Side view of *lions'* pedestals.

2) the *lotus* pedestal of the *ubosot* may be grouped into three types; cyma recta and cyma reverse front window, *lotus* pedestal and pointed torus moulding base found in *Phra Meru Rachikaram Worawihan* (G), *Kasattrathirat Worawihan* (H), *Yai Suwannaram Worawihan* (I), *Koh Kaew Suttharam* (J), *Sala Poon* (K), *Sa Bua* (L), and *Khao Bandai It* (M) (Figure 7).

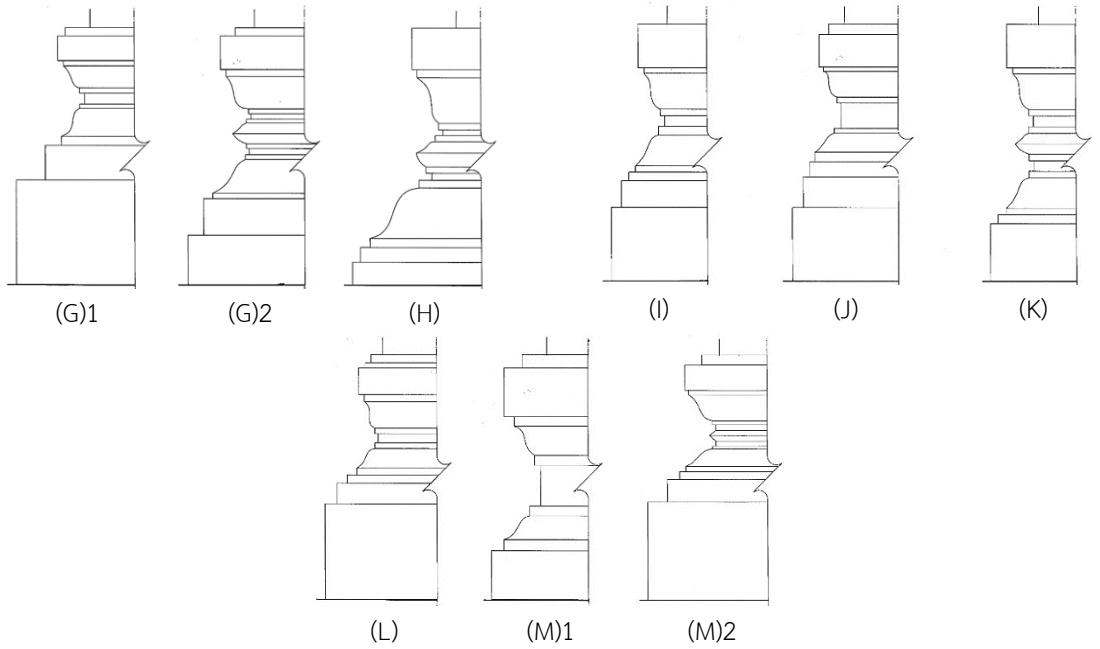


Figure 7 Side views of *lotus* pedestals.

The moulding pedestal in isometric as follow (Figure 8):

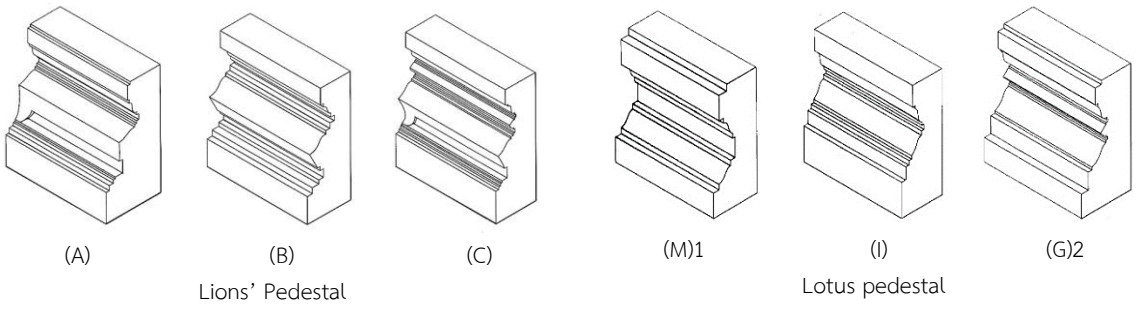


Figure 8 Isometric drawing of moulding pedestals.

Three characteristics of architectural element that casts shadow on pedestal moulding of the *ubosot* base are:

1) Pillar or colonnade: the temples with pillar consist of *Temple of the Emerald Buddha*, *Chetuphon Wimonmangkalaram*, and *Suthat Thepwararam Ratchaworamahawihan*. Temples with balcony posts include *Phra Meru Rachikaram Worawihan*, and *Yai Suwannaram.*

2) Stucco handrailing (*panuk phonla singha*): this element can be seen in the majority of *ubosot* with staircase. These include the *Temple of the Emerald Buddha, Chetuphon Wimonmangkalaram*, *Ratchabophit Sathit Mahasimaram Ratchaworawihan, Suthat Thepwararam Ratchaworamahawihan, Phra Pathom Chedi Ratchaworamahawihan, Phra Meru Rachikaram Worawihan, Sala Poon Worawihan, Kasattrathirat, Yai Suwannaram Worawihan,* and *Sa Bua.*

3) Base with indented corners (*yok ket*): these elements can be divided into indented corners from moulding pedestal of archway and stem from moulding pedestal itself. Those with indented corners from pedestal moulding of archway are found in the *Temple of the Emerald Buddha, Ratchabophit Sathit Mahasimaram, Suthat Thepwararam Ratchaworamahawihan, Sa Bua, Khao Bandai It*, and *Koh Kaew Suttharam.* The ones with *yok ket*, the element that stem from moulding pedestal are the *Temple of the Emerald Buddha, Suthat Thepwararam Ratchaworamahawihan, Phra Pathom Chedi Ratchaworamahawihan, Phra Meru Rachikaram Worawihan,* and *Sala Poon Worawihan.* The isometric drawing of objects that casts shadow on moulding pedestal of *ubosot* can be done by simplifying the details of the moulding elements to make the drawing process easier (Figure 9).

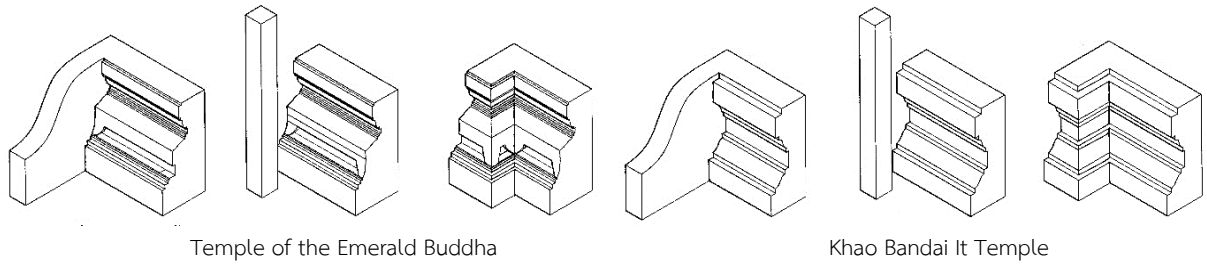


Figure 9 Architectural elements that cast shadow on *ubosot* base.

4.3 Students Experiment with Shade and Shadow Projection Method in Isometric Drawing

To help elucidate the process of isometric shade and shadow projection, the *ubosot* base of *Chetuphon Wimonmangkalaram*, which composed of the *lions'* pedestal and boarder pillar are used as an input for creating example prototype. Then the 1:1.5 light ray box ratio is used in the projection of shade and shadow onto the corners of the plane, and the on curved structure until the outline of the shadow appears and then the shading is rendered. It is found that the use of computer model to assist teaching is very effective as it enables more accurate understanding of the concept of isometric drawing while allowing the observer to view the architectural element from all directions (Figure 10 and 11).

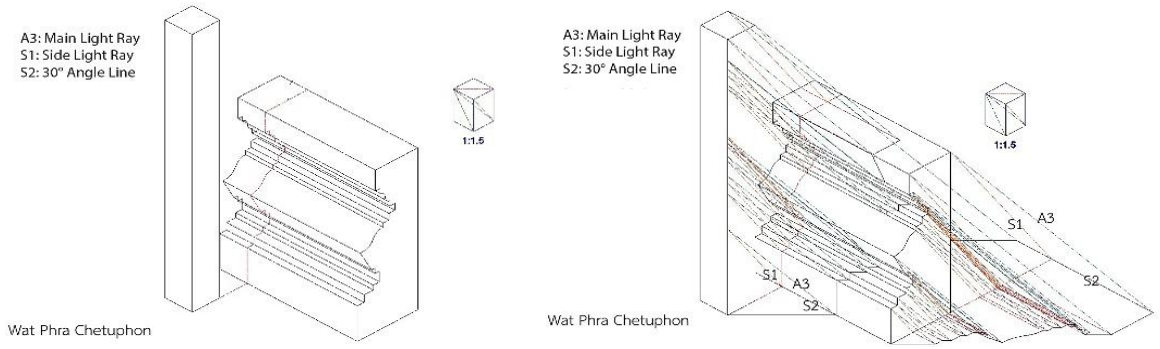


Figure 10 The isometric drawing for shade and shadow of moulding pedestal.

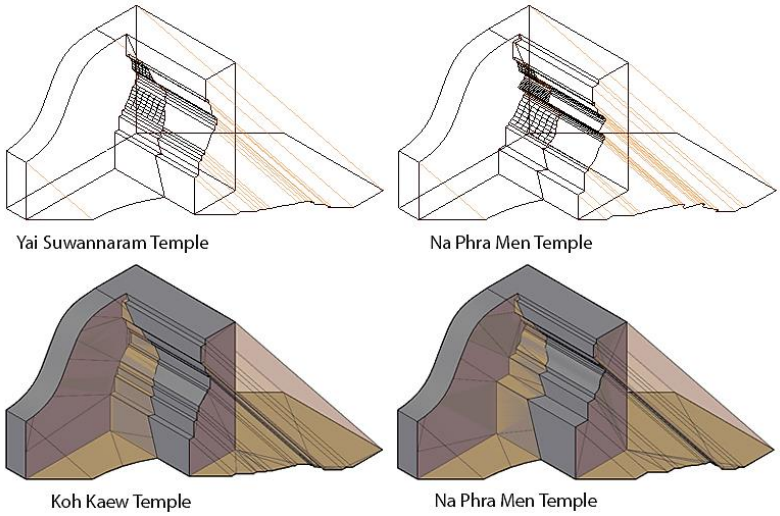


Figure 11 The shade and shadow from *panuk phonla singha* on moulding pedestal with modeling program.

The 112 students perform technical drawings and then are asked to rate level of perceived proficiency of the isometric shade and shadow projection method as well as feedback toward the learning experience and applicability of such methods. (Figure 12)

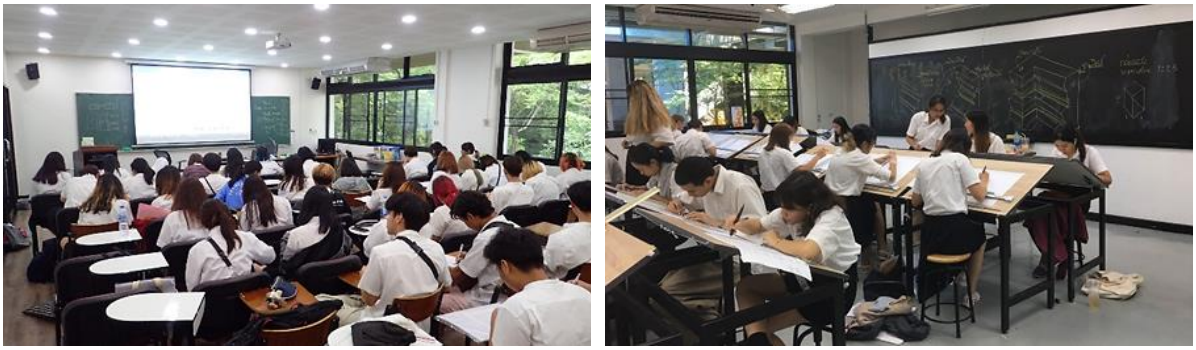


Figure 12 The lecture and students experimenting with shade and shadow projection methods.

5. Research Result

Three computer models for studying of isometric shade and shadow projection has been created as a tool to study its effect on Thai architectural elements by Kuisorn and Bunyarittikit (2015). These models comprise of variation of lighting alternatives: 1) main and above light ray, 2) main and front light ray, and 3) main and side light ray. It is found that the main and side light ray alternative is the most effective method for shade and shadow projection (Figure 13).

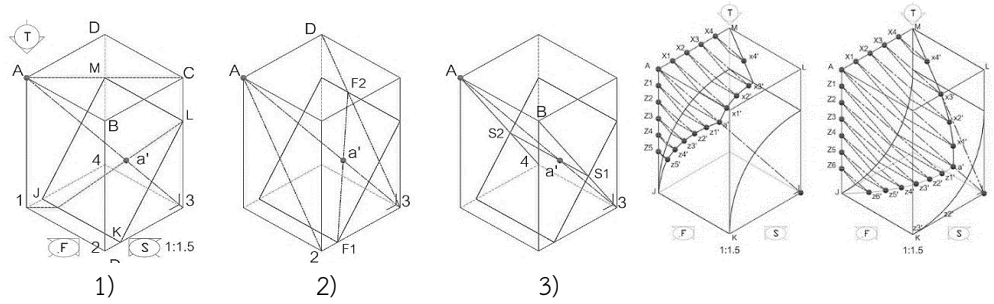


Figure 13 Isometric models with the 1:1.5 light ray box ratio for shade and shadow projection study.

5.1 Case Study: Shade and Shadow Projection on Thai Architecture Moulding Pedestal

The 1:1.5 light ray box ratio for the isometric projection of the architecture element shade and shadow on the moulding pedestal can be demonstrated through the depiction of how the pillar cast shadow on the cyma recta and cyma reverse pedestal, *lotus* pedestal and *lions'* pedestal from the examples drawn from 6 temples (Figure 14).

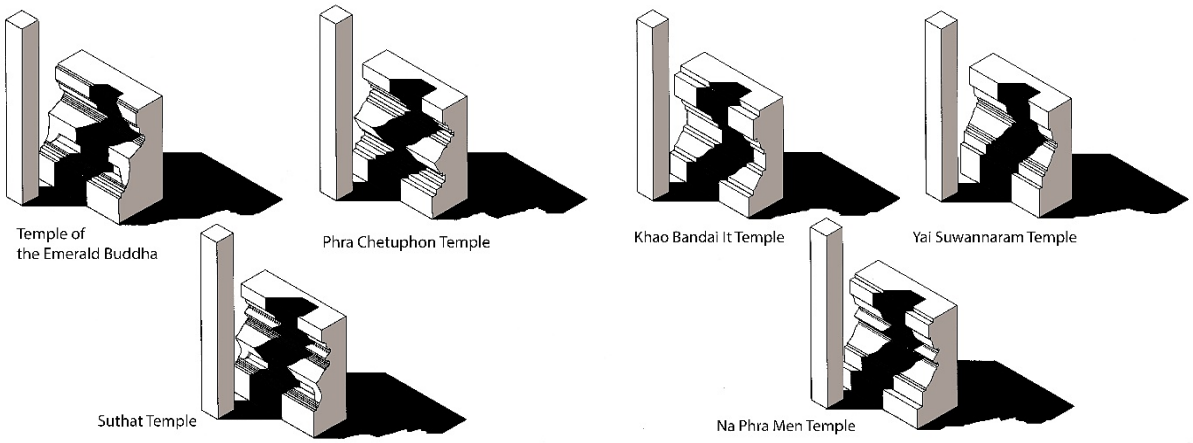


Figure 14 Isometric drawing of pillar shade and shadow casting on the *lions'* pedestals and *lotus* pedestals.

The 1:1.5 light ray box ratio for the isometric projection of architecture element shade and shadow onto the moulding pedestal can be demonstrated through the casting of *panuk phonla singha* on the cyma recta and cyma reverse pedestal, *lotus* pedestal and *lions'* pedestal (Figure 15).

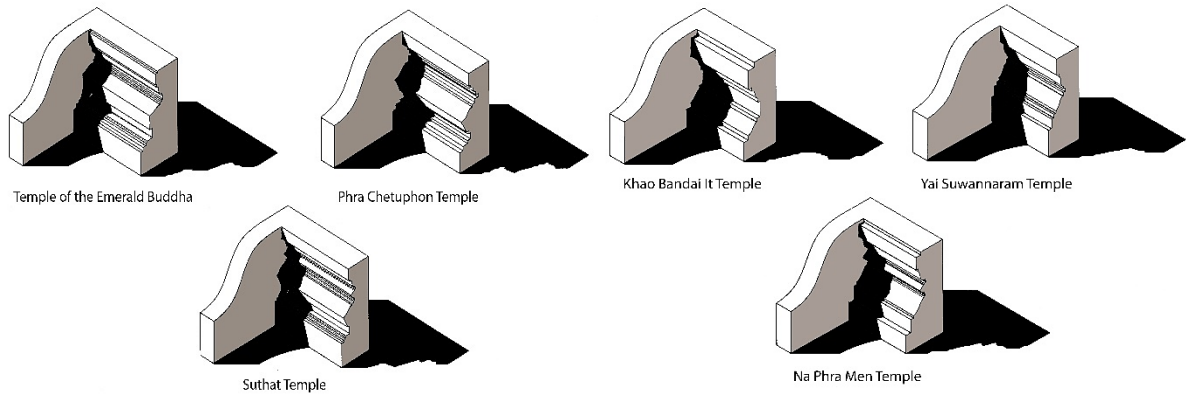


Figure 15 Isometric drawing of *panuk phonla singha* shade and shadow on *lions'* pedestals and *lotus* pedestals.

The use of the 1:1.5 ratio of light ray box, shade, and shadow of moulding pedestal in Thai architecture can be drawn isometrically from case study: *yok ket* on the cyma recta and cyma reverse pedestal, *lotus* pedestal and *lions'* pedestal (Figure 16).

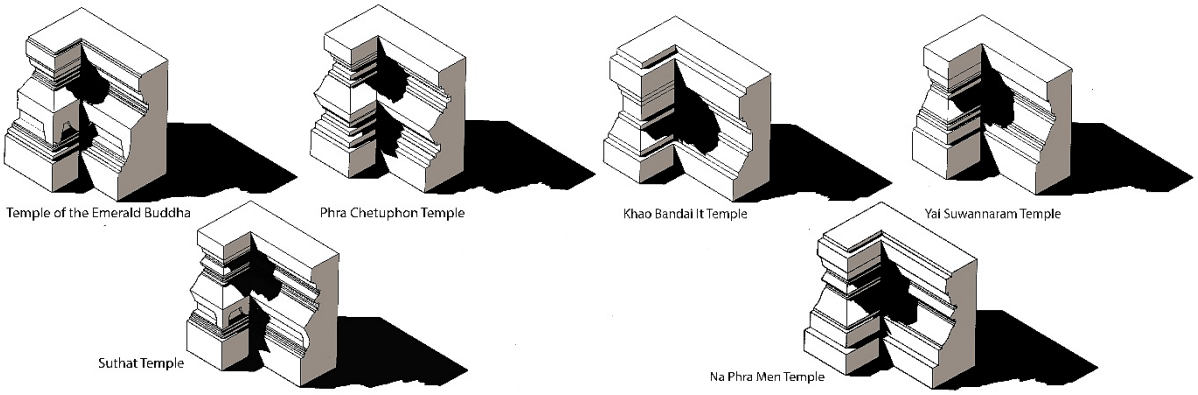


Figure 16 Isometric drawings of *yok ket* shade and shadow casting on *lions'* pedestals and *lotus* pedestals.

5.2 Research Results of Students' Opinion and Satisfaction

5.2.1 The score of the perceived proficiency, of the 1:1 and 1:1.5 light ray box ratio for the isometric drawing of Thai architecture elements shade and shadow projection on the moulding pedestal can be interpreted from the difficulty rating scale, which range from of 1 to 5: where 1 (1.00-1.49) = very easy, 2 (1.50-2.49) = easy, 3 (2.50-3.49) = fair, 4 (3.50-4.49) = difficult, and 5 (4.50-5.00) = very difficult.

The participants include 112 Interior Architecture students are asked to rate the perceived effectiveness of the 1:1 light ray box ratio for isometric shade and shadow projection, on average, students' rate the technique as very difficult (M=4.70, SD=.5, N=112). 79 students (71%) rate very difficult, 33 students (29%) rate difficult, while none of the participant finds the technique as medium (0%), easy (0%), or very easy (0%) to apply (Figure 17).

On average, the students rate the 1:1.5 light ray box ratio for the isometric drawing of Thai architecture element shade and shadow casting on moulding pedestal as "difficult" (M=3.59, SD=.7, N=112). 4 students (3%) rate very difficult, 68 students (61%) rate difficult, and 31 students (28%) rate medium, 9 students (8%) rate easy, and no one finds the method very easy (0%).

Although the average numbers of students' rate both the 1:1 and the 1:1.5 light ray box ratio as very difficult and difficult, but the mean of the 1:1 light ray box ratio (M=4.79) is slightly higher than the 1:1.5 light ray box ratio method (M=3.59). This probably because the 1:1 light ray box ratio is only applicable with a 30-degree main light ray, and difficult to apply to a curved component. However, the 1:1.5 light ray box ratio is more flexible and lend itself to 3 variation of lighting alternatives (Figure 13). Thus, the author proposed that students try using the third lighting variation (main and side light ray) on the model with curvature component.

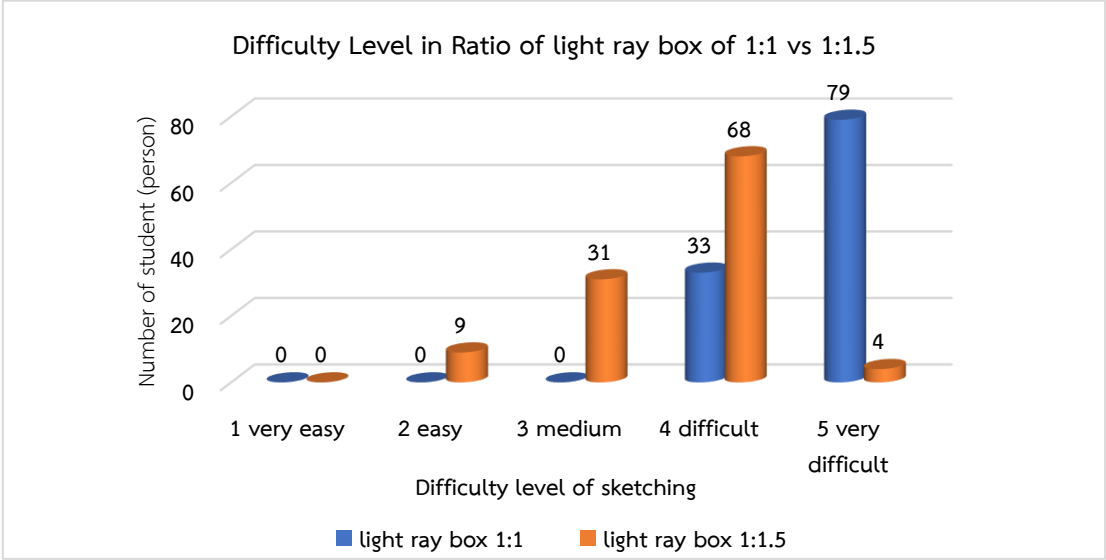


Figure 17 Comparison of difficulty rating of the 1:1 versus 1:1.5 light ray box ratio methods.

5.2.2 Comparison of the method effectiveness categorized by the pedestal moulding type (Table 1 & Figure 18). The cyma recta and cyma reverse pedestal is rated by the students as fair or at the medium level of difficulty (1), *lotus* pedestal is rated as difficult (2), and *lions'* pedestal is rated very difficult (3). The difficulty rating of isometric shade and shadow projection on pedestal moulding are summarized in the followings. (Table 1 & Figure 18).

Table 1 Comparison of difficulty level of shadow projection categorized by the pedestal moulding types.

Difficulty Level of Sketching	Level 1 medium (students)		Level 2 difficult (students)		Level 3 very difficult (students)	
Cyma Recta and Cyma Reverse Pedestal	109	97%	3	3%	0	0%
Lotus pedestal	29	26%	80	71%	3	3%
Lions' Pedestal	0	0%	29	26%	83	74%

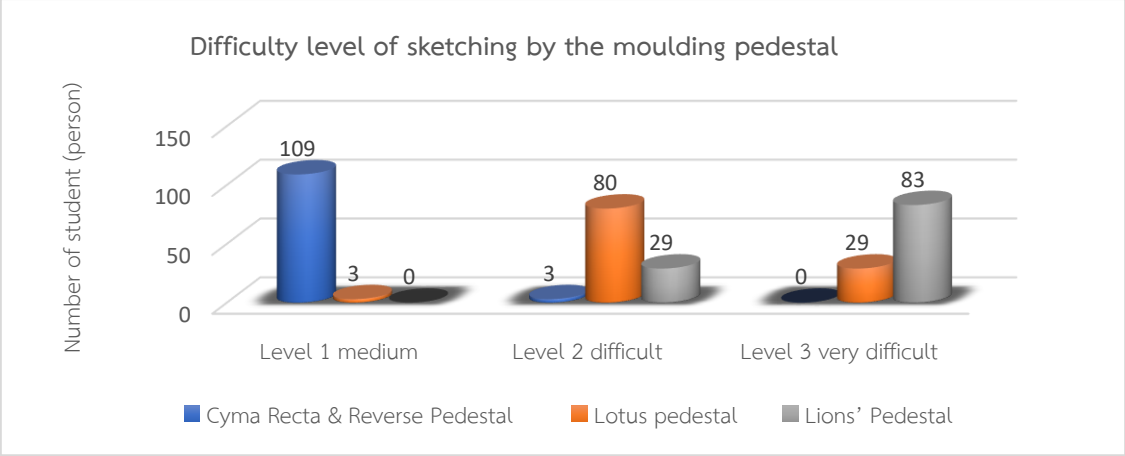


Figure 18 Comparison of difficulty level of shadow projection categorized by pedestal moulding types.

5.2.3 Comparison of difficulty level categorized by the exposed object (architectural elements that cast shadow on the moulding pedestal). (Table 2 & Figure 19). *Panuk phonla singha* is rated by the students as medium difficult (1), pillar/colonnade is rated as difficult (2), and lastly *yok ket* is rated as the very difficult (3) for shade and shadow projection.

Table 2 Comparison of difficulty level of shadow projection categorized by the elements that casts shadow.

Difficulty Level of Sketching	Level 1 medium (students)		Level 2 difficult (students)		Level 3 very difficult (students)	
Pillar/Colonnade	46	41%	65	58%	1	1%
Panuk Phonla Singha	66	59%	46	41%	0	0%
Yok Ket	0	0%	1	1%	111	99%

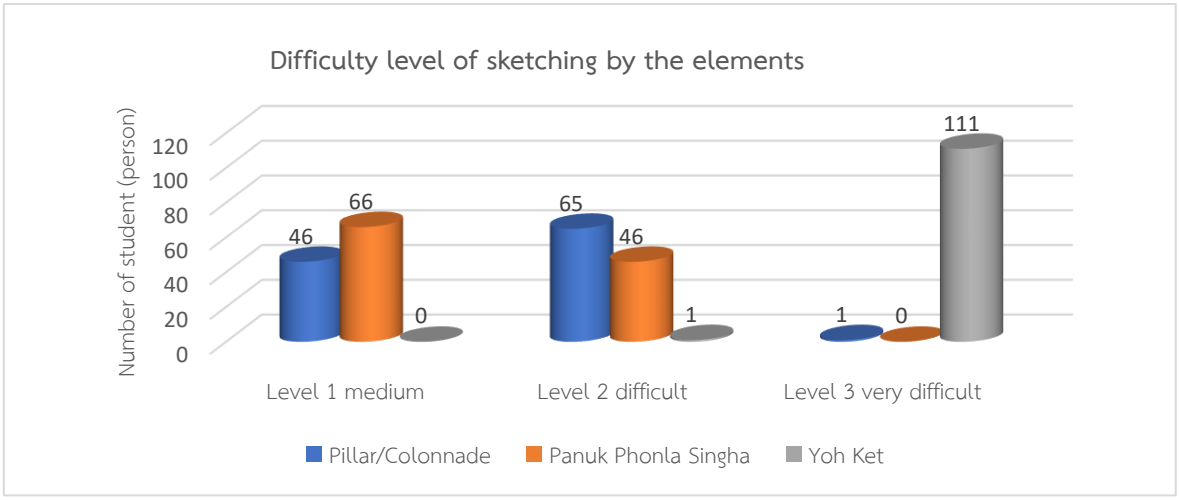


Figure 19 Comparison of difficulty level of drawing categorized by the elements that casts shadow.

The result of this research study can be used for the Fundamental Architectural Drawing instructor to arrange and structure the lessons and sequence of isometric drawing class from the easiest to the most difficult ones.

6. Discussion, Conclusion and Recommendation

This quantitative research study explores students' perceived effectiveness of two isometric shade and shadow projection on Thai architectural elements obtained from field survey. The investigation compiles 12 *ubosot* base or pedestal moulding from temples in the central Thai region and classified according to Sathapitanonda & Mertens (2012), and Sinnugool (2014) taxonomy system. Finally, the isometric drawing experiment of these traditional Thai architectural elements are used as models for the students to create isometric shade and shadow shade and shadow projection by using the methods devised by Kuisorn and Bunyarittikit (2015), Ratanatassanee (2007) and Chulasanic (1994).

This research has no precedent since none of previous literature is found on such topic. It merits both the fundamental architectural drawing as well as the traditional Thai architecture studies. For the fundamental architectural drawing, this research results can be used to improve the learning process and the organization of the content introduced to the students. As for the Thai architecture, the data from pedestals mouldings categorization will contribute enrich the understanding of the implementation of architectural elements of the central Thai *ubosot.*

6.1 Accuracy of shade and shadow in isometric drawing

The majority of the students (108 students: 96%) perceives that the 1:1.5 light ray box ratio are effective for the isometric shade and shadow projection, onto various Thai moulding pedestals design, when using the intersection of light source and vanishing point projection. The students indicate that, when compared to another method, the 1:1.5 light ray box ratio is the easiest and most expedient method especially when dealing with object's curved edge on a curved plane. It is also observed that the students are able to use this method to create an accurate shade and shadow projection even without prior instruction or experience.

6.2 Research on Isometric shade and shadow projection on pedestal moulding

The traditional Thai architecture elements that cast shadow on the moulding pedestal are *panuk phonla singha*, pillar/colonnade, and *yok ket* where the moulding pedestrals consist of cyma recta and cyma reverse, *lotus* pedestal, and *lions'* pedestal.

Varying degree of difficulties in the shade and shadow projection occur when both elements combine. The combination of architectural elements and mouldings base ranging from the least to the most complicate drawings may be presented as 1) pillar on cyma recta and cyma reverse pedestals, 2) pillar on *lotus* pedestal, 3) pillar on *lions'* pedestal, 4) *panuk phonla singha* on cyma recta and cyma reverse pedestal, 5) *panuk phonla singha* beside *lotus* pedestal, 6) *panuk phonla singha* beside *lions'* pedestal, 7) *yok ket* of the cyma recta and cyma reverse, 8) *yok ket* of *lotus* pedestal on indented base and 9) *yok ket* of *lions'* pedestal.

The students indicate the level of perceived difficulty in creating isometric shade and shadow projection of the moulding base from the least difficult to most difficult in respective order as *lions'* pedestal, *lotus* pedestal and cyma recta and cyma reverse pedestal respectively. The students also feel that it is difficult to project the shadow of *yok ket,* pillar and *panuk phonla singha* on the moulding pedestals respectively (Table 3).

Table 3 Comparison of difficulty level of shade and shadow projection based on the combination of architectural elements and types of pedestals mouldings

Difficulty Level of Sketching	Level 1 medium	Level 2 difficult	Level 3 very difficult
1) Moulding pedestal	Cyma Recta and Cyma Reverse Pedestal	*Lotus* pedestal	*Lions'* Pedestal
2) Elements that casts shadow	*Panuk Phonla Singha*	Pillar/Colonnade	*Yok Ket*

The students' feedback on the difficulty levels of the isometric shade and shadow projection on moulding pedestals are similar to the instructor's speculation, while the feedback on the difficulty toward the architecture elements caused shadow on moulding pedestals were different. Interestingly, the pillar is perceived as the easiest element, to draw a shadow projection on the moulding base, for the instructor, while the *panuk phonla singha* is for the students.

6.3 Recommendation

The structure of isometric shade and shadow projection of traditional Thai architecture elements on moulding pedestal lesson should begin with the easiest one namely, pillar on cyma recta and cyma reverse. Then, as the lesson progress, and increasing degree of difficult exercise may be introduced. However, the isometric shade and shadow projection of the indented lion base should be saved for the very last lesson as it is most difficult one.

7. Acknowledgement

This research was supported by School of Architecture, Art, and Design, King Mongkut's Institute of Technology Ladkrabang (Grant Number 2562-0202006), the author would like to thank Chatchai Intrachod and Chumporn Moorapun for useful comments and thank our colleagues from Department of Interior Architecture who provided insight and expertise that greatly assisted the research.

References

Chulasanic, E. (1994). **Basic Architectural Drawing.** 2nd Edition, Bangkok: Faculty of Architecture KMITL.

Jirathutsanakul, S. (2016). **Technical Terms in Thai Architecture, Volume 2: Base Components.** Bangkok: E.T. Publishing.

Khetpiyarat, P. and Vikromprasit, S. (2010). **Study the Satisfaction of Students with the Business Administration Program in Service Business Management (4-year).** Uttaradit: Faculty of Management Sciences, Uttaradit Rajabhat University.

Kuisorn, W. (2017). A Study of the Shade and Shadow Projection Method of Stairs in Isometric Drawing. **Journal of the Faculty of Architecture KMITL.** 25(2), 124-138.

Kuisorn, W. and Bunyarittikit, S. (2015). A Study of the Shade and Shadow Projection Method in Isometric Drawing. **Journal of the Faculty of Architecture KMITL.** 21(2), 108-122.

Office of the Royal Society, (2003). **Royal Institute Dictionary (1999).** Bangkok: Nanmeebook Publication.

Office of the Royal Society, (2011). **Dictionary of Architecture.** Bangkok: Thana Press.

Phrombhichitr, P. (1952). **Buddhist Art Early Architecture.** Bangkok: Silpakorn University.

Ratanatassanee, C. (2007). **Architectural Drawing.** 9th Edition, Bangkok: Chulalongkorn University Press.

Sathapitanonda, N. and Mertens, B. (2012). **Architecture of Thailand: A Guide to Tradition and Contemporary Forms.** USA: Didier Millet.

Sinnugool, S. (2014). The Connection of Moulding Pedestal in Thai Architecture Case Study: Thai Architecture at Wat Phrasriratana Sasadaram, Bangkok. **Journal of the Faculty of Architecture KMITL.** 18(1), 49-64.