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QUANTIFICATION OF AESTHETIC COMPOSITION ON ARCHITECTURE

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ABSTRACT
Subjectivity in assessing the aesthetics of a composition in architecture and interior design industry and even education is commonplace today. A less objective assessment can blurry a person's ability of designing building's aesthetic. In fact, there were quantitative rules for judging the beauty of building appearance in Classical Architecture era. Therefore, the aim of this study is getting quantitative measurement for composition's aesthetics of building. To achieve that, qualitative research method is used with grounded theory approach. The result shows that aesthetic value can be calculated using a quantitative formula. Despite the formula founded by this study has several weaknesses, this formula was generated from and modestly tested using the questionnaires distributed to various categories of respondents, from public to those who involved in architecture and design education and industry, showing quite high suitability and reliability.

KEYWORDS: aesthetic measurement, architectural aesthetic, composition aesthetic

Subjektivitas dalam menilai estetika suatu komposisi dalam industri dan bahkan pendidikan arsitektur maupun desain interior telah dianggap sesuatu yang lazim saat ini. Penilaian yang kurang objektif dapat mengaburkan kemampuan seseorang dalam merancang estetika bangunan. Padahal pada era arsitektur klasik, terdapat aturan secara kuantitatif untuk dapat menyebut suatu tampilan bangunan itu indah. Oleh karena itu, studi ini bertujuan untuk menemukan cara mengukur estetika komposisi dalam bangunan secara kuantitatif. Untuk mencapainya, digunakan metode penelitian kualitatif dengan pendekatan grounded theory*. Hasil pembahasan menunjukkan bahwa nilai estetika dapat dihitung menggunakan rumus. Meskipun masih memiliki beberapa kelemahan, rumus ini digenerasi dari serta diuji secara sederhana menggunakan hasil penyebaran kuesioner kepada berbagai kategori responden, dari masyarakat umum hingga yang berkecimpung dalam industri serta pendidikan arsitektur dan desain, menunjukkan kesesuaian dan keandalan yang cukup tinggi.*

KATA KUNCI: *pengukuran estetika, estetika arsitektur, estetika komposisi*

INTRODUCTION

Aesthetics is a value that evokes pleasure through sight. Since ancient times, aesthetics has been an important criterion in evaluating architectural elements (Ramli et al., 2020). There are two different opinions of theorists in viewing aesthetics (Jin et al., 2022). The first is called objective aesthetics which states that aesthetics arise from its power in beautiful objects and is not influenced by personal emotional conditions because aesthetics exist regardless of the person who appreciates it. While subjective aesthetics is defined as something that is with the human self, it is conceived in the mind of the person who appreciates it. Therefore, subjectivity in disciplines involving aesthetics is something that seems common, even though there are other engineering sciences in it, such as interior design or architecture which include building engineering science.

Architecture has been known to rely on the subjectivity of its designer. In fact, when associated with the function of architecture as a container for human activities, then every design decision should be scientifically accountable (Larasati, 2023). For example, determining the interior color needs to be based on scientific evidence in order to provide more meaning and benefits to the lives of its users. This statement is also supported by Raharja (2020) who stated that since the Renaissance, architectural aesthetics have been calculated using mathematical logic. One example is the use of the 'Golden Ratio' on buildings which was used by the ancient Greeks because it was believed to produce eye comfort when seeing a form. It also has compatibility to the "Fibonacci Series" which was basically discovered by mathematicians who did not aim for aesthetics, which the ratio is called the "Golden Section". The compatibility is when larger numbers involved in this series, the ratio will be closing to the golden ratio, which is around 1.618 or called phi.

Accurate aesthetic measurement will be useful not only to evaluate the aesthetics of a product, but

also to determine the preferences so it can improve the design efficiency and effectiveness. In several previous studies on design preferences, some showed similar results when comparing two or more different groups of respondents, or even different results. A study on the aesthetic quality of architectural elements in colonial buildings showed similarities in the measurement results by the architectural and non-architectural communities (Ramli et al., 2020). The assessment was carried out using architectural element parameters. Measuring public perception of the visual aesthetics of a historic corridor also showed similarities between residents and visitors (Kamurahan et al., 2014), using parameters in the form of aspects that form beauty. Both studies asked respondents to weight each measurement parameter.

A study on the differences between architecture and civil engineering students in assessing architectural forms, resulting similarities in responses regarding the selection of adjectives, but different when responding to likes and dislikes, and assessments based on preferences (Garip & Garip, 2012). Jennath & Nidhish (2016) also explained that the justification of aesthetic parameters by architecture and non-architecture students has similarities in the index used, while differences occur in aesthetic preferences. Another study was conducted to compare the aesthetic preferences of young architects and experienced professional architects, concluding that both groups have more similar preferences (Šafárová et al., 2019). However, in previous studies showed differences between the aesthetic preferences of professional architects and the public. The similarities that emerge indicate the possibility of the same measurement parameters by each person. While the differences indicate the existence of other variables that influence the aesthetic assessment of each person or certain groups of people compared to others.

A study using a fairly in-depth and mathematical aesthetic measurement tool has been conducted by Hu et al. (2022), trying to capture the relationship between product aesthetic indicators and user preferences. However, the measurements are intended for the design of the front face of the camera, not buildings, using aesthetic measurements from the principles of balance, proportion, simplicity, cohesion, symmetry, contrast, and harmony. Meanwhile, the mathematical formula for aesthetic measurement has been previously expressed by Birkhoff, namely taking into account Order and Complexity, and there have been many studies that prove the results of its application. One of them is the combination of Birkhoff's calculation results with Gestalt values and involves ranking buildings based on perception to assess the aesthetics of the building, by Yammiyavar & Roy (2021). It was concluded that it is necessary to ensure that the order value contributes twice as much as complexity. However, the order factor still uses Gestalt values, which are intended for the visualization of a graphic composition, not for buildings.

Domestically, the parameters of the Birkhoff formula have been redefined to adopt it, which was originally used to measure the aesthetics of geometric art, to be specific for architecture (Saputro & Rito, 2020). However, there is a gap in the study, namely the determination of the composition factor was not explained scientifically, especially the architecture, and assuming that all factors have the same weight. This is possibly one of the causes of differences in aesthetic measurements result by various respondents and objects on that study. Strengthened by Das & Cithra (2015) which argues that Birkhoff's theory, which considers geometric regularity as a major aspect, is less effective in evaluating building aesthetics because irregularities or "imperfections" in architecture also define beauty. They propose to involve more detailed analysis involving composition and complexity in the context of building.

Various evidences of quantitative aesthetic measurement above and its recommendations are showing that aesthetics can basically be calculated, including aesthetics in building design such as architecture and interiors. In the Classical Architecture Era, it has been proven that the success of aesthetic quantification can produce beautiful products. However, later era today, it seems more unclear how to measure the value of beauty because of the stronger opinion about the portion of subjectivity. In fact, the success of aesthetic measurement in buildings will be beneficial for industry player (Paryoko & Zakariya, 2023), and will certainly be able to help in architectural or interior design education which is well-known of its subjective in learning evaluation. Based on these, this study was conducted to formulate a quantitative measurement specific for architectural aesthetics so it can be used by industry players to predict the success of their designs, as well as for building design educators to evaluate the success of their students. As stated by Das & Cithra (2015), the measurement method is still very open for development. In the measurement parameters, the weight of each parameter is also studied as it for contribute to the measurement of aesthetics, aiming to increase the effectiveness of the measuring instrument.

METHODS

Qualitative with Grounded Theory approach is used for this study, and supported by quantitative questionnaires. This approach refers to research that allows for the formulate and constructing theories from data directly collected by researchers (Groat &

Wang, 2013). Researchers do not start a study with a theoretical assumption, unless the goal is to elaborate or develop an existing. This study places aesthetic theory as a general theory that will be developed more specifically in the field of architecture, aims to produce a detailed mathematical formulation with the various weight of each composition principle, based on the questionnaire data. This study is using multi-tactics, namely starting with a literature review, continuing with analyzing the results of the graphic composition assessment questionnaire to describe the weighting numbers to formulate aesthetic measurements, then testing the aesthetic measurement formula by comparing it with the how respondents valuing the architectural object qualitatively.

The first stage is to conduct a literature study to formulate parameters or factors that form the order (O) and complexity (C) of the basic formula of Birkhoff's theory, namely M = O / C. The factors are formulated based on various theories of specific composition principles for buildings or architecture. In addition, various results of previous studies and research related to aesthetic measurement are also reviewed, aiming to reduce the weaknesses arising from the application of the Birkhoff formula.

The questionnaire is divided into two parts or groups of questions. The first group of questions is to provide a selection of the most aesthetic buildings or architectural works which display and provide choices from several photos of different building views. The aim is to test the level of conformity between the assessment of quantitative aesthetic measurements using a formula based on the weighting of the results of the second part of the questionnaire, to the qualitative aesthetic ranking in this first part of the questionnaire which is without mathematical measurement. This question is given before the respondents answer the second part of the questionnaire about the weight of each composition principle to obtain the natural condition of the respondents who have not been conditioned consciously or unconsciously by the second part of the questions.

The criteria for the selected building are those have prominent aesthetic superior in one of the aesthetic principles. The graphic abstraction of the building then modified into several variations that represent the weighting of each aesthetic principle. The respondents were asked to chose two building which considered as the most aesthetic of the category where the stay at. To reduce differences in the aesthetic assessment of each building related to factors other than aesthetic principles, the building photos must meet certain criteria, including:

1. Using photos with the same angle of view nearly frontal of the building and displaying all parts of the building, for pressing the context of the angle of view;
2. Minimizing the display of background around the building to pressing the environmental context;
3. All objects used are displayed by grouping them based on building categories to maintain the equality of the measured building scope.

Figure 1. Selected Examples of Building Photos in the High-Rise Building Category
(Source: Archdaily, 2024)

To obtain higher quality measurement results, the buildings selected, include four building above, were chosen from those nominated for international awards, including:

1. 2023 Education Facility Design Award oleh Institute of Architects Committee on Architecture for Education;
2. 2022/2023 International High-Rise Award oleh Deutsches Architekturmuseum (DAM);
3. 2022 International Architecture Awards oleh The Chicago Athenaeum and The European Centre.

Those building grouped into categories of simple single mass buildings, single mass buildings, multi-mass buildings, art and cultural buildings, and high-rise buildings. There are four building in each category, ordered by complexity of their form composition.

The second part of questionaries is asking respondents to choose one of four graphic compositions that they consider the most aesthetic. Each aesthetic/composition principle is questioned by one question. The goal is to map the weight of each aesthetic principle contributing to the aesthetics of the

graphic composition. The images are juxtaposed sequentially from the simplest to the most extreme implementation of the related principle. Through their responses, it can be estimated how much weight the principle contributes to the aesthetics of the composition as a whole. For example, the four images below represent a hierarchy principle, from extreme (left) to smooth (right) hierarchy.

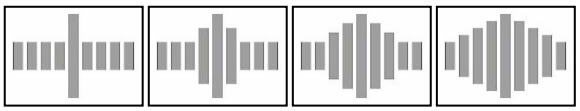

Figure 2. Selected Examples of Images/Graphics about Hierarchy/Order
(Source: Author's Document, 2024)

The respondents of this questionnaire are building design practitioners, building design teachers, building design students above the first year, new building design students as well as from other than building design department, and the public who are not involved in the building design industry. Responses from the group of building design teachers and practitioners will be given further analysis because the results are considered as valid enough to test the success rate of the proposed measurement formula for their expertise.

RESULTS AND DISCUSSION

Aesthetic measurement has been initiated by Birkhoff, namely the aesthetics of art objects, measured by the formula M = O/C, where O is for order and C is for complexity (Douchová, 2015). The specific definition of order and complexity depends on the type of art object being analyzed. This definition is very important because it will affect the results of the aesthetic quality assessment. The value of the arrangement is the sum of all types of efforts multiplied by the number of occurrences. While complexity is the number of units in an object that require conscious attention.

According to Birkhoff, aesthetic experience consists of three stages, namely:

1. Initial effort for attentional action, which is needed to shape perception and increase the proportion of the complexity of the object (C);
2. Feeling of value or size of aesthetic (M) which is the result of this effort;
3. Awareness that the object's characteristics is composed by a certain harmony, balance, or arrangement (O), to produce aesthetic effect. While connotative associations are not taken into account in the measurement, namely other than formal, such as usefulness.

An example of aesthetic measurement for a polygon tile panel, is M = O/C = (V+E+R+HV-F)/C, as follows:

1. Vertical symmetry (V), given a value of 0 to 1;
2. Equilibrium balance (E), given a value of -1 to 1;
3. Rotational symmetry (R), given a value of -1 to 1;
4. Horizontal and vertical relationship (HV), 0 to 2;
5. Unsatisfactory shape (F), given a value of 0 to 2:
6. While complexity (C) is the number of lines on the edge of the polygon.

Various studies and further research around the world have been conducted to respond to Birkhoff's theory, related to weaknesses, confirmations, and the results of its application. The dominant opinion is to refute Birkhoff's formula because it does not take into account the connotative arrangement or subjectivity of the observer of the object being measured, especially from psychology circles (Douchová, 2015). However, Birkhoff's formula is basically not a formula that is intended to be applied to everything, but rather its initial purpose is to understand aesthetics in terms of formality by trying to remove subjectivity in its measurement. It is also explained that the factors or parameters that form the arrangement (O) or complexity (C) can be defined in more detail depending on the type of object whose aesthetics are being measured.

A study which developing the Birkhoff formula for the field of architecture was conducted by Yammiyavar & Roy (2021), aims to produce a decision-making tool or measure that can consider the aesthetic preferences of public and the assessment of architects at the same time. This measurement attempts to involve the subjectivity of the observer by measuring the observer's perception of the object. The Order (O) factor uses Gestalt Values which are basically used to visualize composition, not buildings. These values are proximity, similarity, enclosure, closure, continuity, and connection. This measurement is called the Frontage Aesthetic Perception Index of Likeability (FAPIL), namely FAPIL = M (Birkhoff) X General Rating Weight / 10, where the Order (O) in Birkhoff's formula is defined from six Gestalt values, while the General Rating Weight is an assessment based on the perception of the 10 best objects, which are averaged by 10 in the formula.

However, the FAPIL formula actually adds subjectivity that should be suppressed or avoided in this author's study. In addition, the subjectivity in the FAPIL formula is obtained from comparing 10 objects to be assessed and assigning a ranking to them. The source of weighting in this ranking is not explained, so it seems gray. Ultimately, every time the FAPIL formula will be used, it is necessary to determine the comparison object to assess an object. Therefore, the author defines aspects or parameters in the Order (O) of the Birkhoff formula with the specific architectural composition principles in this study. Compatible by Wijaya et al. (2019) where the beauty of form is something measurable and real so that to assess the

aesthetic quality of a building, it is necessary to use measurable indicators. Thus, the next stage is to compare various composition principles related to building aesthetics published in the last 20 years, to determine what parameters influence the observer's perception in assessing the aesthetic composition.

Table 1. Comparison of Aesthetic Composition Theories

Composition Principles (Ching, 2014)	**Architectural Aesthetics** (Sebestyen, 2003)	**Composition Principles** (Salvan, 1999)
Axis		Balance
Symetry		
Hierarchy	Articulation	Unity and Hierarchy
Datum		
Rhythm (irama)		Rhythm
Repetition		
Transformation	Geometry	Contrast
	Size, scale, and proportion	Proportion
		Scale
	Colour, light, and shadow	Character
	Recesses, cavities, holes, canted/slanted lines and planes	

(Source: Author's Analysis, 2024)

There are three theories that are compared, derived from primary library sources in the form of books. One principle that is always present in the three theories is an articulation or often called accentuation. Accentuation is an element of pressure in a composition that is generally a minority that is different or anomalous when compared to other elements that dominate the composition (majority). By Ching and Salvan, this principle is called a hierarchy because an accentuation that is not harmonious with other elements to be considered less aesthetic. By Salvan, hierarchy is also directly linked to unity, which all elements in the hierarchy, both minority and majority, need to be in harmony with each other. While Ching uses a term that can have a broader meaning to unite all elements in a composition, namely datum, which said that unity can also be obtained by integrating with elements that are able to bind the whole, even though the patterns or shapes are different. Another principle also used by the three theorists is the existence of a diversity of compositional elements that can be produced through the process of changing forms or transformations.

The principle of composition mentioned by two theorists is rhythm, which is arranging several elements simultaneously to avoid monotonous or boring repetition. Another principle is balance. Ching separates balance from the axis, which serves as a reference or starting point in arranging a composition. Meanwhile, Salvan combines the two in the principle of balance. Another principle also mentioned by both theorists is size, scale, and proportion, which are interconnected. Size and scale are used to create a certain impression (image), while proportion binds the two together to create an aesthetic.

The principle of character is specifically used by Salvan to illustrate that a pattern has a specific meaning to produce a certain impression. Sebestyen's character builder is separated into two, emphasizing that it is used by designers to develop creativity in arrangement, meanwhile, Salvan emphasizes its function to form a character. However, these principles are not examined further in this study because they are only used by one theorist, have the potential for very wide variations, and greatly influence or are influenced by style.

Visual aesthetics depend on the level of arousal triggered by a stimulus (Mshelia et al., 2017), which is characterized by provisions related to the variables of novelty and complexity, and faced with the right proportion of all these variables. That is, a comparative value of the calculated results that means that the aesthetics of an object being measured is good or bad. Therefore, the next stage in this study was to determine the weight of each aspect or parameter in the Structure (O) and Complexity (C). For this purpose, data was collected through a questionnaire filled out by people involved in the world of architecture and not. Of the 140 respondents, their disciplines and status were divided into five categories. This categorization aims to reduce response bias that can arise from differences in the respondents' aesthetic experiences. The ratio column on the far right is the comparison of the number of respondents in each category to the total number of respondents.

Table 2. Respondent Category

Respondent Category	**Code**	**Numbers of Respondent**	**Ratio**
Lecturer / Teaching Staff in Architecture or Design (A/D)	DA	22	16%
Practitioner in A/D	PA	11	8%
Students of A/D Study Program	MA	68	49%
Public (not involved/expertised in the field of A/D)	MU	14	10%
Students from other than A/D	MSA	25	18%

(Source: Author's Analysis, 2024)

Meanwhile, the parameters of the Order (O) are determined from the composition principles of the comparative analysis results of three different theorists that have been carried out previously, namely: pressure/accentuation, hierarchy/order, unity/harmony, rhythm, transformation, and balance.

Each respondent chooses one of four image/graphic options that represent each parameter of the Order (O). The images are arranged sequentially, where number 1 is the simplest arrangement related to the parameters discussed, while 4 is the most extreme arrangement. This sequence is intended so that the selection of this image is also a weighting of each parameter of the Composition (O) so that it can be calculated in the aesthetic calculation formula as a whole.

Based on the second part questionnaire responses, it was obtained that the average response of all respondents regarding the principle of balance was to choose a weight of 1.91 on a scale of 1-4. The graphic choice at a weight of 1 is perfect symmetrical balance, 2 is asymmetrical balance, while the next is the higher the number means the more extreme imbalance. So, the weight obtained illustrates that the composition that is considered aesthetic is one that is truly balanced but asymmetrical. This value is almost the same in each category of respondents, except for students other than D/A study programs, who chose an average weight of 1.52. This category can be interpreted as the public with lowest aesthetic experience among all respondents, so this difference of opinion can be considered as a result of these shortcomings.

Figure 3. The Chart of Responses to the Principles of Balance (top) and Rhythm (bottom)
(Source: Author's Analysis, 2024)

The responses to the rhythm questionnaire showed an average weight of all respondents of 2.89. The higher the weight of the graphic object, the greater the change in shape from the repetition of the objects that are aligned, and more irregular rhythmic arrangement. A similar trend is seen in the responses to this principle of all respondent category, which the higher a person's aesthetic experience, the more they choose extreme repetition of form. Meanwhile, compositions with flat or monotonous rhythm that are merely repetitions of a form, almost no one considers it is aesthetic.

The average weight of responses to the principle of accentuation is 2.19, and has a similar trend in almost all categories of respondents. Accentuation is considered to be a must in a composition, but is not too extreme in its difference in form compared to other parts of the composition. In this questionnaire, a weight of 1 to 4 is interpreted as an accentuation that is almost similar to very different from other parts of the graphic composition.

Principle that has almost same weight in each respondent category is hierarchy or sequence, namely choosing the 4th graphic which has the softest hierarchy of accentuation to other parts in a composition. The average weight of this principle is 3.62 on a scale of 1-4. Graphics with a weight of 1 which illustrates weak hierarchy/sequence are only chosen by 0.7% of respondents. The most widely chosen graphic alternative other than the 4th is the 3rd.

Figure 4. The Chart of Responses to the Principles of Accentuation/Stress (top) and Hierarchy/Order (bottom)
(Source: Author's Analysis, 2024)

Composition principle that also has almost the same weight in each respondent category is transformation. The average weight is 2.86, where the highest choice is the 3rd graphic. This graphic illustrates that changes in form should be present and extreme but do not suppress the overall harmony of the composition. Almost no one chose the 1st graphic because it illustrates the absence of transformation,

while the 4th graphic also had very few voters because it illustrates a transformation that increasingly forgets the harmony between parts in a composition.

Figure 5. The Chart of Responses to the Principles of Transformation (top) and Unity/Harmony (bottom) (Source: Author's Analysis, 2024)

The principle of unity/harmony is the principle with the highest weight after the hierarchy, which is 3.31. The 4th graphic depicts perfect harmony where all parts have exactly the same form. The 3rd graphic depicts the same basic form but experiences changes in size between each other. The 2nd graphic depicts unity that is realized through a datum line that binds various different forms. While the 1st graphic depicts the 2nd graphic without a datum line, which is very rarely chosen by respondents. The responses of various categories of respondents show a regular trend where lower a person's aesthetic experience, the more they want absolute harmony. While the higher a person's aesthetic experience, the more they want harmony that is also colored by changes in form.

The results of the questionnaire response measurement of the composition principles section above show the temporary conclusion of the weight of the six composition principles to measure the aesthetics of a graphic composition. The next step is to determine the weight of each principle to be collaborated as an Order (O) in the aesthetic measurement formula. The weight of each principle is determined by adjusting the weight of the questionnaire results (QW) into a scale range that is easier to calculate, which the perfect value called 10, stored in most right column on table (FW).

Based on table 3, it can be written that the formula to create an aesthetic Order (O) is O = (2E + 1.1S + 1.7T + 1.7I + 2.2H + 1.3A) / 100, or can be abbreviated as ESTIHA / 100. To facilitate the calculation, the same range of values is needed to assess each composition principle, where in the formula above it uses a range of 1-10 so that the divisor of the Order (O) is 10 x 10 = 100. If the value of all the composition components is 10, then the final value is 100: 100 = 1. Thus, a composition that has a calculation value of the aesthetic formula above that is close to 1 is the best. However, this divisor can be adjusted according to needs, for example if the range of values for each composition principle is 1-5, then the divisor is 5 x 10 = 50.

Table 3. Weight of the Composition Principles

Principle	Criteria for Improving Aesthetics	QW	FW
Unity (Code=E)	Must be there	3,31	2,0
Balance (Code=S)	Very necessary, but more aesthetically pleasing asymmetrical than absolute balance.	1,91	1,1
Transformation (Code=T)	It should be high, but not to the point of disrupting harmony.	2,86	1,7
Rhythm (Code=I)	Must be there, but arranged in regularly manner	2,89	1,7
Hierarchy (Code=H)	There must be and be tiered in a smooth manner	3,62	2,2
Emphasis (Code=A)	Very necessary, but not too contrasting to the rest of the elemen.	2,19	1,3

(Source: Author's Analysis, 2024)

The first part of the distributed questionnaire is to choose one to two architectural works built from the four choices provided, which are considered to be the most aesthetic in composition. There are five questions given, namely choosing buildings in the categories written in left column of the Table 3. The purpose of this part of the questionnaire is to test the reliability of the formula found on earlier stage. In order to be able to carry out this test, each building in each question is assessed using the previously found formula. It can be seen in table that the assessment of each aesthetic principle uses a value range of 1-5. Therefore, the Total Value column in the table uses a specific aesthetic measurement formula, namely ESTIHA / 50.

The next step is to compare the values obtained from the formula above with the responses of the first part of the questionnaire, shown in charts below. In order to be able to compare them responsibly, both of them are converted into percentages. The values from formula calculations are presented in the form of area, while the questionnaire results are shown in the form of lines. Of the five building categories, it can be seen

that values from formula calculations are flatter in slope compared to respondents' responses from the questionnaire which steeper. This is possible due to the use of a short range of values for each composition principle in the formula, namely 1-5.

Table 4. Measuring the Aesthetic Value of Buildings

Building Type	Building Number	Compiler Value						Total Value
		E	S	T	I	H	A	
Maximum		5	5	5	5	5	5	
Simple Single Mass	1	4	2	2	5	3	5	0,70
	2	4	5	3	4	2	2	0,65
	3	2	3	2	3	4	4	0,60
	4	3	3	5	2	1	3	0,55
Simple Single Mass	1	5	5	2	5	5	5	0,90
	2	3	4	3	4	3	3	0,66
	3	4	3	5	3	4	4	0,78
	4	2	2	4	2	2	2	0,47
Multi Masses	1	5	5	2	5	5	5	0,90
	2	4	4	2	4	4	5	0,76
	3	3	3	3	4	3	2	0,61
	4	1	1	5	1	1	3	0,39
Cultural-Arts	1	5	4	2	2	4	5	0,73
	2	5	4	2	2	4	4	0,70
	3	5	2	3	4	5	5	0,83
	4	4	2	4	2	2	3	0,57
High-rise	1	5	4	2	4	2	5	0,71
	2	5	4	4	5	5	4	0,92
	3	5	3	5	3	3	5	0,80
	4	3	2	3	2	3	3	0,54

(Source: Author's Analysis, 2024)

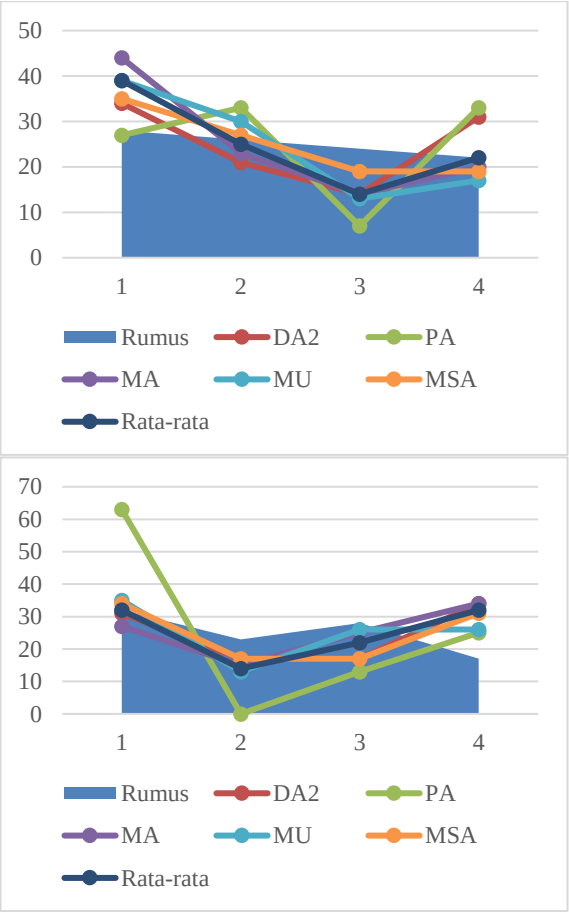

Figure 6. The Chart of Responses to the Most Aesthetic Simple (top) and Non-Simple (bottom) Single Mass Building (Source: Author's Analysis, 2024)

The most aesthetic building from the responses and questionnaires as well as the ESTIHA/50 Formula are the same, namely number 1. However, the lowest is different. In general, the trend conformity between the assessment results of the two techniques is quite high. The discrepancy appears in several cases, one of them is in the Simple Single Mass Building Category where the value of building number 3 is lower than number 4 on the average questionnaire response, but the formula results show otherwise. However, when the responses are viewed separately between respondent categories, D/A Practitioners (PA) have a different assessment, namely building number 1 is considered less aesthetic than number 2, in contrast to the average value.

Another discrepancy is in the Single Mass Building Category where building number 4 has the lowest value from the ESTIHA/50 Formula even though it is the most aesthetic building from the questionnaire responses, balanced with building number 1. The questionnaire responses that are in line are only by the Public (MU), while that had quite extreme different from other categories is the A/D Practitioner (PA), who considers building number 1 to be much more aesthetic than the others, and considers number 2 to be very low on aesthetic.

Responses from the Public (MU) show the opposite trend to other respondent categories and the results of the ESTIHA/50 Formula calculation for the Multi-Mass Building Category. Meanwhile, the responses of A/D Lecturers (DA) show the most conform trend to the ESTIHA/50 Formula results. However, when viewed based on the average value of the questionnaire responses, the ESTIHA/50 Formula results are quite matched. The choice of buildings that are considered the most aesthetic from both results are the same too, namely number 1.

A discrepancy also shown in Art-Culture Building Category, but the difference is not too significant. Building number 2 is rated slightly lower than number 1, while the questionnaire response is otherwise, showing the most extreme trend difference between respondent categories compared to other categories. Meanwhile, respondents from A/D Lecturers (DA) have the same trend as ESTIHA/50 Formula but the difference in value between objects is very high. Meanwhile, the Public (MU) has a trend that is quite different from the formula. However, the response trend that is most in line with the formula is from D/A Lecturers and Practitioners, thus supporting the reliability of the ESTIHA/50 Formula, which the

building that is considered the most aesthetic from both techniques is the same, namely number 3.

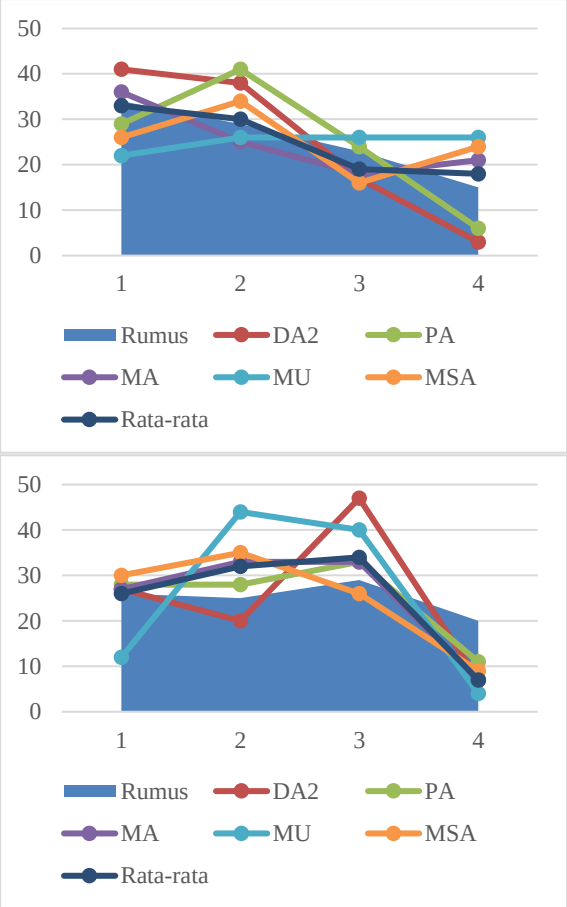

Figure 7. The Chart of Responses to the Most Aesthetic Multi Masses Building (top) and Art and Culture (bottom) (Source: Author's Analysis, 2024)

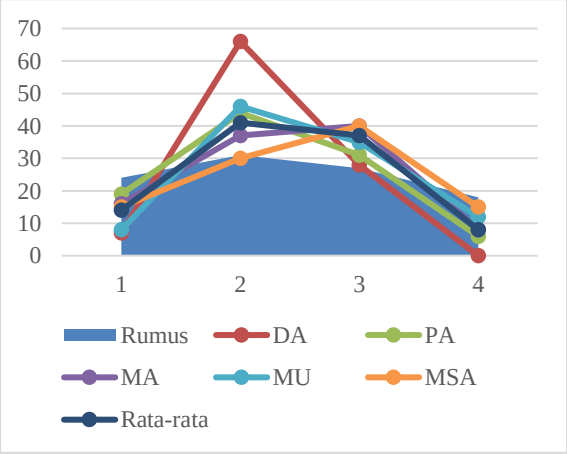

Figure 8. The Chart of Responses to the Most Aesthetic High-Rise Building
(Source: Author's Analysis, 2024)

In the High-rise Building Category, building number 2 was considered the most aesthetic based on both questionaries and formula, also the average trend. A slightly different trend was seen in the responses of student respondents, both from architecture (MA) and non-architectural (MSA) backgrounds. However, a consistent trend was shown by both the D/A Lecturer and Practitioner.

CONCLUSION

Based on the analysis above, it can be concluded that the ESTIHA Formula can be relied on to be used to measure the aesthetics of an architectural composition, although there are still weaknesses so that there are differences in the order of buildings from the highest to the lowest value (trend) between the results of the questionnaire responses to the results of the ESTIHA Formula calculations.

Something that needs to be noted and may be a weakness in this study is that Complexity (C) which should be a factor in dividing the Order (O) to measure the Aesthetic Value (M), has not been taken into account in this ESTIHA Formula. The Complexity (C) factor is temporarily ignored because this factor has not been studied in terms of how to assess it. Unlike Birkhoff's original formula which can count the number of lines as one way to measure complexity, measuring the complexity of an architectural composition or other complex product design is not possible by counting each line one by one. However, the four selected objects in each category of buildings or architectural works assessed in the first part of the questionnaire have been arranged based on complexity. Where building number 1 is the simplest, while number 4 has the highest composition complexity. However, the response data from all respondents is very lacking in showing a trend or relationship between complexity and the selection of buildings considered the most aesthetic.

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