An Evaluation Study of Shading Devices and Their Impact on the Aesthetic Perception vs. Their Energy Efficiency

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Abstract

Sunlight control tools, such as shading devices, are used to improve buildings' thermal and visual conditions. One of the concerns about using shading devices is their potential to harm the visual appearance of buildings. This study aims to study the aesthetic perception of different shading devices while concurrently evaluating their energy performance. Augmented reality was used to place virtual shading devices onto a building's façade at Jordan University of Science and Technology (JUST). One hundred two students from JUST evaluated eight shading devices on a seven-step semantic differential scale. Participants comprised 49 students from Architecture and Design College and 53 students from other colleges. The energy efficiency of shading devices was tested using DesignBuilder. The results revealed that certain types of shading devices were perceived as more aesthetically pleasing than others. Architecture students and non-architecture students showed significant differences in their affective responses. Regarding shading devices, shape-morphing and horizontal-louvres devices are the most preferred by participants, while egg-crate devices are the least recommended. Regarding energy efficiency, results showed that the tested shading devices improved buildings' energy efficiency by 7% (vertical fins) to 17% (egg crate) compared to the base case and did not negatively impact their visual appearance.

Keywords

shading device, experimental aesthetics, perception, augmented reality, semantic differential scale, energy efficiency

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1 INTRODUCTION

Research on shading devices has a long tradition. Since their invention, shading devices have become vital tools in improving energy efficiency and thermal comfort in buildings with glazed façades. The Building Energy Conservation Design Standard defines shading devices as devices installed to reduce solar heat entering a room (Kim, Shin, Kim, & Cho, 2017). They are primarily used to prevent overheating and reduce peak cooling loads in hot seasons, thus enhancing thermal comfort therefore saving energy (Nadiar & Nusantara, 2021; Rana, Hasan, & Sobuz, 2022). Additionally, shading devices should allow maximum solar energy penetration during cold seasons to minimize heating loads (Kim et al., 2017). Furthermore, by carefully controlling the distribution of luminance and illuminance, shading devices can address glare and visual discomfort issues, contributing to a more comfortable visual environment (Freewan, 2014; Esquivias, Munoz, Acosta, Moreno, & Navarro, 2016).

Research on shading devices is ample and mainly focused on their thermal and visual performance (Alzoubi and Al-Zoubi, 2010; David, Donn, Garde, & Lenoir, 2011; Choi, Lee, Ahn, & Piao, 2014; Freewan, 2014; Nadiar & Nusantara 2021; Rana et al., 2022). Recently, researchers have shown a growing interest in exploring the combination of photovoltaic cells and shading devices (Zhang, Lau, Lau, & Zhao, 2018; Custódio, Quevedo, Melo & Rüther, 2022). Additionally, researchers have been investigating the impact of shading devices on energy usage and carbon dioxide emissions, as shown in the study conducted by Razazi, Mozaffari Ghadikolaei & Rostami (2022).

For architects and designers, shading devices hold significance beyond their functional role as façade design elements. However, if not designed properly, these devices can negatively influence the aesthetics of a building's façade (Freewan, 2014). In research, the aesthetic aspect of shading devices and their influence on the visual appearance of buildings have not received extensive attention. As far as the authors know, only a few researchers and designers have attempted to explore the aesthetic qualities of shading devices. For instance, the Adaptive Building Initiative (ABI), an institution dedicated to developing environmental building performance, created Tessellate, a shading device that combines aesthetic appeal with energy and mechanical efficiency (Drozdowski, 2011). Furthermore, Al-Masrani, Al-Obaidi, Zalin, & Isma (2018) studied the aesthetic appeal of shading devices that utilize parametric designs.

Based on the short preview above, there is a lack of research on how shading devices impact the aesthetic perception of building façades or spaces. To fill this gap, this study aims to explore the aesthetic preferences of users when shading devices are integrated into building façades. The main hypothesis is that different types of shading devices can impact the aesthetic preference and evaluation of building façades. Additionally, based on previous research, the study suggests that the user's experience and knowledge impact the aesthetic perception and evaluation process. As such, architects and non-architects may have different perceptions of these shading devices. Equally important, the study will assess the compatibility between users' preferences for shading devices and their energy efficiency.

1.1 TYPES OF SHADING DEVICES

Shading devices can be categorized using various classification systems, most commonly orientation-based. This system categorizes shading devices into vertical, horizontal, and egg-crate types. Vertical shading devices are widely used on western and eastern elevations but are deemed the least effective (Choi et al., 2014; Esquivias et al., 2016). Horizontal shading devices are most effective on southern and northern elevations (Choi et al., 2014; Esquivias et al., 2016). Lastly, egg-crate devices combine both vertical and horizontal elements (Nadiar & Nusantara, 2021) and are considered more energy-efficient compared to vertical and horizontal fins (Esquivias et al., 2016; Al-Masrani et al., 2018).

Another categorization system is based on energy requirements (Al Dakheel & Tabet Aoul, 2017; Al-Masrani et al., 2018). This system classifies shading devices into passive, active, and hybrid groups. Passive shading devices operate without energy and can be either fixed or movable. Fixed shading devices eliminate the issue of user performance but block the view permanently (Esquivias et al., 2016; Al Dakheel & Tabet Aoul, 2017; Zulkarnain, Salleh, & Aziz, 2021). Movable shading devices offer user control and privacy, but their performance depends on user behaviour (Esquivias et al., 2016; Al-Masrani et al., 2018; Vercesi, Speroni, Mainini, & Poli, 2020). Passive shading devices are cost-effective and easy to install but lack year-long adaptability and struggle to control daylight under different sky conditions (Al-Masrani et al., 2018).

On the other hand, active shading devices require energy to operate and are mechanically movable systems that can rotate, fold, or slide. They can be automatically or manually controlled, with the automatically controlled ones responding to external environmental conditions (Al Dakheel & Tabet Aoul, 2017; Al-Masrani et al., 2018). Automatically controlled shading devices are considered more efficient than passive devices as they do not depend on user behaviour (Al-Masrani et al., 2018). However, active shading devices are more complex and have higher costs and risks of failure (Al Dakheel & Tabet Aoul, 2017; Al-Masrani et al., 2018).

The third category, hybrid shading systems, incorporates smart materials and biomimetic designs. Shape-morphing façades use smart materials that respond to environmental stimuli, such as heat or light, by changing their shape (Al-Masrani et al., 2018; Fiorito et al., 2016). However, the usability of these systems may be limited due to the inability of manual intervention (Barozzi, Lienhard, Zanelli, & Monticelli, 2016). Hybrid shading devices are still in the early stages of development, with solar shading devices made entirely of smart materials being limited by cost and the experimental stage of shape-memory materials (Al Dakheel & Tabet Aoul, 2017; Premier, 2019). The efficiency and effectiveness of hybrid shading devices in improving energy efficiency are still under investigation and are the subject of several research projects (Sheikh & Asghar, 2019; Yoon & Bae, 2020; Vercesi et al., 2020).

Figure 1 presents a combination of the mentioned categorization systems, showcasing various types of shading devices that will be analysed from an aesthetic standpoint. Table 1 summarises the different categorizations, advantages, and challenges of shading devices.

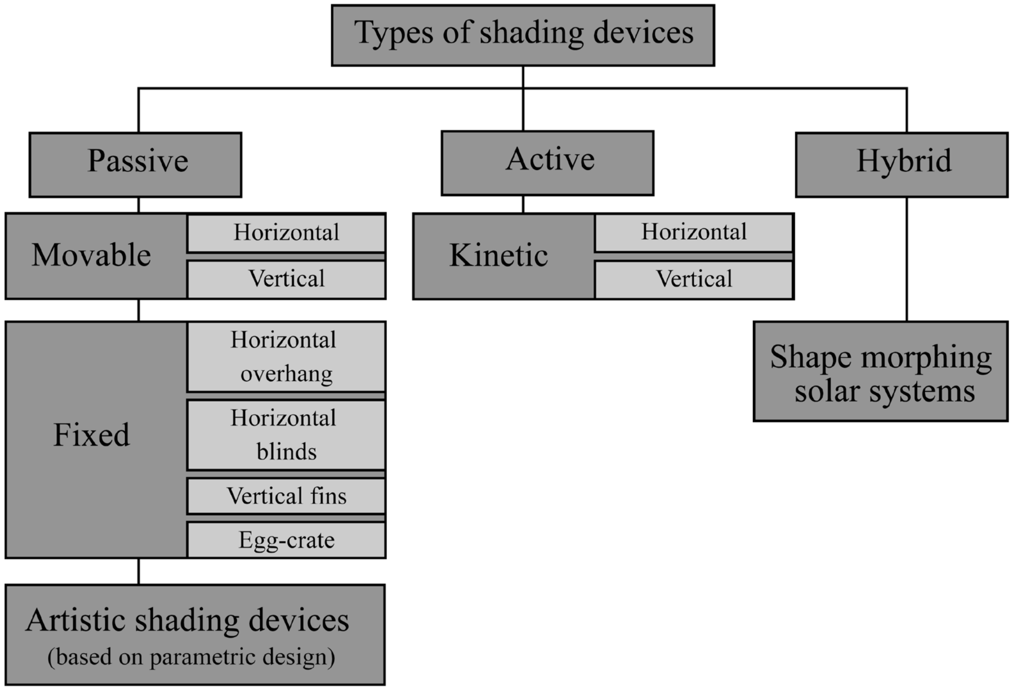

FIG. 1 Types of shading devices.

TABLE 1 Comparison between different shading devices in terms of advantages and challenges of every technology

Shading Device Category	Advantages	Challenges
Vertical Shading Devices	- Suitable for western and eastern elevations	- Least effective shading type - May not be suitable for all orientations
Horizontal Shading Devices	- Most effective in southern and northern elevations	- May not be suitable for all orientations
Egg-Crate Shading Devices	- Combines advantages of both vertical and horizontal shading	- More complex design
Passive shading devices	- No energy requirements - Simple, low-cost, and easy to install	- Limited adaptability to changing environmental conditions - Ineffective in controlling daylight in different sky conditions
Passive Shading Devices (movable)	Allow users to control their environment and offer privacy when required	- Depends highly on the user's preference and behaviour
Passive Shading Devices (Fixed)	- Does not depend on users' performance	- Permanently block the outside view
Active Shading Devices	- Automatically respond to environmen-tal conditions	- Higher complexity and costs
Hybrid Shading Systems/ Shape-Morphing Shading Devices	- Improved energy efficiency	- Limited efficiency due to exposure to external conditions - Limited by material cost and testing stage

1.2 EXPERIMENTAL AESTHETICS

It is important to illustrate the fundamentals of human affective responses, including aesthetical judgements, to understand the logic behind how people perceive shading devices. Experimental aesthetics, a branch of psychology, was founded in 1876 by Gustav Fechner, who suggested that aesthetics can be measured objectively (Brachmann & Redies, 2017). Aesthetic experience includes three main domains: perception, or the initial gathering of information about an environment (Lang, 1987); cognition, or the processing of the information to develop an understanding (Veitch & Arkkelin, 1995); and affect, or the initial response to the environment (Brachmann & Redies, 2017). These three domains and their relation to the observer are illustrated in FIG. 2.

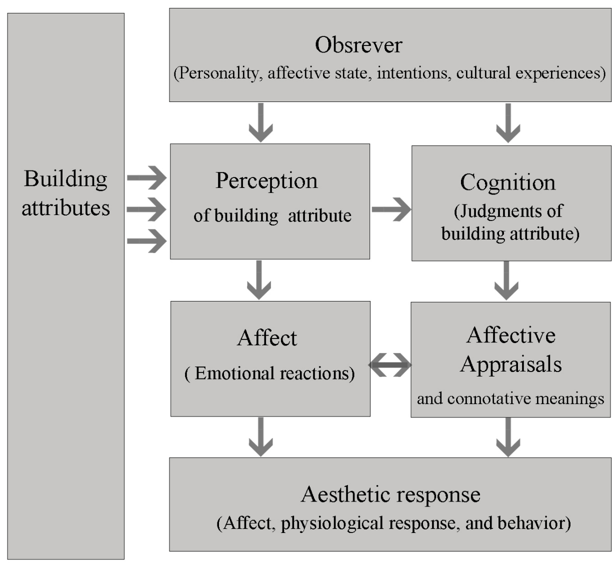

FIG. 2 Aesthetic response model (After Nasar, 1994).

Numerous studies in the field of architecture have concentrated on assessing the aesthetic worth of architectural elements and surroundings and comprehending the mechanisms that govern the evaluation process. (Ibrahim, Abu-Obeid, & Al-Simadi, 2002; Abu-Obeid, Hassan, & Ali, 2008; Yazdanfar, Heidari, & Aghajari, 2015; Shemesh, Talmon, Karp, Amir, Bar & Grobman, 2017; Moscoso & Matusiak, 2018).

Researchers in the field of experimental aesthetics agree on three polar components of feelings relevant to aesthetic judgements: pleasure, arousal, and dominance. Pleasure and dominance have positive and negative extensions, whereas arousal begins at zero and can only increase (Stamps, 2013; Veitch & Arkkelin, 1995). These dimensions were first defined and developed in the studies of Osgood (1957) and Berlyne (1971) and were further studied later. Biaggio & Supplee (1983) described the three dimensions mentioned above as hedonic tone, arousal, and uncertainty, standing for the dimensions defined by Osgood as evaluating, activity, and potency.

In their early research, Nasar (1994) suggested two dimensions that affect aesthetic judgments: formal variables, which are features that concern the physical form of objects, and symbolic variables, which are the human responses to the content of objects. Moreover, other researchers have tried to identify these dimensions. Shemesh et al. (2017) defined the dimensions affecting aesthetic judgments as physical and cultural dimensions. Yazdanfar et al. (2015) added a personal dimension to the previous dimensions. Personal dimension was the focus of a study by Ibrahim et al. (2002), who studied personal traits mediating perception and aesthetic judgments. Education was also considered a variable by several researchers (Nasar ,1994; Abu-Obeid et al., 2008; Akalin et al. 2009; Marković & Alfirević, 2015; Yazdanfar et al., 2015). The studies conducted by these researchers have provided evidence to support the notion that the aesthetic evaluation of an architect is distinct from that of a non-architect. Consequently, the current research acknowledges education as a variable that has the potential to influence aesthetic evaluation.

2 METHODOLOGY

The current study's assumptions were examined by an experimental approach and by administering a survey that measured participants' opinions as the dependent variables and considered the physical structure of shading devices as the independent variables. The study employed Augmented Reality (AR) as a visualization tool. Furthermore, an assessment of the energy efficiency of each shading device was conducted. A flowchart detailing the procedure is depicted in Figure 3.

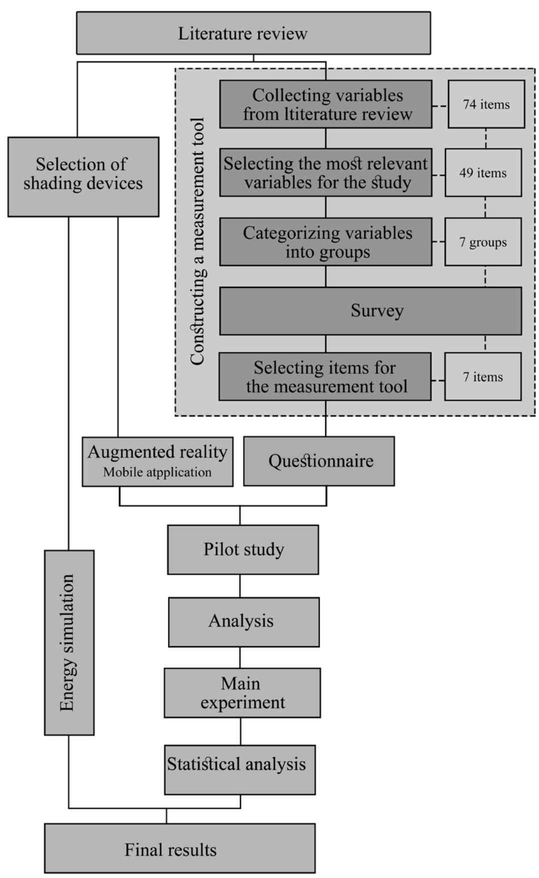

FIG. 3 Data collection procedure.

2.1 MEASUREMENT TOOL – SEMANTIC DIFFERENTIAL SCALE

The Semantic Differential Scale, SDS, was used as a measurement tool. The SDS uses words to determine feelings based on the notion that language is a means of communication. The tool relies on contrasting adjectives or expressions denoting object properties (Seyedkolaei, Alishah, Rasouli & Siami, 2015; Zeisel, 2006). To develop the scale for this study, 49 pairs of aesthetic semantics were collected from previous studies of experimental aesthetics. These semantics were categorized into seven groups based on their qualitative characteristics and meanings. To minimize the number of semantics, a ranking question survey was conducted by a group of qualified academic architects from Jordan University of Science and Technology (JUST). Survey respondents were tasked with ranking items within each group of attributes in terms of relative importance. Multiple correspondence analysis was conducted to analyse the pattern of relationships within each of the seven groups. The attribute with the highest loading was then chosen from each group (Table 2).

TABLE 2 Highest loading for items within groups (multiple correspondence analysis)

Group #	Item	Loading value	Range of loadings for group
1	Bright – Dull	.753	.453 – .753
2	Unique – Common	.721	.406 – .721
3	Depressing – Cheerful	.701	.453 – .701
4	Impressive– Unimpressive	.753	.507 – .753
5	Protected – Exposed	.778	.285 – .778
6	Rugged – Delicate	.670	.389 – .670
7	Loose – Tight	.708	.409 – .708

The attributes were further categorized into groups similar to Osgood's categorization to understand the results obtained from the final data analysis. This categorization was based on the studies of Hershberger & Cass (1974), Nasar (1994), and Marković & Alfirević (2015) as follows:

1 Affective variables, similar to Hedonic tone or Evaluative factor: Bright – Dull, Impressive – Unimpressive, and Cheerful – Depressing.
2 Formal variables, similar to Arousal or Activity factor: Unique – Common and Tight –Loose
3 Organizational variables, similar to Potency or Uncertainty factor: Protected – Exposed and Delicate – Rugged.

For the affective variables, bright, impressive, and cheerful are the positive adjectives. In other words, if a respondent perceives an object as bright, impressive, or cheerful, that object positively impacts the respondent's perception. Therefore, based on the survey responses, the eight tested shading devices were ranked from 1 (most favourable shading device) to 8 (least favourable shading device) `based on their impact on the affective variables.

The concept of positivity and negativity for other formal and organizational variables is subjective. The designation of positive or negative may depend on the gender of the perceiver, the context, and other situational factors, or some attributes may not have negative and positive polarity (Al-Hindawe, 1996). According to Veitch & Arkkelin (1995), there is an inverted U-shape relation between uniqueness and aesthetic value. It must be remembered that people perceive objects with moderate levels of uniqueness to be more pleasant than extremely common or extremely unique objects.

2.2 PARTICIPANTS

A random sample of 102 students from JUST participated in this study. Respondents were categorized into the expert group, which included 49 architecture students (14 males and 35 females), and the non-expert group, which included 53 students from other majors (13 males and 40 females). Participants in the expert group were selected from sophomore and above levels, while in the non-expert group, participants were from different academic levels and were aged between 18 and 23 years.

2.3 STIMULUS MATERIAL

Based on the classification of Choi et al. (2014), Esquivias et al. (2016), Al Dakheel & Tabet Aoul (2017), and Al-Masrani et al. (2018) (FIG. 1), eight shading devices that covered both passive and active movable shading devices were selected:

1. Horizontal overhang;
2. Fixed horizontal fins;
3. Fixed vertical fins;
4. Egg crate;
5. Parametric-designed shading device, taken from Al-Masrani et al. (2018);
6. Movable horizontal louvres;
7. Movable vertical louvres and
8. Shape-morphing shading device, taken from Al-Masrani et al. (2018).

Movable vertical and horizontal louvres were not specified as manually or automatically controlled.

2.4 AR APPLICATION

Augmented Reality (AR) was implemented in this study to present shading devices to participants through a mobile application specially developed for this research. AR is an interactive, real-time tool that adds virtual objects into real environments (Tecchia, 2016). This technology combines the flexibility of computer-generated environments with the comfort and familiarity of real environments (Wang, 2009).

An ample number of studies have used Virtual Reality (VR) to understand users' perceptions of architecture (Orzechowski, de Vries, & Timmermans, 2003; Shemesh et al., 2017; Moscoso, Chamilothori, Wienold, Andersen, & Matusiak, 2021; Banaei, Ahmadi, Gramann, & Hatami, 2020). According to Milovanovic, Moreau, Siret, & Miguet (2017), VR applications are used more frequently than AR in sense and cognition research due to the immersive experience offered by VR visualization. However, Tan, Yang, Leopold, Robeller, & Weber (2019) claimed that AR is easier to use and less time-consuming than VR. Compared to the AR technique, VR devices need more preparation before the virtual experience, including installation and instruction. AR applications provide a simpler alternative to VR. Projecting virtual objects onto real-world scenes enhances the sense of scale. Shadow projections enhance realism in AR applications by making a solid connection between virtual and real objects (Ghadirian & Bishop, 2002). The increased realism in AR applications increases the validity of the augmented experience. With these features in mind, AR technology was demonstrated to be an efficient method of representation in architecture by Tan et al. (2019) and Lee, Seo, Abbas, & Choi (2020). This study used a marker-based AR application.

A professional specialist programmer created a mobile application specifically for the present study. Autodesk Maya and Unity 3D software created an interactive AR mobile application that places virtual shading devices onto a building surface from the outside and the inside. Researchers, with the help of an expert, worked on transforming shading devices into virtual objects. Cirulis & Brigmanis (2013) recommended that the application recognize surfaces based on a QR code programmed for this experiment.

The application's home screen asks users if they are standing inside or outside the building. Based on the answer, the application uses the device's camera to display shading devices on the screen. The virtual shading devices were designed to fit the façade so the participant could move the camera around the building to see the shading devices from different angles. When a participant views the shading devices from inside the building, the application casts a virtual shadow that mimics the shadow of the real shading device.

2.5 SETTING

The study was conducted on the halls complex of JUST. The complex consists of two longitudinal buildings. Each building includes seminar halls on the three floors: basement, ground, and first. It is a long, curved, and linear building running from the southeast to the south with a single-loaded corridor plan. The northern building of the halls complex, specifically the ground floor of the south-oriented façade, was selected for the experiment. This particular study location is due to the building's south-facing continuous glazed façade. This feature allows participants to concentrate solely on the shading device without any distractions from the design or appearance of the façade itself (see FIG. 4). Furthermore, feedback from users of this specific building indicates that a control strategy is required to manage excessive solar exposure, making it a suitable and relevant location for experimenting.

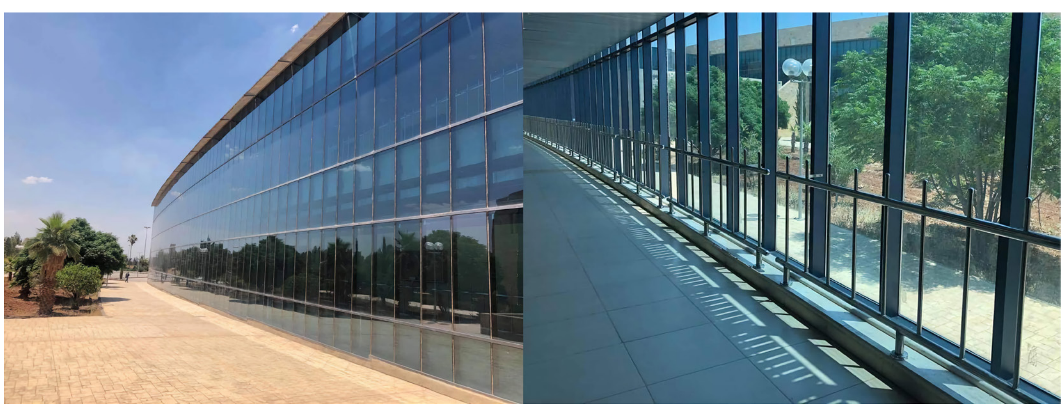

FIG. 4 Outdoor and indoor shots from the ground floor of the northern building of the halls complex.

2.6 THE QUESTIONNAIRE

The questionnaire included a cover page with initial directions, followed by the body of the questionnaire, and a closing page with a thank you note. The body of the questionnaire was divided into two parts. The first part included a total of 18 questions about the physical attributes of the shading devices, categorized into indoor and outdoor questions. Each participant evaluated different scenes using a seven-step SDS without numerical values to avoid bias related to positivity and negativity.

The first part of the questionnaire included scenes of the façade under various conditions: without any shading device (base case) and with eight different shading devices (Shading Device 1 to Shading Device 8). Participants evaluated each scene from both outdoor and indoor perspectives.

In the second part of the questionnaire, participants were asked demographic questions to ensure the sample's representativeness and gain insights into potential response variations based on the participants' backgrounds. The demographic questions included age, gender, and field of expertise (architect or non-architect).

2.7 EXPERIMENT

The experiment occurred between October and November 2020, specifically between 9:00 am and 12:00 pm. It spanned 23 days. Throughout the duration, the weather remained consistently sunny with clear skies. A QR code was printed and affixed to the glass surface of the building's façade to facilitate the experiment. Another code was attached to the inner surface of the same façade. Each participant was provided a 10-inch tablet with the required application installed and ready for use. The respondents were instructed to view the building using the tablet's camera with virtual shading devices. In total, eight shading devices were individually presented to the participants for evaluation (see FIG. 5).

The dimensions of the chosen shading devices are as follows:

1. Horizontal overhang: 1 m depth and 0.02 m thickness.
2. Fixed horizontal fins: 0.02 m depth with a spacing of 0.25 m between slats.
3. Fixed vertical fins: 0.1 m depth with a spacing of 0.1 m between fins.
4. Egg crate: 0.15 m depth with 0.15 spacing between vertical slats and 0.15 spacing between horizontal slats.
5. Artistic shading device – parametrically designed (adapted from Al-Masrani et al., 2018).
6. Movable horizontal louvres: 0.15 m depth with 0.15 m spacing between slats. The control type, encompassing passive and active horizontal movable shading devices, was not specified.
7. Movable vertical louvers: 0.15 m depth with 0.15 m spacing between louvers. The control type, encompassing passive and active vertical movable shading devices, was not specified.
8. Shape-morphing shading device (adapted from Al-Masrani et al., 2018).

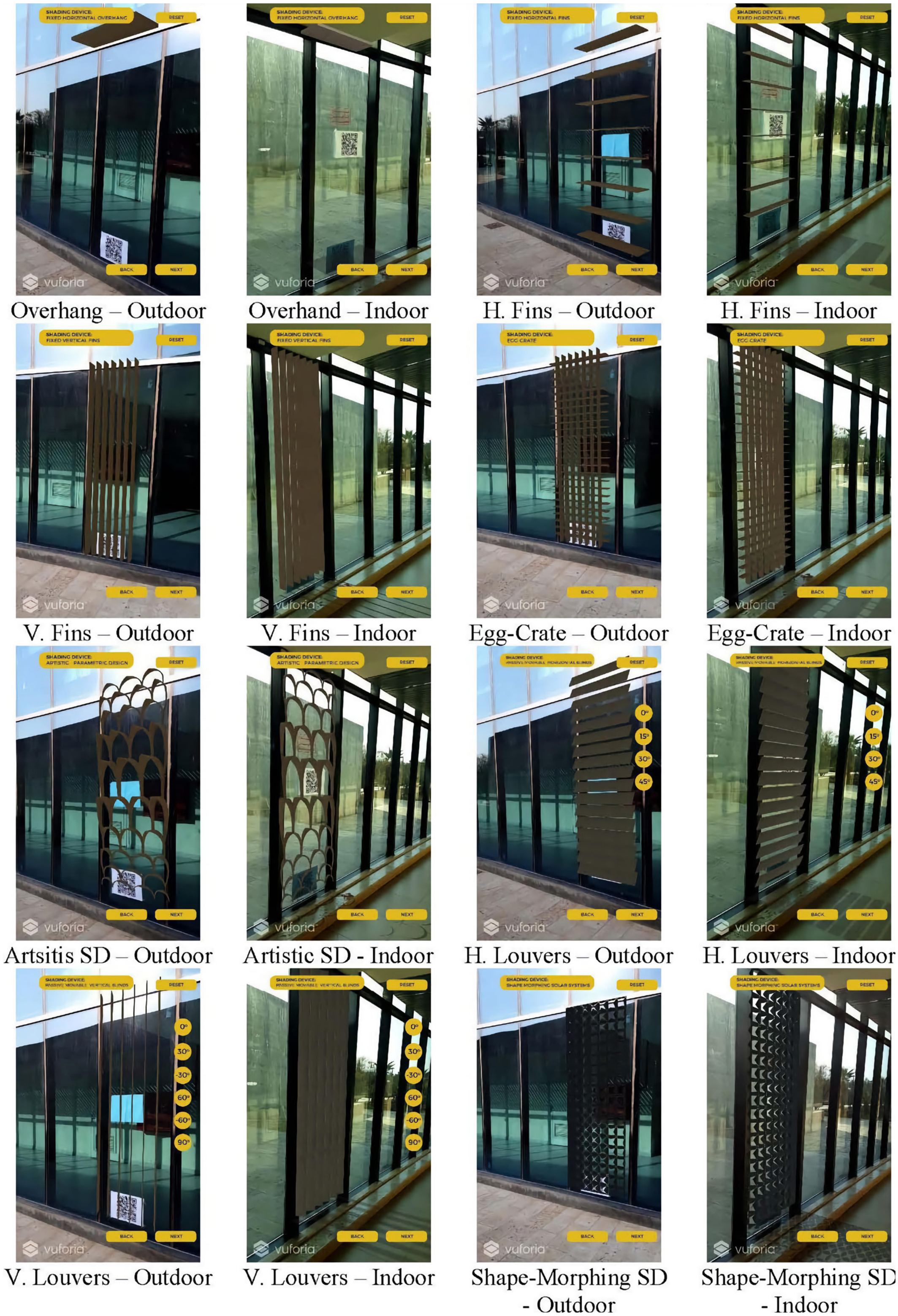

FIG. 5 The eight shading devices as they were screened using AR, outdoor/indoor.

2.8 ENERGY SIMULATION

A simulation was run using the DesignBuilder software to examine the thermal efficiency of the shading devices. The simulation focused on a prototype seminar room (FIG. 6) located in the halls complex of JUST, situated in Irbid, Jordan, at a longitude of 35.9° East and a latitude of 31.90° West. The seminar room is a prototype seminar room with a capacity of 100 people and covers an area of 136 m^2. The south elevation of the building is 100% glazed, while the north elevation has a continuous strip window with a 30% window area.

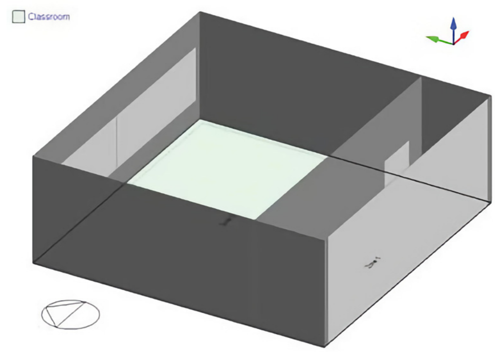

FIG. 6 Classroom model.

The energy simulation was conducted for one year, considering the region's specific cooling and heating demands. The cooling period was set from April 1 to October 31, while the heating period covered November 1 to March 31. The building operates as classrooms with a schedule of five days a week, from Sunday to Thursday, operating from 8:00 am to 5:00 pm.
To define the thermal properties of the building elements, the following U-values were considered: walls (0.42), roof (0.22), floor (0.25), and glazing (1.6). These values conform to the local Jordanian codes. The heating load set-point was set to 19°C with a set-back temperature of 14°C, while the cooling load set-point was set to 25°C with a set-back temperature of 30°C.

For comparison purposes, the simulation included a base case and four shading devices: a 1-m depth overhang, horizontal fins, vertical fins, and an egg crate.

2.9 DATA MANAGEMENT AND ANALYSIS

The study employed t-tests and one-way ANOVA with post hoc analysis to analyse the collected data. The t-tests assessed differences in perceptions between architect and non-architect groups, while ANOVA explored aesthetic attributes of shading devices. Augmented Reality (AR) was used for visualization, with physical attributes of shading devices as independent variables and participant opinions as dependent variables. The study thoroughly examined aesthetic values such as brightness, uniqueness, cheerfulness, impressiveness, protectiveness, delicateness, and tightness.

Additionally, simulation results were presented to illustrate the energy performance of shading devices. This holistic approach, combining statistical methods, AR technology, and simulation, provided a thorough understanding of the aesthetic perceptions and potential differences between user groups.

3 RESULTS

Two types of statistical analysis were used to analyse the collected data: *t*-test and one-way analysis of variance (ANOVA) with post hoc analysis. T-test is used to determine if there is a significant difference between two groups of variables, using the mean for each group as a basis. The difference between the means of the two groups is *t*, represented in standard error units. It is assumed that the two means are equal, and the rejection of this null hypothesis indicates a significant difference between the two groups—the greater the magnitude of *t*, the greater the evidence against the null hypothesis. The present study used a t-test to assess the differences between the architect and non-architect groups.

Additionally, this study used an ANOVA F-test to analyse the results concerning the devices' aesthetics. The ANOVA F-test is used to determine if there is a significant difference between three or more groups of variables, once again using the mean for each group. ANOVA uses F-tests to test the equality of the means statistically. If F-test results show significant differences between the means, then post hoc analysis is used to compare individual differences between each pair of variables. The F-test and post hoc pairwise comparisons were used in the present study to determine the differences between the eight types of shading devices.

3.1 AESTHETIC VALUE OF SHADING DEVICES

3.1.1 Bright – Dull

The results of the F-test show that there was a significant difference in the perception of different types of shading devices in terms of brightness: $F(1,101) = 1418.410$, $p = .00$. Based on the ANOVA results, movable vertical louvres are the brightest, and the egg crate is the dullest (Table 3 and FIG. 7).

TABLE 3 Pairwise comparisons (Bright – Dull)

	Overhang		Horizontal fins		Vertical fins		Egg-Crate		Artistic SD		Horizontal louvers		Vertical louvers		Shape-Morphing SD	
	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.
Overhang			-.108	.469	-.466(*)	.009	.745(*)	.000	-.490(*)	.012	-.191	.358	-1.000(*)	.000	-.745(*)	.001
Horizontal fins	.108	.469			-.358(*)	.029	.853(*)	.000	-.382(*)	.045	-.083	.634	-.892(*)	.000	-.637(*)	.004
Vertical fins	.466(*)	.009	.358(*)	.029			1.211(*)	.000	-.025	.897	.275	.117	-.534(*)	.000	-.279	.189
Egg-Crate	-.745(*)	.000	-.853(*)	.000	-1.211(*)	.000			-1.235(*)	.000	-.936(*)	.000	-1.745(*)	.000	-1.490(*)	.000
Artistic SD	.490(*)	.012	.382(*)	.045	.025	.897	1.235(*)	.000			.299	.194	-.510(*)	.003	-.255	.255
Horizontal louvers	.191	.358	.083	.634	-.275	.117	.936(*)	.000	-.299	.194			-.809(*)	.000	-.554(*)	.007
Vertical louvers	1.000(*)	.000	.892(*)	.000	.534(*)	.000	1.745(*)	.000	.510(*)	.003	.809(*)	.000			.255	.238
Shape-Morphing SD	.745(*)	.001	.637(*)	.004	.279	.189	1.490(*)	.000	.255	.255	.554(*)	.007	-.255	.238		

3.1.2 Unique – Common

The results of the F-test show that there was a significant difference in the perception of different types of shading devices in terms of uniqueness: F (1,101) = 988.374, p = .00. Based on the ANOVA results, the shape-morphing shading device is the most unique, and the horizontal overhang is the most common (Table 4 and FIG. 7).

TABLE 4 Pairwise comparisons (Unique – Common)

	Overhang		Horizontal fins		Vertical fins		Egg-Crate		Artistic SD		Horizontal louvers		Vertical louvers		Shape-Morphing SD	
	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.
Overhang			.574(*)	.000	-.480(*)	.011	-.775(*)	.001	-1.495(*)	.000	-.485(*)	.008	-.873(*)	.000	-2.064(*)	.000
Horizontal fins	.574(*)	.000			.093	.530	-.201	.337	-.922(*)	.000	.088	.583	-.299	.069	-1.490(*)	.000
Vertical fins	.480(*)	.011	-.093	.530			-.294	.125	-1.015(*)	.000	-.005	.979	-.392(*)	.002	-1.583(*)	.000
Egg-Crate	.775(*)	.001	.201	.337	.294	.125			-.721(*)	.000	.289	.219	-.098	.618	-1.289(*)	.000
Artistic SD	1.495(*)	.000	.922(*)	.000	1.015(*)	.000	.721(*)	.000			1.010(*)	.000	.623(*)	.001	-.569(*)	.000
Horizontal louvers	.485(*)	.008	-.088	.583	.005	.979	-.289	.219	-1.010(*)	.000			-.387(*)	.033	-1.578(*)	.000
Vertical louvers	.873(*)	.000	.299	.069	.392(*)	.002	.098	.618	-.623(*)	.001	.387(*)	.033			-1.191(*)	.000
Shape-Morphing SD	2.064(*)	.000	1.490(*)	.000	1.583(*)	.000	1.289(*)	.000	.569(*)	.000	1.578(*)	.000	1.191(*)	.000		

3.1.3 Cheerful – Depressing

The results of the F-test show that there was a significant difference in the perception of different types of shading devices in terms of cheerfulness: F (1,101) = 1298.185, p = .00. Based on the ANOVA results, the shape-morphing shading device is the most cheerful, and the egg crate is the most depressing (Table 5 and FIG. 7).

TABLE 5 Pairwise comparisons (Cheerful – Depressing)

	Overhang		Horizontal fins		Vertical fins		Egg-Crate		Artistic SD		Horizontal louvers		Vertical louvers		Shape-Morphing SD	
	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.
Overhang			-.255	.088	-.294	.147	.426(*)	.040	-.422(*)	.045	-.436(*)	.041	-.775(*)	.000	-1.397(*)	.000
Horizontal fins	.255	.088			-.039	.807	.681(*)	.000	-.167	.400	-.181	.276	-.520(*)	.002	-1.142(*)	.000
Vertical fins	.294	.147	.039	.807			.721(*)	.000	-.127	.519	-.142	.432	-.480(*)	.000	-1.103(*)	.000
Egg-Crate	-.426(*)	.040	-.681(*)	.000	-.721(*)	.000			-.848(*)	.000	-.863(*)	.000	-1.201(*)	.000	-1.824(*)	.000
Artistic SD	.422(*)	.045	.167	.400	.127	.519	.848(*)	.000			-.015	.953	-.353	.076	-.975(*)	.000
Horizontal louvers	.436(*)	.041	.181	.276	.142	.432	.863(*)	.000	.015	.953			-.338(*)	.048	-.961(*)	.000
Vertical louvers	.775(*)	.000	.520(*)	.002	.480(*)	.000	1.201(*)	.000	.353	.076	.338(*)	.048			-.623(*)	.003
Shape-Morphing SD	1.397(*)	.000	1.142(*)	.000	1.103(*)	.000	1.824(*)	.000	.975(*)	.000	.961(*)	.000	.623(*)	.003		

3.1.4 Impressive – Unimpressive

The results of the F-test show that there was a significant difference in the perception of different types of shading devices in terms of impressiveness: F (1,101) = 1052.386, p = .00. Based on these ANOVA results, the shape-morphing shading device is the most impressive, and the egg crate is the most unimpressive (Table 6 and FIG. 7).

TABLE 6 Pairwise comparisons (Impressive – Unimpressive)

	Overhang		Horizontal fins		Vertical fins		Egg-Crate		Artistic SD		Horizontal louvers		Vertical louvers		Shape-Morphing SD	
	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.
Overhang			-.328(*)	.032	-.407(*)	.037	.132	.501	-.260	.211	-.578(*)	.002	-.711(*)	.000	-1.642(*)	.000
Horizontal fins	.328(*)	.032			-.078	.630	.461(*)	.021	.069	.748	-.250	.094	-.382(*)	.027	-1.314(*)	.000
Vertical fins	.407(*)	.037	.078	.630			.539(*)	.009	.147	.522	-.172	.351	-.304(*)	.026	-1.235(*)	.000
Egg-Crate	-.132	.501	-.461(*)	.021	-.539(*)	.009			-.392	.057	-.711(*)	.002	-.843(*)	.000	-1.775(*)	.000
Artistic SD	.260	.211	-.069	.748	-.147	.522	.392	.057			-.319	.223	-.451(*)	.039	-1.382(*)	.000
Horizontal louvers	.578(*)	.002	.250	.094	.172	.351	.711(*)	.002	.319	.223			-.132	.460	-1.064(*)	.000
Vertical louvers	.711(*)	.000	.382(*)	.027	.304(*)	.026	.843(*)	.000	.451(*)	.039	.132	.460			-.931(*)	.000
Shape-Morphing SD	1.642(*)	.000	1.314(*)	.000	1.235(*)	.000	1.775(*)	.000	1.382(*)	.000	1.064(*)	.000	.931(*)	.000		

3.1.5 Protected – Exposed

The results of the F-test show that there was a significant difference in the perception of shading devices in terms of protectiveness: F (1,101) = 1043.372, p = .00. Based on the ANOVA results, the shape-morphing shading device renders the interior the most protected, and the artistic shading device leaves it the most exposed (Table 7 and FIG. 7).

TABLE 7 Pairwise comparisons (Protected – Exposed)

	Overhang		Horizontal fins		Vertical fins		Egg-Crate		Artistic SD		Horizontal louvers		Vertical louvers		Shape-Morphing SD	
	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.
Overhang			-.701(*)	.000	-.289	.102	-1.216(*)	.000	.466(*)	.029	-1.088(*)	.000	-.623(*)	.001	-1.495(*)	.000
Horizontal fins	.701(*)	.000			.412(*)	.007	-.515(*)	.000	1.167(*)	.000	-.387(*)	.007	.078	.598	-.794(*)	.000
Vertical fins	.289	.102	-.412(*)	.007			-.926(*)	.000	.755(*)	.000	-.799(*)	.000	-.333(*)	.008	-1.206(*)	.000
Egg-Crate	1.216(*)	.000	.515(*)	.000	.926(*)	.000			1.681(*)	.000	.127	.462	.593(*)	.000	-.279	.063
Artistic SD	-.466(*)	.029	-1.167(*)	.000	-.755(*)	.000	-1.681(*)	.000			-1.554(*)	.000	-1.088(*)	.000	-1.961(*)	.000
Horizontal louvers	1.088(*)	.000	.387(*)	.007	.799(*)	.000	-.127	.462	1.554(*)	.000			.466(*)	.000	-.407(*)	.008
Vertical louvers	.623(*)	.001	-.078	.598	.333(*)	.008	-.593(*)	.000	1.088(*)	.000	-.466(*)	.000			-.873(*)	.000
Shape-Morphing SD	1.495(*)	.000	.794(*)	.000	1.206(*)	.000	.279	.063	1.961(*)	.000	.407(*)	.008	.873(*)	.000		

3.1.6 Delicate – Rugged

The results of the F-test show that there was a significant difference in the perception of different types of shading devices in terms of delicateness: $F(1,101) = 1779.868$, $p = .00$. Based on the ANOVA results, the artistic shading device is the most delicate, and the egg crate is the most rugged (Table 8 and FIG. 7).

TABLE 8 Pairwise comparisons (Delicate – Rugged)

	Overhang		Horizontal fins		Vertical fins		Egg-Crate		Artistic SD		Horizontal louvers		Vertical louvers		Shape-Morphing SD	
	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.
Overhang			.245	.096	.039	.811	1.044(*)	.000	-.270	.143	.260	.148	-.221	.230	-.093	.659
Horizontal fins	-.245	.096			-.206	.179	.799(*)	.000	-.515(*)	.002	.015	.925	-.466(*)	.006	-.338	.107
Vertical fins	-.039	.811	.206	.179			1.005(*)	.000	-.309	.119	.221	.179	-.260(*)	.041	-.132	.530
Egg-Crate	-1.044(*)	.000	-.799(*)	.000	-1.005(*)	.000			-1.314(*)	.000	-.784(*)	.000	-1.265(*)	.000	-1.137(*)	.000
Artistic SD	.270	.143	.515(*)	.002	.309	.119	1.314(*)	.000			.529(*)	.017	.049	.800	.176	.438
Horizontal louvers	-.260	.148	-.015	.925	-.221	.179	.784(*)	.000	-.529(*)	.017			-.480(*)	.003	-.353	.068
Vertical louvers	.221	.230	.466(*)	.006	.260(*)	.041	1.265(*)	.000	-.049	.800	.480(*)	.003			.127	.563
Shape-Morphing SD	.093	.659	.338	.107	.132	.530	1.137(*)	.000	-.176	.438	.353	.068	-.127	.563		

3.1.7 Tight – Loose

The results of the F-test show that there was a significant difference in the perception of different types of shading devices in terms of tightness: $F(1,101) = 1716.687$, $p = .00$. Based on the ANOVA results, the egg crate is the tightest, and the artistic shading device is the loosest (Table 9 and FIG. 7).

TABLE 9 Pairwise comparisons (Tight – Loose)

	Overhang		Horizontal fins		Vertical fins		Egg-Crate		Artistic SD		Horizontal louvers		Vertical louvers		Shape-Morphing SD	
	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.	Mean Dif.	Sig.
Overhang			-.314(*)	.028	-.147	.330	-1.039(*)	.000	.402(*)	.041	-.588(*)	.000	.083	.651	-.461(*)	.024
Horizontal fins	.314(*)	.028			.167	.210	-.725(*)	.000	.716(*)	.000	-.275	.063	.397(*)	.017	-.147	.414
Vertical fins	.147	.330	-.167	.210			-.892(*)	.000	.549(*)	.005	-.441(*)	.003	.230	.114	-.314	.068
Egg-Crate	1.039(*)	.000	.725(*)	.000	.892(*)	.000			1.441(*)	.000	.451(*)	.010	1.123(*)	.000	.578(*)	.004
Artistic SD	-.402(*)	.041	-.716(*)	.000	-.549(*)	.005	-1.441(*)	.000			-.990(*)	.000	-.319	.103	-.863(*)	.000
Horizontal louvers	.588(*)	.000	.275	.063	.441(*)	.003	-.451(*)	.010	.990(*)	.000			.672(*)	.000	.127	.467
Vertical louvers	-.083	.651	-.397(*)	.017	-.230	.114	-1.123(*)	.000	.319	.103	-.672(*)	.000			-.544(*)	.003
Shape-Morphing SD	.461(*)	.024	.147	.414	.314	.068	-.578(*)	.004	.863(*)	.000	-.127	.467	.544(*)	.003		

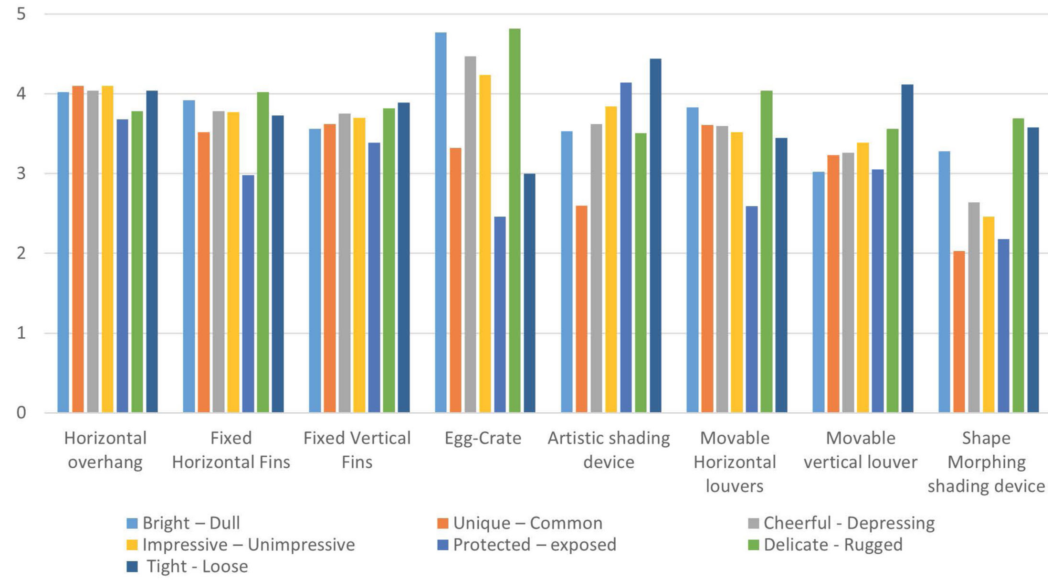

FIG. 7 The order of shading devices based on the results of the F-test.

3.2 ARCHITECTS VS. NON-ARCHITECTS

T-tests were conducted separately for each variable to determine the differences in perception between architect and non-architect groups. The results indicated significant differences between the two groups in their perception of shading devices.

The findings indicated that the variations between architects and non-architects were most pronounced when it came to their assessments of impressiveness, followed by the attributes of brightness and cheerfulness. The results suggest that non-architects viewed shading devices as impressive, whereas architects perceived them as more neutral or unimpressive. Similarly, non-architects perceived shading devices as brighter and more cheerful than architects (Table 10).

3.3 SIMULATION RESULTS

The results of the energy performance simulation for each shading device are presented in Table 11, depicting the heating and cooling loads resulting from the DesignBuilder simulation. Specifically, the energy consumption of a 1-meter overhang, horizontal fins, vertical fins, and egg crate is compared against the base case, representing the building's energy consumption without the use of any shading devices. As indicated in the table, the 1-meter overhang consumes 90% of the energy, horizontal fins consume 84%, vertical fins consume 93%, and egg crate consumes 83%, all compared to the base case's energy consumption.

TABLE 10 Significant results of T-test based on academic major (architects and non-architects)

Variables		College	N	Mean	Std. Deviation	*t*	Sig. (2-tailed)
Fixed Vertical Fins – Outdoor	Impressive – Unimpressive	Arch.	49	4.10	1.558	2.729	.008
		Non-arch.	53	3.15	1.925		
Egg-Crate – Outdoor	Bright – Dull	Arch.	49	5.39	1.835	2.114	.037
		Non-arch.	53	4.60	1.905		
	Cheerful – Depressing	Arch.	49	5.24	1.762	2.595	.011
		Non-arch.	53	4.28	1.965		
	Impressive – Unimpressive	Arch.	49	5.02	2.046	2.945	.004
		Non-arch.	53	3.81	2.094		
Artistic Shading Device – Outdoor	Protected – Exposed	Arch.	49	3.73	1.955	-2.254	.026
		Non-arch.	53	4.58	1.855		
Movable Horizontal Louvers – Outdoor	Bright – Dull	Arch.	49	4.78	1.817	3.539	.001
		Non-arch.	53	3.45	1.947		
	Cheerful – Depressing	Arch.	49	4.35	1.774	3.137	.002
		Non-arch.	53	3.21	1.885		
	Impressive – Unimpressive	Arch.	49	4.27	1.857	3.405	.001
		Non-arch.	53	3.00	1.891		
Movable Vertical Louver – Outdoor	Impressive – Unimpressive	Arch.	49	3.80	1.779	1.996	.049
		Non-arch.	53	3.09	1.768		
Egg-Crate – Indoor	Bright – Dull	Arch.	49	5.02	1.702	2.517	.013
		Non-arch.	53	4.13	1.851		
	Cheerful – Depressing	Arch.	49	4.67	1.842	2.490	.014
		Non-arch.	53	3.74	1.953		
	Impressive – Unimpressive	Arch.	49	4.67	1.908	2.882	.005
		Non-arch.	53	3.53	2.090		
	Protected – exposed	Arch.	49	2.22	1.403	-2.088	.039
		Non-arch.	53	2.91	1.842		
	Tight – Loose	Arch.	49	2.76	1.690	-2.684	.009
		Non-arch.	53	3.70	1.846		
Movable Horizontal Louvers – Indoor	Bright – Dull	Arch.	49	4.10	1.723	2.874	.005
		Non-arch.	53	3.09	1.811		
	Cheerful – Depressing	Arch.	49	4.12	1.752	3.864	.000
		Non-arch.	53	2.83	1.626		
	Impressive – Unimpressive	Arch.	49	4.02	1.750	3.208	.002
			53	2.91	1.757		

TABLE 11 Heating and cooling loads resulting from DesignBuilder simulation

	Cooling loads (Kwh)	Heating loads (Kwh)	Total	Saving
Base case	27,745.93	1,469.69	29,215.6	
Overhang	24,451.63	1,724.59	26,176.2	3,039.4
Horizontal Fins	21,609.24	2,838.35	24,447.6	4,768.03
Vertical Fins	25,363.25	1,794.29	27,157.5	2,058.08
Egg-Crate	20,604.99	3,623.45	24,228.4	4,987.18

4 DISCUSSION

The primary goal of this research was to investigate the ways shading devices influence the visual perception and assessment of a building. The study also aimed to determine the degree of consistency between the functionality of the shading device and its aesthetic preference. The study's findings demonstrated that shading devices significantly influenced the aesthetic perception and assessment of the building's façade. The impact varied depending on the type of shading device being tested, with some devices being perceived as pleasing while others were found to have a negative effect on the judgment and evaluation of the building's façade. These results strongly support the main hypothesis of the research, highlighting the influence of shading devices on the overall aesthetic appeal of a building.

Two shading devices, namely Shape Morphing and Egg Crate, clearly stood out in terms of respondent preferences. Shape Morphing shading device was rated as the most unique among the tested shading devices and was positively perceived and evaluated. This positive perception can be attributed to their dynamic shape, which can enhance the visual appeal of the building façade. In contrast, the Egg Crate shading device was negatively perceived, with high ratings for dullness, unimpressiveness, and a sense of depression. The grid-like pattern of the Egg Crate devices might be found unappealing for the participants.

Vertical Movable Louvers were rated as the brightest and the second most cheerful and impressive option. Other shading devices showed relatively similar evaluation results, including Horizontal Overhang, Fixed Horizontal Fins, and Fixed Vertical Fins. However, Horizontal Overhang was evaluated as the most common shading device and was perceived as dull and unimpressive. This finding is consistent with Berlyne's proposition of an inverted U-shaped relationship between uniqueness and aesthetic value (Veitch & Arkkelin, 1995). According to this theory, individuals tend to find objects with moderate levels of uniqueness more enjoyable than objects that are extremely common or excessively unique.

4.1 ARCHITECTS VS. NON-ARCHITECTS

The study results revealed significant differences in the assessments of shading devices between architects and non-architects. These findings align with previous research (e.g., Ibrahim et al. (2002)) and are particularly evident in the affective aspects of impressiveness, brightness, and cheerfulness. While the non-architect group evaluated the shading devices as impressive, bright, and cheerful, the architect group tended to have more neutral or unimpressed perceptions.

The outcome of non-architects perceiving shading devices as impressive supports the notion that individuals without architectural training or expertise may greatly appreciate these devices' visual impact and functionality. Factors such as novelty or aesthetic appeal could influence their perception of impressiveness. Conversely, more rational architects may judge aesthetics more strictly than non-architects, as Yazdanfar et al. (2015) explained. Furthermore, these results emphasize the previous studies conducted by Hershberger & Cass (1974), Nasar (1994), Abu-Obeid et al. (2008), and Akalin et al. (2009), which provided evidence that experts and non-experts perceive architectural objects differently. These researchers attributed this difference to the influence of experience and continuous exposure to architecture throughout an architect's career's learning and practice stages.

Furthermore, this difference in perception could also stem from varied perspectives on lighting preferences or the effectiveness of shading devices in creating a visually pleasant and uplifting environment. Non-architects may prioritize a brighter and cheer ambience, while architects may consider more nuanced factors related to lighting design and specific project requirements.

In contrast to the significant differences concerning affective variables, the outcomes relating to organizational variables revealed only slight disparities between architects and non-architects, while the formal variables demonstrated almost negligible distinctions. This finding can be better interpreted by referring to a study conducted by Šafárová, Pírko, Juřík, Pavlica, & Németh (2019), which concluded that architecture students, who are not yet considered experts due to their limited practical experience, perceive the physical characteristics of buildings in a relatively similar manner to non-architects. This suggests that during the early stages of their architectural education, students may exhibit more similarities with non-architects in their perceptions, indicating that they are still developing their expertise.

4.2 SHADING DEVICES AND ENERGY EFFICIENCY

As anticipated, the simulation results confirmed that shading devices are effective in terms of their energy performance and ability to reduce energy consumption to various degrees. This finding aligns with previous studies conducted by Freewan (2014), Esquivias et al. (2016), and Al-Masrani et al. (2018). However, a discrepancy was observed between the aesthetic preferences for shading devices and their efficiency and performance.

Contrary to the aesthetic preferences, the most efficient shading device in terms of energy performance was the egg crate, followed by horizontal fins, overhang, and vertical fins, with vertical fins demonstrating the least efficient performance. This discrepancy can be explained by inefficient vertical shading devices used on south-oriented façades. While Choi et al. (2014) suggested using vertical shading devices on western and eastern elevations, Esquivias et al. (2016) claimed that this type of shading device is the least effective, especially in preventing solar exposure from the east due to the lower intensity of morning solar radiation. This claim is consistent with the results of the present study.

It is important to note that other types of shading devices were not simulated due to limitations in the modelling tools of the simulation software. However, other research has provided findings on these devices. Al-Masrani et al. (2018) tested a parametrically designed shading device and found that it improves daylight quality inside buildings and reduces lighting demands. Regarding shape-morphing systems, previous research has highlighted the need for more studies to assess the performance of these devices over extended periods and under real conditions (Al-Masrani et al., 2018; Premier, 2019). Additionally, Sheikh & Asghar (2019) attempted to calculate the energy efficiency of a biomimetic façade but did not compare it to other types of shading devices.

5 CONCLUSIONS

This study aimed to investigate the impact of shading devices on the visual perception of buildings while also comparing their energy efficiency. The findings indicate that incorporating shading devices into buildings enhances their energy efficiency without necessarily compromising their visual appearance. These results hold true despite the varying degrees of favorability that users associate with different types of shading devices and the differences observed in the energy performance of various shading devices. Acknowledging the distinctions between architects and non-architects in this evaluation process is important. Understanding these assessment patterns can assist architects and designers in making informed decisions about selecting and designing shading devices. This involves considering not only functional requirements but also the aesthetic preferences and perceptions of the building's occupants and users. Based on this study and the integration of the results regarding aesthetic value and energy performance, the following conclusions can be drawn:

- Horizontal louvres are the most recommended shading device for southern and northern façades. They ranked third in terms of aesthetic value and second in energy performance.
- Fixed horizontal fins and artistic shading devices are the second recommended types. Fixed horizontal fins showed high effectiveness in reducing energy demands despite being among the three least favourably rated in terms of aesthetics. The artistic shading device, although not simulated, is assumed to provide solar control similar to an egg crate and horizontal fins, indicating its potential for effective energy demand reduction. Aesthetically, the artistic shading device and horizontal fins were rated as moderate in terms of affective variables, suggesting that parametric design can play a role in creating aesthetically pleasing shading devices.
- Overhangs, while not highly ranked in terms of aesthetics, proved effective in energy performance and are therefore recommended, albeit after other horizontal shading devices.
- Vertical louvres and vertical fins were favourably rated in terms of affective variables but demonstrated the least efficiency in terms of energy. Hence, they are not recommended.
- Egg-crate shading devices had the best energy performance but had a negative impact on the visual appearance of buildings. Therefore, designers are not recommended to use egg-crate shading devices.
- Shape-morphing shading devices had the most positive effect on the visual appearance of buildings among the tested shading devices. Further research is needed to understand how their energy efficiency compares to other types of shading devices.

There is much room for further progress in determining the effect of shading devices on the perception of buildings:

- Further research is needed to establish a recommendation for shape-morphing shading devices.
- Future studies should evaluate a more comprehensive range of shading devices.
- Future studies should consider the experience stage of architects and the differences between academic architects and architects from the practical fields.
- Shading devices may be studied in contexts other than educational buildings to enhance the generalizability of the present results.

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