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Smart Painting Display Board with Adjustable Illumination

Marlo Victor A. Bacuna

Capiz State University-Main Campus,

Roxas City, Capiz, Philippines

Abstract*:* Common exhibits use painting stands, display panels, and boards to hold artworks, but lack proper illumination, which is vital for enhancing the visual impact of the displayed artworks. This study used a developmental research method. A researcher-made evaluation sheet, validated by field and academic experts, was used to assess the display board. The main objective of the study was to design and develop a smart painting display board with adjustable illumination. The device could mount paintings ranging from small (16" × 20") to large (36" × 48") without displacement, maintaining a vertical upright position at a 90-degree angle. The illuminance coverage was adequate across all size categories, indicating that the painting surfaces were fully illuminated and rated "Good." The average illuminance was 55.6 lux, which closely aligns with the 50 lux recommendation for highly light-sensitive materials. In addition, the system demonstrated responsive performance in both the color adjustment and on/off functions. It demonstrates excellent operational performance, with high stability in both stationary and moving positions. Overall, the device was rated "Very Acceptable" for usability, illumination quality, visual enhancement, and safety.

Keywords: smart painting display board, adjustable illumination, system responsiveness, operating performance.

I. INTRODUCTION

Background of the Study

The way artworks are presented plays a vital role in how they are perceived and appreciated. On a global scale, art exhibitions rely on various display systems such as painting stands, panels, and boards to showcase artworks. However, many traditional display methods lack adequate, adaptive illumination, which is essential for enhancing the visual impact of artworks. Lighting significantly influences visibility, color accuracy, texture perception, and the overall emotional effect of a painting (Boyce, 2019 [1]; Cuttle, 2016 [2]). Conventional display systems often depend on static light sources such as fixed LED or fluorescent lighting, which, although functional, are limited in their ability to adapt to varying environmental conditions, artwork materials, and aesthetic requirements. As a result, issues such as glare, uneven illumination, and inconsistent lighting conditions may distort artworks' true appearance and degrade their visual quality (DiLaura et al., 2020) [3]. Modern lighting solutions, such as flexible spotlights with adjustable beam angles and dimming capabilities, provide more precise illumination, enhancing detail and preserving color fidelity (Boyce, 2019) [1]. Technological advancements have further enabled the development of smart lighting systems capable of real-time adjustments in brightness, color temperature, and direction. These innovations contribute to more dynamic and adaptive display environments, improving both the presentation and viewer experience (Park & Kim, 2021) [4]. Despite these developments, many existing systems remain fragmented, with lighting and display components functioning independently rather than as an integrated system, limiting efficiency and usability. In response to these concerns, this study centers on the design and development of a smart painting display board with adjustable illumination. The device integrates adjustable lighting and a stable structural framework into a single system, aiming to provide uniform and adaptive illumination, reliable performance, and enhanced visual presentation of artworks. By combining principles of design engineering, electronics, and art presentation, the study seeks to produce a functional and innovative display solution. Furthermore, the study aligns with broader development goals, particularly in fostering innovation within the creative industries. Ultimately, the smart painting display board with adjustable illumination is envisioned to enhance the appreciation of artworks and to advance art presentation practices.

Significance of the Study

The study is beneficial to artists and curators, gallery owners, art enthusiasts, interior designers, visual art teachers, and students.

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Scope and Limitation of the Study

This study focused on the design, development, and evaluation of a smart painting display board with adjustable illumination. The study involved the fabrication of a device with three main components: a structural framework to ensure stability and mobility; an illumination system using adjustable LED spotlights for brightness and color control; and a smart control system to control the light functions via a smartphone.

II. METHODOLOGY

This study used the developmental method of research. The designing and evaluation type of study was adopted and used in this study. The researcher designed and developed a smart painting display board with adjustable illumination to enhance the visual impact of displayed paintings in museum exhibits, galleries, or related events.

III. RESULTS AND DISCUSSION

Technical Features and Functions of Smart Painting Display Board with Adjustable Illumination (SPDBAI)

The following were the technical features, compositions, and functions of SPDBAI:

Display Board. A 48" width and 60" height with a 12" thick board made of 1/4" aluminum acrylic panel for exterior covering, supported with 1" x 1" tubular and 1" flat bars as interior framing that supports the overall stability of the board. The display board holds the painting vertically and serves as its background.

Side extension display board. Two sliding extension boards are located on both sides of the painting display board. The side extension boards are used to extend the main display board when additional width is needed for displaying large paintings or two or more smaller paintings.

Adjustable overhead lights. A lighting system composed of three adjustable lamps was designed, with two lamps on either side and attached to a sliding railing that allowed lateral movement to adjust their placement. The adjustable overhead lamps were used to illuminate the displayed paintings.

Side adjustable lights. An additional light is located on both sides of the main display board. Side-adjustable lights are used when additional illumination is needed for displaying large or multiple smaller paintings.

Adjustable bottom lights. Two adjustable lamps are positioned at the bottom front of the painting display board, facing upward toward the artwork. They are mounted on a sliding platform that allows movement closer to or farther from the display board. The adjustable bottom lights provide focused illumination for the artwork. Users can adjust both the color and position of the lamps to enhance the appearance of the displayed painting.

Manual control board. An electrical manual control setup is located at the back of the display board. The manual control board is used to operate and adjust the lighting as needed to illuminate and enhance the visual appearance of the displayed painting.

Smart Lighting Control System. A system integrating the Internet of Things (IoT) has been developed to control the lighting functions of the painting display board. This is achieved using smart plugs connected to both the overhead lighting system and the adjustable bottom lights. The controls are registered on a smartphone through an internet connection, enabling the user to operate and manage the lighting functions remotely via the mobile application.

Telescopic Hanger Bar. A 4 ft. cylindrical steel bar with 18" extension on both sides. It is placed horizontally at the top of the display board and extends along both extension sides. The hanger bar is used to hold the paintings vertically, with nylon strings attached to the back of each painting.

Caster Wheels with Lock. Located at the base of the painting display board are eight wheels in total. Four wheels are attached to the main board, while four locking wheels are distributed across the side extension boards to provide smooth sliding and secure locking functions. Caster wheels allow the device to be easily moved to any location the operator chooses.

The device's framing and sliding extension mechanisms align with the modular structural design principles described by Smith and Chen (2018) [5], emphasizing stability and adaptability in exhibition settings. The modular, extendable display structures of the SPDBAI demonstrated effective load distribution and flexibility across multi-size installations.

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Operating Performance of the Smart Painting Display Board with Adjustable Illumination In terms of Stability

Table I shows the operating performance of the smart painting display board with adjustable illumination in terms of stability. The stability of the Smart Painting Display Board was evaluated by measuring its vertical upright position before and after mounting artworks of varying sizes. Results showed that for all size categories from small (16”×20” and 18”×24”), medium (24”×24” and 24”×36”), and large (36”×48”), the vertical alignment remained at 90 degrees both before and after mounting the artworks. No displacement was observed across all tested sizes. This indicates that the structural framework of the display board maintained its vertical integrity regardless of the weight and dimensions of the mounted paintings. The absence of angular deviation confirms that the board’s support system effectively distributes load and prevents tilting or imbalance.

The stability of the SPDBAI was further examined during the adjustment of the extension side panels and was observed by evaluators. The results indicate that both the left-side and right-side panels were rated “Stable” during adjustment across all painting sizes. This suggests that the sliding mechanism and locking components of the extension panels functioned securely and did not compromise the overall structural balance. The stability observed during panel extension confirms that the adjustable feature does not negatively affect the board’s stability, even when expanded.

The display board’s mobility was tested while carrying artworks of small, medium, and large sizes. Across all size categories, movement was rated “Smooth” by art practitioners and exhibitors, and Architectural Drafting teachers. This indicates that the caster wheels and locking mechanisms effectively supported the unit’s weight while allowing controlled repositioning. Even when carrying larger artworks (36”×48”), the board remained smooth and stable. The results imply that the device's mechanical design and structural composition can support the intended operational loads while maintaining stability. Overall, the results confirm that the Smart Painting Display Board demonstrates excellent operational performance, with high stability in both stationary and moving conditions.

This result supports Ashby's (2017) [6] findings that structural stability is achieved when a system maintains equilibrium and resists deformation under applied loads. The absence of displacement in the present study suggests that the device's materials and frame design effectively distribute weight and maintain structural integrity.

Table I. Operating performance of the Smart Painting Display Board with Adjustable Illumination in terms of stability

Vertical Upright Measurement					Stability During Extension Side Panel Adjustment	Stability During Movement
Size Category	Specific Size	Before Mounting the Artwork	After Mounting the Artwork	Displacement	Stable/Moderately Stable/Unstable	Smooth/Moderate/ Difficult
Small	16”x20”	90 degrees	90 degrees	none	Stable	Smooth
	18”x24”	90 degrees	90 degrees	none	Stable	Smooth
Medium	24”x24”	90 degrees	90 degrees	none	Stable	Smooth
	24”x36”	90 degrees	90 degrees	none	Stable	Smooth
Large	36”x48”	90 degrees	90 degrees	none	Stable	Smooth

Note: Ratings are based on observation and evaluation of the researcher and art practitioners and exhibitors

Legend:

Stability During Extension of Side Panels	Stability During Movement
Stable	Smooth
Moderately Stable	Moderate
Unstable	Difficult

Operating Performance of the Smart Painting Display Board with Adjustable Illumination in terms of Illuminance Coverage

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Table II shows the result of the operating performance of the smart painting display board with adjustable illumination in terms of illuminance coverage. For illuminance coverage, the illumination system was evaluated across different artwork sizes by evaluators. Results indicated that illuminance coverage was adequate across all size categories, from small (16"×20" and 18"×24") to medium (24"×24" and 24"×36") to large artworks (36"×48"), ensuring the painting surface was fully illuminated. The results demonstrate that the adjustable lighting system effectively covers most standard artwork sizes commonly used in exhibitions. The presence of overhead, bottom, and side-adjustable lights contributed to adequate lighting distribution and minimized shadow formation. Based on observation and user feedback, both indoor and outdoor illumination performance were rated "Good". This indicates that the lighting system maintained sufficient brightness, clarity, and visual comfort under varying environmental conditions. The "Good" rating suggests that the illumination system provided clear visibility of artwork details without causing glare or visual discomfort. The adjustability of light intensity likely contributed to its adaptability in different lighting environments. Overall, the illumination component of the Smart Painting Display Board demonstrated satisfactory operating performance, supporting effective artwork presentation.

The results of this study conform to the findings of Boyce (2019) [1], who emphasized that effective lighting systems must provide adequate luminance, uniform distribution, and appropriate color rendering to enhance visibility without distorting the appearance of objects. The consistent, adequate lighting performance of the SPDBAI across different painting sizes, along with its favorable ratings in both indoor and outdoor settings, demonstrates that the smart painting display board with adjustable illumination is an effective device for illuminating displayed paintings.

Table II. Operating performance of the smart painting display board with adjustable illumination in terms of illuminance coverage

Categorized Sizes	Specific Painting Sizes	Illuminance Coverage Rating	Illuminance Performance in Indoor	Illuminance Performance in Outdoor
Small	16"x20"	Adequate	Good	Good
	18"x24")	Adequate	Good	Good
Medium	24"x24"	Adequate	Good	Good
	24"x36"	Adequate	Good	Good
Large	36"x 48"	Adequate	Good	Good

Illuminance Coverage Rating
Adequate (Fully Covered)
Inadequate (Partially Covered)

Illuminance Performance Indoor/Outdoor
Good – Fair - Poor

Operating Performance of the Smart Painting Display Board with Adjustable Illumination in terms of Illuminance Measurement

Table III presents the surface illuminance measurements of the smart painting display board with adjustable illumination (SPDBAI). Measurements were taken directly on the display surface at five strategic points: upper left, lower left, center, upper right, and lower right. The values were expressed in lux (lx), consistent with museum lighting standards, which evaluate illuminance at the artwork surface. At maximum intensity, the overhead adjustable lighting system produced an average illuminance (Eavg) of 754.8 lux, with a peak value of 1500 lux at the center. This level significantly exceeds the recommended 150–200 lux for moderately sensitive artworks such as oil and acrylic paintings. While such intensity enhances visual brilliance and color vibrancy, prolonged exposure may accelerate photochemical deterioration in sensitive materials. At minimum intensity, the overhead lights recorded an average of 171.8 lux, which falls within the recommended museum range for moderately sensitive artworks. This demonstrates that the dimming mechanism effectively ensures compliance with conservation standards while maintaining sufficient visual clarity. For the side lighting system, the minimum intensity yielded an average illuminance of 55.6 lux, which closely aligns with the 50-lux recommendation for highly light-sensitive materials such as watercolor, paper-based art, and textiles. This indicates suitability for conservation-conscious exhibitions. At maximum intensity, however, the average illuminance increased to 424.2 lux, with a concentrated peak of 1886 lux at the center, reflecting a focused beam output. While this enhances visual emphasis and depth perception, it exceeds conservation thresholds and is therefore best suited for short-term or

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non-sensitive displays. The bottom lighting component produced an average of 65 lux. This value is slightly above the 50-lux standard but remains within acceptable limits for controlled display conditions. Since this lighting component lacks dimming capability, exposure duration should be managed when displaying highly sensitive materials.

The data confirm that the multi-source LED configuration provides scalable illumination ranging from conservation-safe levels (~50 lux) to high-impact display levels (>700 lux), demonstrating operational flexibility. Minimum intensity settings align with established conservation standards, validating the device's suitability for museum-grade application when properly regulated.

Based on the lighting guidelines of the Illuminating Engineering Society and the International Commission on Illumination, 50 lux is recommended for highly sensitive materials, 150–200 lux for moderately sensitive artworks, and 300 lux or more for less sensitive materials or short-term displays. Furthermore, DiLaura et al. (2020) [3] noted that adjustable LED lighting enhances visual clarity and adaptability, which aligns with the positive ratings observed in this study.

Table III. Operating performance of the Smart Painting Display Board with Adjustable Illumination in terms of illuminance measurements

Surface Illuminance Measurements (in Lux)					
Measurement Area	**Overhead Lights (Max)**	**Overhead Lights (Min)**	**Side Lights (Min)**	**Side Lights (Max)**	**Bottom Lights**
Upper Left	992	288	25	25	25
Lower Left	490	106	65	150	35
Center	1500	285	93	1886	150
Upper Right	454	110	31	25	19
Lower Right	338	70	64	160	96
Average (Eavg)	**754.8**	**171.8**	**55.6**	**424.2**	**65.0**

Legend:

Illumination guidelines based on Illuminating Engineering Society and International Commission on Illumination standards

Luminosity	**Application**
50 lux	Highly sensitive materials
150–200 lux	Moderately sensitive artworks
above 300 lux	Less sensitive materials or short-term display

Operating Performance of the Smart Painting Display Board with Adjustable Illumination In terms of System Responsiveness

Table IV shows the result for the operating performance of the Smart Painting Display Board with Adjustable Illumination in terms of system responsiveness. System responsiveness was evaluated by measuring the time (in seconds) required for the smart functions to execute commands over ten (10) trials. For the Color Adjustment function, response times ranged from 0.4 to 1.0 seconds, with an average response time of 0.70 seconds. For the On/Off Function, response times ranged from 0.4 to 1.0 seconds, with an average response time of 0.67 seconds. Since both functions recorded average response times below 1.0 seconds, the system is classified as "Responsive". These findings imply that the Smart Painting Display Board with Adjustable Illumination smart lighting functions provides near real-time feedback to user commands. The response speed allows smooth interaction without noticeable delay, enhancing usability and operational efficiency.

The result of the study aligns with the Human-Computer-Interaction (HCI) standard on system responsiveness established by Nielsen (2012) [7], classifying the response time under 1 second to be "Responsive" as affirmed by the study of Alhadreti and Mayhew in 2018 [8], stating that system responsiveness significantly influences perceived usability and user satisfaction, particularly in systems requiring real-time interaction. Having an average response time below 1 second both for the on/off function and color adjustment strongly suggests that the SPDBAI smart control system is functional and effective in controlling these functions with the use of a smartphone.

Table IV. Operating performance of the Smart Painting Display Board with Adjustable Illumination in terms of system responsiveness

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Function	Trials (Time in Seconds)											Performance Interpretation
	1	2	3	4	5	6	7	8	9	10	Ave.	
Color adjustment	1	.7	.6	.8	.5	.6	1	.6	.4	.8	0.70	Responsive
On/Off function	1	.7	.5	.7	.5	.7	.9	.5	.4	.8	0.67	Responsive

Legend:

Response Time (Seconds)	Performance Interpretation
< 0.1 s	Instantaneous
0.1 – 1.0 s	Responsive
> 1.0 – 5.0 s	Noticeable Delay
≥ 5.0 s	Poor / Unacceptable

General Acceptability of Smart Painting Display Board with Adjustable Illumination in Terms of Usability, Illumination Quality, Visual Enhancement, and Safety

Table V shows the overall result of the Smart Painting Display Board with Adjustable Illumination in terms of usability, illumination quality, visual enhancement, and safety. The table revealed that the SPDBAI was "Very Acceptable" across all its factors and parameters, including usability, illumination quality, visual enhancement, and safety, with a total mean of 4.63.

It further revealed that the overall mean for usability was 4.59, interpreted as "Very Acceptable". Likewise, illumination quality has an overall mean of 4.61, visual enhancement has an overall mean of 4.76, and safety has an overall mean of 4.56. All of which were also interpreted as "Very Acceptable". The consistently high ratings across categories indicate that the system effectively integrates mechanical design, adjustable lighting technology, and smart control features into a stable and user-centered display solution.

Table V. General acceptability of Smart Painting Display Board with Adjustable Illumination in terms of usability, illumination quality, visual enhancement, and safety

Factors and Parameters	Mean	Verbal Interpretation
Usability	4.59	Very Acceptable
Illumination Quality	4.61	Very Acceptable
Visual Enhancement	4.76	Very Acceptable
Safety	4.56	Very Acceptable
Overall Mean	**4.63**	**Very Acceptable**

Legend:

Scale of Means	Verbal Interpretation
4.21-5.00	Very Acceptable
3.41-4.20	Acceptable
2.61-3.40	Moderately Acceptable
1.81-2.60	Less Acceptable
1.0-1.80	Least Acceptable

IV. CONCLUSION

Based on the findings of the study, the following conclusions were drawn:

The smart painting display board with adjustable illumination (SPDBAI) features specific technical specifications, composition, and functions that enhance the visual impact of showcased paintings in both indoor and

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outdoor exhibits. The device has a functional, responsive smart control system, enabling it to be turned on/off and color adjustment to be easier and more accessible via smartphones.

The structural framework of the display board maintains its vertical integrity regardless of the weight and dimensions of the mounted paintings. The sliding mechanism and locking components of the extension panels function securely and do not compromise the overall structural balance.

The smart painting display board's adjustable illumination provides adequate coverage across different painting sizes; the lighting system effectively covers most standard artwork sizes commonly used in exhibitions. The lighting system maintained sufficient brightness, clarity, and visual comfort under varying environmental conditions and can be used in both indoor and outdoor exhibits. The SPDBAI can operate within established museum lighting standards when properly adjusted. The availability of dimming and multi-source illumination enhances flexibility, allowing users to adjust light exposure based on artwork sensitivity and display requirements.

The device's system responsiveness in both on/off and color adjustment functions is good. The response speed allows smooth interaction without noticeable delay, enhancing usability and operational efficiency for the smart control using smartphones.

The Smart Painting Display Board with Adjustable Illumination performs effectively under operational conditions. The structure maintained full vertical alignment with no displacement; extension panels remained stable during adjustment; movement was smooth across all load sizes; illumination was adequate and adaptable for indoor and outdoor use; and smart functions responded within acceptable response-time thresholds. Collectively, the smart painting display board with adjustable illumination meets functional performance expectations and is suitable for practical exhibition use.

The consistently high ratings for stability, illumination quality, visual quality, and safety indicate that the system effectively integrates mechanical design, adjustable lighting technology, and smart control features into a stable, user-centered display solution.

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