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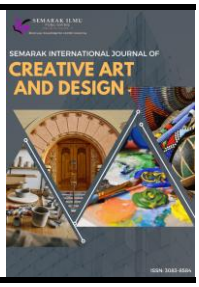

Functional Sculpture: Pinball Machine

Nor Aiman Sukindar[1], Alya Darwisyah Hajizul[1,*], Nur Ain Jazrina Mohamad Yakop[1], Muhammad Hamizan Zaini[1]

[1] School of Design, Universiti Teknologi Brunei, Jalan Tungku Link, Gadong BE1410, Brunei Darussalam

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ABSTRACT

This research delves into the design and development of a functional sculpture representing the School of Design. To establish a clear understanding of student preferences, a comprehensive survey was conducted, capturing the diverse interests and design sensibilities of the student body. Following this, the Pugh method was employed for concept selection, facilitating a systematic evaluation of multiple design ideas. The chosen design—a pinball machine—seamlessly integrates elements of surrealism and fantasy, while serving a practical purpose. The sculpture incorporates architectural, fashion, and product design elements, creating an interactive and engaging representation of the school. The design utilizes materials such as plywood and PLA (Polylactic Acid) for its construction, with the implementation of Arduino technology and sensors to enhance interactivity. Wave-inspired forms, symbolic lighting, and carefully crafted spatial experiences result in a multi-sensory and immersive artwork that reflects the creative spirit of the School of Design.

1. Introduction

Sculptures are parts of many different regions and cultures to convey different meanings and stories. The infamous examples of Greek, Chinese and Western sculpture curated by different artists lived for as long as it had been created till today. Greek Sculpture had many eras—namely, the Archaic Period where the earliest phase of Greek Sculpture presents stories through the stiffness, characteristic of its symmetrical poses and famously "Archaic" Smile, thus, the name of the period.

Whereas the Classical Period (480 until 323 BCE) sculpture had been observed owning the characteristics of naturalism, idealism and intricate detail of accuracy, proportionate and contrapposto. Meanwhile, The Hellenistic Period (323 until 30 BCE) has the characteristics of emotionality, drama, realism depicted in form of violence, suffering of the sculpted models in the storytelling by the artist [1]. Compared to Chinese sculpture in history, it has always been focusing on the simplified forms on lines, blocks and spatial patterns to symbolize different meanings and essence rather than straight-forward information [2]. As for the West, realism and anatomical

[*] *Corresponding author.*
E-mail address: alya.hajizul2@gmail.com

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accuracy was the way to convey stories. Though, sculpture along the way has been shifting from static to dynamic. The industrial revolution and scientific boom have made an impact on the way sculpture has been created, where it is not merely just a decoration to be perceived but slowly moving into the phase where consumers are able to interact and engage with the sculpture [3]. The communication of sculpture has since evolved from beyond the formation of shapes into the movement and spatial spaces of the consumers. On top of that, the meaning of sculpture is no longer on the physical forms but rather, the artistic journey that the artists went through has since created the meaning behind them [4].

Historically, sculpture and painting played pivotal roles in advancing anatomical knowledge. Before the advent of photography, artists collaborated with anatomists to create accurate and detailed representations of the human body. Sculptures offered idealized forms, while paintings delved into internal structures. These visual representations were instrumental in medical education and research thus served as functional sculptures [5]. Nowadays, the presentation of sculpture is a collaborative process between the artist and the designer. The designer's role involves carefully considering the unique qualities of each sculpture, creating harmonious displays, and optimizing the viewer's experience. This includes factors such as lighting, placement, and the integration of display elements with the sculptures themselves [6]. Additionally, environmental labels have emerged as a significant component of contemporary sculptural practice, particularly within the American context. Artists like Robert Glenn have pioneered the use of these labels to provide contextual information and influence viewer interpretation. By incorporating environmental labels, sculptors can offer insights into the artwork's materials, inspiration, and relationship to its surroundings, blurring the lines between sculpture and informational text. These labels serve not only as informational tools but also as integral elements that shape the overall viewer experience [7]. The boundaries between product design and sculpture are increasingly blurred. Contemporary designers are incorporating sculptural elements into functional products, creating objects that are both aesthetically pleasing and useful. The convergence of traditional sculpture and digital technology has opened up new possibilities for artistic expression. Digital tools, such as 3D scanning, printing, and virtual reality, enable sculptors to experiment with form, replication, and interactive experiences. However, this integration presents challenges in preserving the authenticity and artistic integrity of traditional sculptures [8]. This integration offers opportunities for innovation and emotional connection with consumers. However, it also presents challenges in balancing functionality, aesthetics, and production costs. [9]

Moreover, the main sculptures are to be implemented into the product as the elements and landscapes in a pinball machine where it highlights certain aspects. This likely explores how pinball machines use the design of the landscapes to create a sense of challenge and amusement for the player [10]. In addition, programming will be input in the machine and by having this concept, it will allow students to directly interact with the pinball machine's controls and functionalities [11]. Pinball machines are intricate devices that combine mechanical, electrical, and electronic components to create an engaging gaming experience. At the heart of a pinball machine is its playfield, which includes various features such as flippers, bumpers, ramps, and targets. The flippers are player-controlled devices that propel the ball around the playfield. Bumpers and targets are strategically placed to score points and add elements of challenge. Designing pinball games can be used for this purpose since pinball machines interface to the physical world. They contain actuators (in the form of motors and solenoids), sensors (in the form of switches) and visual outputs (in the form of lights and the dot-matrix display) [11]. Moreover, the game requires concentration and strategic thinking, potentially promoting a sense of flow and mental absorption in which this can improve skills and achieving high scores can boost self-esteem and provide a sense of accomplishment [12]. While

pinball machines have a nostalgic and historical appeal, their economic, social, and technological drawbacks suggest that they may not be the best use of resources in a modern context where the use of seemingly unrelated topics/themes decline the pinball industry. It reinforces the game themes of loss, decline and the struggle to find meaning for the overall product [13]. However, one of the breakdowns of the arguments is that there is a shift from seeing pinball machines as solely games of skill or chance, and instead analyzing them as complex systems with rich narratives and design elements [14].

The School of Design currently lacks a physical representation to showcase to visitors and effectively embody the faculty's identity. Hence, this paper aims to document the design process involved in creating a functional sculpture that addresses this issue.

2. Methodology

2.1 Research Analysis

Survey has been sent out to the students of the School of Design faculty to identify potential consumers of the functional sculpture and subsequently to generate concepts. Questions posted on the survey aim to collect information that can act as a guide for the ideation processes such as consumer's preferences, to aid the formation of the sculpture's shapes as well as taking account of the performance of the product's functionality.

According to the survey about the preferences of indoor or outdoor sculpture in Figure 1, 78.6% of respondents prefer sculpture to be placed indoor while 21.4% prefer outdoor. Getting user's opinion on the potential placement of the sculpture is essential as they will be the one using the sculpture, the sculpture subconsciously creates the flow of movement of the consumers around it.

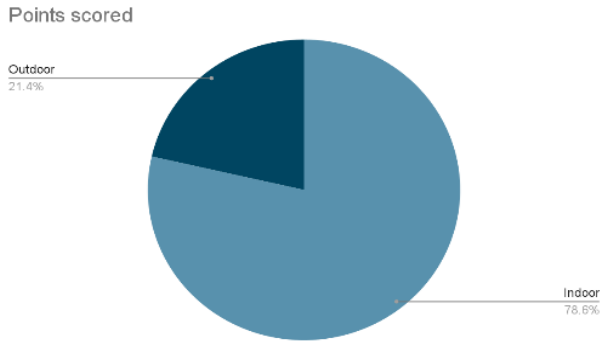


Fig. 1. Consumer's sculpture placement preference

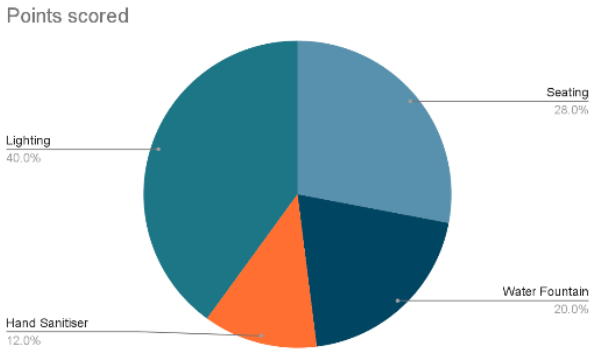


Fig. 2. Consumer's wants and needs for a functional sculpture

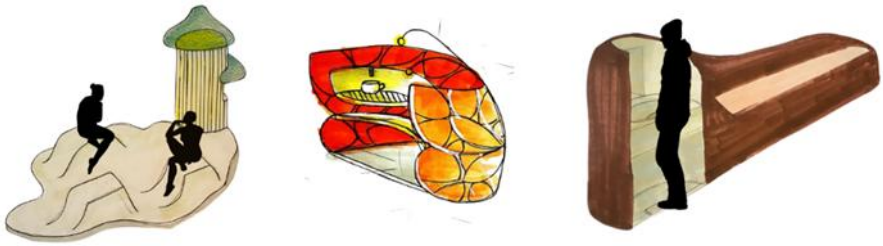
Aside from that, the consumer's expectations of what the sculpture could do was needed to be able to create a functional sculpture (Figure 2). Respondents were asked "what specific features would they expect to have their needs met" from the sculpture, 40% expected Lighting, 28% would like to have a seating area, 20% wanted a water fountain and 12% expected hand sanitiser dispensers. User's input about what they want in a sculpture helps tremendously in determining the design process after.

In another survey question, respondents were asked to describe product design in one word to inform sculpture selection. Words that come up frequently are 'Industrial', 'Metals & Art', 'Unity', 'Designers' and 'Creative'. Additionally, participants were asked to describe the concept of product design in their own words. Keywords that were submitted were: 'Product', 'Prototype', 'Autocad',

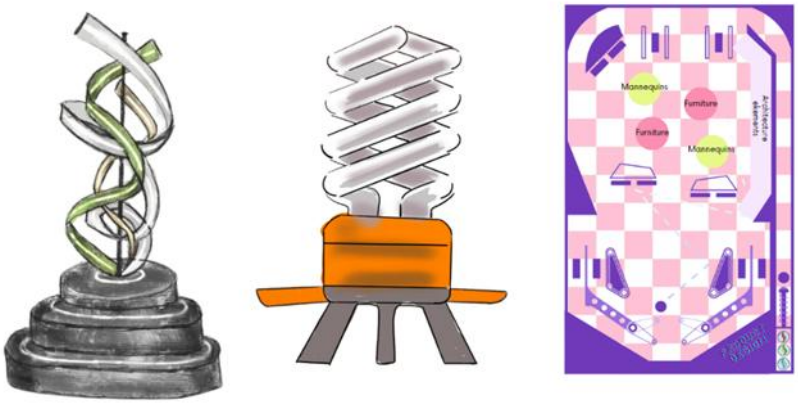
'Functionality'. From these questions and keywords entered by potential users, it can be used to generate concepts.

2.2 Sketching

Based on the survey respondent, a total of 9 sketches were produced as shown in the Figure 3.



(a)



(b)

(c)

Fig. 3. 9 Different sketches with different concepts

As for the concept, different themes were explored. In Figure 3(a), firstly, the concept of Jellyfish and butterflies, with their ethereal and delicate qualities, have captivated artists for centuries. Jellyfish, in particular, offer a unique blend of surrealism and fantasy with their otherworldly appearance, inspiring dreamlike compositions. Their fluid forms also provide a rich source for exploring themes of movement and transformation. Butterflies, on the other hand, often symbolize fragility and the ephemeral nature of beauty. Their vibrant colors and intricate wing patterns offer endless possibilities for artistic interpretation. Both subjects, when combined with the dynamic energy of wave forms, can create artworks that are both visually stunning and conceptually rich.

In Figure 3(b), the Motion Lighting Sculpture embodies the synergy of form and function, its three spiraling forms mirroring the waves' energy transfer. The sensor-activated illumination amplifies this dynamic display. The Lightbulb Water Dispenser, symbolic of knowledge and enlightenment, contrasts the practical function of hydration while sharing a common energy consumption. The Pinball Machine, a fusion of product design, fashion, and architecture, offers an interactive platform for students.

Integrating mannequins and furniture as obstacles, this machine incorporates architectural elements while representing the three design courses through distinct marbles. Together, these installations create a multifaceted exploration of design, technology, and symbolism.

The idea of Figure 3(c). Drawing inspiration from the dynamic nature of waves, our design incorporates undulating elements into both seating and sanitation. The wave-inspired seats feature an up-and-down motion, while the hand sanitizer's curved form echoes the ocean's rhythm. The sanitizer's luminous top not only dispenses cleansing fluid but also illuminates the surrounding area. A nod to the beach, the hollow space evokes the image of a seashell, offering a serene retreat for contemplation and creativity. Soft lighting within this space fosters inspiration and provides a backdrop for photography. The spiral motif, reminiscent of underwater vortices, symbolizes progress and aspiration. Each color within the spiral represents a unique design course, while the central ball signifies the ultimate goal. This integrated design concept seamlessly blends form, function, and symbolism.

2.3 Selection of Ideas

In order to select the best design among the 9 options, the Pugh Method was used. This method assigns scores to each design, allowing for the identification of which design outperforms the DATUM. The DATUM is set individually for each design in which the final design was determined by adding the weighted sum of positive scores, the number of neutral scores and the weighted sum of negative scores as evaluated by each team member. As for the DATUMs, it has been set for each of the user requirements, that is, on how the product should perform to achieve the requirements such as: to determine comfort, it has to feel soft and support the natural position of the human’s body. Another example is the smart system whereby the usage of automated features like buttons replacing manual levers are leveraged in the making of the design.

The design concepts were then narrowed down to 3 according to the Figure 4(a), (b), (c) and subsequently narrowed down into 1 in Figure 4(d).

MIZAN'S PUGH METHOD

	Importance	DATUM	Idea #1	Idea #2	Idea #3
Comfort	**5**	**cushioned, soft, natural**	-	-	-
Size	**4**	**Accordance to human anthropometry**	+	+	+
Aesthetics	**5**	**Design**	-	-	+
Interactive	**4**	**User can play around with it**	s	s	+
Environmental Impact	**4**	**Materials are environmentally friendly**	+	+	+
Weighted Sum of Positives			2	3	5
Number of Sames			2	1	0
Weighted Sum of Negatives			-2	-3	1

(a)

AIN'S PUGH METHOD

	Importance	DATUM	Idea #1	Idea #2	Idea #3
Comfort	**5**	**cushioned, soft, natural**	-	+	s
Size	**4**	**Accordance to human anthropometry**	+	+	+
Aesthetics	**5**	**Design**	+	+	+
Interactive	**4**	**User can play around with it**	-	s	s
Environmental Impact	**4**	**Materials are environmentally friendly**	+	+	+
Weighted Sum of Positives			3	4	4
Number of Sames			1	2	2
Weighted Sum of Negatives			-2	-0	-0

(b)

ALYA'S PUGH METHOD

	Importance	DATUM	Idea #1	Idea #2	Idea #3
Comfort	**5**	**cushioned, soft, natural**	-	+	-
Size	**5**	**Accordance to human anthropometry**	s	s	s
Easy to use	**5**	**no further instructions needed**	+	+	+
Water quality	**5**	**taste of water**	+	-	-
smart control	**3**	**usage of automated features**	-	-	-
brightness	**4**	**intensity of light being used**	s	+	s
Weighted Sum of Positives			2	3	1
Number of Sames			2	1	2
Weighted Sum of Negatives			2	2	3

(c)

CURRENTCRAZE'S PUGH METHOD

	Importance	DATUM	Alya's	Ain's	Mizan's
Comfort	**5**	**Ergonomics**	-	-	-
Size	**4**	**Accordance to human anthropometry**	+	+	+
Aesthetics	**5**	**Features**	-	+	+
Interactive	**4**	**User can play around with it**	-	+	-
Environmental Impact	**4**	**Materials are environmentally friendly**	s	+	s
Weighted Sum of Positives			1	4	2
Number of Sames			1	0	2
Weighted Sum of Negatives			-3	-1	-2

(d)

Fig. 4. Pugh Method used to narrow down designs

3. Results & Discussion

3.1 Final Detailed Design

The resurgence of retro arcades and vintage games has brought pinball back into the spotlight after a near extinction a decade ago. Mechanical pinball blends contemporary technology with intricate mechanisms to resurrect the elements of School of Design, offering a personalized gaming experience. Despite the complexity, modern pinball machines are designed for casual players, integrating pop culture themes to attract a wide audience while maintaining loyalty through meticulous design. The design feature intricate patterns inspired by Islamic geometric textiles that emphasize unity and symmetry, which integrated as the background of the gameplay. his fusion of entertainment and education would create a culturally immersive experience, bridging tradition with modern gaming (Figure 5).

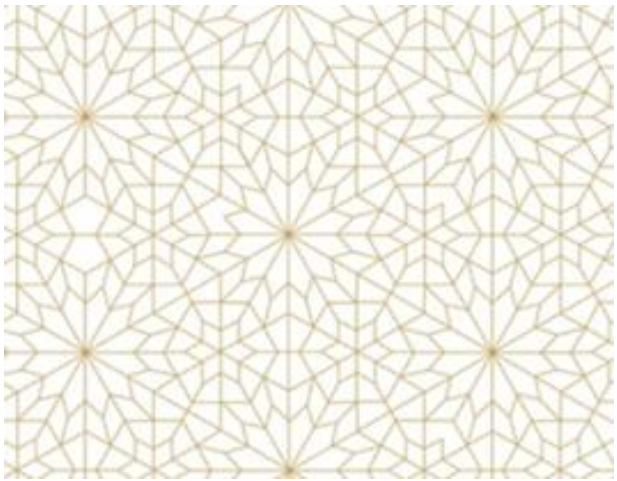
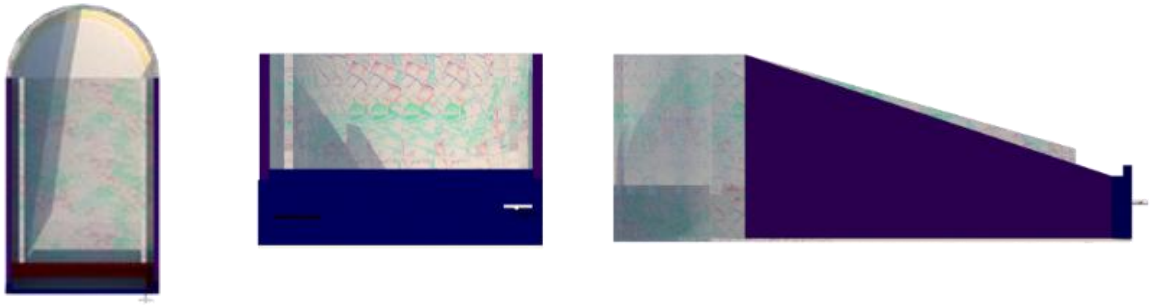


Fig. 5. Islamic pattern

3.1.1 Views



(a) (b) (c)

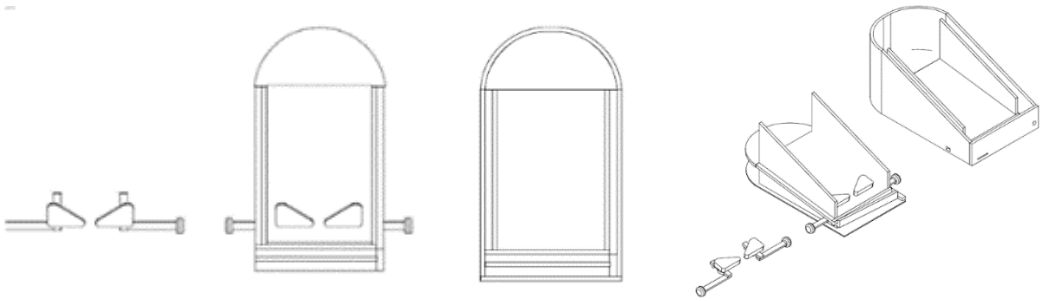
Fig. 6. Different views of sculpture

The functional sculpture presents distinct visual narratives from different perspectives. The top view in Figure 6(a) offers a comprehensive overview of the layout and arrangement of its components, highlighting its spatial organization. The front view in Figure 6(b), conversely, emphasizes the sculpture's primary function and aesthetic appeal, showcasing its interactive elements and visual impact. From the side in Figure 6(c), the sculpture reveals its volumetric form, structural integrity, and the interplay of light and shadow, contributing to its overall three-dimensional character.

3.1.2 Isometric views

Isometric views provide a three-dimensional representation of the functional sculpture, combining elements from top, front, and side perspectives. The top view reveals the overall layout and spatial arrangement of the sculpture's components. The front view emphasizes the sculpture's primary function and aesthetic appeal, showcasing its interactive elements. The side view provides insight into the sculpture's volumetric form, structural integrity, and how it interacts with its surroundings.

3.1.3 Exploded views



(a) (b) (c)

Fig. 7. Exploded views of sculpture

Exploded views (Figure 7(a)-(c)) offer a detailed breakdown of the functional sculpture's internal mechanism. Focusing on the flipper and pusher components, these views illustrate how these elements interact with the side and outer walls of the sculpture. By dissecting the assembly, these

views provide a clear understanding of the component relationships, assembly sequence, and potential points of maintenance or modification.

3.1.4 Diagram of detailed element

Fig. 8. Obstacles labels

Architectural columns (1), which provide structural support and aesthetic appeal to buildings, can also symbolize the various forms of support available to students in a school of design. Just as columns uphold and stabilize a building, the support systems in an educational environment provide stability, guidance, and strength to students. This metaphor highlights the importance of a strong support network in fostering students' academic and personal growth, ensuring they can thrive and succeed just as a well-supported building stands tall and resilient. Gear (2), symbolizes Universiti studies, as designing homes is a fundamental aspect of architectural education. Students learn about various elements such as space planning, structural integrity, aesthetics, sustainability, and the cultural and social needs of residents. Through studying and designing residential buildings, students apply theoretical knowledge to practical scenarios, develop problem-solving skills, and understand the impact of architecture on people's daily lives. This hands-on experience is crucial for shaping competent and innovative architects. Spiral structure (4) A 3-spiral sculpture with three different colors represents the three courses in the School of Design. Each spiral's unique color symbolizes a distinct course highlighting their individual importance within the school.

The upward movement of the spirals signify the academic and personal growth of students as they progress through their studies, illustrating the dynamic and evolving nature of their educational journey (5). These furniture pieces symbolize the hands-on experience that product design students gain while creating innovative yet functional products. Figure 8 illustrate how students engage directly with materials and design processes to develop practical, real-world skills. This hands-on approach is essential for fostering creativity, problem-solving, and the ability to design products that are both aesthetically pleasing and useful.

3.2 Operational Design

3.2.1 Sustainability

Sustainability in making a pinball machine involves integrating eco-friendly practices at every stage of production. By using recycled wood, and biodegradable plastics, the machine’s materials can significantly reduce its environmental footprint. Energy efficiency is also crucial, with LED lighting and low-power electronics minimizing energy consumption during gameplay. Designing the machine with modular components ensures easy repairs and upgrades, extending its lifespan and reducing waste.

By sourcing materials locally, the entire supply chain supports a greener approach to pinball machine production.

3.2.2 Maintainability

Condition-based maintenance is a key aspect of the maintenance anticipated for the project. Regular inspections of both minor and major components, including the flipper mechanism and ball launcher, are necessary as they are prone to failure.

3.2.3 Disposability

The pinball machine, designed with sustainability in mind, emphasizes disposability and reusability principles. It offers an environmentally conscious choice with its primary material being wood, which is renewable and biodegradable. Selected for durability, the wooden parts can be recycled or repurposed, extending their lifecycle. Additionally, the design ensures recyclability of its components, facilitating proper disposal and reuse. Through meticulous material selection, the pinball machine serves both as a stylish interactive product and aligns with the principles of the circular economy.

3.3 Final Prototype

Fig. 9. Final complete prototype

Most elements used in the pinball machine are 3D printed due to the significant benefits of this technology (Figure 9). 3D printing allows for high precision and customization, enabling the creation of complex designs that would be difficult or impossible to achieve with traditional manufacturing methods. It also reduces material waste and production time, leading to more efficient and cost-effective processes. Additionally, 3D printing offers flexibility in design iterations, making it easier to make adjustments and improvements during the development phase. It also ensures that each component of the pinball machine meets specific design and functionality requirements, contributing to a higher-quality final product. In Figure 10 below, these are some examples of the obstacles that were 3D printed.

Fig. 10. Obstacles for pinball

3.4 Adjustments

Major adjustments were made to the prototype along the way (Figure 11). The wood thickness was changed from 5mm to 12mm to ensure the curved part of the product matched the rest of the walls. Initially, the ramps were designed as two-piece structures, with a semi-circle ramp kept flat to maintain all obstacles level. However, testing revealed that the flat ramp caused the marble to get stuck, so the tilt of the lower ramp was adjusted to keep the ball rolling. The ramp design originally featured a two-tier structure with an additional layer added for aesthetic purposes, but this made it difficult to retrace exact measurements and caused the ball to hit the uneven height, disrupting game flow. Additionally, the number of obstacles was reduced to fit within the increased wall thickness. The initial dimensions of 67cm x 37cm, combined with the thicker walls, resulted in smaller interior spaces, affecting obstacle spacing and necessitating a reduction in the number of obstacles.

Fig. 11. Process of Assembling New Wood

3.5 Arduino

Arduino is implemented in the pinball machine to control various components, including sensors and LEDs (Figure 12). The infrared (IR) sensor acts as an input device. When it detects an ID card, it sends a signal to the main Arduino board indicating detection (LOW). Upon receiving this signal, the Arduino sends a current to the light bulbs, causing the LEDs to light up (HIGH). If the sensor does not detect an ID card, it sends no signal to the main Arduino (else), and the LEDs remain unlit (LOW). This setup allows the Arduino to manage the lighting based on the presence of the ID card.

Fig. 12. Visualisation of ID Card usage of sensors

4. Conclusions

The design process of creating a pinball machine as a representative piece for the School of Design presented numerous challenges. While the nostalgic appeal of pinball machines was a driving factor, integrating the core elements of the School of Design into the design proved to be a complex task. Despite these hurdles, the project offered valuable insights into the design process and the potential for merging entertainment with educational representation.

References

[1] Hameed, Umer. "Greek Sculpture." University of Liverpool, 2024, pp. 1-32. Accessed January 2024.
[2] University of Science and Technology Liaoning, and Chang Pan. "Application of the Beauty of Meaning in Chinese Sculpture Art." Scientific and Social Research, vol. 6, no. 5, 2024, pp. 261-264. Accessed 3 June 2024. http://dx.doi.org/10.26689/ssr.v6i5.6855 https://doi.org/10.26689/ssr.v6i5.6855
[3] Kracke, Bernd. "Sculpture as process." PhD diss., Massachusetts Institute of Technology, 1981. https://dspace.mit.edu/handle/1721.1/75490
[4] Yavuz, Ömer Emre. "A STUDY ON THE PROBLEM OF MEANING IN THE ART OF SCULPTURE." ArtGRID-Journal of Architecture Engineering and Fine Arts 5, no. 2 (2023): 147-158. http://dx.doi.org/10.57165/artgrid.1293752 https://doi.org/10.57165/artgrid.1293752
[5] Garrison, Fielding H., and Edward C. Streeter. "Sculpture and Painting as Modes of Anatomical Illustration." Annals of Medical History 2, no. 4 (1919): 305. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7944748/
[6] Ryder, Charles F. "Two sculpture displays: The designer's view." Museum Management and Curatorship 11, no. 3 (1992): 235-255. https://doi.org/10.1016/0964-7775(92)90036-5
[7] Mustafa, D. Sami Ismael, and Karazan Ahmed. "The function of environmental labels in modern American sculpture (Artist Robert Glenn) for example." Fine Arts 4, no. 2 (2023).
[8] Yang, Zeyin. "Application and development of digital enhancement of traditional sculpture art." Scientific Programming 2022, no. 1 (2022): 9095577. https://doi.org/10.1155/2022/9095577
[9] Yi, Wu. "THE INTEGRATION OF PRODUCT DESIGN AND SCULPTURE AI UNDER THE BACKGROUND OF CREATIVE DESIGN INDUSTRY." International Journal of Organizational Innovation (Online) 15, no. 2 (2022): 135-146. https://ijoi-online.org/attachments/article/412/1273%20Final.pdf
[10] Edler, Dennis. "Taunting landscapes in pinball games." In The Social Construction of Landscapes in Games, pp. 149-161. Wiesbaden: Springer Fachmedien Wiesbaden, 2022. https://doi.org/10.1007/978-3-658-35403-9_9
[11] Wong, Daniel, et al. "Implementing games on pinball machines." FDG '10: Proceedings of the Fifth International Conference on the Foundations of Digital Games, 2015, pp. 240 - 247. https://doi.org/10.1145/1822348.1822380
[12] Johnson, Daniel, Katelyn Wiley, Cale Passmore, Ella M. Horton, Roger Altizer, and Regan L. Mandryk. "Shoulder-to-Shoulder: How Pinball Supports Men's Wellbeing." Proceedings of the ACM on Human-Computer Interaction 6, no. CHI PLAY (2022): 1-25. https://doi.org/10.1145/3549514
[13] Banfi, Ryan. "Disco Pinball: Declining Games and Depression in Disco Elysium." Games and Culture (2024): 15554120241240018. https://doi.org/10.1177/15554120241240018
[14] Banfi, Ryan. "Toward a Study of Pinball." Games and Culture 17, no. 7-8 (2022): 931-953. https://doi.org/10.1177/15554120211058315